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NATOPS FLIGHT MANUAL NAVY MODEL F-14B AIRCRAFT

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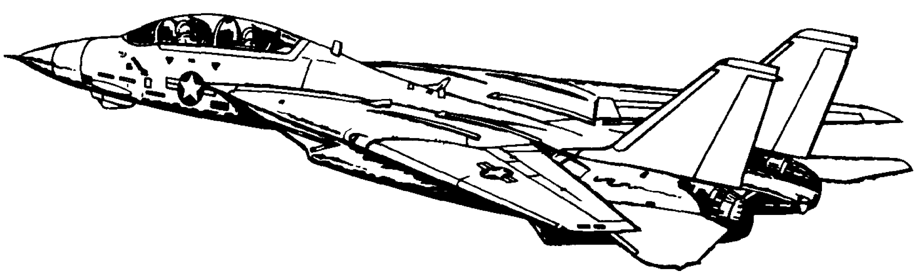

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DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

1 August 2001

LETTER OF PROMULGATION

1. The Naval Air Training and Operating Procedures Standardization (NATOPS) Program is a positive approach toward improving combat readiness and achieving a substantial reduction in the aircraft mishap rate. Standardization, based on professional knowledge and experience, provides the basis for development of an efficient and sound operational procedure. The standardization program is not planned to stifle individual initiative, but rather to aid the commanding officer in increasing the unit's combat potential without reducing command prestige or responsibility.

2. This manual standardizes ground and flight procedures but does not include tactical doctrine. Compliance with the stipulated manual requirements and procedures is mandatory except as authorized herein. In order to remain effective, NATOPS must be dynamic and stimulate rather than suppress individual thinking. Since aviation is a continuing, progressive profession, it is both desirable and necessary that new ideas and new techniques be expeditiously evaluated and incorporated if proven to be sound. To this end, commanding officers of aviation units are authorized to modify procedures contained herein, in accordance with the waiver provisions established by OPNAVINST 3710.7, for the purpose of assessing new ideas prior to initiating recommendations for permanent changes. This manual is prepared and kept current by the users in order to achieve maximum readiness and safety in the most efficient and economical manner. Should conflict exist between the training and operating procedures found in this manual and those found in other publications, this manual will govern.

3. Checklists and other pertinent extracts from this publication necessary to normal operations and training should be made and carried for use in naval aircraft.

M.J. McCABE
Rear Admiral, U.S. Navy
Director, Air Warfare

INTERIM CHANGE SUMMARY

The following Interim Changes have been cancelled or previously incorporated into this manual.

INTERIM CHANGE NUMBER(S)	REMARKS/PURPOSE
1 thru 31	Previously incorporated

The following Interim Changes have been incorporated into this Change/Revision.

INTERIM CHANGE NUMBER(S)	REMARKS/PURPOSE
32	Spoiler Malfunctions
33	Currency Requirements
34	F–14A Transition NATOPS Qualification Requirements
35	On–Deck Emergency Egress from Aircraft
36	GRU–7A Ejection Seat Preflight
37	Functional Checkflight Procedures
38	Ejection Seat Preflight Warning
39	Roll Maneuvering Limits
40	Ejection Seat Injury Risks Warnings
41	Catapult Takeoff Procedures
42	Digital Flight Control System (DFCS)
43	Advance Change Items (AFCS Aircraft only)
44	Functional Checkflight Engine Runup Check Procedures
45	Rudder Hardover, Controllability, Uncommanded Roll and/or Yaw Procedures
46	Advance Change Items

Interim Changes Outstanding — To be maintained by the custodian of this manual.

INTERIM CHANGE NUMBER	ORIGINATOR/DATE (or DATE/TIME GROUP)	PAGES AFFECTED	REMARKS/PURPOSE

Summary of Applicable Technical Directives

Information relating to the following technical directives has been incorporated into this manual.

ECP NUMBER	DESCRIPTION	DATE INC. IN MANUAL	VISUAL IDENTIFICATION
AFC 654	Engine Stall Warning	1 August 2001	
AFC 663	Airstream Sensors	1 August 2001	
AFC 688	Turbine/Compressor Blanket	1 August 2001	
AFC 717	Spoiler Operation to 62 degrees	1 August 2001	
AFC 735	Mod DLC	1 August 2001	
AFC 2342	APC/Boost Disengage	1 August 2001	
AFC 823	Control Stick Paddle Switch Modification	1 August 2001	
AFC 4409	Engine Mode Select Panel Modification	1 August 2001	
AFC 4410	Control Stick Modification	1 August 2001	
AFC 840	Upgrade Program: Airframe/Elect/AVI	1 August 2001	
AFC 863	Night Vision Imaging System Lighting	1 August 2001	
AFC 869	Digital Flight Control System	1 August 2001	
AFC 871	EGI Upgrade	1 August 2001	
AFC 883	Low–Altitude Warning System Modification	1 August 2001	
AFC 8921	DFCS Circuit Breaker Modification	1 August 2001	
AFC 899	PTID Upgrade Wiring	1 August 2001	

RECORD OF CHANGES

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LIST OF ACRONYMS AND ABBREVIATIONS

A

A/A. Air-to-air.

A/C. Aircraft /Air-conditioning.

AAA. Anti-aircraft artillery.

AAC. Aviation armament change.

AAW. Antiair warfare.

AB. Afterburner.

ac. Alternating current.

ACC. Aircrew system change.

ACL. Automatic carrier landing.

ACLS. Automatic Carrier Landing System.

ACM. Air combat maneuvering.

ACP. Armament control panel.

ACQ. Acquisition (TCS).

ACS. Automatic channel select.

A/D. Analog-to-digital.

ADAC. Airborne data acquisition computer.

ADD. Angle of attack as measured by the alpha probe.

ADF. Automatic direction finder.

ADI. Attitude director indicator.

ADL. Armament datum line.

ADRL. Automatic Distribution Requirements List.

AEC. Automatic exposure control.

AFB. Airframe bulletin.

AFC. Airframe change; afterburner fuel control.

AFTC. Augmenter fan temperature control.

A/G. Air-to-ground.

AGL. Above ground level.

AHRS. Attitude Heading Reference System.

AIC. Air inlet control.

AICS. Air Inlet Control System.

AIM-7. Sparrow Missile.

AIM-9. Sidewinder Missile.

AIM-54. Phoenix missile.

ALR. Radar warning receiver.

AM. Amplitude modulation.

ANT. Antenna.

AOA. Angle of attack.

APC. Approach power compensator.

APCC. Advanced pod control computer.

ARI. Automatic rudder interconnect.

ASH. Automatic stored heading.

ASR. Air surveillance radar.

ATDC. Airborne tactical data control.

ATDS. Airborne tactical data system.

ATLS. Asymmetric Thrust Limiting System.

ATTK. Attack.

AVB. Avionics bulletin.

AVBUS. Avionics bus.

AVC. Avionic change.

AVIA. PTID AOA, VV, ILS, and ACLS.

AVTR. Airborne video tape recorder.

AWCS. Airborne Weapons Control System.

AWL. All-weather landing.

AYC. Accessories change.

B

BARO. Barometric.

BATR. Bullet at target range.

BDHI. Bearing-distance-heading indicator.

BER. Bearing.

BFCM. Backup flight control module.

BIDI. Bi-directional hydraulic pump.

BINGO. Return fuel state.

BIST. Built-in self-test.

BIT. Built-in test.

BLS. Basic landing display.

BMT. BIT moving target.

Bolter. Hook down, unintentional touch and go.

BRU. Bomb rack unit.

BTOF. Buffer time of fail.

C

CAD. Cartridge-actuated device.

CADC. Central air data computer.

CAP. Combat air patrol/computer address panel.

CARQUAL. Carrier qualifications.

CAS. Calibrated airspeed.

CAT. Catapult.

CATCC. Carrier air traffic control center.

cb. Circuit breaker.

cc. Cubic centimeter.

CCA. Carrier-controlled approach.

CCDL. Cross channel data link.

CDNU. Control display navigation unit.

CEM. Computer-expanded memory.

CEP. Circular error probable.

CEU. Central electronics unit.

cg. Center of gravity.

CGTL. Command ground track line.

CHAL. Challenge.

Charlie Time. Expected time over ramp.

CIACS. Coded integrated armament control system.

CICU. Computer integrated converter unit.

CIPDU. Control indicator power distribution unit.

CLSN. Collision.

CM. Continuous monitor.

CMB. Code matrix box.

CMD. Command.

CMPTR. Computer.

CNI. Communication-navigation-identification.

CO_2. Carbon dioxide.

COATS. **CIACS** Operational Assessment Timing System.

COT. Crew operation trainer.

CP. Central processor.

CPA. Closest point of approach.

CPS. Controller processor signal unit/cycles per second/Control power supply.

CRT. Cathode ray tube.

CSD. Constant speed drive/computer signal data.

CSDC. Computer signal data converter.

CSDC(R). Computer signal data converter (replacement).

CSS. Control stick steering.

CTVS. Cockpit television sensor.

CV. Aircraft carrier.

CVA. Aircraft carrier approach.

CVS. Course vectoring symbol.

CWI. Continuous-wave illuminator.

D

D/A. Digital-to-analog.

dB. Decibel.

dc. Direct current.

DCP. DFCS control panel.

DD. Digital display.

DDD. Detail data display.

DDI. Digital data indicator.

DDS. Data Display Dystem; Digital Data System.

DECM. Defensive electronic countermeasure.

deg/sec. Degrees per second.

DEST. Destination.

DF. Direction finder.

DFCC. Digital flight control computer.

DFCS. Digital Flight Control System.

DFM. Dogfight mode.

DG. Directional gyro.

DGR. Degrade (DFCS).

D/L. Data link.

DLC. Direct lift control.

DLM. Data logging module.

DLS. Data-link transceiver.

DMA. Degraded mode assessment.

DME. Distance measuring equipment.

DPGS. Data processing ground station.

DRO. Destructive readout.

DS. Detection sensitivity.

DSS. Data storage set.

DTF. Differential tail fadeout.

DTM. Data transfer module.

E

EAC. Expected approach clearance time.

EAS. Equivalent airspeed.

ECA. Expanded chaff adapter.

ECCM. Electronic counter-countermeasures.

ECM. Electronic countermeasures.

ECMD. Electronic countermeasures display.

ECS. Environmental control system.

ECU. Environmental control unit.

EHE. Estimated horizontal error.

EGI. Embedded GPS/INS.

EGT. Exhaust gas temperature.

EIF. Exposure interval factor.

EIG. Engine instrument group.

EMCON. Electronic radiation control.

EMSP. Engine monitoring system processor.

ETA. Estimated time of arrival.

F

FAM. Familiarization.

FCF. Functional checkflight.

FCLP. Field carrier landing practice.

FCS. Flight control system, fire control set.

FD. Fault direction.

FEMS. Fatigue Engine Monitoring System.

FF. Fuel flow.

FF/DL. Fighter-to-fighter data link.

FI. Fault isolation.

FL. Flight level.

FLC. Film motion compensation.

FLOLS. Fresnel Lens Optical Landing System.

FLRP. Fighter link reference point.

FMC. Fighter mode command/film motion compensation/F-14 mission computer.

FMI. Flight maintenance indicator.

FMLP. Field mirror landing practice.

FOD. Foreign object damage.

FOM. Figure of merit.

FOV. Field of view.

FRL. Fuselage reference line.

FRS. Fleet replacement squadron.

FTCM. Flight test continuous monitoring.

FWD. Forward.

G

G. Guard channel.

g. Gravity.

G/A. Ground to air.

GACH. Gimble angle crosshair.

GC. Gyro compass.

GCA. Ground-controlled approach.

GCI. Ground-controlled intercept.

GCU. Generator control unit.

GDOP. Geometric dilution of precision.

GHz. Gigahertz.

GPS. Global Positioning System.

GRB. Ground roll braking.

GRD. Grid data.

GSS. Gun Scoring System.

GT. Ground track.

H

HCU. Hand control unit.

HDG. Heading.

HERO. Hazards of electromagnetic radiation to ordnance.

HRWS. Hot range while search.

HSD. Horizontal situation display.

HSI. Horizontal situation indicator.

HUD. Heads-up display.

HYD. Hydraulic.

Hz. Hertz.

I

IAS. Indicated airspeed.

IBIT. Initialized built-in-test.

ICAO. International Civil Aviation Organization.

ICS. Intercommunications.

IDG. Integrated-drive generator.

IEU. Inertial electronics unit.

IFF. Identification friend or foe.

IFR. Instrument flight rules.

IFT. In-flight training.

IGV. Inlet guide vane.

ILS. Instrument Landing System.

IMA. In motion alignment.

IMC. Instrument meteorological conditions.

IMN. Indicated Mach number.

IMU. Inertial measurement unit.

INBD. Inboard.

InHg. Inch of Mercury.

INIT. Initialization.

INS. Inertial Navigation System.

IP. Initial point.

IR. Infrared.

IRCM. Infrared countermeasures.

IRLS. IR line scanner.

IRNR. IR not ready.

IROT. IR/TV on target.

IRRS. Infrared reconnaissance set.

IRW. IR wide.

ITER. Improved triple ejector rack.

ITS. Integrated trim system.

J

JAT. Jam angle track.

K

KCAS. Knots calibrated airspeed.

kHz. Kilohertz.

KIAS. Knots indicated airspeed.

KTS. Knots.

kVA. Kilovolt-ampere.

L

LARI. Lateral automatic rudder interconnect.

LAT. Latitude.

LBA. Limits of basic aircraft.

LCD. Liquid crystal display.

LCOS. Lead computing optical sight.

LD. Landing.

LE. Leading edge.

LONG. Longitude.

LOROP. Long-range oblique photography.

LOS. Line of sight.

LOX. Liquid oxygen.

LPA. Life preserver assembly.

LS. Line scanner.

LSK. Line select key.

LSO. Landing signal officer (Paddles).

LSRI. Lateral stick-to-rudder interconnect.

LSXC. Low speed cross control.

LTE. Launch to Eject.

M

M. Mach.

MAC. Mean aerodynamic chord.

MAD. Magnetic azimuth detector.

MAG VAR. Magnetic variation.

MAS. Missile auxiliary subsystem.

MATS. Missile auxiliary test.

MAX. Maximum.

MBE. Mux bus emulator.

MCM. Monitor control message.

MCT. Memory confidence test.

MDIG. Multipurpose display indicator group.

MDL. Mission data loader.

MDP. Mission data processor.

Meatball. Glideslope Image of Mirror Landing System.

MEC. Main engine control.

MER. Multiple ejector rack.

MFD. Multifunction displays.

MGRS. Military Grid Reverence System.

MH. Magnetic heading.

MHz. Megahertz.

MIL. Military.

MITS. Missile interface test set.

MLC. Mainlobe clutter.

MLG. Main landing gear.

MOAT. Missile on aircraft test.

MMGS. Multiple mode gun sight.

MR. Maintenance readout.

MRT. Military rated thrust.

MSL. Mean sea level.

MTDS. Marine Tactical Data System.

MTM. Magnetic tape memory.

MWOD. Multiple word of the day.

N

NAG. Air-to-ground mode.

NATO. North Atlantic Treaty Organization.

NATOPS. Naval air training and operating procedures standardization.

NATSF. Naval Air Technical Services Facility.

NAV BUS. Navigation bus.

NAV GRID. Navigation command and control grid.

NDRO. Nondestructive readout.

NED. North/east/down.

NESA. Nose equipment support assembly.

NFL. Notch filter left.

NFO. Naval flight officer.

NFOV. Narrow field of view.

NFR. Notch filter right.

nm. Nautical miles.

NOTAM. Notices to airmen.

NOZ. Nozzle.

NPS. Navigation power supply.

NR. Number.

NRNG. No range.

NTDS. Naval Tactical Data System.

NVIS. Night Vision Imaging System.

NWP. Naval warfare publication..

NWPM. Non-write-protected memory.

NWS ENGA. Nosewheel steering engaged.

N_1. Low-pressure compressor rotor speed.

N_2. High-pressure compressor rotor speed.

O

OAT. Outside air temperature.

OBC. On-board check.

OFS. Operational flight software.

OFT. Operational flight trainer.

OUTBD. Outboard.

OV SWP. Oversweep.

OWF. Overwing fairing.

OXY. Oxygen.

P

Paddles. Landing signal officer.

PAN. Panoramic.

PAP. Precision approach point.

PAR. Precision approach radar.

PBIT. Periodic built-in test.

PC. Pulse compression.

PCD. Precision course direction.

PCL. Pocket checklist.

PD. Pulse Doppler.

PDCP. Pilot display control panel.

PDS. Pulse Doppler search.

PDSTT. Pulse Doppler single target track.

PGU. Improved round for the M-61 gun (new bullet).

PH. Phoenix missile.

PID. Program identification.

PIO. Pilot-induced oscillation.

PLM. Pilot lock-on mode.

PMDIG. Programmable multiple display indicator group.

PP. Peak power.

PPC. Powerplant charge.

pph. Pounds per hour.

PPI. Plan position indicator.

PPS. Precise Positioning System.

PQVM. Pitch/roll voter monitor.

PRF. Pulse repetition frequency.

PRI. Primary.

PS. Pulse search.

P_s. Static pressure.

psi. Pounds per square inch.

PSTT. Pulse single target track.

PSU. Power switching unit.

PT. Engine power trim.

P_t. Total pressure.

PTID. Programmable tactical information display.

PTO. Pilot takeover.

P_{T7}. Turbine exhaust pressure.

Q

q. Dynamic pressure.

QADL. Cue-to-ADL.

QDES. Cue-to-designate.

QHUD. Cue-to-HUD.

QSNO. Cue-to-snowplow.

QWP. Cue-to-waypoint.

R

RACH. Radar angle crosshair.

RARI. Rudder automatic rudder interconnect.

RATS. Reduced Arrestment Thrust System.

RDO. Recovery duty officer.

RDR. Radar.

RDROT. Radar on target.

RDY. Ready.

REC. Receive.

RECON. Reconnaissance.

RET. Retract.

rf. Radio frequency.

RID. Reject image device.

RIO. Radar intercept officer.

RLG. Ring laser gyro.

RNAV. Area navigation.

ROM. Read-only memory.

ROT. Range on target.

rpm. High-pressure compressor rotor speed (N_2).

RSTV. Radar slaved TV.

RWR. Radar warning receiver.

RWS. Range while search.

S

SA. Semiautomatic acquisition mode.

SAI. Situational awareness indicator.

SAL. Semi-active launch.

SAM. Surface-to-air missile.

SAR. Search and rescue.

SAS. Stability Augmentation System.

SC. Sensor control.

SCADC. Standard central air data computer.

SCP. Sensor control panel.

SDC. Signal data converter.

SEAM. Sidewinder expanded acquisition mode.

SEAWARS. Seawater-activated Release System.

SEC. Secondary.

SEP. Spherical error probable.

SIF. Selective identification feature.

SINS. Ship Inertial Navigation System.

SP. Sparrow missile.

SPAM. Special aid to maintenance.

SPS. Standard Positioning System.

STAB AUG. Stability augmentation.

STBY. Standby.

STT. Single target track.

SSI. Standard serial interface.

SW. Sidewinder missile.

T

Tacan. Tactical air navigation.

TAC DRO. Tactical destructive readout.

TARPS. Tactical air reconnaissance pod system.

TAS. True airspeed.

TCA. Turbine compressor assembly.

TCR. Time code readout.

TCS. Television camera set.

TDRS. Tactical Data Recording System.

TDS. Tactical Data System.

TED. Trailing edge down.

TER. Triple ejector rack.

TEU. Trailing edge up.

TIT. Turbine inlet temperature.

TNG. Training.

TOD. Time of day.

TOF. Time of fall.

TOT. Time on target.

T/R. Transformer-rectifier.

TREL. Time-to-release.

TRK. Track.

TS. Static temperature.

T_S. Free air temperature.

TSPS. Targeting set power supply.

T_{T2}. Compressor inlet temperature.

T_{T4}. Compressor discharge temperature.

TTFF. Time to first fix.

TV. Television.

TVS. Television search.

TVT. Television track.

TWS. Track while scan.

U

UHF. Ultra-high frequency.

UHT. Unit horizontal tail.

UTC. Universal Coordinated Time.

UTM. Universal test message.

V

Vac. Volts alternating current.

Vc. Closing velocity rate.

vC. Computed/calculated MAG VAR.

Vdc. Volts direct current.

VDI. Vertical display indicator.

VDIG. Vertical display indicator group.

VEC. Vector.

VERT. Vertical.

VFR. Visual flight rules.

Vg/H. Velocity/height.

V/H. Velocity altitude factor (Vg/H).

VID. Visual identification.

vM. Manual MAG VAR.

VMC. Visual meteorological conditions.

VMCG. Minimum control groundspeed.

VMCU. Voltage monitor control unit.

Vmin and Vmax. Minimum and maximum velocity.

VNAV. Vertical navigation.

VR. Rotation speed.

VSI. Vertical speed indicator.

VSV. Variable stator vane.

VTR. Video tape recorder.

VV. Vertical velocity.

V_1. Critical engine failure speed.

W

WCP. Weapons control processor.

WCS. Weapons Control System.

WFOV. Wide field of view.

WOD. Wind over the deck/word of the day.

WOW. Weight on wheels or weight off wheels.

WP. Way point.

WPM. Weapons program memory.

WRA. Weapons replaceable assembly.

WRS. Wing rock suppression.

WST. Weapons system trainer.

Y

YY. Geographic reference point for NAV GRID.

Z

ZFGW. Zero fuel gross weight.

PREFACE

SCOPE

The NATOPS Flight Manual is issued by the authority of the Chief of Naval Operations and under the direction of Commander, Naval Air Systems Command in conjunction with the Naval Air Training and Operating Procedures Standardization (NATOPS) Program. This manual contains information on all aircraft systems, performance data, and operating procedures required for safe and effective operations. However, it is not a substitute for sound judgment. Compound emergencies, available facilities, adverse weather or terrain, or considerations affecting the lives and property of others may require modification of the procedures contained herein. Read this manual from cover to cover. It is your responsibility to have a complete knowledge of its contents.

APPLICABLE PUBLICATIONS

The following applicable publications complement this manual:

NAVAIR 01–F14AAP–1.1 (Performance Charts)

NAVAIR 01–F14AAA–1A (Supplemental)

NAVAIR 01–F14AAP–1B (Pocket Checklist)

NAVAIR 01–F14AAP–1F (Functional Checkflight Checklist)

NWP 55–5–F14 Tactical Manual, Vol I (NAVAIR 01–F14AAA–lT)

NWP 55–5–F14 Tactical Manual, Vol II (NAVAIR 01–F14AAA–lT–1)

NWP 55–5–F14 Tactical Manual, Vol III (NAVAIR 01–F14AAA–1T–2)

NWP 55–5–F14 Tactical Pocket Guide, (NAVAIR 01–F14AAA–lT–3)

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UPDATING THE MANUAL

To ensure that the manual contains the latest procedures and information, NATOPS review conferences are held in accordance with OPNAVINST 3710.7 series.

CHANGE RECOMMENDATIONS

Recommended changes to this manual or other NATOPS publications may be submitted by anyone in accordance with OPNAVINST 3710.7 series.

Routine change recommendations are submitted directly to the Model Manager on OPNAV Form 3710/6 (4-90) shown herein. The address of the Model Manager of this aircraft is:

Commanding Officer
Fighter Squadron 101
NAS Oceana
Virginia Beach, VA 23460
DSN: 433–5147
Commercial: (757) 433–5147

Attn: F–14B Model Manager

Change recommendations of an URGENT nature (safety of flight, etc.), should be submitted directly to the NATOPS Advisory Group Member in the chain of command by priority message.

YOUR RESPONSIBILITY

NATOPS Flight Manuals are kept current through an active manual change program. Any corrections, additions, or constructive suggestions for improvement of its content should be submitted by routine or urgent change recommendation, as appropriate at once.

NATOPS FLIGHT MANUAL INTERIM CHANGES

Flight Manual Interim Changes are changes or corrections to the NATOPS Flight Manuals promulgated by CNO or NAVAIRSYSCOM. Interim Changes are issued either as printed pages, or as a naval message. The Interim Change Summary page is provided as a record of all interim changes. Upon receipt of a change or revision, the custodian of the manual should check the updated Interim Change Summary to ascertain that all outstanding interim changes have been either incorporated or canceled; those not incorporated shall be recorded as outstanding in the section provided.

CHANGE SYMBOLS

Revised text is indicated by a black vertical line in either margin of the page, like the one printed next to this paragraph. The change symbol shows where there has been a change. The change might be material added or information restated. A change symbol in the margin by the chapter number and title indicates a new or completely revised chapter.

WARNINGS, CAUTIONS, AND NOTES

The following definitions apply to WARNINGs, CAUTIONs, and Notes found throughout the manual.

WARNING

An operating procedure, practice, or condition, etc., that may result in injury or death, if not carefully observed or followed.

CAUTION

An operating procedure, practice, or condition, etc., that may result in damage to equipment, if not carefully observed or followed.

Note

An operating procedure, practice, or condition, etc., that is essential to emphasize.

WORDING

The concept of word usage and intended meaning adhered to in preparing this Manual is as follows:

1. Shall has been used only when application of a procedure is mandatory.

2. Should has been used only when application of a procedure is recommended.

3. May and need not have been used only when application of a procedure is optional.

4. Will has been used only to indicate futurity, never to indicate any degree of requirement for application of a procedure.

NATOPS/TACTICAL CHANGE RECOMMENDATION
OPNAV 3710/6 (4-90) S/N 0107-LF-009-7900

DATE ____________________

TO BE FILLED IN BY ORIGINATOR AND FORWARDED TO MODEL MANAGER

FROM (Originator)	Unit
TO (Model Manager)	Unit

Complete Name of Manual/Checklist	Revision Date	Change Date	Section/Chapter	Page	Paragraph

Recommendation (Be specific.)

☐ CHECK IF CONTINUED ON BACK

Justification

Signature	Rank	Title

Address of Unit or Command

TO BE FILLED IN BY MODEL MANAGER *(Return to Originator)*

FROM	DATE
TO	

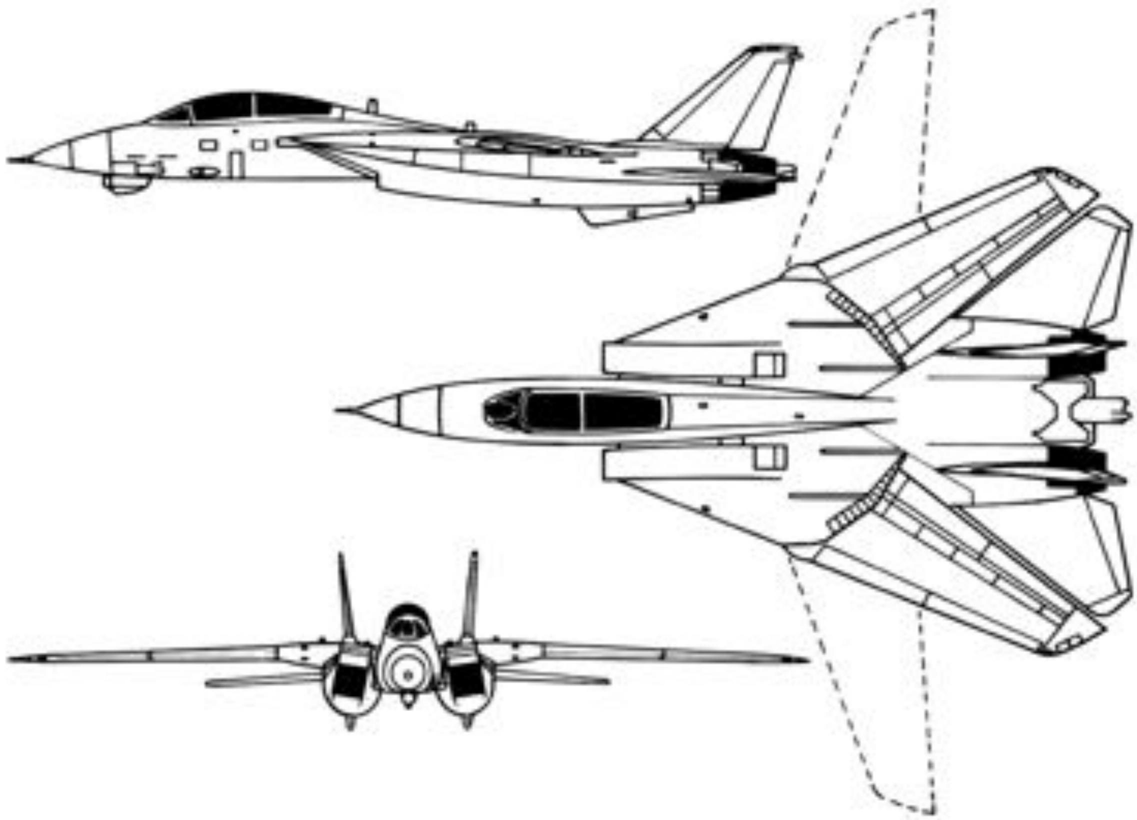
REFERENCE
(a) Your Change Recommendation Dated ____________________

☐ Your change recommendation dated ____________________ is acknowledged. It will be held for action of the review conference planned for ____________ to be held at ____________________

☐ Your change recommendation is reclassified URGENT and forwarded for approval to ____________________ ____________ by my DTG ____________________

/S/ ____________________ MODEL MANAGER ____________________ AIRCRAFT

F-14B TOMCAT



PART I

The Aircraft

CHAPTER 1

Aircraft and Engine

1.1 AIRCRAFT

The F-14B aircraft is a supersonic, two-place, twin-engine, swing-wing, air-superiority fighter designed and manufactured by Grumman Aerospace Corporation. In addition to its primary fighter role, carrying missiles (Sparrow and/or Sidewinder) and an internal 20-millimeter gun, the aircraft is designed for fleet air defense (Phoenix missiles) and ground attack (general purpose and precision ordnance) missions. Armament and peculiar auxiliaries used only during secondary missions are installed in low-drag, external configurations. Mission versatility and tactical flexibility are enhanced through independent operational capability or integration under existing tactical data systems.

The forward fuselage, containing the flightcrew and electronic equipment, projects forward from the midfuselage and wing glove. Outboard pivots in the highly swept wing glove support the movable wing panels, which incorporate integral fuel cells and full-span leading-edge slats and trailing-edge flaps for supplemental lift control. In flight, the wings may be varied in sweep, area, camber, and aspect ratio by selection of any leading-edge sweep angle between 20° and 68°. Wing sweep can be automatically or manually controlled to optimize performance and thereby enhance aircraft versatility. Separate variable-geometry air inlets, offset from the fuselage in the glove, direct primary airflow to two F110-GE-400 dual axial-compressor, turbofan engines equipped with afterburners for thrust augmentation. The displaced engine nacelles extend rearward to the tail section, supporting the twin vertical tails, horizontal tails, and ventral fins. The middle and aft fuselage, which contains the main fuel cells, tapers off in depth to the rear where it accommodates the speedbrake surfaces and arresting hook. All control surfaces are positioned by irreversible hydraulic actuators to provide desired control effectiveness throughout the flight envelope. Stability augmentation features in the flight control system enhance flight characteristics and thereby provide a more stable and maneuverable weapons delivery platform. The tricycle-type, forward-retracting landing gear is designed for nosegear catapult launch and carrier landings. Missiles and external stores are carried from eight hardpoint stations on the center fuselage between the nacelles and under the nacelles and wing glove; no stores are carried on the movable portion of the wing. The fuel system incorporates both in-flight and single-point ground refueling capabilities. Aircraft general dimensions are shown in Figure 1-1. FO–1 and FO–2 show the general placement of components within the aircraft.

1.1.1 Aircraft Weight. The basic empty weight of the aircraft when configured to the current fleet specification is approximately 43,600 pounds. This includes trapped fuel, oil, gun, sub pylons (without missile rails/launchers) and aircrew. Consult the applicable Handbook of Weight and Balance (NAVAIR 01-1B-40) for the exact weight of any series aircraft.

1.1.2 Cockpit. The aircraft accommodates a two-man crew consisting of a pilot and RIO in a tandem seating arrangement. To maximize external field of view, stations within the tandem cockpit are prominently located atop the forward fuselage and enclosed by a single clamshell canopy. Integral boarding provisions to the cockpit and aircraft top deck are on the left side of the fuselage. Each crew station incorporates a rocket ejection seat that is vertically adjustable for crew accommodation. A single environmental control system provides conditioned air to the cockpit and electronic bays for pressurization and air-conditioning. Oxygen for breathing is supplied to the crew under pressure from liquid storage bottles. The cockpit arrangement provides minimum duplication of control capability that, of necessity, requires two crewmen for flight.

1.1.2.1 Pilot Cockpit. The forward station of the cockpit is arranged and equipped for the pilot. In addition to four electronic displays for viewing tactical, flight, navigational, and ECM data, the pilot instrument panel also contains armament controls and flight and engine instruments.

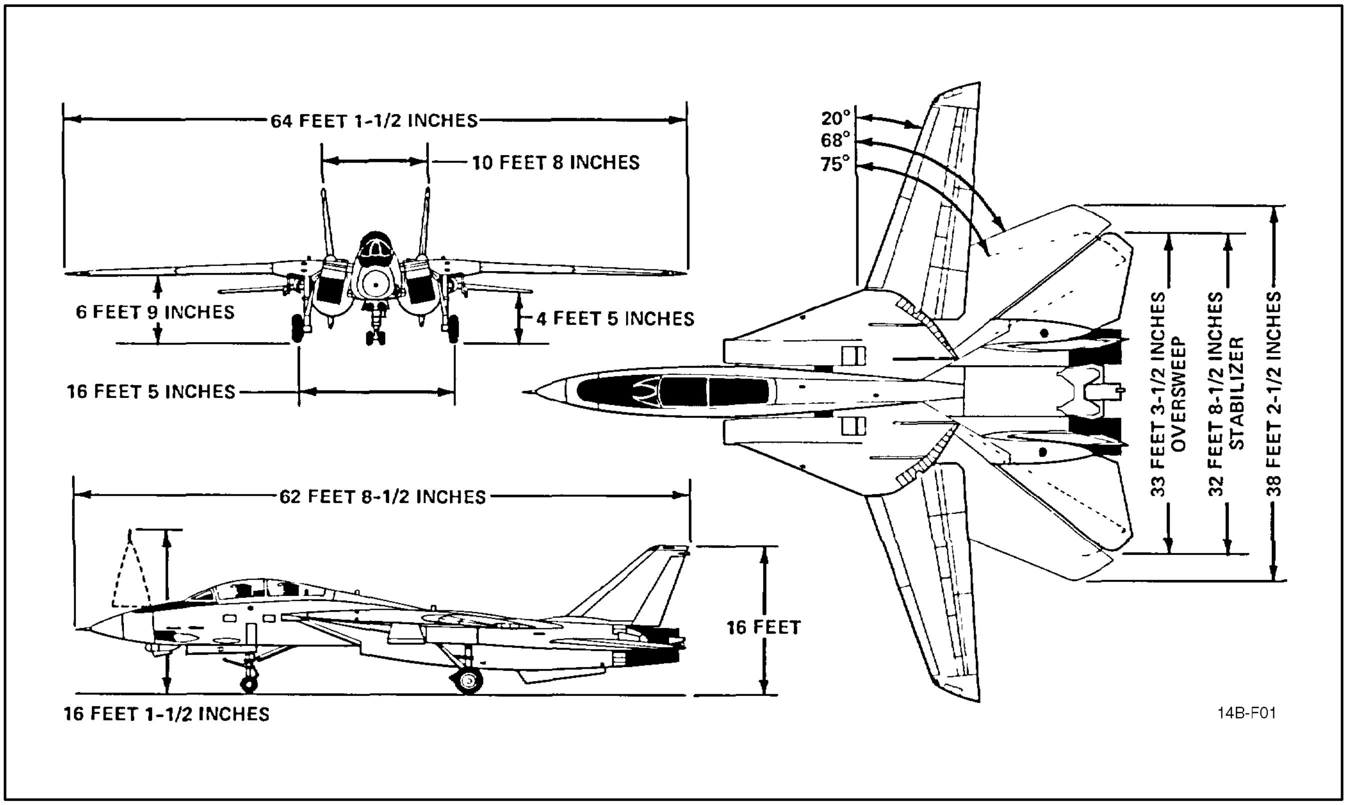


Figure 1-1. Aircraft Dimensions

Engine controls, fuel management, auxiliary devices, autopilot and communication control panels are on the left console. Display, power, lighting, and environmental controls are on the right console.

1.1.2.2 RIO Cockpit. The aft station of the cockpit is equipped for the RIO. This instrument panel contains controls and displays for the AN/AWG-9 airborne weapon control system, an ECM display, and navigational flight instruments. Armament controls, sensor controls, keyboard panels, and communication panels are on the left console. The right console contains a navigational display, ECM controls, data-link controls and lighting, and the identification friend or foe panel. Refer to FO–3 and FO–4 for illustrations of cockpit arrangements.

1.1.3 Electronic Nomenclature. Figure 1-2 is an alphabetical listing of the tactical, communication, navigation, flight control, and instruments in the aircraft.

1.1.4 Technical Directives. As technical changes are made to the aircraft, those that affect aircraft operation or pilot and RIO need-to-know operation will be incorporated in the appropriate sections and listed in the Summary of Applicable Technical Directives in the front of this manual. In some instances, technical directives may be incorporated on the aircraft while it is still on the production line before delivery. Check the technical directives section of the aircraft logbook for applicable modifications. The following are types of technical directives used in this manual:

AAC	Aviation Armament Change
ACC	Aircrew System Change
AFC	Airframe Change
AVB	Avionics Bulletin
AVC	Avionics Change
AYC	Accessories Change

TACTICAL

AIRBORNE WEAPON CONTROL SYSTEM	AN/AWG-9
CENTRAL AIR DATA COMPUTER	CPU-175/A
CHAFF DISPENSING SET	AN/ALE-39
COMPUTER SIGNAL DATA CONVERTER(R)	CP-1448A/A
CONTROL INDICATOR/BUS CONTROLLER	AN/AWG-15H
DATA DISPLAY SYSTEM	AN/ASQ-172
DIGITAL DATA LINK	AN/ASW-27B/C
ELECTRONIC COUNTERMEASURES SET	AN/ALQ-126A/B
F-14 MISSION COMPUTER (FMC)	CP-2213/AWG-9
FUZE FUNCTION CONTROL SET	AN/AWW-4
GUN CONTROL UNIT	C-8571/A
IFF INTERROGATOR SET	AN/APX-76B
IFF TRANSPONDER SET	AN/APX-72
IR RECONNAISSANCE SET	AN/AAD-5
INTERFERENCE BLANKER	MX-10161/A
LANTIRN CONTROL PANEL	C-12500/AAQ-25
MISSION DATA LOADER	AN/ASQ-215
PANORAMIC CAMERA	KA-99A/93
PROGRAMMABLE MULTIPLE DISPLAY INDICATOR GROUP	CP-2212B/ASA-79
PROGRAMMABLE TACTICAL INFORMATION DISPLAY	IP-1643A/A
RADAR WARNING SET	AN/ALR-67
SERIAL FRAME CAMERA	KS-87B
TACTICAL CONTINGENCY POD	AN/ALQ-167
TACTICAL IMAGING SET (FTI)	AN/AVX-3
TARPS POD	LA-610
TELEVISION CAMERA SET	C-10157
VERTICAL DISPLAY INDICATOR GROUP	AN/AVA-12

COMMUNICATION

CRYPTOGRAPHIC SYSTEM	TSEC/KY-58
INTERCOMMUNICATIONS SYSTEM	LS-460/B
UHF COMMUNICATIONS SET	AN/ARC-159(V)5
VHF/UHF COMMUNICATIONS SET	AN/ARC-182

NAVIGATION

ATTITUDE HEADING REFERENCE SET	A/A24G-39
CONTROL DISPLAY NAVIGATION UNIT	C-12284/A
CRYPTO LOAD PANEL	A51AM1112-1
EMBEDDED GPS/INS	CN-1689(V) 8/ASN
RADAR ALTIMETER	AN/APN-194(V)
RADAR BEACON AND AUGMENTOR SET	AN/APN-154B(V) and R-1623
RECEIVER DECODER GROUP	AN/ARA-638
SIGNAL DATA CONVERTER	CV-4138/A
TACTICAL NAVIGATION SET	AN/ARN-84(V)
UHF-DF DIRECTIONAL FINDER	AN/ARA-50

FLIGHT CONTROL AND INSTRUMENTS

AIR INLET CONTROL PROGRAMMER	C-8684B/A
AIRSPEED AND MACH NUMBER INDICATOR	AVU/-24/A
APPROACH POWER CONTROL SET	AN/ASW-105
DIGITAL FLIGHT CONTROL SET	AN/ASW-59
BEARING DISTANCE HEADING INDICATOR	ID-663-D/U
COCKPIT ALTIMETERS	AAU-19/A
VERTICAL VELOCITY INDICATOR	AAU-18A
STANDBY COMPASS	AQU-5/A

Figure 1-2. Electronic Nomenclature

1.1.5 Block Numbers. The following production block numbers correspond to aircraft serial numbers (BuNo). Selected block 115 through 130 aircraft are updated to F-14B/block 145 configuration.

Block No.	Serial No. (BuNo)
115	161287
120	161416–161442
	161444
125	161599
	161601

Block No.	Serial No. (BuNo)
125	161608
	161616
130	161851
	161870
	161871
	161873
145	162910–162927
150	163215–163229
155	163407–163418

CHAPTER 2

Systems

2.1 AIR INLET CONTROL SYSTEM

The purpose of the AICS is to decelerate supersonic air and to provide even, subsonic airflow to the engine throughout the aircraft flight envelope. The AICS consists of two variable geometry intakes, one on each side of the fuselage at the intersection of the wing glove and fuselage. Intake inlet geometry is varied by three automatically controlled hinged ramps on the upper side of the intakes. The ramps are positioned to decelerate supersonic air by creating a compression field outside the inlet and to regulate the amount and quality of air going to the engine. The rectangular intakes are spaced away from the fuselage to minimize boundary layer ingestion and are highly raked to optimize operation at high angle of attack.

Inlet ramps are positioned by electrohydraulic actuators, which respond to fixed schedules in the AICS programmers. Separate programmers, probes, sensors, actuators, and hydraulic power systems provide completely independent operation of the left and right air inlet control systems. Figure 2-1 shows the basic elements of AICS mechanization.

Electrical power for the AICS programmers is provided by the ac and dc essential No. 2 buses. The ramp stow function is powered by the dc essential No. 1 bus. Hydraulic power is supplied individually to the left AICS from the combined hydraulic system and to the right AICS from the flight hydraulic system. The left AICS programmer also functions as a wing-sweep backup computer.

2.1.1 Normal AICS Operations. No pilot control is required during the normal (AUTO) mode of operation. Electronic monitoring in the AICS detects failures that would degrade system operation and performance (refer to AICS BIT). AICS caution lights (L and R INLET, L and R RAMPS) and INLET RAMPS switches are shown in Figure 2-2.

Sectional sideviews of representative variable geometry inlet configurations scheduled by AICS programmers and descriptive nomenclature are shown in Figure 2-3.

2.1.1.1 Ground and Low-Speed. During ground static and low-speed (Mach <0.35) operation, the inlet ramps are mechanically restrained in the stowed (retracted) position. The predominant airflow is concentrated about the lower lip of the inlet duct and is supplemented by reverse airflow through the bleed door around the forward lip of the third ramp. As flight speed is increased to 0.35 Mach, hydraulic power is ported to the ramp actuators, but the ramps are not scheduled out of the stowed position until Mach 0.5 (Figure 2-4). The bleed slot bleeds low-energy, boundary-layer air from the movable ramps.

2.1.1.2 Subsonic and Transonic Speeds. At airspeeds greater than 0.5 Mach, the ramps program primarily as a function of Mach for optimum AICS performance. At transonic speeds, a normal shock wave attaches to the second movable ramp. The third ramp deflects above 0.9 Mach to maintain proper bleed slot height (Δh) for transonic and low-supersonic flight. At supersonic speeds, four shock waves compress and decelerate the inlet air. The bleed slot removes boundary layer air and stabilizes the shock waves. This design results in substantially higher performance above Mach 2 than simpler inlet designs.

2.1.2 AICS Test. Two types of AICS tests are provided to check the general condition of the AICS and to pinpoint system components causing detected failures: AICS built-in test and onboard check.

2.1.2.1 AICS Built-In Test. BIT in the AICS computer programmer is automatically and continually initiated within the programmer to check AICS components when the programmer is energized.

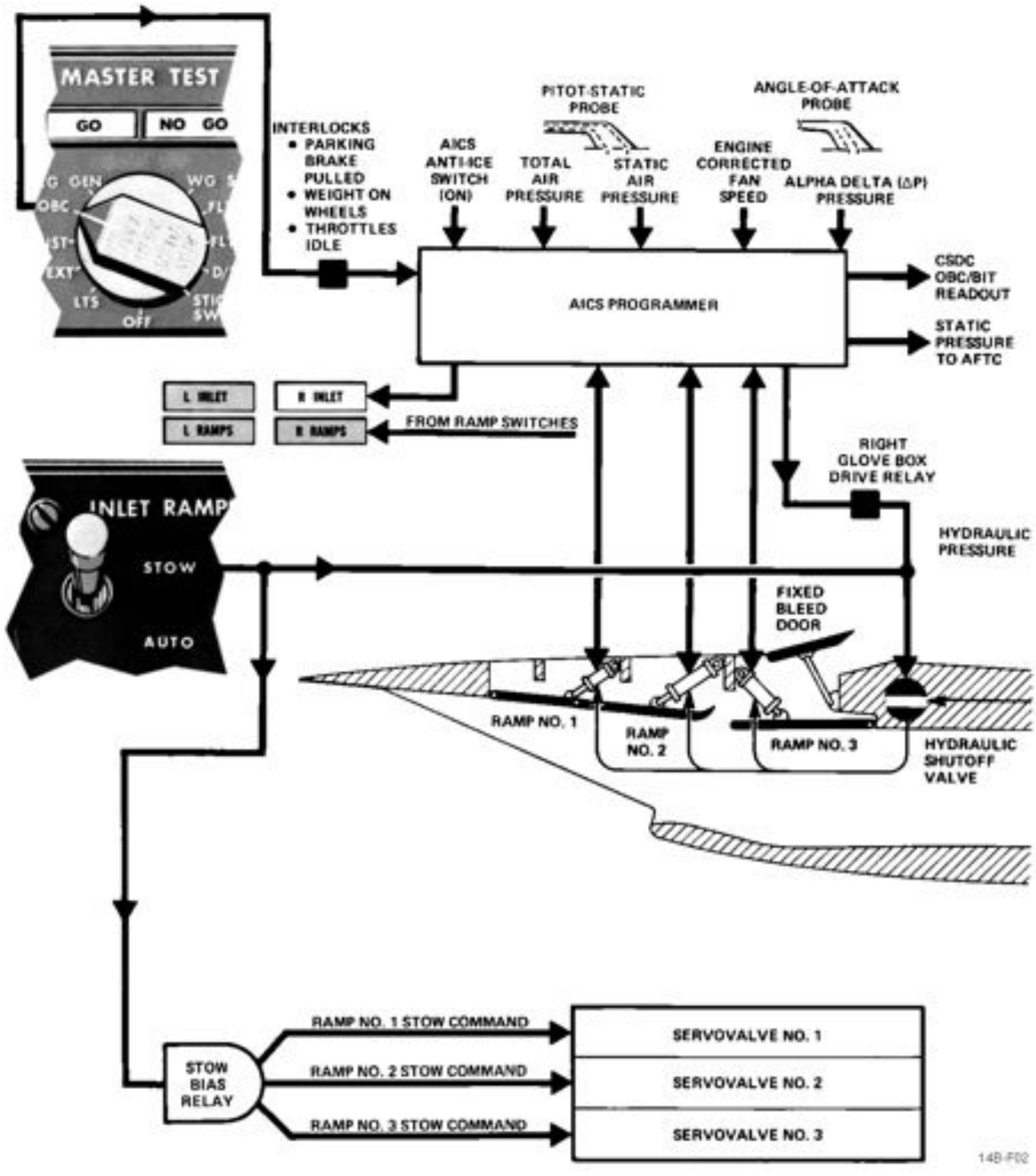
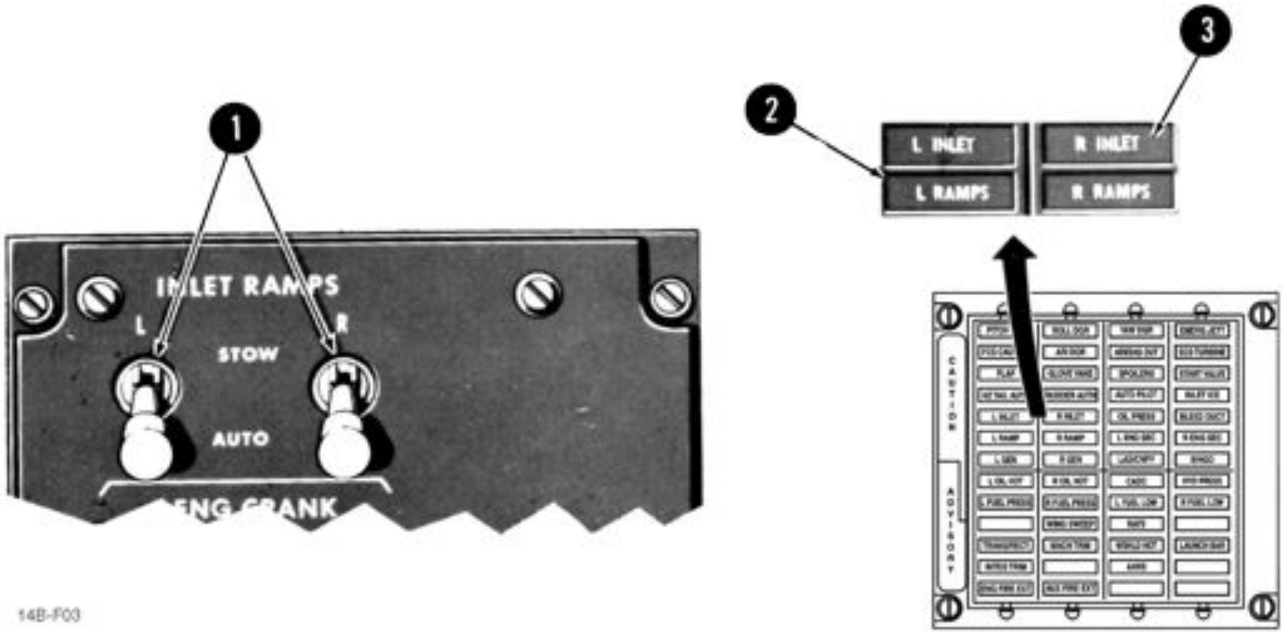


Figure 2-1. AICS Control System



NOMENCLATURE	FUNCTION
1 INLET RAMPS switches	AUTO — Inlet ramp position is determined by the AICS programmer. STOW — Electrically commands the respective inlet ramp actuator to the stow position; opens the appropriate hydraulic shutoff valve.
	WARNING • DO NOT takeoff with the INLET RAMPS switches in STOW. Hydraulic power is on and may drive the ramps out of the stow locks during certain servocylinder failure modes causing an engine stall. • If wing sweep advisory light illuminates, cycling L AICS circuit breaker (LF2) may cause unintentional wing sweep unless WING SWEEP DRIVE No. 1 (LE1) and WG SWP DR No. 2/MANUV FLAP (LE2) circuit breakers are pulled. **Note** Cycling either AICS circuit breaker while airborne may result in DFCS air data failures, illuminating the FCS CAUTION and ARI DGR lights, and cause degraded control system capability. MASTER RESET should restore normal operation once the cb(s) are reset.
2 RAMPS caution light	Indicates ramps not positioned in either stow or trail locks during critical flight conditions (see Figure 2-5).

Figure 2-2. AICS Control and Indicators (Sheet 1 of 2)

NOMENCLATURE	FUNCTION
3 INLET caution light	Indicates AICS programmer/system failure: Reduce airspeed to Mach 1.2 and check AICS acronym for failure indication. AICS FAILURE Less than Mach 0.5: Ramps should be restrained by actuator stow locks. Greater than Mach 0.5: Ramp movement is restrained by trapped hydraulic pressure and mechanical locks, depending on Mach when INLET light illuminates. Greater than Mach 0.9: Ramp movement is minimized by actuator spool valves and the aerodynamic load profile in this Mach range and a RAMP light should illuminate.

Figure 2-2. AICS Control and Indicators (Sheet 2)

The operational status of the AICS depends on BIT-detected failures in AICS components. Failures of static or total pressure sensors, ramp Nos. 1, 2, or 3 positioning, programmer continuous end-to-end BIT, or hydraulic pressure to any of the ramp actuators would seriously degrade AICS performance. Detected failures of these items cause the AICS to automatically transfer to a significantly degraded fail-safe mode of operation, indicated by illumination of an INLET caution light.

Detected failures of angle of attack, engine fan speed, or out-of-calibration detection of the difference between P_1 and P_2 (ΔP), P_s or P_t sensors will cause the AICS to revert to the slightly degraded fail-operational mode of operation. Nominal values of angle of attack, total temperature, or engine fan speed are substituted for the failed values in the AICS programmer without illumination of an INLET caution light.

In both fail modes of operation, detected failures are continuously registered by the in flight performance monitoring system and displayed with air inlet control acronyms on the horizontal situation display and the tactical information display (Figure 2-6 and Figure 2-7).

2.1.2.2 AICS Onboard Check. OBC, initiated by the pilot during poststart or ground maintenance checks, performs a dynamic check of the left and right AICS. In addition to the regular AICS BIT program, sensor calibration checks are made. The status of the programmer electronics and the ramp actuators are checked throughout an altitude and airspeed schedule as pseudo-pneumatic inputs to the programmer are varied to simulate a flight sequence of maximum airspeed condition and back to static sea-level conditions within 65 seconds. This cycles the ramp actuators through their full range, illuminates the ramp lights, exercises the complete AICS for preflight failure detection, and ensures the ramps are in their stow locks. OBC is the only way to ensure stow lock integrity since it verifies the ramps are in the stowed position and then removes ramp hydraulic power. Detected AICS failures are indicated by AIC acronyms or AIC acronym(s) with associated INLET caution light(s) displayed after completion of OBC.

Note

- With INLET RAMP switches in STOW, AICS OBC will fail test and INLET lights will illuminate.
- If the engine enters secondary mode during OBC, the ramps will stow and fail OBC. To re-initiate OBC, select primary mode and reset the AICS.

2.1.3 AICS Failure Modes of Operation. AICS mode of operation following a BIT detected failure may be either fail-operational mode (Figure 2-6) or fail-safe mode (Figure 2-7).

2.1.3.1 Fail-Operational. Failures in the air inlet control system are detected by the AICS programmer, which automatically initiates appropriate corrective action. Mode entry is indicated by the display of a fail operational AIC acronym. The fail-operational mode results in no significant degradation in AICS operation and the mission can be continued without any flight restrictions or corrective action by the pilot.

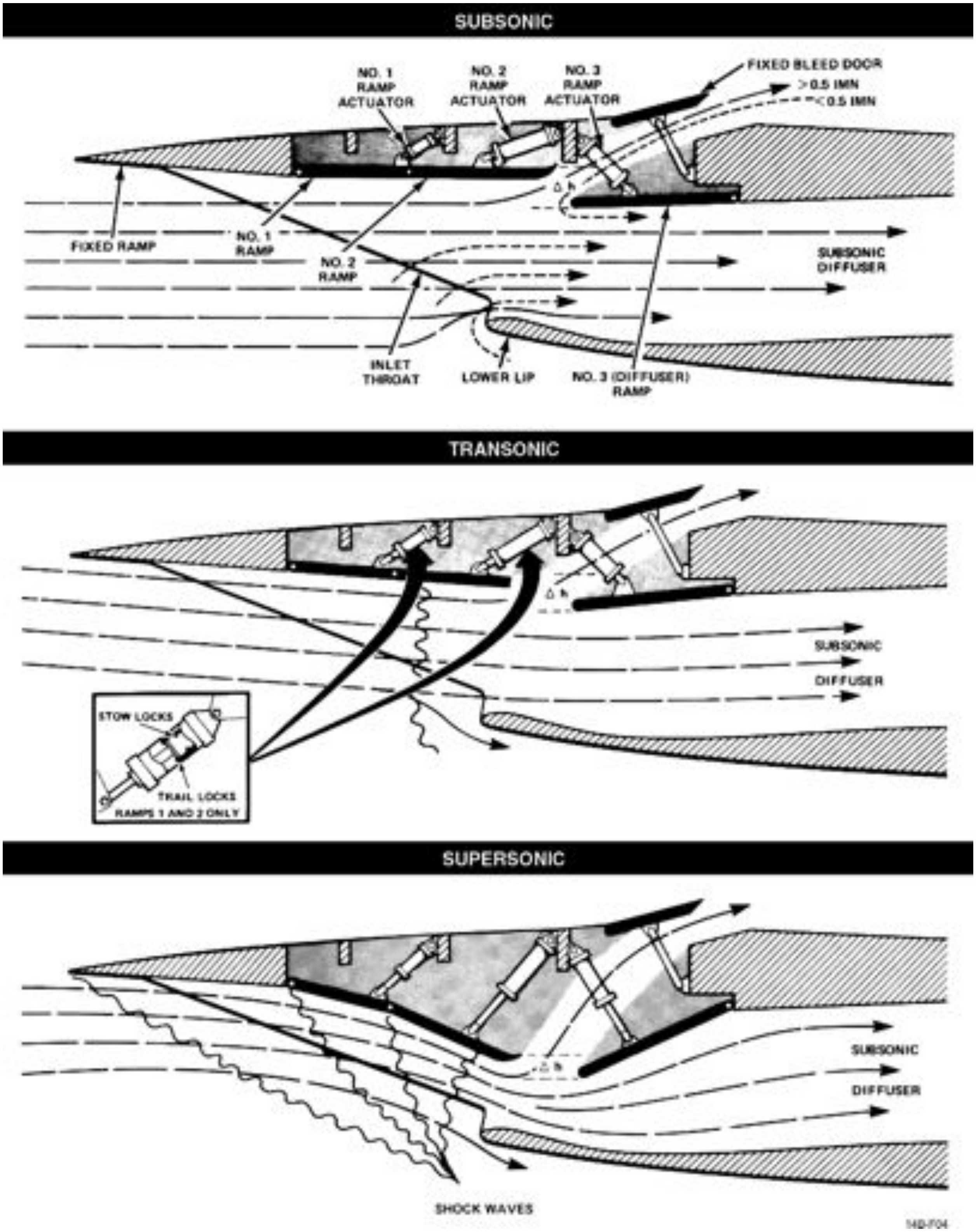


Figure 2-3. Variable Geometry Inlet Configuration

FLIGHT CONDITION	HYDRAULIC POWER RAMP ACTUATORS	ACTIVATOR POSITION		
		RAMP NO. 1	RAMP NO. 2	RAMP NO. 3
M < 0.35	OFF	Mechanically restrained by stow locks in stowed position; electrical stow commands output from AICS programmer.		
M >0.35 to <0.5	ON	Electrical stow commands output from AICS programmer.		
M >0.5 to <2.2	ON	Variable position scheduled by AICS programmer as a function of mach number and angle-of-attack. Ramps no. 1 and no. 2 begin positioning at mach 0.5, ramp no. 3 begins at mach 0.9.		
M >2.2	ON	Variable position scheduled by AICS programmer as a function of mach number.		

Figure 2-4. AICS Normal Operating Mode

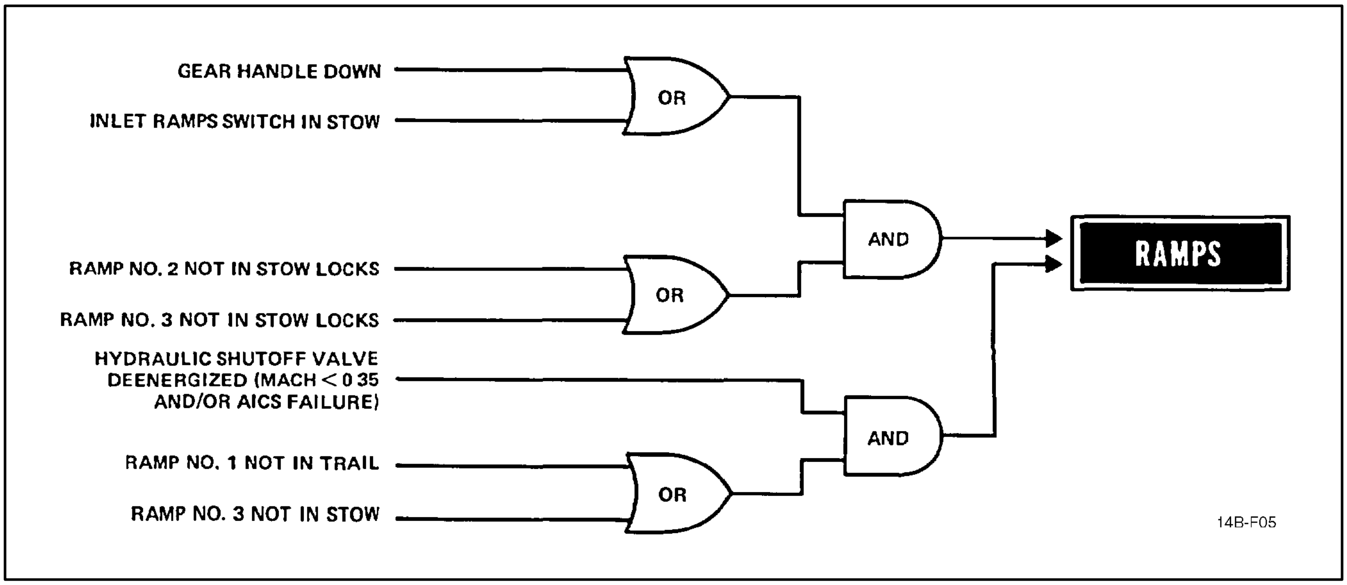


Figure 2-5. Ramp Monitor Logic

Note

Transferring to SEC mode will revert the AICS programmers to the REV 4 (TF-30/F14A) schedule because of the loss of the AFTC N_1 speed signal and will display an S4 acronym. Below 25,000 feet and at airspeeds greater than 1.1 IMN, unloading the aircraft to less than 1g will reduce inlet stability and may result in inlet buzz and possible engine stall. To restore full REV 5 (Fl10/F14B/D) schedule and eliminate S4 acronym following an airborne engine mode reset to PRI, recycle AICS circuit breakers at constant subsonic Mach number.

2.1.3.2 Fail-Safe. The fail-safe mode results in significantly degraded AICS operation. Mode entry is indicated by the display of a fail-safe AIC acronym and illumination of the appropriate INLET caution light. Under these conditions, the AICS programmer provides a shutoff signal to close the ramps' hydraulic shutoff valves. If the hydraulic shutoff valve closes below Mach 0.9, the ramps are normally in a safe configuration (No. 1 ramp within trail locks, No. 3 ramp in stow locks, and No. 2 ramp is restrained by trapped hydraulic pressure.) Engine operations may be successful below 1.2 IMN in this configuration; however, corrective procedures shall be performed.

Note

Fail-safe operations result in a slight degradation of cruise and excess thrust performance because of the off-optimum configuration.

FAILURE MAINTENANCE READOUT ACRONYM	DETECTED FAILURE	CAUSE	RESULT
AIC S1, S2 (Possible only during OBC)	P_s P_t or Programmer out of calibration.	Limits exceeded.	Ramps may not program during OBC. Reset AICS L and R circuit breakers (LF2, LG2) prior to attempting another OBC.
NONE	Engine fan speed RPM from AFTC.	Loss of engine fan speed signal.	Substitutes 7,300 RPM. Ramps do not program during OBC.
AIC S3	None	None	Mask continuous monitor (CM) so that subsequent AIC acronyms are displayed.
AIC S4	Angle-of-attack or engine fan speed.	Limits exceeded.	IN FLIGHT: Substitutes +2° angle-of-attack or 7,300 RPM.
AIC S4 (During OBC)	Alpha delta pressure sensor out of calibration or engine fan speed	Limits exceeded. Augmenter fan temperature controller (AFTC) may be in secondary mode.	• Substitutes +2° angle-of-attack value until reset • Substitutes 7,300 RPM.
AIC A4	Open wire	Open wire	None
Note AIC symbol has L or R appended (AICL, AICR) to identify on which side failure was detected.			

Figure 2-6. Fail Operational Mode — No INLET Light

If the hydraulic shutoff valve closes above Mach 0.9, the ramps are normally in an unsafe configuration and the appropriate RAMPS caution light will accompany the INLET caution light (Figure 2-5). Above Mach 0.9, the No. 3 ramp normally begins programming below the actuator stow lock. When the fail-safe mode is entered above Mach 0.9, the unpowered No. 3 ramp will eventually move and may cause compressor stalls at higher power settings. The aircraft shall be decelerated below 1.2 IMN, and the appropriate INLET RAMPS switch shall be selected to STOW.

CAUTION

Do not select STOW at speeds greater than 1.2 IMN. Compressor stalls may occur because of ramp mispositioning.

2.1.3.3 Stow Mode of Operation. STOW commands the appropriate hydraulic shutoff valve to open and provides a direct electrical signal to the ramp actuators, porting hydraulic pressure directly to the retract side of the actuator. When the ramps are retracted to the stow position, the RAMPS light will extinguish and the stow locks should remain engaged even if hydraulic power is subsequently lost. Once in the stow position, AICS programmer-detected electronic failures may be reset below Mach 0.5.

2.1.3.4 Hydraulic Shutoff and Dump Inhibit. The AICS hydraulic systems include a hydraulic shutoff valve to control hydraulic system pressure. The hydraulic shutoff valve is normally controlled by the AICS programmer, which removes the hydraulic-on signal below 0.35 IMN or in the event of a programmer failure. The STOW position of the INLET RAMPS switch bypasses the AICS programmer to energize the hydraulic shutoff valve, providing pressure for ramp motion. To ensure hydraulic pressure is shut off, the respective AICS programmer must be deenergized by pulling the circuit breaker (LF2, left or LG2, right) and the INLET RAMPS switch placed in the AUTO position.

Note

Cycling either AICS circuit breaker while airborne may result in DFCS air data failures, illuminating the FCS CAUTION and ARI DGR lights, and cause degraded control system capability. MASTER RESET should restore normal operation once the cb(s) are reset.

FAILURE MAINTENANCE READOUT ACRONYM	DETECTED FAILED	CAUSE	RESULT	
			MACH <0.5	MACH >0.5
AIC P AIC S1 AIC S2	AICS programmer (P) Static pressure (P_s) Total pressure (P_t)	Failed end-to-end BIT Minimum or maximum limits exceeded	Hydraulic shutoff valve remains closed. Ramp actuators remain mechanically restrained within stow locks, provided they failed within stow locks.	Ramp movement is restrained by actuator mechanical locks if failure occurred with ramps within locks. Otherwise ramp(s) move slowly with aerodynamic loads.
AIC A1 AIC A2 AIC A3	Ramp No. 1 Ramp No. 2 Ramp No. 3	Sustained command and feedback error		
AIC A1, AIC A2, or AIC A3 (INLET caution light eventually illuminates >0.5 Mach)	Hydraulic pressure loss of ramp No. 1, No. 2, or No. 3	Sustained error due to loss of hydraulic pressure		Ramp(s) may move if failure occurred with ramp(s) out of mechanical locks. RAMP light will illuminate.
NONE (No INLET caution light < 0.5MACH)		Loss of hydraulic pressure		

Note

AIC symbol has L or R appended (AICL, AICR) to Identify on which side failure was detected.

Figure 2-7. Fail-Safe Mode — INLET Light Illuminated

Whenever the hydraulic shutoff valve closes (i.e., fail-safe mode entry), hydraulic spool valves in the ramp actuators sense the absence of pressure and block the actuator pressure and return ports, causing a hydraulic lock (dump inhibit). This feature reduces ramp movement when an AICS failure occurs and the ramps are not being restrained by mechanical actuator locks. Although dump inhibit prevents the ramp from rapidly extending and causing an engine stall, the ramps will still slowly move. Under normal circumstances, the pilot will have sufficient time to select STOW and prevent an engine stall. F-14 flight test results show that with dump inhibit, the time interval between illumination of a RAMPS caution light and engine stall following an AICS failure was 15 to 40 seconds on the ground at military (MIL) power and approximately 50 seconds at 10,000 feet at MIL power.

2.1.3.5 Ramp Actuator Mechanical Locks/Positioning. In addition to the actuator stow locks, the first and second ramp actuators have another set of latches (trail locks) that prevent further ramp actuator extension after a failure within these trail locks. The actuator stow and trail locks restrain actuator movement in tension only. Hydraulic pressure (500 psi) is required to disengage the lock finger latches.

Safe positioning of the ramp actuators is monitored by the ramp monitor logic shown in Figure 2-5. A RAMPS light should always be accompanied by an INLET light with the landing gear handle UP. With the landing gear handle DOWN, a RAMPS light can be illuminated without an INLET light. The emergency procedures in any case are the same. RAMPS lights will extinguish when a safe configuration is attained.

Note

- Following an AICS programmer/ramps failure, the safest configuration results when the ramps are in the stowed position; the programmers are disabled by pulling the affected AICS circuit breaker and returning the INLET RAMPS switch to AUTO.

- Cycling either AICS circuit breaker while airborne may result in DFCS air data failures, illuminating the FCS CAUTION and ARI DGR lights, and cause degraded control system capability. MASTER RESET should restore normal operation once the cb(s) are reset.

- In the event of an engine or hydraulic failure, the following conditions exist with respect to AICS reset.

1. If hydraulic pressure is zero, there is no need to safe the ramps (by stowing ramps, pulling AICS circuit breakers, and returning to AUTO) since selecting STOW will have no effect without hydraulic pressure.

2. If airspeed is less than 0.35 IMN, there is no need to safe the ramps since hydraulic pressure has already been removed and ramps should be in the stow locks. If the ramps are not in the stow locks, the RAMP light will illuminate when the gear handle is lowered. If the RAMP light does illuminate, then the ramps should be stowed and the AICS programmer reset. Depressing MASTER RESET following an AICS programmer reset should restore normal DFCS operation.

3. If hydraulic pressure is greater than zero and airspeed is greater than 0.35 IMN, then following an engine failure or hydraulic emergency the ramps should be stowed and, if time allows, the programmer reset. This will ensure that if the ramp is out of the stow lock (as is normal above 0.5 IMN), it will be returned to the stow lock and kept there for landing regardless of subsequent hydraulic or electrical malfunctions.

2.1.3.6 AICS Failure In-Flight Operation. Most AICS failures occurring in flight do not require rapid pilot response because of system design features for fail-safe operation. In flight, the No. 1 and 2 ramps tend to blow back to the stow position or are restrained within the trail locks because of aerodynamic loads. The hydraulic restriction of all ramps during loss of hydraulic power and after fail-safe mode entry should prevent rapid ramp movement. Internal failure of an actuator, especially the No. 3 ramp actuator, may allow rapid ramp extension and cause engine stall. Additionally, failure to stow the ramps in a reasonable amount of time after INLET light illumination or inability to stow following a hydraulic system failure may result in compressor stalls at high-power settings. Engine start attempts may not be successful unless the RAMPS are stowed (RAMPS caution light extinguished).

2.1.4 AICS Anti-Ice. AICS anti-ice is activated only by selecting ON with the AICS ANTI-ICE switch and airspeed between 0.35 to 0.9 Mach (hydraulic power is available at 0.3 Mach). Above and below these airspeeds, the AICS anti-ice is disabled. When the ENG/PROBE anti-ice switch is in AUTO, the AICS anti-ice is off. When AICS anti-ice is activated, the AICS programmer repositions the No. 1 and No. 2 ramps to positions below the No. 3 ramp (Figure 2-8) so that ice will not form above the No. 3 ramp.

2.2 ENGINE

The aircraft is powered by two F110-GE-400 turbofan engines (Figure 2-9) with variable exhaust nozzles and afterburner augmentation. They are dual-rotor engines consisting of a three-stage fan driven by a two-stage, low-pressure turbine and a mechanically independent, aerodynamically balanced, nine-stage high-pressure compressor driven by a single-stage, air-cooled, high-pressure turbine. Engine operation is automatically regulated and maintained electrically by the augmenter fan temperature control unit and by throttle inputs to the main engine control.

Each engine is slung in a nacelle with the thrust axis laterally offset approximately 4-1/2 feet from the aircraft centerline. The installed static engine thrust at military power (MIL) is 13,800 pounds and, at maximum afterburner power, thrust is 23,600 pounds. Installed engine thrust at maximum AB at 0.9 M at sea level is 30,200 pounds. Acceleration time from idle to military power is approximately 4 seconds.

During operation, air entering the engine is directed into the fan that initially pressurizes the air and directs its flow into the engine core compressor and fan bypass duct. Direction of airflow into the fan is optimized by

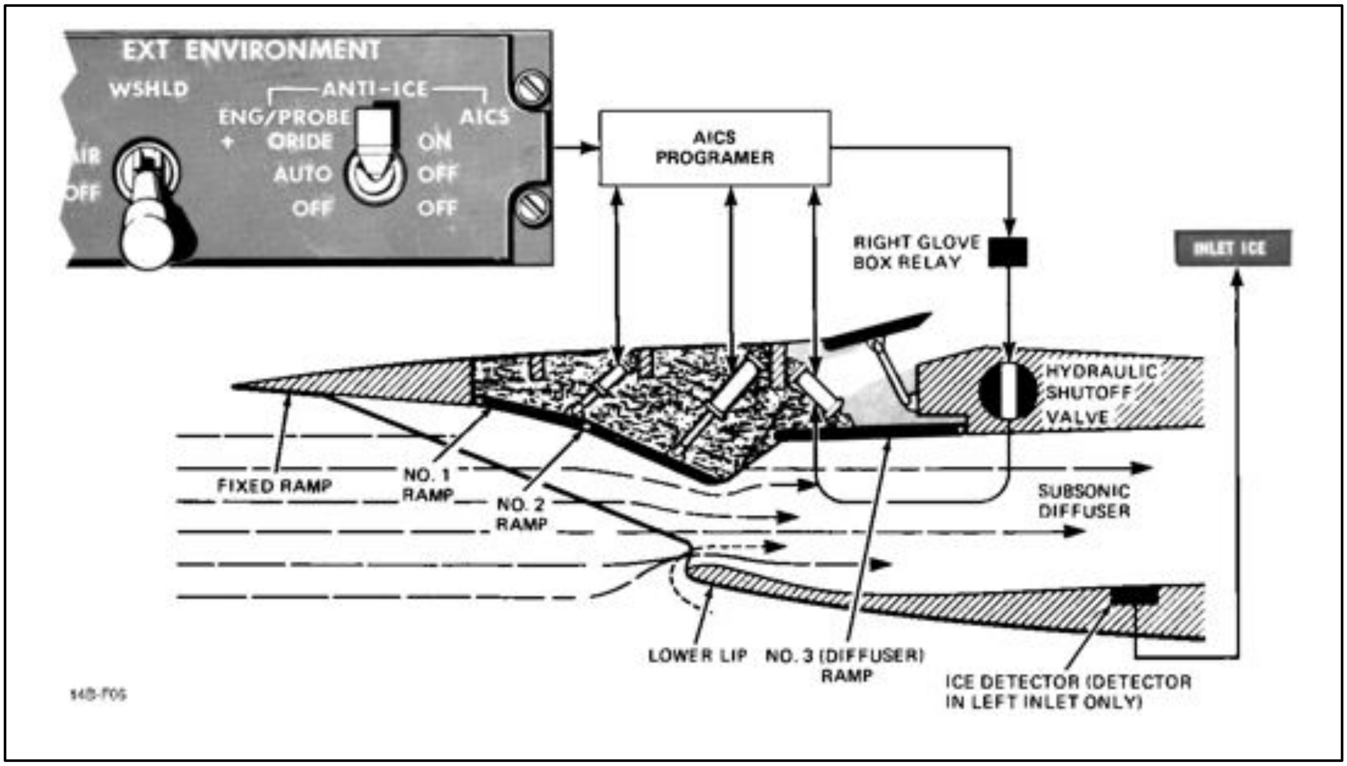


Figure 2-8. AICS Anti-Ice System

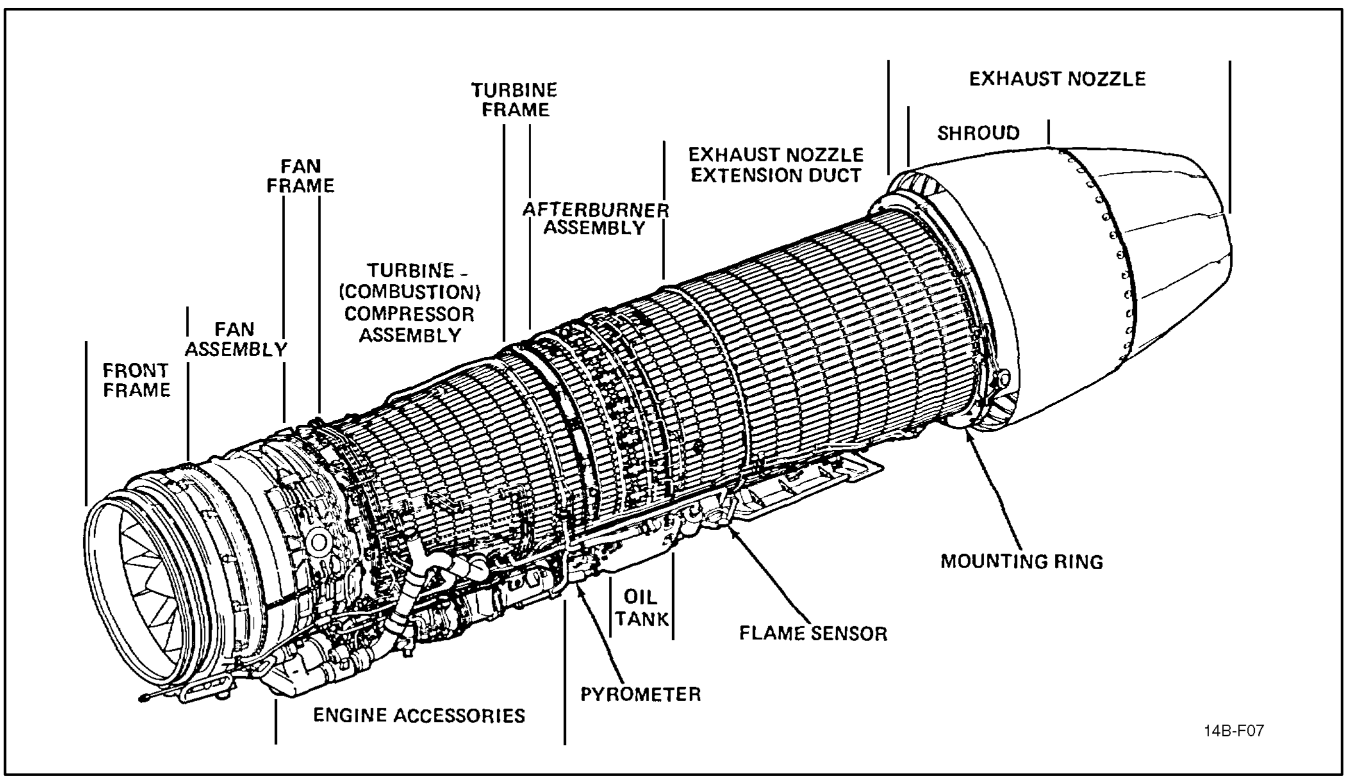


Figure 2-9. Engine F110-GE-400

variable-geometry IGVs and into the compressor by variable geometry stator vanes. The high-pressure compressor further compresses the air through the nine-stage compressor before discharging it into the annular combustion chamber to mix with fuel from the fuel nozzles. This fuel-air mixture is initially ignited by the main spark igniter in the combustion chamber. As a result of this combustion, expanding gases drive the high- and low-pressure turbines. Power to drive the two accessory gearboxes is obtained from the high-pressure rotor.

From the turbine section, the exhaust gases pass into the afterburner section and are mixed with air from the fan bypass duct. During afterburner operation, fuel is sprayed into this mixed airflow and ignited for additional thrust.

WARNING

During night and/or IFR conditions, the increased acceleration during use of afterburner will result in inner ear disturbances that may cause flightcrew confusion/disorientation. The large amount of light generated by the afterburner exhaust reflecting around the aircraft will compound this condition. These factors may result in severe aircrew disorientation/vertigo.

2.2.1 Engine Control. The engine is controlled by three units: the hydromechanical main engine control, the electronic augmenter fan temperature controller, and the afterburner fuel control. There are two modes of operation: primary (electronic) and secondary (mechanical) with provisions for automatic and manual switchover to secondary. Manual selection is controlled through the ENG MODE SELECT panel (Figure 2-10). Automatic or manual selection of the secondary mode illuminates an ENG SEC caution light. When one engine reverts to secondary mode the other engine continues in primary mode. Cycling the ENG MODE SELECT switch may reset the AFTC if the faults are temporary. If the change back to primary mode is successful, the ENG SEC light will go out. Automatic or manual selection of secondary mode is possible throughout the flight envelope. Selection of secondary mode will cause a loss of fan speed signal to the AICS.

Note

SEC mode transfer while in AB may result in pop stalls. Nonemergency manual selection of SEC mode should be performed in basic engine.

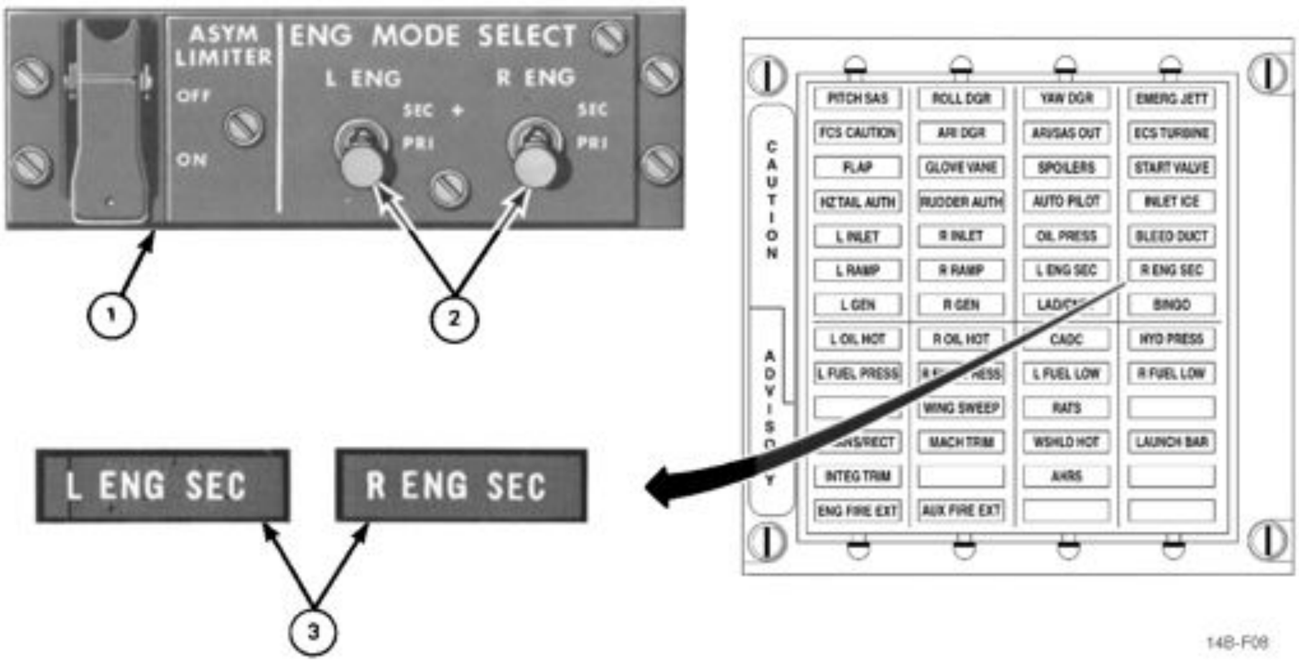
Transferring to SEC mode will revert the AICS programmers to the REV 4 (TF-30/F14) schedule because of the loss of the AFTC N_1 speed signal and will display an S4 acronym. Below 25,000 feet and at airspeeds greater than 1.1 IMN, unloading the aircraft to less than 1g will reduce inlet stability and may result in inlet buzz and possible engine stall. To restore full REV 5 (F110/F14B/D) schedule and eliminate S4 acronym following an airborne engine mode reset to PRI, recycle AICS circuit breakers at constant subsonic Mach number.

2.2.1.1 Main Engine Control. The MEC is a hydromechanical control that provides fuel shutoff, variable stator vane scheduling, and main fuel metering in both primary and secondary modes. The MEC controls fuel flow until 59-percent rpm, and provides high-pressure compressor rotor overspeed protection automatically by securing fuel flow to the engine when an overspeed condition of 110 percent is reached.

Note

To regain engine operation following an automatic engine overspeed shutdown, the throttle must be cycled to OFF then IDLE.

2.2.1.2 Augmenter Fan Temperature Control. The AFTC is a modular, solid-state, electronic device that performs control schedule computations, integration and logic functions, limit control, failure detection and provides engine core speed (N_2) signal for instrument display and engine fanspeed (N_1) signal to the AICS. It also controls the distribution of electrical power to the entire engine electrical and monitoring systems. Figure 2-11 shows the various interface signals used by the AFTC. Normally the central air data computer supplies Mach number value to the AFTC. If this signal is erroneous, the AFTC assumes a default Mach number value in order to continue operation.



NOMENCLATURE	FUNCTION	
1 ASYM LIMITER switch	ON —	Reduces AB thrust asymmetry in the event of AB blowout or if one engine fails to light when commanded to AB. Limits operating engine to minimum AB until other engine attains minimum AB.
	OFF —	Either engine may operate at any AB power setting independently of the other engine.
2 L/R ENG MODE SELECT switch	PRI —	Primary mode, augmenter temperature fan control (AFTC) controls main and AB fuel flow, fan inlet guide vanes, nozzle area, and ignition.
	SEC —	Secondary mode, main fuel flow is scheduled hydromechanically by the main engine control (MEC). AB is inhibited.
3 L/R ENG SEC caution light	Illuminates when the engine is in secondary mode. AB operation is inhibited for engine with light Illuminated. AICS on affected engine side reverts to fail-op mode.	

Figure 2-10. Engine Mode Select Panel and ENG SEC Lights

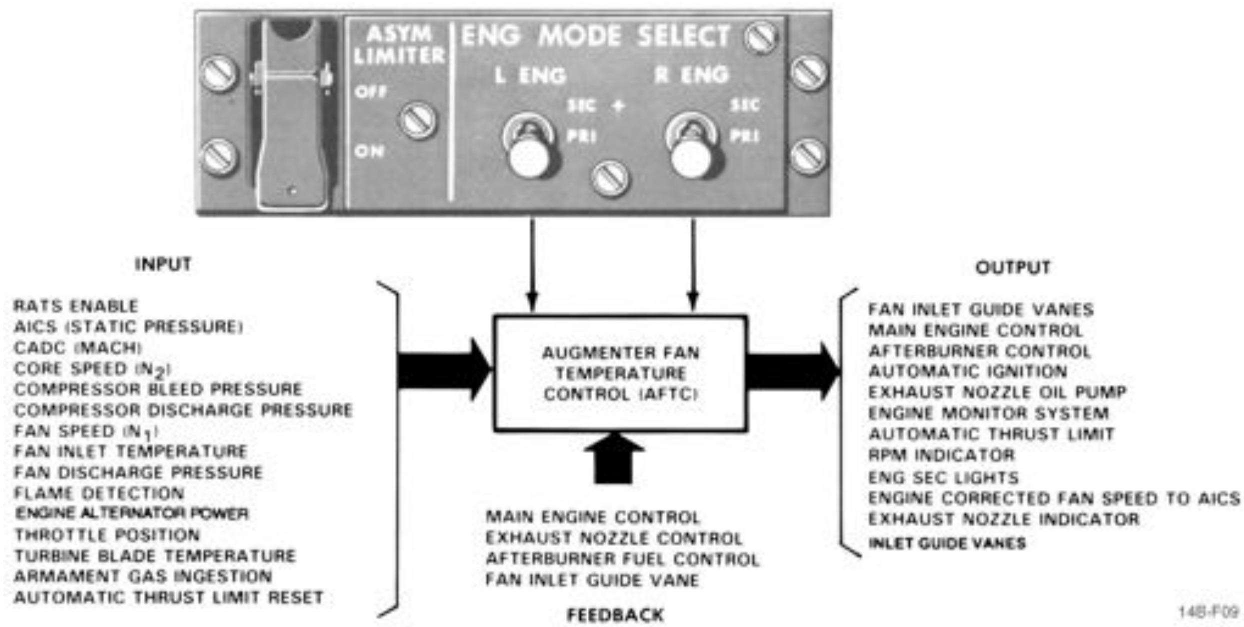


Figure 2-11. AFTC Functional Relationships

WARNING

The loss of Mach number signal from the CADC results in the loss of both airflow limiting and idle lockup functions of the AFTC. This may result in pop stalls at supersonic speeds (on a cold day) at high power and inlet buzz, resulting in pop stalls at idle power. If this occurs, decelerate in military power until below Mach 1.1.

2.2.1.3 AB Fuel Control. The AFC is controlled by the AFTC for afterburner operation. The AFTC schedules AB fuel flow ratios and provides them to the AFC. The AFC converts ratio commands to metered fuel flows into local, core, and fan AB fuel manifolds. When staging up AB, local fuel flow is initiated first, followed by core, and fan flow last. When staging down, the reverse sequence occurs. Thrust changes are smooth when staging up or down.

2.2.1.4 Primary Mode. In the primary mode, the AFTC controls the MEC, AFC, and AB nozzle hydraulic pump to provide optimum engine operation with unrestricted throttle movement throughout the flight envelope. AFTC computations are used to control basic engine and AB fuel flow, IGV, and AB nozzle positioning; VSV positioning is controlled by the MEC. The AFTC incorporates independent control schedules that are prioritized so that the optimum amount of fuel flow is provided to the main combustor. At any given time, only one of these schedules is actually in control of fuel flow. The remaining schedules are always active and are calculating the change in fuel flow required (if any) to attain the desired value of their assigned parameter. The selection of the schedule in control is accomplished by a series of minimum and maximum selectors. These control scheduling of the following:

1. Acceleration/deceleration
2. Minimum/maximum compressor discharge pressure
3. Minimum/maximum rpm
4. Fan speed limiting

5. Maximum turbine blade temperature limiting

6. Idle lockup speed.

Other AFTC functions include engine start control, asymmetric thrust limiting, automatic relight, and fault detection. Fault detection automatically switches the engine control to secondary mode in the event of core overspeed, fan speed signal loss, AB nozzle demand full open when not at idle or maximum AB, AFTC power deviations, fuel flow demand full increase or full decrease, fan speed greater than 800 rpm below schedule and not accelerating, or throttle signal error.

2.2.1.4.1 AB Operation (Primary Mode). For AB operational characteristics, refer to Figure 2-12. Unrestricted throttle operation into and out of AB is permitted throughout the flight envelope. During AB operation, rpm, EGT, fuel flow, and nozzle position vary with altitude and airspeed. The nozzle position will also increase as the throttle is transitioned from minimum to maximum AB. If an AB blowout occurs, the auto relight feature attempts to reinitiate AB without throttle movement. The engine has reduced AB region of operation at high altitudes and low airspeeds. An AFTC control feature called rich stability cutback reduces or limits the maximum AB fuel flow in this region to prevent AB instabilities (Figure 2-12). Indication of rich stability cutback is a nozzle position of approximately 30 to 50 percent at maximum AB rather than the normal 60 to 70 percent. Also because of airflow and temperature characteristics, AB light-off characteristics are slower at high altitudes and low airspeeds.

2.2.1.5 Secondary Mode. Basic engine operation in SEC mode is extremely reliable. In the secondary mode, the electronic functions performed by the AFTC are eliminated. The MEC provides complete control of the engine with the exception of fan speed limiting, which is powered by the higher of 28-Vdc aircraft electrical power or engine alternator electrical power. SEC mode is manually selected via the ENG MODE SELECT switch or the autopilot emergency disengage paddle switch, or via automatic default. In SEC mode, the exhaust nozzle is commanded full closed, the nozzle position indicator goes to the not-powered position (subzero indication), the IGVs are fixed full open, high-energy ignition is continuously energized, afterburner is inhibited, and idle lockup protection is lost.

In SEC mode, engine stall margin is decreased at low rpm because of IGV positioning. The fatigue engine monitoring system engine-stall-detection circuit is inoperative, but overtemperature warning is still available. A low-level vibration/rumble may be sensed in ground idle operation in secondary mode. This vibration/rumble has no adverse affect on the engine and disappears when the throttle is advanced slightly up to 5-percent rpm increase. Maximum thrust available at military power in SEC mode is depicted in Figure 14-4.

CAUTION

SEC mode transfer with throttles in AB above 450 KIAS could result in pop stalls and damage to the IGV linkage.

Note

Non-emergency manual selection of SEC mode on the ground should be performed in basic engine. Non-emergency manual selection of SEC mode airborne should be performed in basic engine with power set above 85-percent rpm.

2.2.1.6 Engine Alternator. Each engine's electrical system is powered by an alternator mounted on the engine aft gearbox. The alternator consists of four windings. Two windings are redundant in providing power to the AFTC and its components. A third winding provides power for both main high-energy ignition and AB ignition. The fourth winding provides power to the engine monitoring system processor (for fatigue engine monitoring system), and a signal for the rpm gauge. The last winding is also an alternate source of power for the fan speed-limiting circuit. The fan speed-limiting circuit may be powered by either the essential No. 2 dc bus or the engine-driven alternator winding, depending on which source has the highest stable output.

If engine alternator power output drops below a preset value, engine control will automatically transfer to SEC mode, illuminating the respective engine SEC light. If the alternator fails because of shearing of the engine alternator drive shaft, the respective engine SEC light will not illuminate. Cockpit indications will be loss of engine rpm and nozzle position indicating below zero. If the engine reverts to SEC mode as a result of a sheared alternator shaft, engine high-energy ignition will not be available. In all failure modes, redundant aircraft electrical power will be available for fan

RICH STABILITY CUTBACK

- REGIONS A, B AND C – UNRESTRICTED THROTTLE MOVEMENT.
- REGION A – FULL AB OPERATION EXPECTED.
- REGION B – TRANSITION REGION, FULL OR REDUCE AB OPERATION IS NORMAL.
- REGION C – REDUCE AB OPERATION EXPECTED (NOZ POS INDICATION 30 – 50 PERCENT)

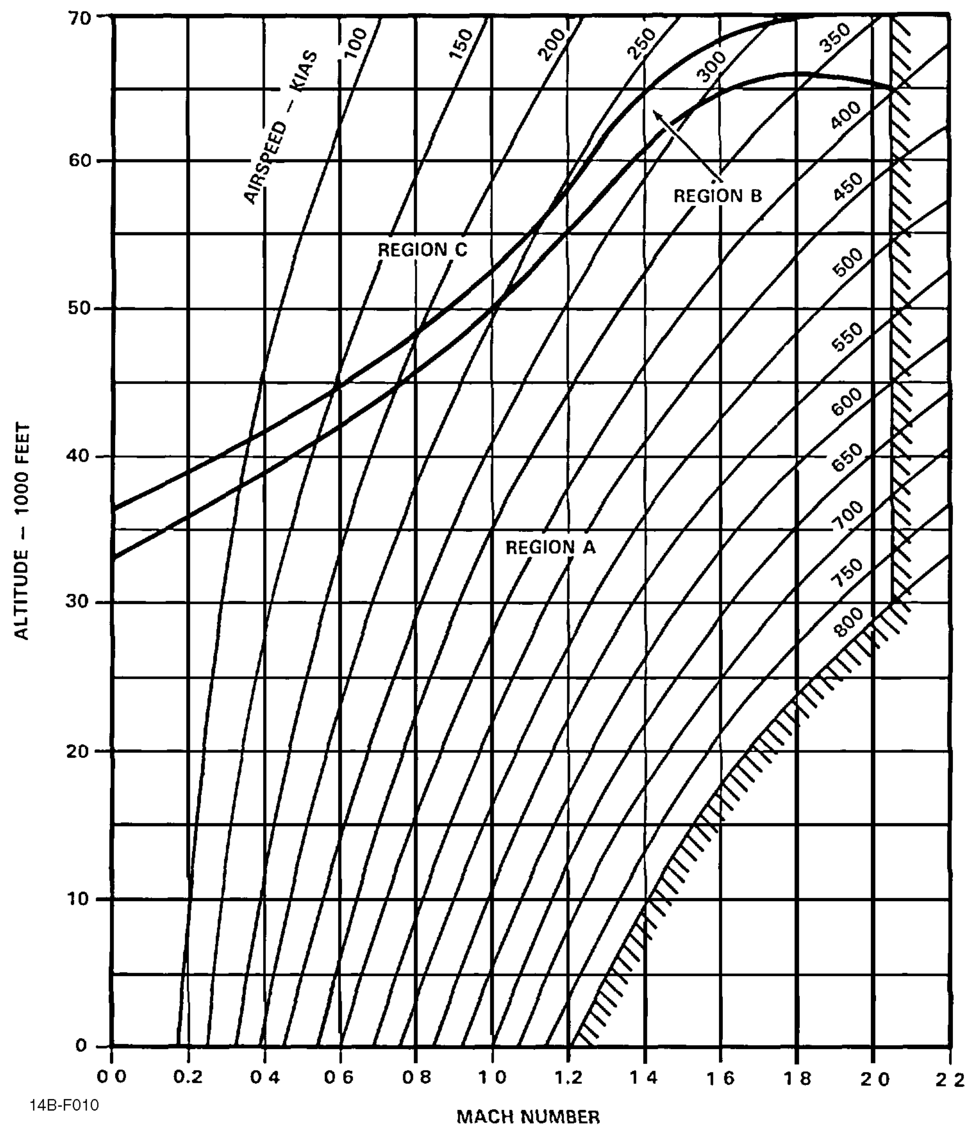


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Figure 2-12. Rich Stability Cutback

overspeed protection. The engine is completely operable should the aircraft experience a total electrical failure. The engine operates in either PRI or SEC mode, which can be selected automatically or manually. In case of a total electrical failure, all engine lights and indicators are inoperative.

2.2.1.7 Turbine Blade Temperature (Pyrometer). The pyrometer is a fuel-cooled, photodiode, optical unit that measures infrared radiation on the metal surface of the high-pressure turbine blades. This temperature signal is transmitted to the AFTC and is used to regulate engine fuel flow, which maintains turbine blade temperature within limits. There are no cockpit indications of turbine blade temperature.

2.2.1.8 Flame Sensor. The flame sensor is an ultraviolet radiation sensing unit in the AB duct. During AB operation, ultraviolet rays detected through a quartz window activate a gas-filled sensor that electrically transmits a flame present signal to the AFTC. Without this signal, only minimum AB fuel flow is available. AB will be inhibited if the flame sensor fails on.

2.2.1.9 Asymmetric Thrust Limiting. The asymmetric thrust limiting circuit is designed to hold both engines to minimum AB until both ABs are lit-off. The AFTC releases the hold on the AB when both engine AB pumps are on and both engines' flame sensors are on. Selecting the ASYM LIMITER switch to OFF (guard cover up) overrides the comparison of left and right AB status and allows each AB to operate independently.

WARNING

A malfunctioning or deselected asymmetric thrust limiting system can greatly increase the magnitude of asymmetric thrust because of engine stall/failure.

2.2.1.10 Reduced Arrestment Thrust System. The RATS is a feature of the AFTC provided to reduce thrust for carrier landings to a level consistent with carrier wind-over-deck operations. When activated, the AFTC automatically reduces the MIL power core speed (N_2) by approximately 4.5 percent. This results in an approximate 20- to 25-percent decrease in thrust. For purposes of comparison, this reduced thrust level is approximately equal to MIL power of a TF-30 engine on a cold day.

RATS employs two enabling circuits: an engine circuit incorporated within each engine's AFTC and an aircraft circuit. The engine circuit is enabled by the aircraft circuit via switch closure. Since the engine circuit is a function of the AFTC, it is not available in SEC mode and can be overridden in PRI mode with selection of afterburner. The aircraft circuit is enabled when weight is placed on either or both main landing gears with the hook handle down or the hook out of the stowed position. The RATS light, located on the pilot's advisory panel, illuminates when the aircraft circuit is activated, but it is not an indication that the engines are operating at reduced thrust. Illumination of the RATS light during preflight hook drop/lights master test verifies aircraft circuit operation.

Note

The RATS light will be illuminated any time the aircraft circuit is enabled, even if the engines are operating in SEC mode or the engine circuit has been overridden by selection of afterburner.

2.2.2 Variable Exhaust Nozzle. Engine exhaust gases at higher thrust settings are discharged through the nozzle throat at sonic velocity and are accelerated to supersonic velocity by the controlled expansion of the gases. Varying nozzle throat area controls fan stall margin, which optimizes performance.

The variable exhaust nozzle is a three-flap, convergent-divergent type nozzle. Nozzle variation is accomplished by axial movement of four hydraulic actuators mechanically synchronized for geometric stability. These hydraulic actuators use oil from a separate compartment in the engine oil storage tank and are operated by a hydraulic pump that responds to AFTC signals. A failed-open nozzle may indicate an oil leak, but if the leak is in the nozzle hydraulic circuit, only a portion of the main engine lube oil will be lost. During basic engine operation, the nozzle area is modulated to a near-closed position and, in AB, the nozzle area is infinitely variable to a full-open position. The nozzle will go full open airborne with the throttle at IDLE at low altitude and airspeeds. See Figure 2-13. A gauge for each engine on the pilot instrument panel next to the engine instruments indicates nozzle position

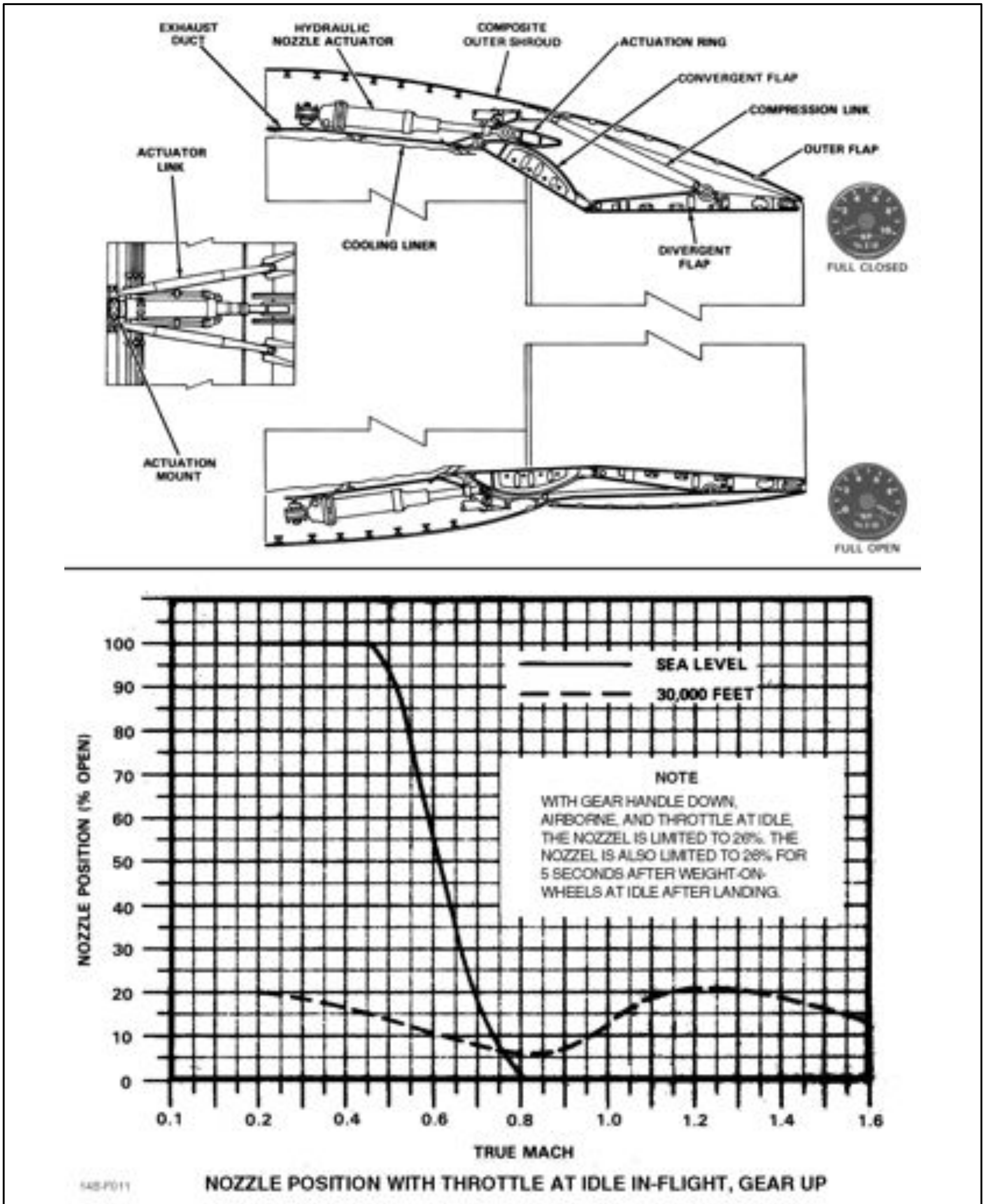


Figure 2-13. Variable Area Exhaust Nozzle

in percentage from 0 to 100. Normal indication for maximum AB is approximately 70 percent.

Note

When AFTC is operating in secondary mode, the nozzle is commanded closed and the exhaust nozzle indicator is inoperative.

With the landing gear handle down and weight off wheels, the nozzle is restricted to a near-closed position (maximum 26 percent) to prevent exhaust nozzle flap contact with the deck/hook during landing. Five seconds after weight on wheels, the nozzle resets to full open to reduce idle power during landing rollout and while taxiing. On deck in PRI mode with throttle above IDLE detent, nozzle position varies linearly with throttle position.

2.3 FATIGUE ENGINE MONITORING SYSTEM

2.3.1 FEMS Functional Description. The FEMS (Figure 2-14) is a solid-state, electronic unit that provides data acquisition, processing, and storage. The system accumulates airframe stress and fatigue data and relevant engine performance data, both in flight and on deck, from the engine monitoring system processors. Engine faults detected are isolated to the appropriate WRA or combinations of WRAs and recorded for later transfer to the DPGS ground station for diagnostic analysis, troubleshooting, and appropriate maintenance. The DPGS also computes and stores engine parts life-tracking and failure-trending data. This tracking of engine data extends the life and safety of fleet aircraft by permitting maintenance routines at periodic intervals. FEMS also provides a signal to the stall warning system that initiates a 10-second warning tone (identical to overtemperature tone) and illuminates the L or R STALL warning light, indicating an engine stall. FEMS will record aircraft overstress when it determines that normal acceleration has exceeded the following limits:

1. 7.5g with landing gear UP and Mach greater than 0.24
2. 4.5g with landing gear DOWN (as in hard landing)
3. 4.5g when Mach is 0.24 or less

2.3.1.1 Engine Monitoring System Processor. The EMSP is engine mounted and engine powered and converts control system electrical signals from the AFTC into digital format for transmission to the ADAC. It also receives and digitizes other noncontrol, system-related data such as anti-icing system status, lube oil level, and lube temperature data for transmission to the ADAC. In addition, the EMSP calculates and stores engine cycle count data, making this data readily available for each serial-numbered engine even when the engine is not installed in an aircraft.

Note

EMSP is only operational with the engines in primary mode.

2.3.1.2 Airborne Data Acquisition Computer. The ADAC is the central processor of FEMS and executes airframe and engine algorithms. The ADAC acquires aircraft data by direct analog and digital inputs. Additional aircraft data received by the ADAC from the CSDC to be stored as a result of structural, engine, or other mission events are transferred to the data storage set for postflight analysis.

In addition, the ADAC stores fault code messages, in nonvolatile memory, for display on the flight maintenance indicator. The ADAC is powered by the 28-Vdc right main bus.

2.3.1.3 Data Storage Set. The DSS, placed in the rear cockpit, includes the data storage unit and the data storage unit receptacle. The DSU is a removable cartridge data recorder that is unloaded and reinitialized by transferring the collected data to a local data processing ground station where the data can be displayed for engine diagnostic purposes or compiled for long-term maintenance records. A fault code on the flight maintenance indicator will alert the maintenance crew when the DSU has reached 80 percent of its capacity. If the DSS is inoperative or is not loaded with a cartridge, engine part life-tracking data are still maintained by the EMSP.

2.3.1.4 Flight Maintenance Indicator. The FMI displays to the maintenance crew ADAC data for engine/airframe status. It is mounted in an easily accessible location on the forward bulkhead in the nose wheelwell (Figure 2-15). After each flight, the FMI FAIL, CAUTION, and/or FLUIDS fault trip indicators will be either black, signifying the absence of a

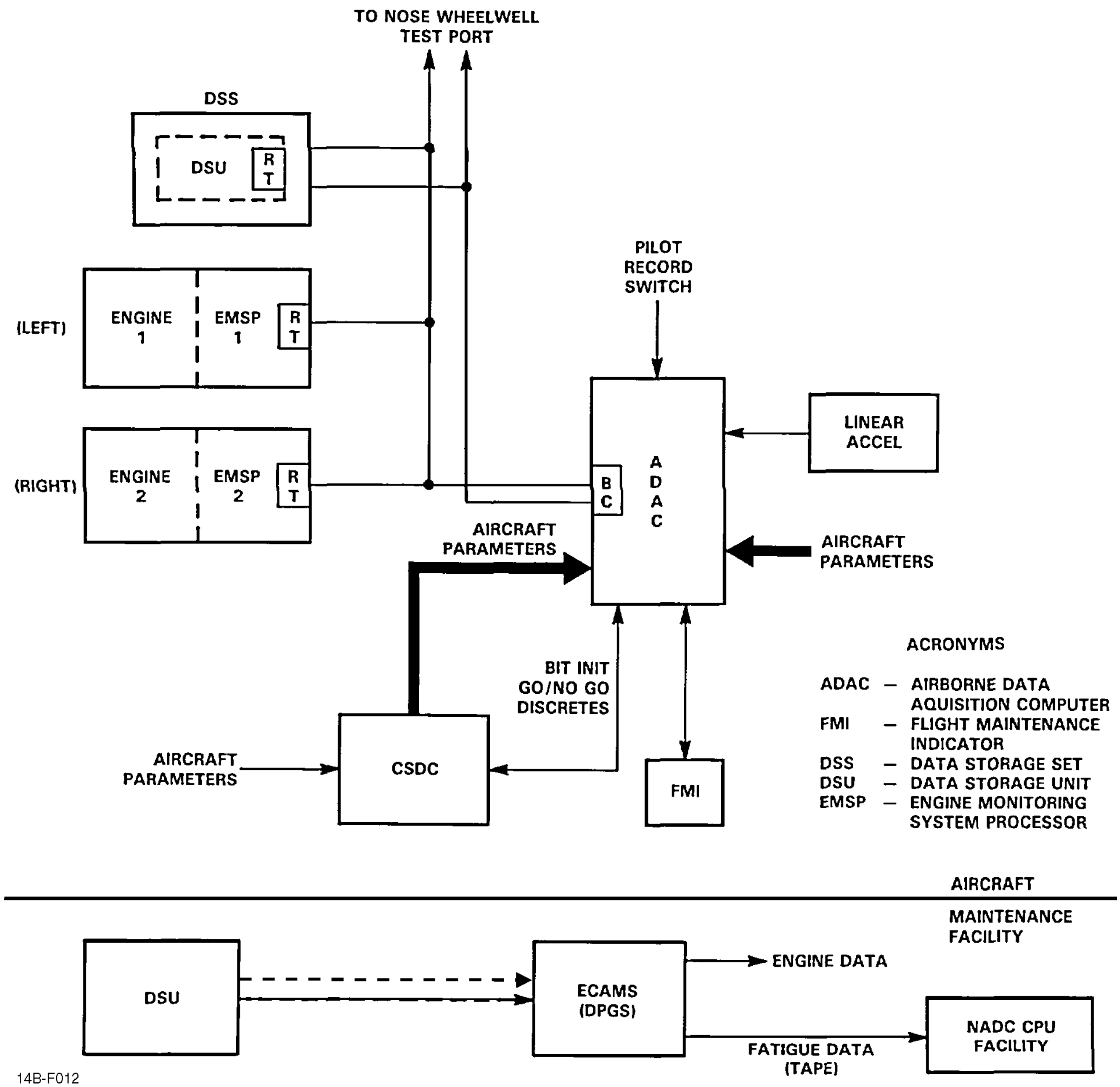


Figure 2-14. FEMS Block Diagram

FEMS-detected failure, or white, indicating FEMS detected a failure. The indicators should normally be reset by maintenance personnel prior to flight. With electrical power applied to the aircraft, depressing the STATUS SWITCH button displays either a fault code (if a fault is present) or NONE in the STATUS window. All fault codes may be scrolled line by line by depressing the STATUS SWITCH button once for each line. When no more fault codes are displayed, the display will read END*. When END* is displayed, depressing and holding the CLEAR button changes the display from END* to CLR for approximately 5 seconds followed by NONE, erasing all fault codes.

Note

- Do not press both CLEAR and STATUS switch at the same time. Failure to comply will result in the FEMS onboard clock being altered.
- The FMI is designed to be a maintenance tool only and should not be used as a go/no-go device by aircrew on preflight. Likewise aircrew should not take it upon themselves to reset the device.

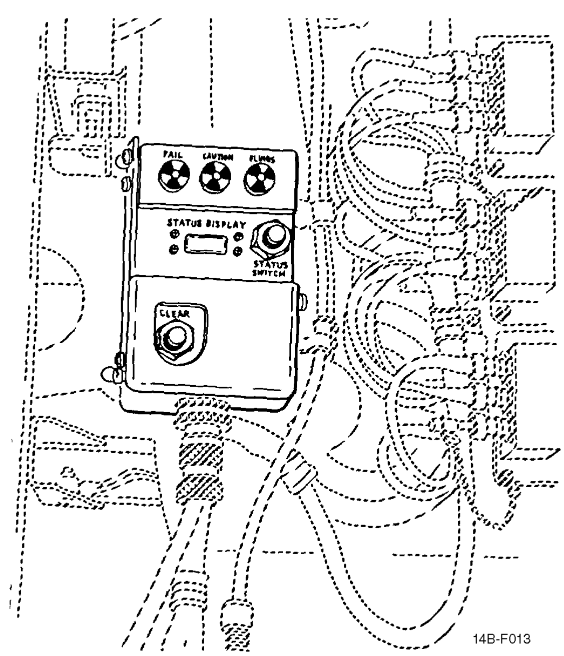


Figure 2-15. Flight Maintenance Indicator

The following is a composite listing of the data automatically recorded in memory for maintenance and displayed in numeric code on the FMI:

1. RATS failure
2. AB signal on but not selected
3. Fan/core overspeed
4. Turbine blade temperature limit exceeded
5. Rapid loss of compressor discharge pressure or out of limits
6. Decay in core speed
7. Compressor stall
8. Anti-icing fault
9. Low oil quantity
10. Oil overtemperature
11. AB fuel valve dry operation
12. Pilot-initiated EMS data
13. AFTC/MEC takeoff parameters fault (on deck only)
14. Data storage set memory full and requires service
15. AFTC/EMSP interfaces fault
16. No AB light-off signal
17. AB blowout
18. Repeatable engine fault data
19. AB fuel schedule fault
20. Exhaust nozzle near or exceeding schedule
21. Exhaust nozzle open satisfactory check
22. Fan inlet guide vanes off schedule
23. AFTC power-out of limits
24. Mach signal to AFTC fault
25. Secondary mode operation

26. EMSP fault

27. ADAC BIT fault and system failure

28. ADAC battery low

29. Throttle/AFTC signal fault

30. Aircraft 28-volt supply to AFTC fault

31. Aircraft overstress

32. System DSS

33. ADAC A-6 failure.

2.3.2 FEMS Operation. FEMS data acquisition for monitoring engine performance is automatic. However, the pilot may encounter unusual engine behavior of a nature that does not automatically initiate data recording. These data are valuable for diagnosis of the cause of unusual behavior and should be recorded by the pilot by depressing the ENG RCD button on the fuel management panel. Pressing the ENG RCD button momentarily causes 21 seconds of engine data to be recorded: 6 seconds before and 15 seconds after switch initiation. It is important to remember that if a transient problem is to be recorded by FEMS, the ENG RCD button must be activated quickly so the actual event is not missed. Manual recording will not interfere with data automatically saved by the FEMS.

Note

When operating with a TARPS pod-equipped aircraft, the TARPS POD present I.D. must be sent to the FEMS to allow proper airframe structural stress computation. Procedures to ensure that this requirement is met are contained in Chapter 24.

2.3.3 FEMS and OBC. FEMS is checked during OBC preflight and in flight (class III). It is designated by a FEM acronym. This acronym is displayed at the completion of OBC if FEMS fails its BIT during OBC. Engine-life tracking data are still available through EMSP if FEMS is lost.

2.4 ENGINE FUEL SYSTEM

The engine fuel system, which is identical for each engine, provides motive flow fuel to effect fuel transfer and metered fuel for combustion as a function of pilot throttle commands and numerous engine parameters (Figure 2-16).

2.4.1 Motive Flow Fuel Pump. The motive flow fuel pump is a gear-driven centrifugal pump on each engine accessory gearbox that returns high-pressure fuel to the fuselage and wing tanks to effect normal fuel transfer. Motive flow is used to power the boost pump in the respective sump tank. This fuel continues through control valves to ejector pumps in the fuselage and wing fuel tanks. There is no cockpit control for the motive flow fuel pumps. Failure of one pump illuminates the R or L FUEL PRESS caution light and reduces the rate of fuel transfer but does not inhibit the transfer of fuel from any tank. A motive flow pump failure causes the engine to draw fuel through suction feed. Higher altitudes and decreased ambient pressure result in reduced fuel flow that may cause engine flameout because of fuel starvation. With a single motive flow fuel pump failure, AB selection above 15,000 feet MSL may cause engine flameout. With failure of both motive flow fuel pumps, high power settings in basic engine may cause flameout above 25,000 feet MSL. If a dual motive flow fuel pump failure occurs, wing fuel will not be available.

2.4.2 Engine Fuel Boost Pump. The engine (total flow) fuel boost pump is an engine-driven centrifugal pump on the aft accessory gearbox that provides boosted pressure and flow from the fuel supply system to meet main and AB fuel requirements. The pump receives fuel at aircraft boost pressure and boosts fuel pressure to levels adequate to operate the engine at all power settings (maximum 40 psi pressure rise). During non-AB operation the fuel is circulated between AB fuel control and the engine fuel boost pump so that fuel pressure is readily available to the spray bars for AB light-off.

2.4.3 Main Fuel Pump. The main fuel pump is a two-stage pump that receives fuel flow from the engine fuel boost pump. It provides additional fuel pressurization and mechanical-gear-driven power to the MEC.

2.4.4 Main Engine Control. The MEC is a fuel operated, hydromechanical fuel flow regulator that operates in tandem with the main fuel pump and is capable of operating in two modes. In the primary mode it meters main fuel flow as required by the AFTC and provides VSV scheduling. The secondary mode hydromechanically governs N_2 speed based on pilot throttle

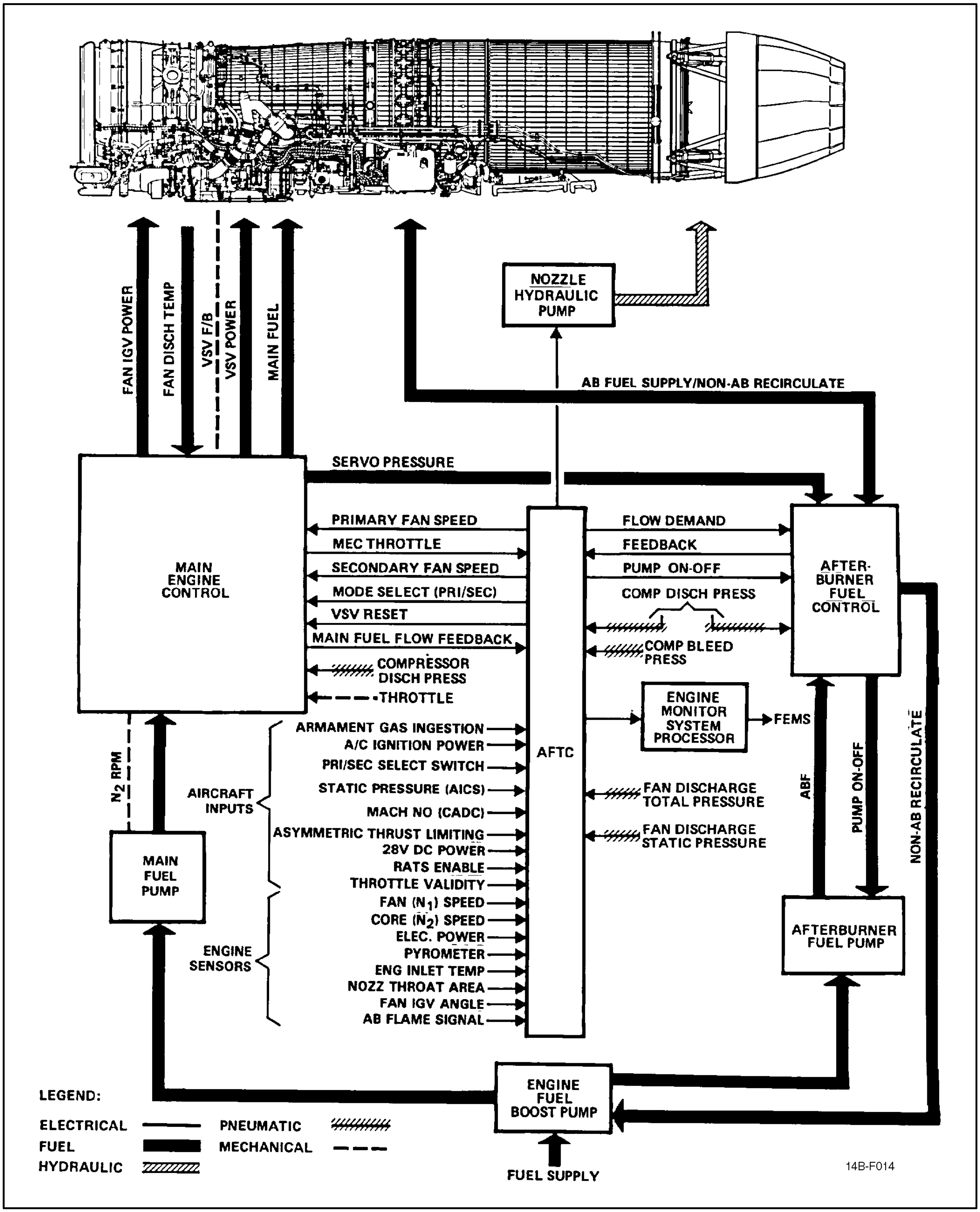


Figure 2-16. Engine Fuel System

commands and provides basic engine control except for AFTC fan speed limiting.

VSV aerodynamically matches high- and low-pressure compressor stages by changing the angle at which airflow enters the compressor rotor blades. The MEC contains the scheduling mechanism and provides fuel pressure to vary VSV positioning. A flexible mechanical cable provides feedback from the compressor stator to the MEC.

2.4.5 Afterburner Fuel Pump. The AB fuel pump is a centrifugal gear-driven pump that receives fuel from the engine boost pump, increases pressure, and delivers fuel to the AB fuel control. During non-AB operation, fuel is circulated between the AB fuel control and the engine boost pump; the AB fuel pump impeller runs dry with the bearings lubricated by the engine oil system. Failure of an AB fuel pump will result in an AB blowout.

2.4.6 Afterburner Fuel Control. The AB fuel control is a fuel-operated, electro-hydromechanical unit that regulates fuel flow in response to AFTC scheduling and compressor discharge pressure. Fuel pressure from the AB fuel control provides on-off signals to the AB fuel pump.

The AB fuel control splits fuel flow into three metered streams (local, core, and fan) on a sequential basis into the AB manifolds for distribution through spraybars in the AB duct. Throttle commands initiate local fuel flow and AB ignition (minimum afterburner). Once local fuel flow and flame are established, core fuel flow commences. As maximum core fuel flow is established, fan fuel flow commences and increases until maximum AB is achieved. The transitions between local, core, and fan fuel flow are smooth and unnoticed (Figure 2-17). During non-AB operation, fuel flow is circulated through the AB manifolds to prevent thrust lags and surges when AB is initiated.

WARNING

Zero or negative-g flight longer than 10 seconds in AB or 20 seconds in MIL or less will deplete the fuel sump tanks (cells 3 and 4), resulting in flameout of both engines.

WARNING

- To prevent engine instability and/or flameout, avoid holding zero or negative g when doing a low-altitude, maximum thrust acceleration followed by a push-over (that is, bugout).
- With fuel in feed group below 1,000 pounds, AB operation could result in AB blowout.

Note

Fuel dump operations with either engine in AB are prohibited. The fuel dump mast can be torched.

2.5 THROTTLES

Two throttle levers for regulating engine thrust are on the left console of the front cockpit. Unrestricted engine operation under independent control is afforded; however, normal symmetric thrust control is provided by collective movement of the throttle levers. Numerous engine control and subsidiary functions are performed by movement of the throttle levers within the full range of travel as shown in Figure 2-18. The forward and aft throw of each throttle lever in the quadrant is restricted by hard detents at the OFF, IDLE, MIL, and MAX (afterburner) positions. At the OFF and IDLE detents, the throttles are spring loaded to the inboard position. At the MIL detent, the throttles can be shifted outboard to the AB sector or inboard to the basic engine sector of operation by merely overcoming a lateral breakout force. Lateral shifting of the throttles at the MIL detent does not affect engine control. Thus, placement of the throttle outboard at MIL provides a natural catapult detent to prevent unintentional retarding of the throttles during the launch. This, however, does not inhibit the selection of afterburner. The friction control lever on the outboard side of the quadrant permits adjustment of throttle friction to suit individual requirements. With the friction lever in the full-aft position, no throttle friction is applied at the quadrant; increased throttle friction is obtained by forward movement of the lever.

A locking pin device prevents the left throttle from moving into the cutoff position when the right throttle is either traversing or at rest on the face of the right-hand idle stop block.

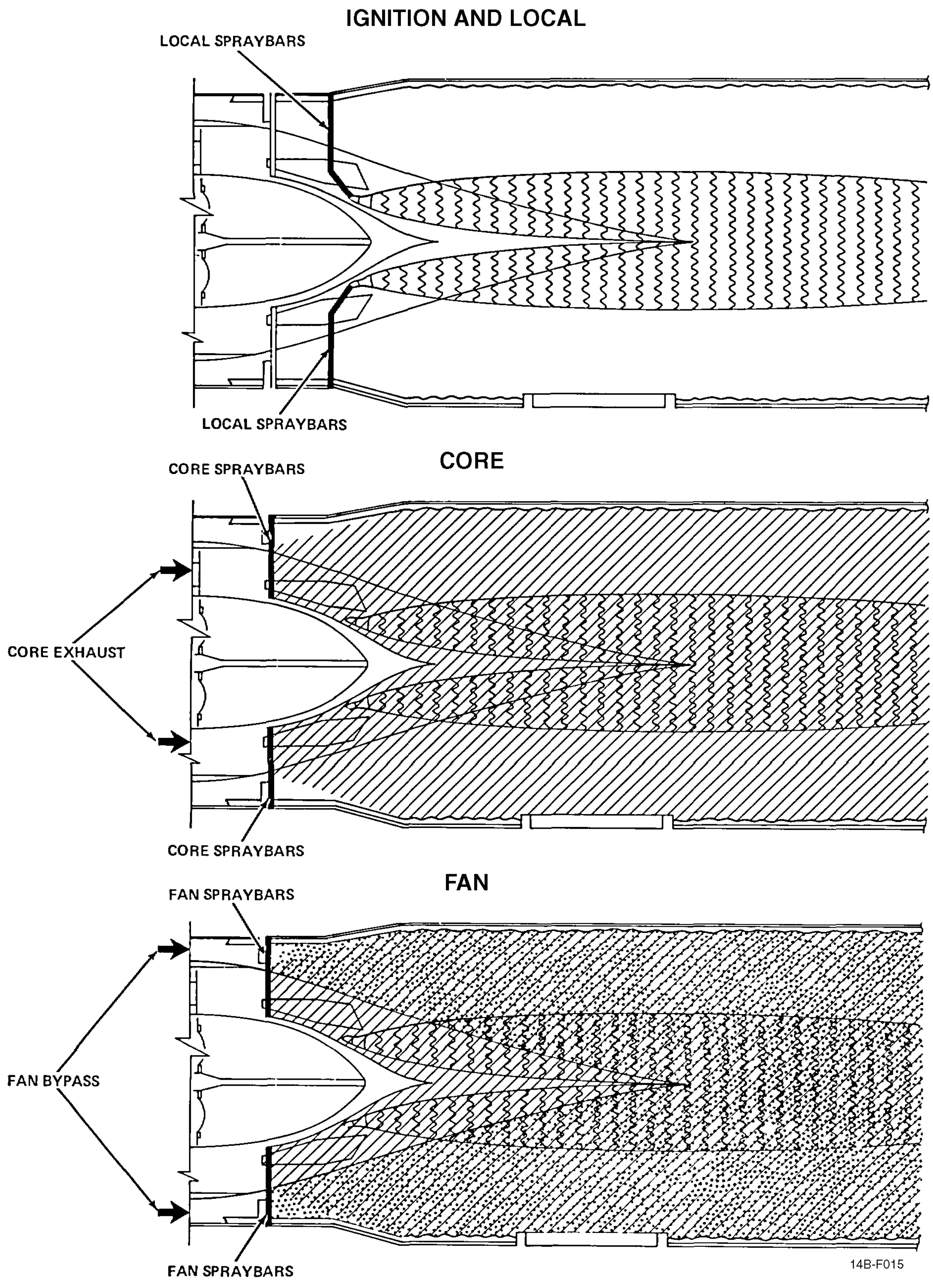


Figure 2-17. Afterburner Fuel Sequencing

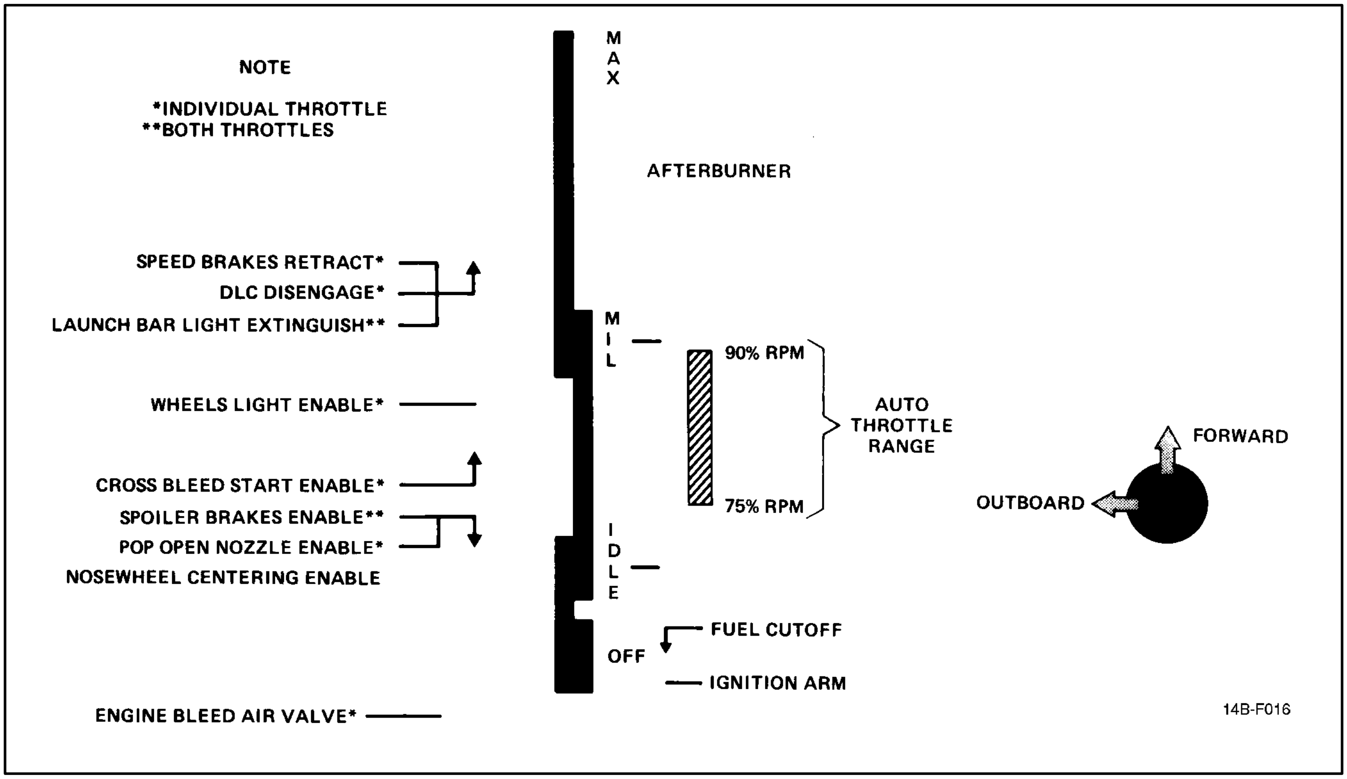


Figure 2-18. Throttle Interlocks

2.5.1 Throttle Control Modes. Manual, boost, and auto are the three modes of throttle control over engine operation selectable by the THROTTLE MODE switch located outboard of the quadrant on the pilot console. The toggle switch must be lifted out of a detent to select MAN from BOOST or BOOST from MAN. The switch is solenoid held in AUTO upon successful engagement of AUTO mode. A functional schematic of throttle control modes, including system major components, is shown in Figure 2-19. Except for the autothrottle computer and mode control switch, the throttle control system for each engine is completely redundant. Independent engine operation is possible in the manual or boost mode of throttle control; however, full system operation is necessary in the auto mode since operation under single-engine control is impracticable because of asymmetric thrust considerations.

2.5.1.1 Manual Throttle Mode. The manual throttle is a degraded mode of operation and was designed as a backup system. Because of hysteresis and friction in the manual system, engine rpm may vary from the boost mode at a given throttle position. If an engine fails to secure when the throttle is moved to the OFF position, the throttles have probably reverted to the manual mode and are slightly out of rig. Cycling the throttle switch to MANUAL and back to BOOST may allow engine shutdown. If shutdown is unsuccessful, then the engine may be secured with the fuel shutoff handle.

CAUTION

- Engine shutdown at high power settings using the fuel shutoff handle may result in damage to the aircraft fuel system.
- Engine startup in manual mode may cause tailpipe fires as fuel flow may not be secured.

In the manual mode of operation, movement of each throttle is mechanically transmitted to the respective engine by a push-pull cable and a rack-and-sector mechanism mounted to the main engine control power lever shaft. An electric clutch in the throttle servo actuator, which is also mounted to the power lever shaft, is disengaged in the manual mode to reduce operating forces.

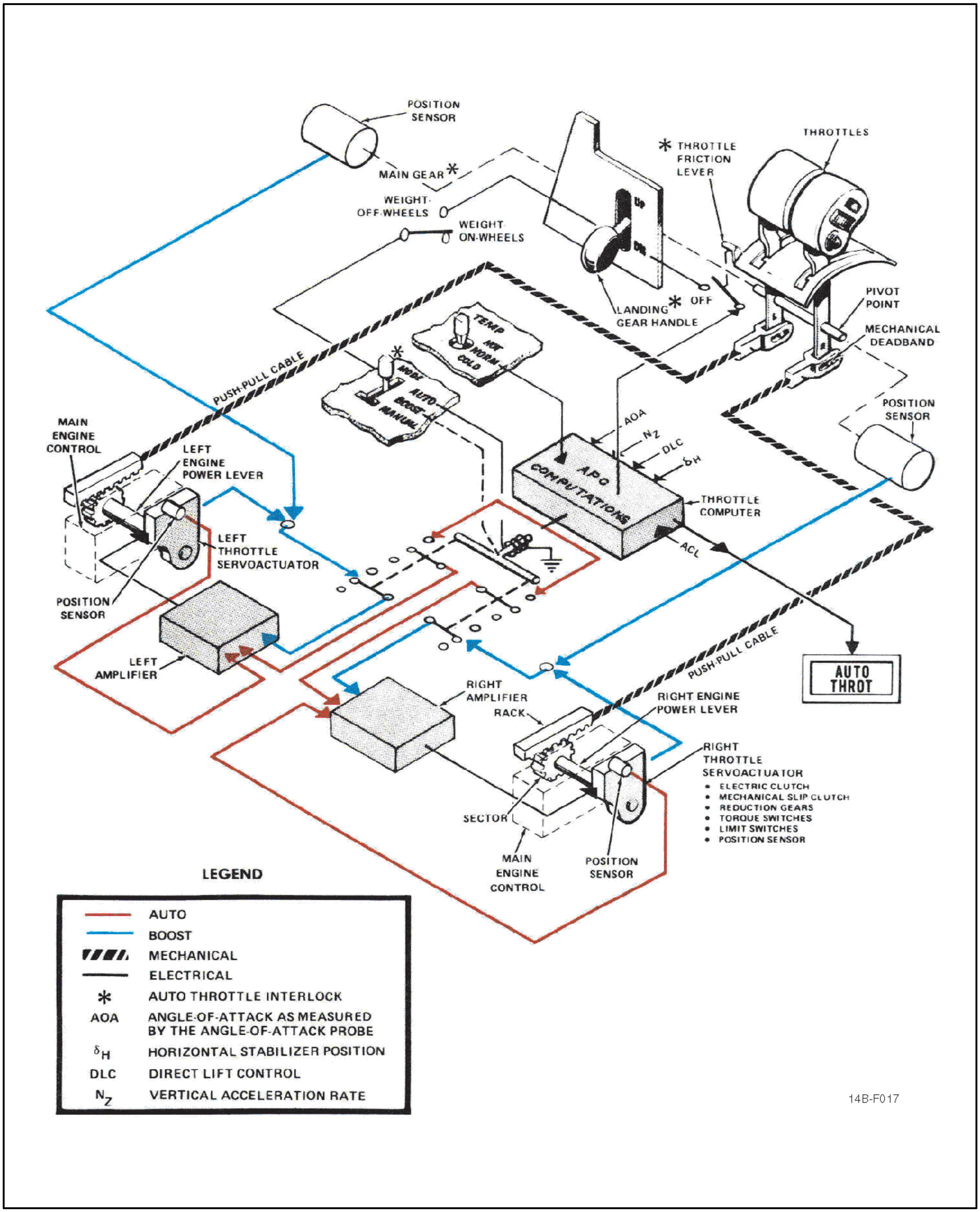


Figure 2-19. Throttle Control

With the throttle friction off, approximately 8 pounds of force per throttle must be applied at the grip to operate the throttles in IDLE to MAX range.

2.5.1.2 Boost Throttle Mode. The boost mode of throttle is used for normal operations. A force of 2 to 3 pounds at the grip is required to move each throttle throughout its range with the throttle friction lever OFF. Essentially, the boost mode provides electric throttle operation, with the push-pull cables serving as a backup control path. Throttle movement is detected by the throttle position sensor. The signal is resolved in the amplifier to provide positional followup commands to the actuator. Movement of the actuator rotates the engine power lever shaft, which drives the push-pull cable.

If a boost system malfunctions, applying approximately 17 pounds at the throttle grip automatically reverts the throttle control to the manual mode by disengaging the actuator electric clutch. The throttle control reverts to manual mode in 0.25 second. In the event of a boost system malfunction, the THROTTLE MODE switch will remain in the BOOST detent. By manually placing the THROTTLE MODE switch in MAN and then back to BOOST, transient failures in the boost mode can be reset. Additionally, if an actuator seizes, a mechanical clutch in the actuator will slip when a force of approximately 50 pounds is applied at the throttle grip. This permits the pilot to override an actuator seizure. There is no visible warning of these anomalies, only the noticeable increase in the forces required to manipulate the affected throttle.

2.5.1.3 Approach Power Compensator (Auto Throttle Mode). The auto mode of throttle control is a closed-loop system that automatically regulates basic engine thrust to maintain the aircraft at an optimum approach angle of attack for landing. All components of the throttle control system except the throttle position sensor are used in the auto mode of control. The angle-of-attack signal from the angle-of-attack probe on the left side of the forward fuselage is the controlling parameter within the autothrottle computer. Additional parameters are integrated within the computer to improve response. The air temperature switch on the pilot left console effects a computer gain change to compensate for pilot preferred reaction rate. In order to engage the autothrottle, throttles must be between 75- to 90-percent rpm with weight off wheels, gear handle down, and throttle friction off. With all conditions met, the THROTTLE MODE switch will be held by an electrical solenoid when placed in AUTO. The throttle control mode automatically reverts to the boost mode upon interruption of any interlock in the system or by manually overriding the throttles with a force of approximately 11 pounds per throttle in either direction. The THROTTLE MODE switch automatically returns to BOOST and the AUTO THROT caution light illuminates for 10 seconds. See Figure 2-20 for autothrottle controls.

The pilot can revert from auto to boost mode by depressing the CAGE button on the outboard throttle grip. This provides a smooth throttle override for an auto-to-boost mode approach, while maintaining a grip on both throttles.

2.5.1.3.1 Autothrottle Test. An automatic check of the autothrottle control system while on deck is accomplished during OBC. Signals to the servoactuators are inhibited during the OBC autothrottle test so that the engines remain at idle thrust. A malfunction is indicated by an APC acronym at the conclusion of OBC.

Rotating the MASTER TEST switch to FLT GR DN and depressing it bypasses the autothrottle weight-on-wheels interlock and an end-to-end check of the autothrottles may be performed on deck. The throttles should be placed at about 80-percent rpm and the throttle MODE switch placed in AUTO. The throttles must be positioned above idle before selecting AUTO to ensure a valid test. Once AUTO is engaged, the control stick should be programmed fore and aft to check for the appropriate power response.

CAUTION

High-power settings may result during aft stick deflection.

If the THROTTLE MODE switch does not remain engaged or the APC does not respond properly to indicated AOA and longitudinal stick movements, a malfunction exists in the autothrottle system.

NOMENCLATURE	FUNCTION
(1) THROTTLE MODE switch	AUTO — Engine thrust is automatically regulated to maintain optimum angle of attack for landing by the throttle control computer. BOOST — Normal operating mode. Reduces effort required to move throttles manually with friction control aft. MAN — Movement of each throttle Is mechanically transmitted to the respective engine cross-shaft by a push-pull cable.
(2) THROTTLE TEMP switch	Used with the AUTO throttle mode to effect throttle computer gain changes to compensate for air temperature. HOT — Increases normal throttle computer gain. NORM — Normal throttle computer gain. COLD — Decreases normal throttle computer gain.
(3) AUTO THROT caution light	Auto throttle mode is disengaged. During preflight check, remains illuminated for 10 seconds, then goes off and throttle mode switch automatically returns to BOOST **Note** If the auto throttle is disengaged by deselecting the throttle MODE switch, the AUTO THROT light will not illuminate.
(4) CAGE button	With the pilot's weapon select switch in OFF, and the THROTTLE MODE switch in AUTO, depressing the CAGE button reverts the throttles to BOOST mode.
(5) Autopilot emergency disengage paddle	Reverts throttle system from AUTO or BOOST mode to MAN mode only while depressed and with weight on wheels.

Figure 2-20. Autothrottle Controls and Indicators

Depressing and holding the autopilot emergency disengage paddle switch with weight on wheels causes the throttle control system to be placed in the manual mode. If the auto mode was selected before depressing the paddle switch, the THROTTLE MODE switch will automatically move to BOOST. The THROTTLE MODE switch must be moved from BOOST to MAN while holding the paddle switch depressed if the manual mode is desired after the paddle switch is released.

2.6 ENGINE BLEED AIR

Bleed air is extracted from the high-pressure compressor to perform engine-associated services and to supply high-pressure and temperature air for operation of auxiliary equipment. Fifth-stage bleed air supplies hot air for the engine anti-icing system and is used to draw cooling air through the aircraft hydraulic heat exchangers to cool flight and combined fluids and to ventilate the nacelle when weight is on wheels (Figure 2-21). Ninth-stage bleed air supplies hot air to the environmental control system, provides air for cross-bleed engine starts, and draws air through the integrated drive generator heat exchanger (ventral fin) when weight is on wheels.

2.6.1 Engine Anti-Ice. The fan IGV and nose-dome are susceptible to icing under a wider range of conditions, particularly at static or low speed with high engine rpm, than that which causes ice to form on external surfaces of the airframe. Ice formation at the fan face can restrict engine maximum airflow, which results in a thrust loss, decreased stall margin, and dislodgement of ice that can damage the compressor. The engine anti-icing system is designed to prevent the formation of ice rather than deice the IGV and nose dome. Hot bleed air (fifth stage) is passed through the hollow IGV to the nosedome and is discharged into the engine along the vanes and at the rotor hub. Cockpit control of the engine anti-icing system is effected through the ANTI-ICE switch (Figure 2-22).

Note

Because of its adverse effects on engine performance, the engine anti-icing system should be used only when icing conditions exist or are anticipated.

During engine start, the engine anti-ice valve remains open to bleed the compressor to prevent engine stall. The valve closes when the engine approaches idle rpm. In flight, the valve is normally closed unless the ANTI-ICE switch is in ORIDE/ON, or AUTO/OFF, when the ice detector probe in the left inlet is activated.

Ice accumulation on the ice detector illuminates the INLET ICE caution light. The engine anti-icing control valve on the engine is powered closed (fails open) from the essential dc No. 2 bus through the ENG/PROBE/ANTI-ICE circuit breaker (RG2).

2.6.2 ECS Leak Detection. Thermal detection circuits are routed in proximity to ECS ducts and components to provide cockpit indications of high-temperature air leaks. Normal air temperatures range from 520 to 1,180 °F inside the bleed air portion of the ECS and from 400 to 500 °F inside the hot air portion (400 °F manifold).

The entire bleed air portion of the ECS, from engine bleed air shutoff valves to the primary heat exchanger, is monitored by two detection systems. Fire detection circuits monitor the bleed air system from each engine to its respective firewall. When a fire detection circuit in an engine compartment senses temperatures above threshold, the appropriate L or R FIRE warning light illuminates (refer to FIRE DETECTION SYSTEM, paragraph 2.12). The remainder of the bleed air system, from engine firewalls to the primary heat exchanger, is monitored by bleed air leak sensing elements. When the bleed air leak detection circuit detects temperatures in excess of 575 °F, the BLEED DUCT caution light illuminates.

The hot-air portion of the ECS is monitored by hot-air leak sensing elements. The hot-air system extends from the primary heat exchanger to the ECS turbine (turbine compressor). When the hot-air detection circuit detects temperatures in excess of 255 °F, the BLEED DUCT caution light illuminates.

2.7 ENGINE COMPARTMENT VENTILATION

Each engine compartment is completely isolated from the primary air inlet, and the efficiency and cooling of the variable-area exhaust nozzle are not dependent upon nacelle airflow. Therefore, within the bounds of the forward firewall (landing gear bulkhead) and the nozzle shroud, the cooling system for each engine compartment is a separate entity.

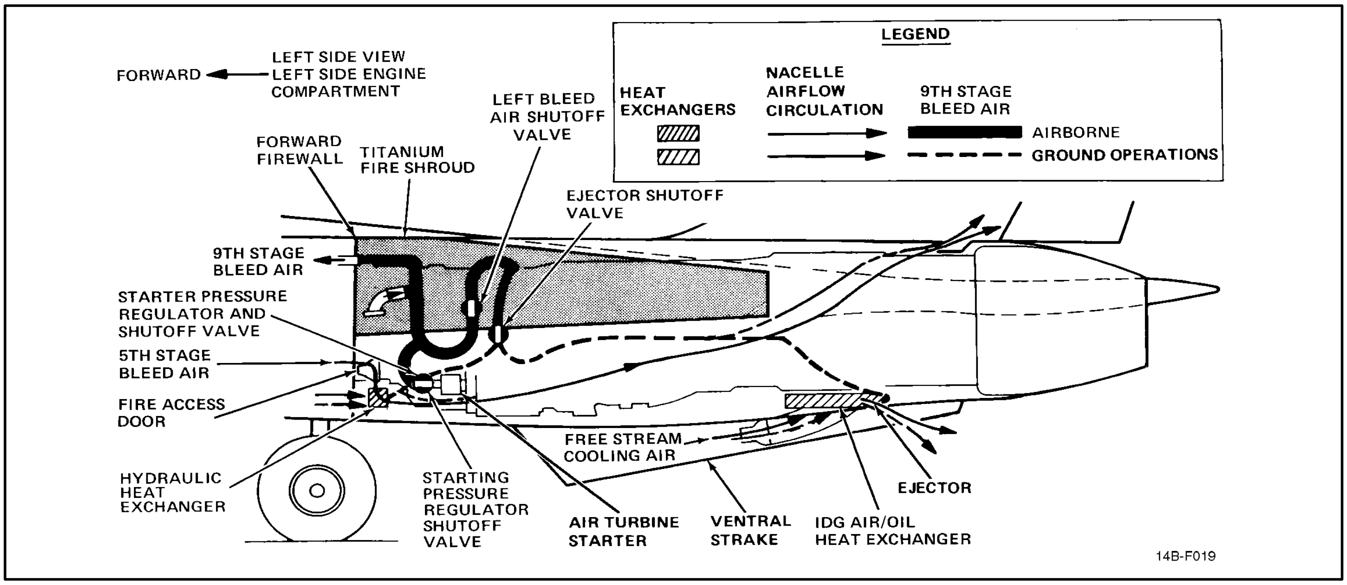


Figure 2-21. Engine Compartment Ventilation

Cooling requirements for the turbofan engine are minimized by the annular fan bypass duct. Figure 2-21 shows cooling air flow patterns through the engine compartment during ground and flight operations. Two air-cooled heat exchangers are also shown; however, only the hydraulic heat exchanger cooling airflow is associated with engine nacelle cooling. Fire access doors are on the outboard side of the nacelles at the forward end to permit insertion of fire suppressing agents by ground personnel in event of an engine compartment fire.

2.7.1 Engine In-Flight Ventilation. In-flight cooling of the engine compartment is accomplished by nacelle ram air scoops, circulating boundary-layer air through the length of the compartment and expelling the air overboard through louvered exits just forward of the engine nozzle shroud.

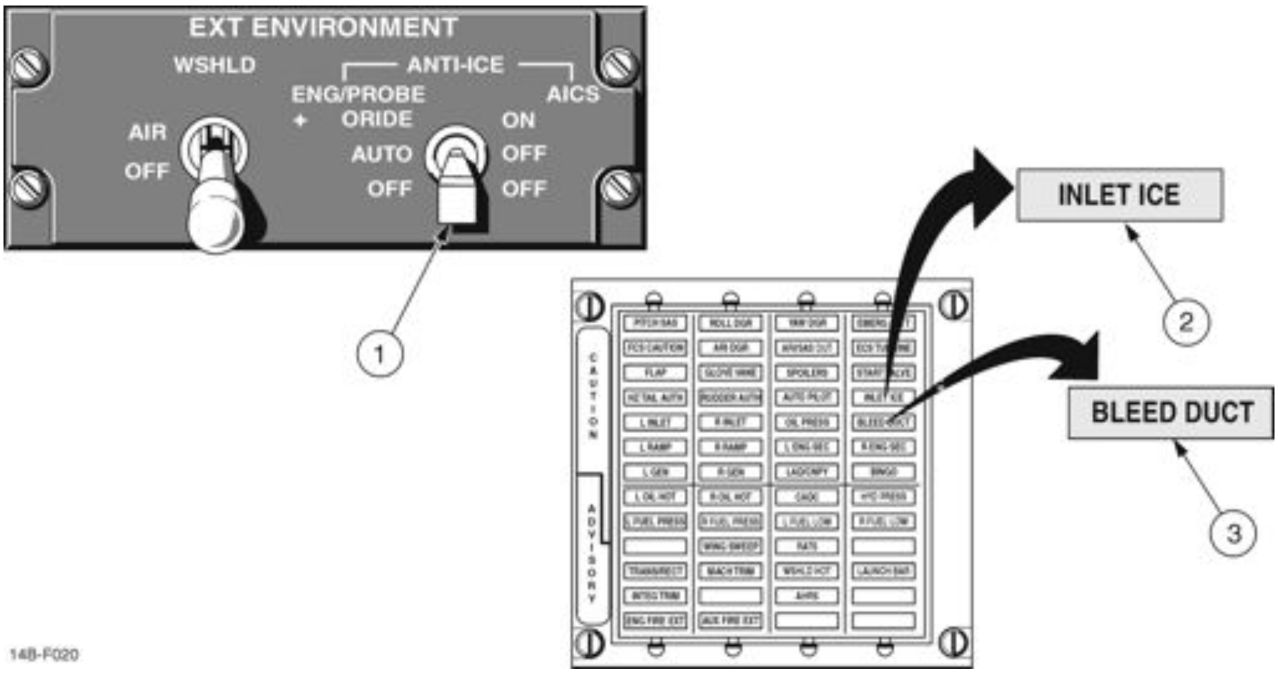
2.7.2 Engine Ground Ventilation. With weight on wheels, cooling airflow through the engine compartment is induced by the hydraulic heat exchanger ejector in the forward end of the compartment. Air enters through the nacelle ram air scoop on the left side, passes through the hydraulic heat exchanger, and is discharged into the engine compartment. The air flows through the full length of the nacelle to discharge overboard through a louvered port atop the nacelle on the outboard side of the vertical tail.

2.8 ENGINE IGNITION SYSTEM

There are three electrical ignition circuits, each utilizing a dedicated ignitor, for each engine: main high energy, afterburner, and backup.

2.8.1 Main High-Energy Ignition. The main high-energy ignition provides ignition in the combustion chamber for ground and air starts. It is powered by one of the four windings in the engine-driven ac alternator. The AFTC provides logic to control main high-energy ignition automatically. Ignition is available when N_2 rpm is 10 percent or greater and is automatically provided from 10- to 59-percent rpm when the throttle is above cutoff. Ignition is secured 0.5 second after N_2 rpm rises above 59 percent. At rpm above 59 percent, ignition is provided if N_2 deceleration exceeds a 5 percent rpm per second rate. Ignition continues for 20 seconds after N_2 deceleration falls below the 5-percent per second rate. Main high-energy ignition is provided continuously when the engine is in the secondary (SEC) mode.

2.8.2 Afterburner Ignition. The AB ignition provides ignition for AB light-offs, and relights in the event of an AB blowout. It is powered by the same winding in the engine-driven alternator that powers the main energy ignition. The AFTC provides logic to control AB ignition automatically and prevents simultaneous powering of the main high-energy and AB ignitions. In the event of an AB blowout, relight is normally provided within 1.5 seconds. AB ignition is not powered if the engine is in SEC mode.



NOMENCLATURE	FUNCTION
(1) ANTI-ICE switch	ORIDE/ON — Overrides ice detector system to turn on INLET ICE caution light, and activate external probe heaters and engine anti-ice. Commands the anti-ice mode to the AICS programmers. AUTO/OFF — When icing is sensed, ice detector activates engine anti-ice system and turns on INLET ICE caution light. External probe heaters activated with weight off wheels. OFF/OFF — Engine anti-ice system and probe heaters shut off. INLET ICE caution light disabled.
(2) INLET ICE caution light	Illuminates when ice accumulates on ice detector with ANTI-ICE switch in AUTO/OFF or if ORIDE/ON is selected. Does not illuminate with switch in OFF/OFF.
(3) BLEED DUCT caution light	Illuminates when bleed air leak sensing elements detect temperatures greater than 575 °F between the left and right firewalls, past the primary heat exchanger and up to the right diverter area. An additional sensor, detecting temperatures of 255° or greater, senses from the right diverter area, along the 400° manifold and Into the bootstrap turbine compartment.

Figure 2-22. Anti-Ice Control

2.8.3 Backup Ignition. The backup ignition provides ignition in the combustion chamber for ground and air starts when the BACK UP IGNITION switch on the throttle control panel is selected ON. It is powered by the essential No. 1 ac bus and provides less power than main high-energy ignition. After use, the BACK UP IGNITION switch should be set to OFF. To allow ground checkout of backup ignition, main high-energy ignition is disabled when the BACK UP IGNITION switch is ON and weight is on wheels.

WARNING

The BACK UP IGNITION switch shall be selected to OFF prior to applying external electrical power to prevent ignition of fuel puddled in the engine.

2.9 ENGINE STARTING SYSTEM

Each engine is provided with an air turbine starter that may be pressurized from an external ground starting cart or by crossbleeding high-pressure bleed air from the other engine. Figure 2-23 shows the components associated with the engine starting system.

2.9.1 External Airstart. A high-pressure (75 psi) air source and 115-volt, 400-Hz ac power are required for engine start on the deck.

The air hose is connected to the aircraft fitting in the left sponson area behind the main gear strut. Ground start air is ducted into a central bleed air (ninth stage) manifold, which interconnects the air turbine starters on both engines. The air supply to each air turbine starter is pressure regulated (52 psi) and controlled by a shutoff and regulating valve at the turbine. Each pneumatic starter is composed of a turbine, gear train, sprag clutch with a speed-sensing device, and an overspeed disengagement mechanism with a shear section.

Shutoff valves in the bleed air manifold selectively isolate the other starter, subsidiary bleed lines, and the environmental control system air supply for effecting a start. Maximum engine motoring speed with the pneumatic starter is approximately 30-percent rpm.

2.9.2 Engine Crank. Placing the ENG CRANK switch in either L or R opens the corresponding starter pressure shutoff valve to allow pressurized air to drive the turbine. The ENG CRANK switch energizes the appropriate shutoff valves to condition the bleed manifold for starting.

2.9.2.1 Engine Crank Switch. The ENG CRANK switch is held in L or R by a holding coil. At approximately 50-percent rpm, a centrifugal cutoff switch closes the turbine shutoff valve and returns the ENG CRANK switch to the center or off position. A START VALVE caution light illuminates if the starter valve remains in the open position after the ENG CRANK switch automatically returns to the center (off) position.

CAUTION

- If the starter valve does not close during engine acceleration to idle rpm, continued airflow through the air turbine starter could result in catastrophic failure of the starter turbine.
- If the START VALVE caution light illuminates after the ENG CRANK switch is off, select AIR SOURCE to OFF to preclude starter overspeed.
- If the ENG CRANK switch does not automatically return to the OFF position by 50 percent, ensure that the ENG CRANK switch is off by 60 percent to avoid starter turbine failure as a result of an inoperative automatic starter cutout.

This action, in turn, reconditions the bleed air manifold valves to permit ninth-stage bleed air to flow to the environmental cooling system and ejectors in the engine compartment.

Starter cranking limits are as follows:

1. Crossbleed — 2 minutes continuous then 10 minutes OFF.
2. Start cart— 5 minutes continuous then 10 minutes OFF.

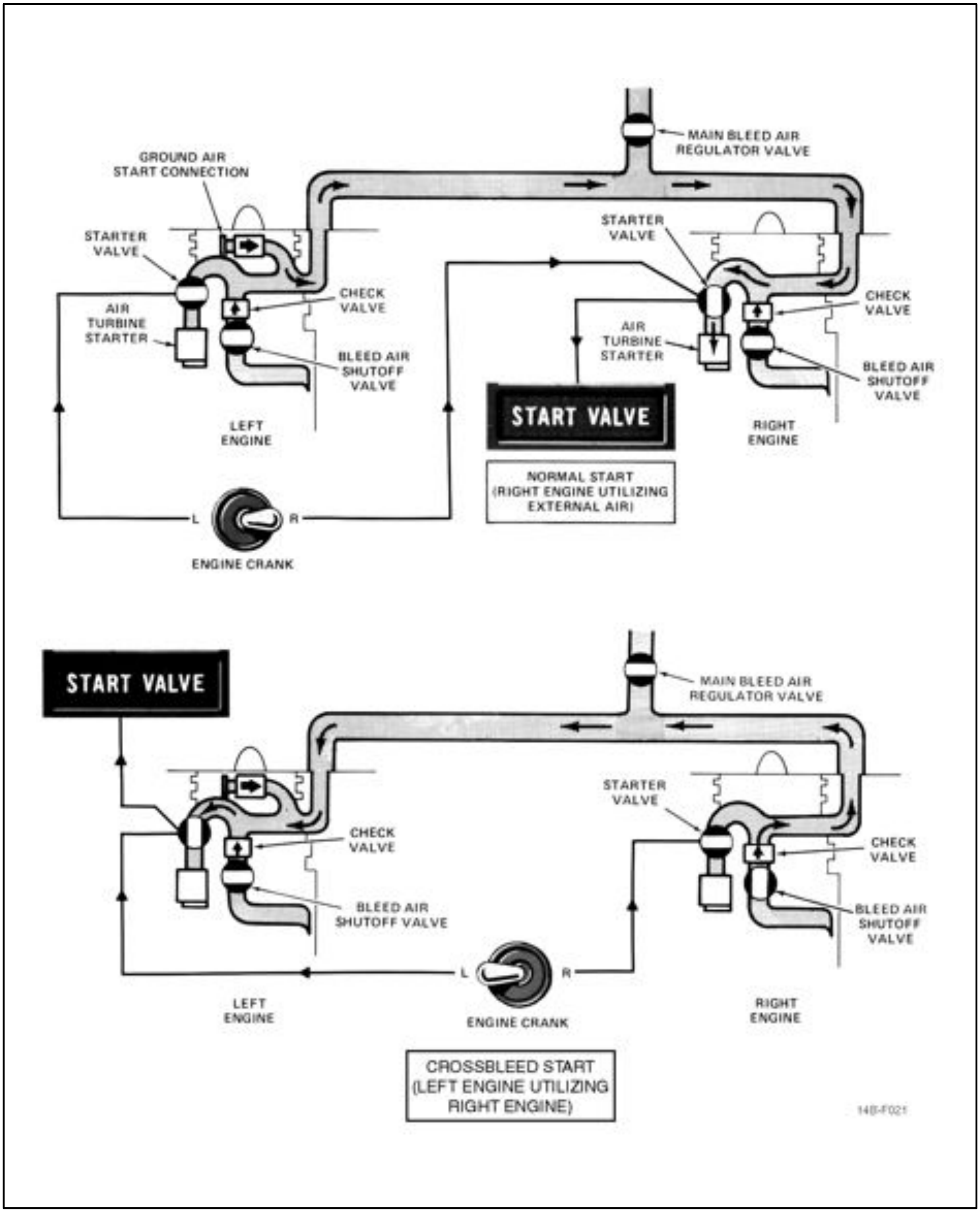


Figure 2-23. Engine Start System

2.9.3 Crossbleed Start. Engine cranking procedures during a crossbleed start are the same as with a ground start cart. Engine crossbleed start on the ground can be accomplished with the throttle on the operating engine at or above idle rpm. When high-residual EGT (remains from a hot start) and/or throttles are advanced from OFF to IDLE prior to 20-percent rpm, higher-than-normal EGT readings may occur.

When initiating crossbleed starts with ambient temperature less than 40 °F (5 °C), the starter torque load is increased. Above 80 °F (27 °C), engine bleed air provides less energy potential to the starter turbine. Either extreme can affect engine starting acceleration rates, resulting in hotter-than-normal starts. When crossbleed starting with an operating engine at idle, operator should be aware of either condition and increase the operating engine rpm in 5-percent increments until normal starting acceleration rate is achieved. Low percentage rpm-to-EGT ratio can increase turbine distress without necessarily exceeding the EGT limit.

When performing an idle crossbleed start, advance the throttles from OFF to IDLE at 20-percent rpm or greater while monitoring EGT. If EGT rises rapidly, advance the operating engine rpm to slightly above idle. The exhaust nozzles start to close when rpm is slightly above idle.

Note

- To prevent possible engine overtemperature during crossbleed and backup ignition start attempts, select AIR SOURCE for the operating engine and return to BOTH after rpm stabilizes at idle or above.
- If attempting a ground restart after a hot-start, windmill the engine until EGT is below 250 °C prior to advancing the throttle from OFF to IDLE to avoid a subsequent hot start.
- When attempting a crossbleed start or normal ground start, do not attempt to reengage the ENG CRANK switch if the engine is spooling down and rpm is greater than 46 percent. Between 30- and 46-percent rpm, the ENG CRANK switch may not stay engaged because of normal variations in starter cutout speed.

The ENG CRANK switch should automatically disengage between 49- to approximately 51-percent rpm during a crossbleed or normal ground start.

2.9.4 Airstart. AFTC logic provides main high-energy ignition automatically during automatic and manual spooldown, crossbleed, and windmill airstarts. Selecting the BACK UP IGNITION switch to ON provides continuous backup ignition to both engines and backs up main high-energy ignition during manual spooldown, crossbleed, and windmill airstarts.

2.10 ENGINE OIL SYSTEM

Each engine has a self-contained, dry-sump, pressure-regulated oil system that provides filtered oil for lubricating and cooling engine main shaft bearing, oil seals, gearboxes, accessories, and provides a hydraulic medium to operate the engine exhaust nozzles (FO–5).

A storage tank feeds oil to an oil pump that supplies oil under pressure to the forward sump in the engine front hub, the mid sump in the fan hub, the aft sump in the turbine hub, and the inlet and accessory gearboxes. Oil is recovered through scavenging from the sumps and accessory gearboxes, pumped past a chip detector, and cooled in a fuel/oil heat exchanger before returning to the storage tank.

A separate compartment in the storage tank provides oil to the exhaust nozzle hydraulic system. Oil returning from the nozzle to the tank provides auxiliary oil supply to the No. 3 bearing when normal supply is interrupted or during engine spooldown.

The oil system permits engine operation under all flight conditions. During zero-g or negative-g flight, oil pressure may decrease but will return to normal when positive-g flight is resumed. Normal oil consumption is 0.03 gallon per operating hour. Capacity of the oil storage tank is 3.7 gallons, with 2.9 gallons usable. A sight gauge on the side of the storage tank indicates down to a 2-quart-low oil level. The protrusion of a bypass indicator underneath the oil scavenge pump indicates a clogged filter element.

Note

- Engine oil level must be checked within 30 minutes of engine shutdown, otherwise run engine at 80-percent rpm or greater for 10 minutes to ensure proper servicing.
- A failed-open nozzle may indicate an oil leak; however, if the leak is in the nozzle hydraulic circuit, only that portion of the main engine lube oil will be lost.

2.10.1 Oil Cooling. Filtered and scavenged oil is cooled by a fuel/oil heat exchanger. This oil is then used in a heat exchanger to cool the exhaust-nozzle oil. A cold-oil bypass valve opens when the heat exchanger pressure differential is 44 psi because of reduced oil temperature or exchanger blockage, allowing oil flow to bypass the heat exchanger (for example, during cold engine starts).

2.10.2 Oil Pressure Indicators. An oil pressure transmitter in each engine's oil supply line provides a continuous signal to the oil pressure indicator. An oil pressure switch in each oil supply line activates the OIL PRESS light when either engine's oil pressure decreases to 11 psi. The oil pressure transmitters and switches receive electrical power from the essential No. 2 ac bus. The OIL PRESS light and oil pressure indicator are independent of each other.

Note

- During cold starts, oil pressure may exceed 65 psi. The 65-psi oil pressure limit should not be exceeded for more than 1 minute.
- Maneuvers that result in zero or negative g's on the engine (such as rapid rolls, pushovers, or bugout maneuvers) may cause oil pressure fluctuations and momentary illumination of the low oil pressure light.

2.10.3 OIL HOT Caution Lights. The L or R OIL HOT caution light may be illuminated by either high engine oil temperature or by high forward engine gearbox scavenge oil temperature. The caution lights illuminate when respective engine oil temperature exceeds 300 °F during a temperature increase and go out at 280 °F minimum during a temperature decrease. The caution lights also illuminate when respective forward engine gearbox scavenge temperature exceeds 375 °F during a temperature increase and go out at 345 °F minimum during a temperature decrease.

2.11 ENGINE INSTRUMENTS

Instruments for monitoring engine operation are on the pilot left knee panel (Figure 2-24). Engine operating parameters are displayed on the EIG, which is a single WRA with liquid crystal display readouts. The display provides white readout segments and scales on a dark background and are red backlighted for night operations. Left and right engine compressor speed (rpm), EGT, and fuel flow are displayed on the EIG. Adjacent to the EIG are circular instruments for both engines' oil pressure and nozzle position. Takeoff checks at military (MIL) thrust should display evenly matched tapes on corresponding vertical scale instruments and all pointers on the circular instruments should be at the 9-o'clock position. Data on engine operating limits are provided in Chapter 4.

2.11.1 Engine RPM Indicator. The RPM indicators (Figure 2-24) have a range of 0 to 110 percent. The tape display steps in 5-percent increments and the upper segment flashes to indicate rpm increasing at more than 0.4-percent per second from 0 to 60-percent rpm. The tape steps in 1-percent increments when greater than 60-percent rpm. Nominal indications are 62 to 78 percent at idle and 95 to 104 percent at military and above. At 107.7 percent and above, the affected engine(s) exceeded portions of the chevrons will flash at a rate of two to three flashes per second. At 20-percent rpm, a horizontal segment will illuminate, giving an indication of proper motoring speed to start the engine. There is an rpm reading for each engine.

Note

An overspeed condition in excess of 110-percent will result in momentary loss of rpm indication until N_2 rpm falls below 110 ±.5 percent. EGT and fuel flow indicators will continue to function normally.

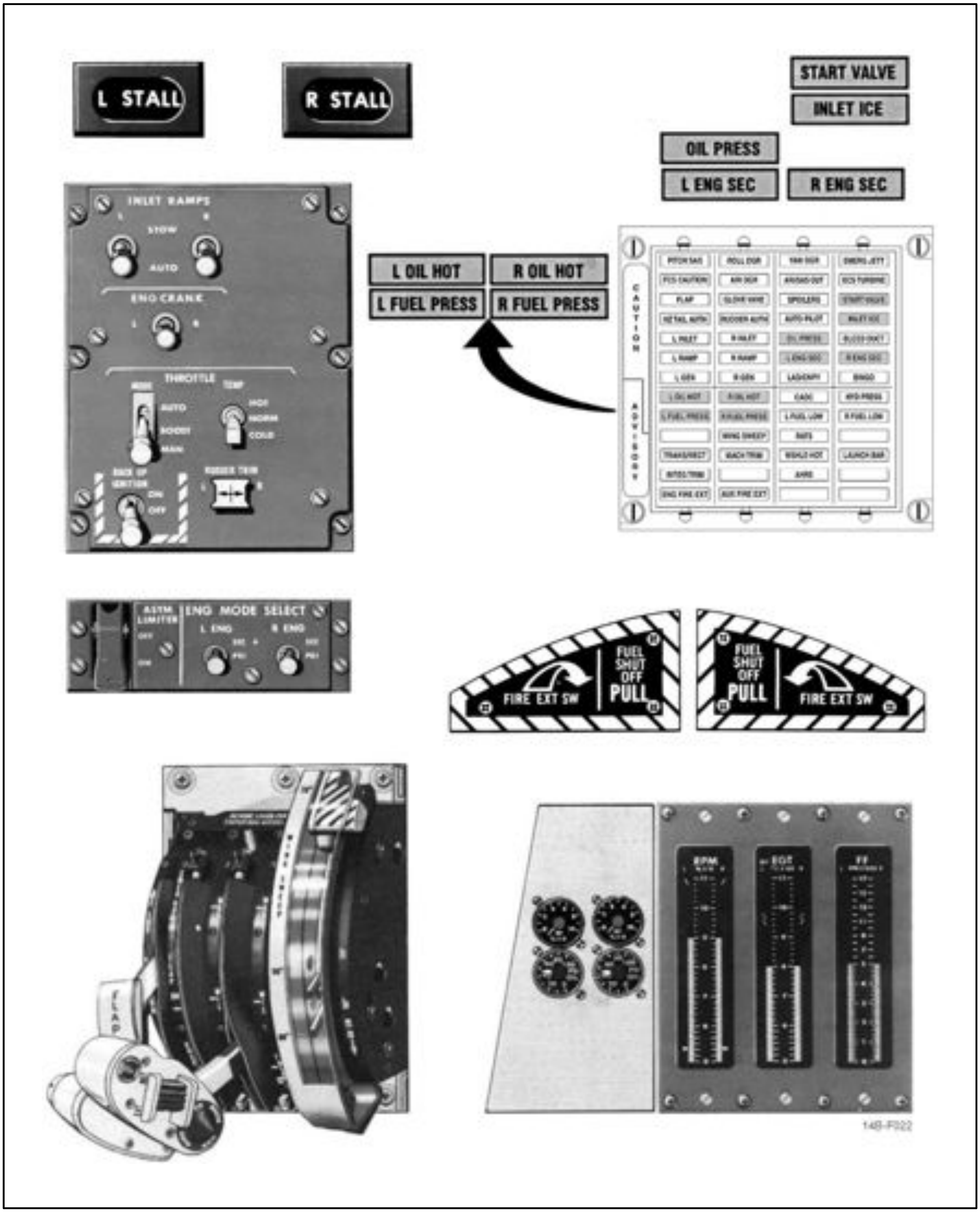


Figure 2-24. Engine Instruments (F110-GE-400)

2.11.2 Exhaust Gas Temperature Indicator. The EGT indicators (Figure 2-24) provide a nonlinear vertical scale with a range of 0 to 1,100 °C. The compressed lower portion has a range of 0 to 600 °C. The expanded upper portion of the scale has a range of 600 to 1,100 °C. The display moves in 50° increments in the compressed portion and 10° increments in the expanded portion of the display. The normal indications are 350 to 650 °C at idle and 780 to 935 °C at MIL and above. Above 940 °C the affected engine(s) exceeded portions of the chevrons flash. With a reading of 940 °C the stall warning light and aural warning tone will be activated signifying an engine overtemperature condition. The tone is present for a maximum of 10 seconds unless the fault clears sooner. There is an EGT reading for each engine.

2.11.3 Fuel Flow Indicator. The fuel flow indicators have a nonlinear vertical scale, with a range of 0 to 17,000 pph. The expanded lower portion of the scale has a range of 0 to 5,000 pph. The compressed upper portion of the scale ranges from 5,000 to 17,000 pph. The display moves in 100-pph increments in the expanded portion and in 500-pph increments in the compressed portion of the display. Normal indications on deck are 350 pph starting, 950 to 1,400 pph at idle, and approximately 10,100 pph at military and above. The fuel flow reading for each engine indicates only basic engine consumption and does not indicate AB fuel flow.

2.11.4 Engine Instrument Group BIT. A degraded mode of EIG operation is indicated if the BIT segment on the top left side of the EGT indicator illuminates. This means that either the primary or backup microprocessors, or the primary or backup power supply channels (internal to the EIG) have failed. An automatic switch to the operative microprocessor/channel takes place if a failure is detected. The instrument still monitors engine operation and accurately reflects rpm, EGT, and fuel flow. If the input processing circuit fails, the affected scale reading goes to zero.

2.11.5 Engine Instrument Group Self-Test. Engine instrument group self-test is selected by the MASTER TEST switch in INST. When master test is initiated, all display segments illuminate, all scales drive to maximum readings, and the warning chevrons (stripes) flash for 5 seconds. The BIT segment on the top left side of the EGT indicator illuminates. L STALL and R STALL warning lights flash and the stall warning/overtemperature tone is present in the pilot's earphones for 10 seconds. After 5 seconds, all EIG scales decrease to predetermined values of equal height that correspond to an EGT reading of 950 ±10 °C. If the BIT segment remains illuminated, the EIG has failed self-test and the BIT remains illuminated until self-test is reinitiated. Total self-test time is 15 seconds. If the master test is deactivated prior to this, the EIG returns to normal mode after the 15-second test. If the MASTER TEST switch remains in INST for more than 15 seconds, the EIG retains equal height readings until master test is deselected.

2.11.6 Engine Oil Pressure Indicator. The engine oil pressure indicators display oil pressure from 0 to 100 psi. Normal oil pressure is 25 to 65 psi and increases in proportion to engine rpm within the pressure-limit range. Stabilized idle oil pressure maybe a minimum of 15 psi.

The OIL PRESS caution light illuminates at 11 psi with decreasing oil pressure and extinguishes at 14 psi with increasing oil pressure. Maximum allowable oil pressure fluctuation is ±5 psi.

2.11.7 Exhaust Nozzle Position Indicator. The nozzle position indicators (Figure 2-24) have a range of 0 to 100-percent open. Normal indications (Figure 2-13) are 100 percent at idle with weight on wheels and vary for in flight, 3 to 10 percent at MIL thrust, 5 to 12 percent at minimum AB, and 60 to 90 percent at maximum AB.

Note

When operating engine in secondary mode, nozzle position indicator is inoperative and indicates below zero. No nozzle position indication is available in secondary mode.

2.11.8 Engine Stall/Overtemperature Warning. An engine stall detection circuit in FEMS monitors each engine. When a stall condition is detected, a L or R STALL warning light (Figure 2-24) on each side of the HUD flashes at approximately 3 Hz until the condition is cleared. In addition, an aural warning tone is activated through the pilot ICS for up to 10 seconds.

When an overtemperature condition occurs, the EGT display rises above 940 °C, the warning chevrons begin to flash, and a signal from the EGT indicator activates the STALL warning lights and the aural warning tone.

In SEC mode, FEMS and, therefore, the engine stall detection circuit, is inoperative. However, overtemperature warning is still available and will activate both the STALL warning lights and aural warning tone.

The overtemperature warning system is checked by the pilot during prestart as part of the MASTER TEST check in INST test. There is no pilot check of the FEMS engine stall detection system.

2.12 FIRE DETECTION SYSTEM

The fire detection system provides a cockpit indication of fire or overheating in either engine compartment. There is a separate system for each engine compartment, each consisting of a thermistor-type sensing loop monitored by a transistorized control unit. The system is powered by 28 volts from the essential No. 1 bus. Figure 2-25 is a functional schematic of the system.

The sensing loop for each engine compartment consists of a 45-foot continuous tubular element routed throughout the entire length of the engine compartment on both sides above the nacelle door hinge line. The tube sheath, which is clamped in grommets to the engine compartment structure, contains a ceramic-like thermistor material in which are embedded two electrical conductors; one of the conductors is grounded at both ends of the loop. Electrical resistance between two conductors varies inversely as a function of temperature and length, so that heating of less than the full length will require a higher temperature for the resistance to decrease to the alarm point. The L or R FIRE warning lights in the cockpit illuminate when the respective entire sensing loop is heated to approximately 600 °F or when any 6-inch section is heated to approximately 1,000 °F.

The fire alarm output relay to the light is a latching type that remains in the last energized position independent of power interruptions until the fault clears.

False alarms triggered by moisture in the sensing element and connectors or by damage resulting in short circuits or grounds in the sensing element are unlikely because of the system design. Additionally, there is no loss or impairment of fire detector capability from a single break in the sensing element as long as there is no

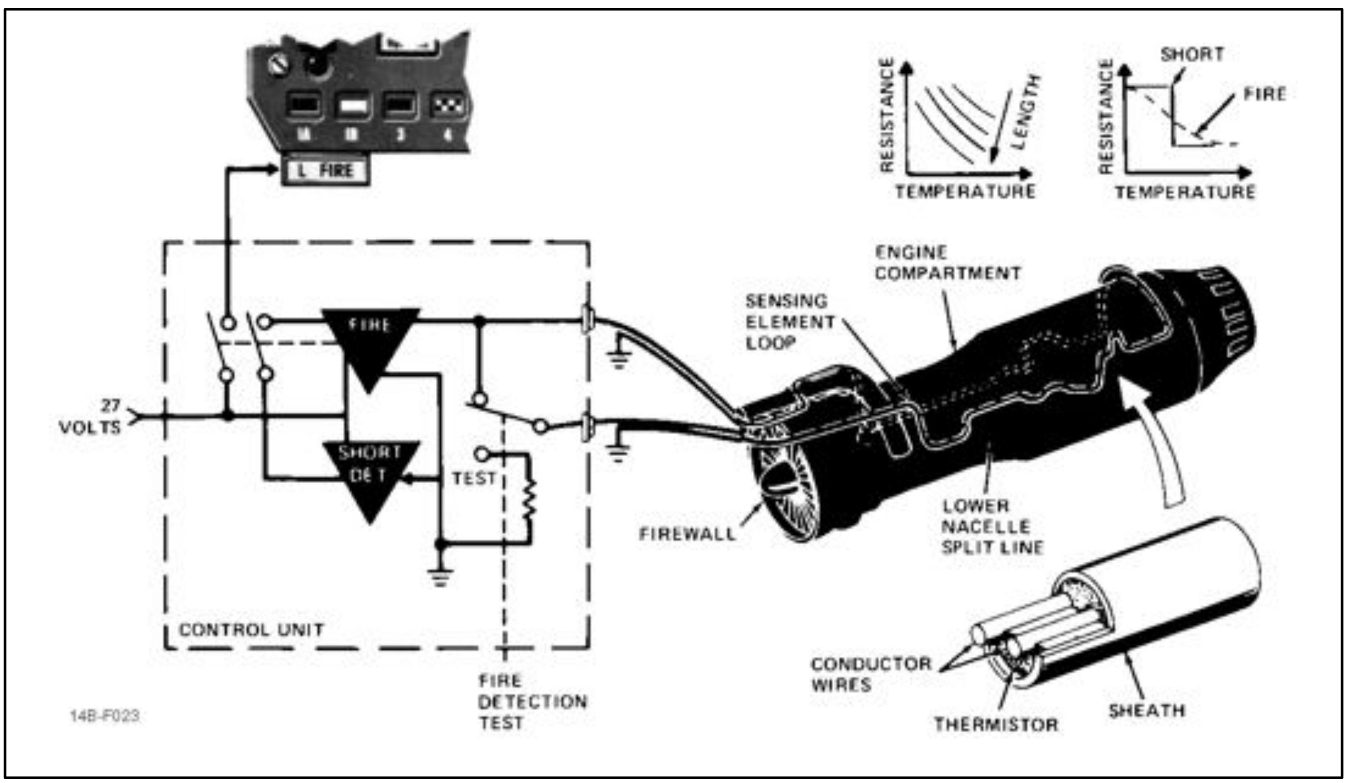


Figure 2-25. Fire Detection System

electrical short. With two breaks in the sensing element, the section between the breaks becomes inactive although the remaining end of segments remain active.

Fire detection circuits in the engine compartments detect a leak in the high-temperature duct and light the appropriate L or R FIRE warning light. Between each engine firewall and the primary heat exchanger, bleed air leak-sensing elements are placed along the outside of the duct. When these sensing elements detect temperatures over 575 °F, the BLEED DUCT caution light is illuminated.

2.12.1 Fire Detection Test. An integrity test of the fire detection system can be performed by selection of FIRE DET/EXT on the pilot MASTER TEST switch. The integrity test simultaneously checks the sensing element loops of both engine compartments for continuity and freedom from short circuits, and the fire alarm circuits and FIRE warning lights for proper functioning. Presence of a short circuit or control unit malfunction causes the warning light to remain out. Fire detection test is not available on the emergency generator.

2.13 FIRE EXTINGUISHING SYSTEM

The fire extinguishing system is capable of discharging an extinguishing agent into either engine nacelle and its accessory section. The system consists of two containers of extinguishing agent, piping and nozzles to route and discharge the agent, cockpit switches to activate the system, and advisory lights that alert the flightcrew to a drop in system pressure beyond a predetermined level.

The fire extinguishing agent is a clean, colorless, odorless, and electrically nonconductive gas. It is a low-toxicity vapor that chemically stops the combustion process. It will not damage equipment because it leaves no water, foam, powder, or other residue.

The retention time of an adequate concentration of the extinguishing agent in the engine compartment will determine probability of reignition and, therefore, the probability of aircraft survival. At high airspeeds, where airflow through the engine compartment is increased, agent retention time is reduced.

The slower the airspeed at the time the extinguisher is fired, the higher the probability of fire extinction and the lower the probability of reignition.

Circuit breaker protection is provided on the RIO DC ESSENTIAL NO. I CIRCUIT BREAKER PANEL by the R FIRE EXT (6C4) circuit breaker and the L FIRE EXT (6C5) circuit breaker.

2.13.1 Fire Extinguisher Pushbuttons. The discharge pushbuttons for the fire extinguishing system are located behind the FUEL SHUT OFF handles. The FUEL SHUT OFF handle for the affected engine must be pulled to make the pushbuttons for that engine accessible (see Figure 2-26). If the left or right fire extinguishing pushbutton is activated, the contents of both extinguishing containers are discharged into the selected engine and its accessory section. Since it is a one-shot system, both system advisory lights, ENG FIRE EXT and AUX FIRE EXT, will illuminate and remain illuminated after container pressures drop below a preset level.

2.13.2 Fire Extinguisher Advisory Lights. Two advisory lights are provided to indicate low pressure in the fire extinguishing agent containers. The lights, ENG FIRE EXT and AUX FIRE EXT, illuminate when container pressure drops 90 psi below a nominal pressure of 600 psi at 70 °F (see Figure 2-26).

2.13.3 Fire Extinguisher Test. The fire extinguishing system is tested by raising and rotating the MASTER TEST switch to FIRE DET/EXT and depressing the knob; the L FIRE and R FIRE warning lights will illuminate. If there is a detection circuit problem, the corresponding FIRE warning light will not illuminate. Simultaneously, the fire extinguishing system initiates a self-test indicated by either a GO or NO GO light. If all tests pass, the GO light illuminates; if the NO GO illuminates or if both or neither GO and NO GO lights illuminate, the system has not tested properly and a failure exists somewhere in the system.

2.14 AIRCRAFT FUEL SYSTEM

The aircraft fuel system normally operates as a split feed system, with the left and aft tanks feeding to the left engine and the right and forward tanks feeding the right engine. (Refer to FO–6.) Except for the external tanks, the system uses motive flow fuel to transfer fuel. The supply of high-pressure fuel from engine-driven motive fuel pumps operates fuel ejector pumps to transfer fuel without the need of moving parts. The system is not dependent on electrical power for normal fuel transfer and feed. Total internal and external fuel quantity indication is provided, with a selective quantity readout

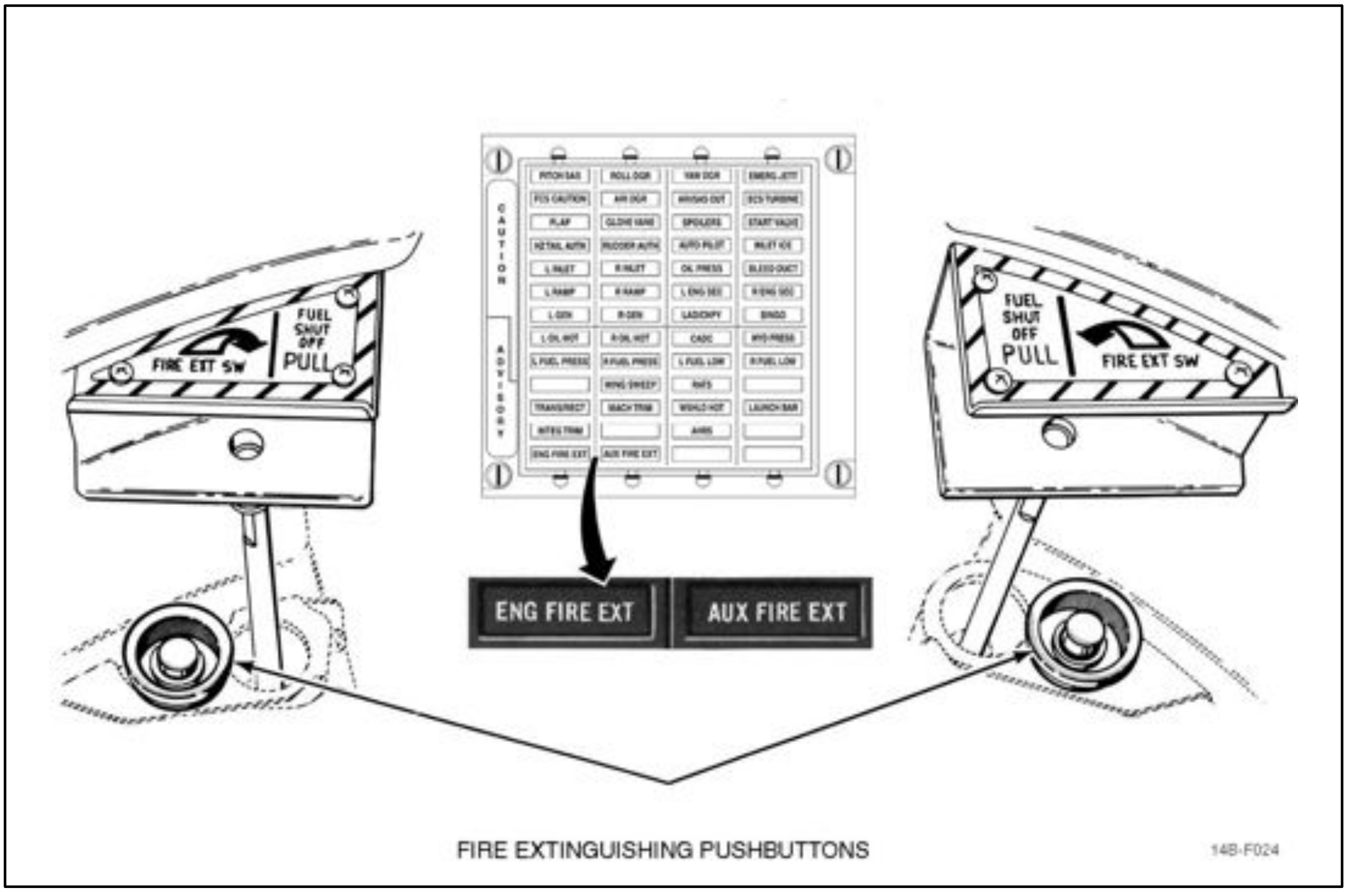


Figure 2-26. Fire Extinguishing Switches and Advisory Lights

for individual tanks. Fuel system management requirements are minimal under normal operation for feed, transfer, dumping, and refueling. Sufficient cockpit control is provided to manage the system under failure conditions. The aircraft fuel system is designed so that all usable fuel will normally be depleted under two- or single-engine operating conditions before an engine flameout occurs from fuel starvation. However, with complete motive flow failure, engine fuel starvation can occur with usable fuel aboard.

Note

All fuel weights in this manual are based on the use of JP-5 fuel at 6.8 pounds per gallon, JP-4 fuel at 6.5 pounds per gallon, or JP-8 fuel at 6.7 pounds per gallon.

2.14.1 Fuel Tankage. Figure 2-27 shows the general fuel tankage arrangement in the aircraft. The fuel supply is stored in eight separate fuselage cells, two wing box cells, two integral wing cells, and (optional loading) two external fuel tanks.

2.14.1.1 Sump Tanks. The engine feed group, consisting of the left and right box-beam tanks and the left and right sump tanks, span the fuselage slightly forward of the mid-center of gravity. Fuel in each box-beam tank gravity flows to its respective sump tank. The sump tanks (self-sealing) are directly connected to the box-beam tanks and contain the turbine-driven boost pumps. The feed tanks supply fuel to the engine. A negative-g check valve traps fuel in the feed tank during negative-g flight.

WARNING

Zero or negative-g flight longer than 10 seconds in AB or 20 seconds in MIL or less will deplete the fuel sump tanks (cells 3 and 4), resulting in flameout of both engines.

WARNING

- Afterburner operation in the 0g to –0.5g regime may result in air ingestion into the fuel boost pumps, causing possible afterburner blowout or engine flameout.
- With fuel in feed group below 1,000 pounds, AB operation could result in AB blowout.

Note

Operation of afterburner with less than 1,000 pounds in either feed group may illuminate the FUEL PRESS light because of uncovering of the boost pump inlet.

2.14.1.2 Forward Tank. The forward fuselage fuel tank is in the center fuselage, between the inlet ducts and immediately ahead of the feed group. The forward tank is partitioned into two bladder cells (Nos. l and 2) that are interconnected by open ports at the top for vent and overflow purposes. Flapper valves at the base provide for forward-to-aft fuel gravity transfer.

2.14.1.3 Aft Tank. The aft fuselage fuel tank group is partitioned into four bladder cells (Nos. 5, 6, 7, and 8) and a vent tank. The forward-most cell in the aft tank group (cell No. 5) lays laterally across the center fuselage. Extending aft are two coffin-shaped tanks that contain two cells (Nos. 6 and 8) on the right side and one cell (No. 7) plus an integral fuel vent tank on the left side. The coffin tanks straddle the center trough area, which contains the control rods, Sparrow missile launchers, and electrical and fluid power lines. All fuel cells in the aft tank group are interconnected by one-way flapper valves at the base for aft-to-forward fuel gravity transfer.

2.14.1.4 Wing Tanks. There are integral fuel cells in the movable wing panels between the front and aft wing spars. Because of the wing-sweep pivot location and the extensive span (20 feet) of the wing tanks, wing fuel loading provides a variable aft cg contribution to the aircraft longitudinal balance as a function of wing-sweep angle. Each wing panel consists of the

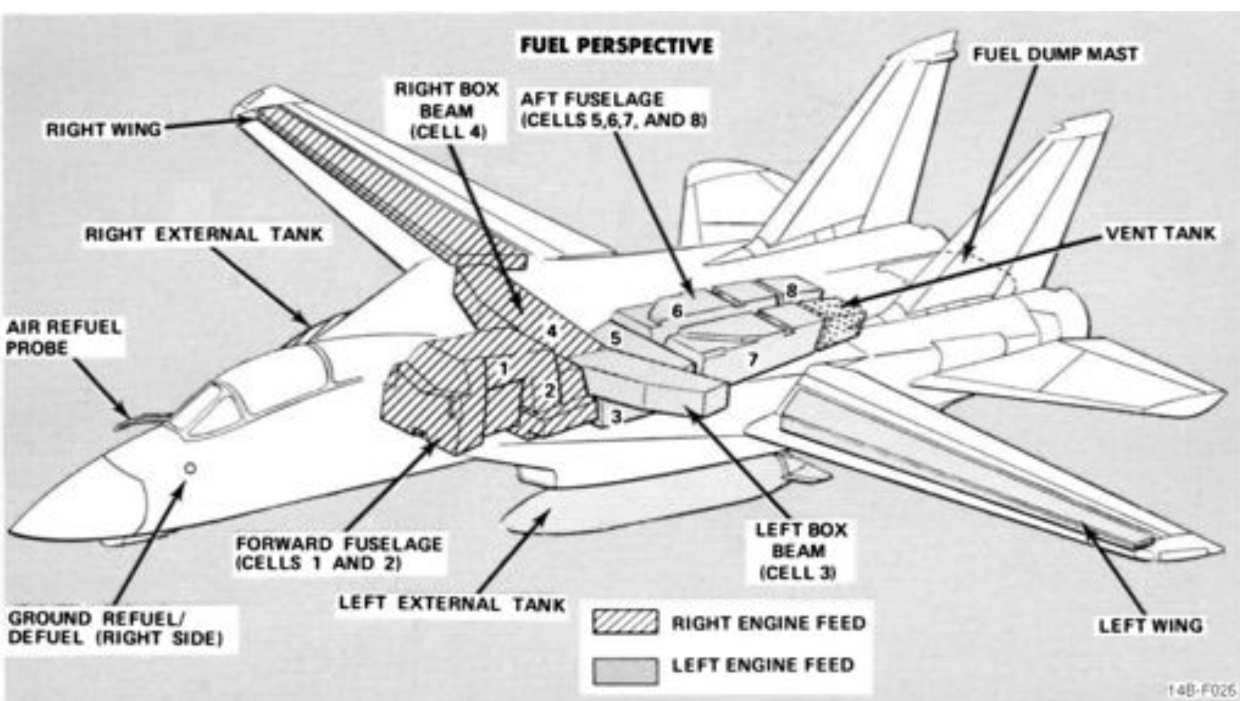


Figure 2-27. Fuel Tanks

integral fuel cell, which is designed to withstand loads because of fuel sloshing during catapulting and extreme rolling maneuvers with partial or full wing fuel. Fuel system plumbing (transfer and refuel, motive flow, and vent lines) to the wing tanks incorporate telescoping sealed joints at the pivot area to provide normal operation independent of wing-sweep position.

2.14.1.5 External Tanks. Fuel, air, electrical, and fuel precheck line connectors are under the engine nacelles for the external carriage of two fuel tanks. Check valves in the connectors provide an automatic seal with the tank removed. Although the location is designated as armament stations 2 and 7, no other store is designed to be suspended there so that the carriage of external fuel tanks does not limit the weapon-loading capability of the aircraft. Suspension of the drop tanks and their fuel content has an insignificant effect on the aircraft longitudinal cg, and, even under the most adverse asymmetric fuel condition, the resultant movement can be compensated for by lateral trimming.

CAUTION

See Chapter 4 for external tank limitations.

2.14.2 Fuel Quantity System. The fuel-quantity measurement and indication system provides the flightcrew with a continuous indication of total internal and external fuel remaining, a selective readout for all fuel tanks, independent low-fuel detection, and automatic fuel system control features.

WARNING

To prevent fuel spills from overfilled vent tank caused by failed level control system, set WING/EXT TRANS switch to OFF if left tape reading reaches 6,200 pounds or right tape reading reaches 6,600 pounds. If either fuel tape reading is exceeded, aircraft shall be downed for maintenance inspection.

Note

Fuel in the vent tank is not gauged.

The quantity measurement system uses dual-element, capacitance-type fuel probes to provide the flightcrew with a continuous display of fuel quantity remaining. Fuel thermistor devices and caution light displays provide a backup fuel low-level indicating system, independent of the capacitance-type gauging system. Additionally, the pilot is provided with a bingo set capability on the fuel quantity indicator to preset the total quantity level for activation of a BINGO caution light.

Note

Fuel quantity system malfunctions that result in erroneous totalizer readings will invalidate the use of the BINGO caution light.

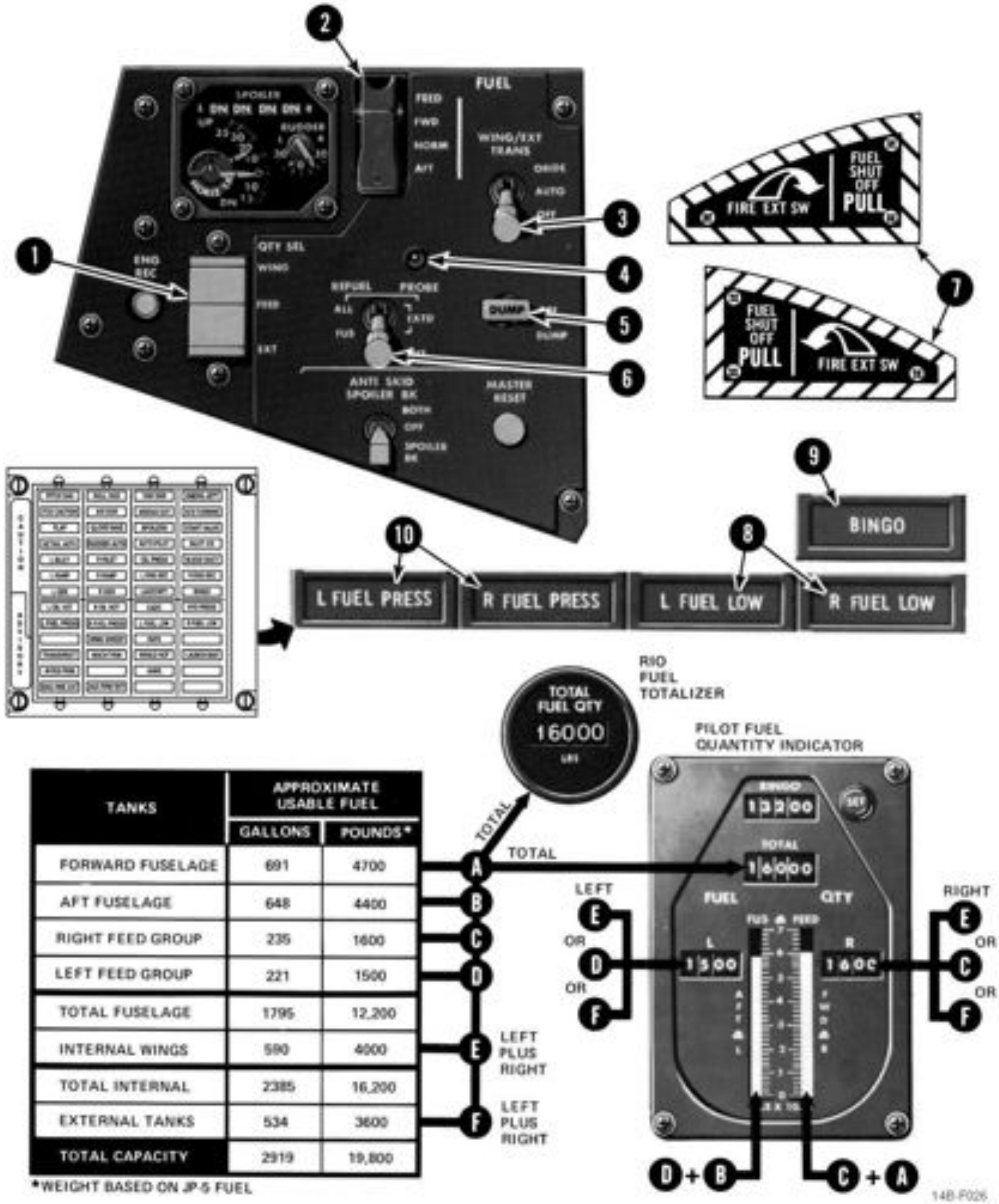
2.14.2.1 Fuel Quantity Indicators. The pilot and RIO fuel quantity indicators are shown in Figure 2-28 with a definitive breakdown of tape and counter readings. The white vertical tapes on the pilot indicator show fuselage fuel quantity. The left tape indicates fuel quantity in the left feed and aft fuselage; the right tape indicates fuel quantity in the right feed and forward fuselage. The L and R labeled counters display either feed group, wing tank, or external tank fuel quantity on the side selected using the QTY SEL rocker switch on the fuel management panel. The rocker switch is spring loaded to FEED. The pilot TOTAL quantity display and the RIO display indicate total internal and external fuel.

Note

The RIO fuel quantity indicator is a repeater of the pilot total fuel indicator. The difference between the two should not exceed 300 pounds.

2.14.2.2 FUEL LOW Caution Lights. A L FUEL LOW or R FUEL LOW caution light illuminates with 1,000 ±200 pounds of fuel remaining in the respective feed group. The RIO is provided with a single FUEL LOW caution light that illuminates with one or both of the pilot FUEL LOW caution lights.

Each FUEL LOW caution light is illuminated by two thermistors operating in series. One set of thermistors is in the right box-beam tank and cell No. 2. The other set of thermistors is in the left box-beam tank and cell No. 5. The FUEL LOW light illuminates only if both thermistors operating in series are uncovered.



TANKS	APPROXIMATE USABLE FUEL GALLONS	APPROXIMATE USABLE FUEL POUNDS*
FORWARD FUSELAGE	691	4700
AFT FUSELAGE	648	4400
RIGHT FEED GROUP	235	1600
LEFT FEED GROUP	221	1500
TOTAL FUSELAGE	1795	12,200
INTERNAL WINGS	590	4000
TOTAL INTERNAL	2385	16,200
EXTERNAL TANKS	534	3600
TOTAL CAPACITY	2919	19,800

*WEIGHT BASED ON JP-5 FUEL

Figure 2-28. Fuel Controls and Indicators (Sheet 1 of 3)

NOMENCLATURE	FUNCTION	
1 QTY SEL switch	WING —	Fuel quantity in each wing is displayed on L and R counter of pilot's fuel quantity indicator.
	FEED —	Rocker switch spring returns to FEED when not held in WING or EXT FEED group fuel quantity displayed on L and R counter of pilot's fuel quantity indicator.
	EXT —	Fuel quantity in each external tank displayed on L and R counter of pilot's fuel quantity indicator.
2 FEED switch	FWD —	Both engines feed from right and forward tanks. Opens sump tank interconnect valve, box beam vent valves, fuselage motive flow isolation valve, defueling and transfer selector valve, and shuts off motive flow fuel to all aft tank ejector pumps.
	NORM — (guarded position)	Right engine feeds from forward and right tanks. Left engine feeds from aft and left tanks.
	AFT —	Both engines feed from aft and left tanks. Opens sump tank interconnect valve, box beam vent valves, fuselage motive flow isolation valve, defueling and transfer selector valves, and shuts off motive flow fuel to forward tank ejector pumps.
3 WING/EXT TRANS switch	ORIDE —	*Airborne* — Allows transfer of wing fuel, fuselage tank pressurization, and pressurization and transfer of external tanks with landing gear down, and with electrical malfunction in transfer system. *Weight on Wheels* — Allows transfer of wing and external tank fuel.
	AUTO —	*Airborne* — Normal position. Wing fuel is automatically transferred. Transfer of external fuel and fuselage pressurization is automatic with landing gear retracted. Automatic shut off of wing and external tanks when empty. *Weight on Wheels* — Automatic transfer of wing and external tank fuel cannot be accomplished; switch must be set to ORIDE for wing fuel transfer.
	OFF —	Closes solenoid operated valve to shut off motive flow fuel to wing and also inhibits external tank transfer and fuselage pressurization. Spring return to AUTO when master test switch is actuated in INST, when either thermistor in cell 2 and 5 is uncovered, when DUMP is selected, or when REFUEL PROBE switch is in ALL EXTD.
4 In-flight refueling probe transition light	Illuminates whenever probe cavity forward door is open during retraction or extension of probe.	
5 DUMP switch	OFF —	Dump valve closed.
	DUMP —	Opens a solenoid operated pilot valve, which ports motive flow fuel pressure to open the dump valve and allows gravity fuel dump overboard from cells 2 and 5. Wing and external tank transfer automatically initiated. Dump electrically inhibited with weight on wheels or speed brakes not fully retracted.

Figure 2-28. Fuel Controls and Indicators (Sheet 2)

NOMENCLATURE	FUNCTION
6 REFUEL PROBE switch	ALL EXTD — Extends refueling probe. Shuts off wing and external tank fuel transfer to permit refueling of all tanks. Returns transfer switch from OFF to AUTO. FUS EXTD — Extends refueling probe. Normal transfer and feed. Used for practice plugins, fuselage-only refueling, or flight with damaged wing tank. RET — Retracts refueling probe.
7 Left and right FUEL SHUT OFF PULL HANDLES	Pulling respective handle manually shuts off fuel to that engine. Push forward resets engine fuel feed shutoff valve to open.
8 L and R FUEL LOW caution lights (Also single light on RIO CAUTION panel.)	Fuel thermistors uncovered in aft and left or forward and right feed group. Illuminates with approximately 1,000 pounds remaining in individual feed group.
9 BINGO caution light	Illuminates when total fuel quantity indicator reads lower than BINGO counter value.
10 L and R FUEL PRESS caution lights	Indicates insufficient discharge pressure (less than 9 psi) from respective turbine driver boost pump.

Figure 2-28. Fuel Controls and Indicators (Sheet 3)

WARNING

- If the thermistors in either cell No. 2 or No. 5 remain covered during a fuel transfer failure, it is possible to partially deplete the sump tank without illuminating the respective FUEL LOW caution light.
- When both FUEL LOW caution lights illuminate, less than 1 minute of fuel is available if both engines are operating in max AB.
- If the OXY/BINGO CAUTION circuit breaker (7F6) is pulled, the L and R FUEL LOW caution lights will be disabled.

2.14.2.3 Fuel Quantity Indication Test. Actuation of MASTER TEST switch in INST causes the fuel quantity indicator to drive to 2,000 pounds and illuminates the FUEL LOW caution lights. The test can be performed on the ground or in flight. The test does not check the fuel probes or the thermistors. A test of the bingo set device can be obtained concurrently with the INST test by setting the bingo level at greater than 2,000 pounds. In this case, the BINGO caution light will illuminate when the totalizer reading decreases to a value less than the bingo setting.

2.14.3 Engine Feed. The feed group for each engine is comprised of a box-beam tank and a sump tank. The box-beam tanks hold approximately 1,300 pounds of fuel each and are fed from external tank transfer, wing transfer, and fuselage transfer from cell No. 2 or 5. When a box-beam tank is full, excess fuel is returned to the fuselage tanks through an overflow pipe. The sump tanks, which hold approximately 300 pounds of fuel each, are located directly beneath the box-beam tanks and have three sources of fuel (see Figure 2-29 for identification of tank interconnects).

1. Interconnects A or B provide gravity sump from the respective box-beam tank.
2. Interconnects C or D connect the sump tank to its respective fuselage tank (cell No. 4 to cell No. 2/cell No. 3 to cell No. 5).
3. The sump tank interconnect line and valve E connect the two sump tanks.

The proportion of fuel supplied to each sump tank through the five interconnects (A through E) is a function of the pressure differential existing at each of the interconnects. The interconnect with the highest pressure differential will provide the most fuel. Valve E

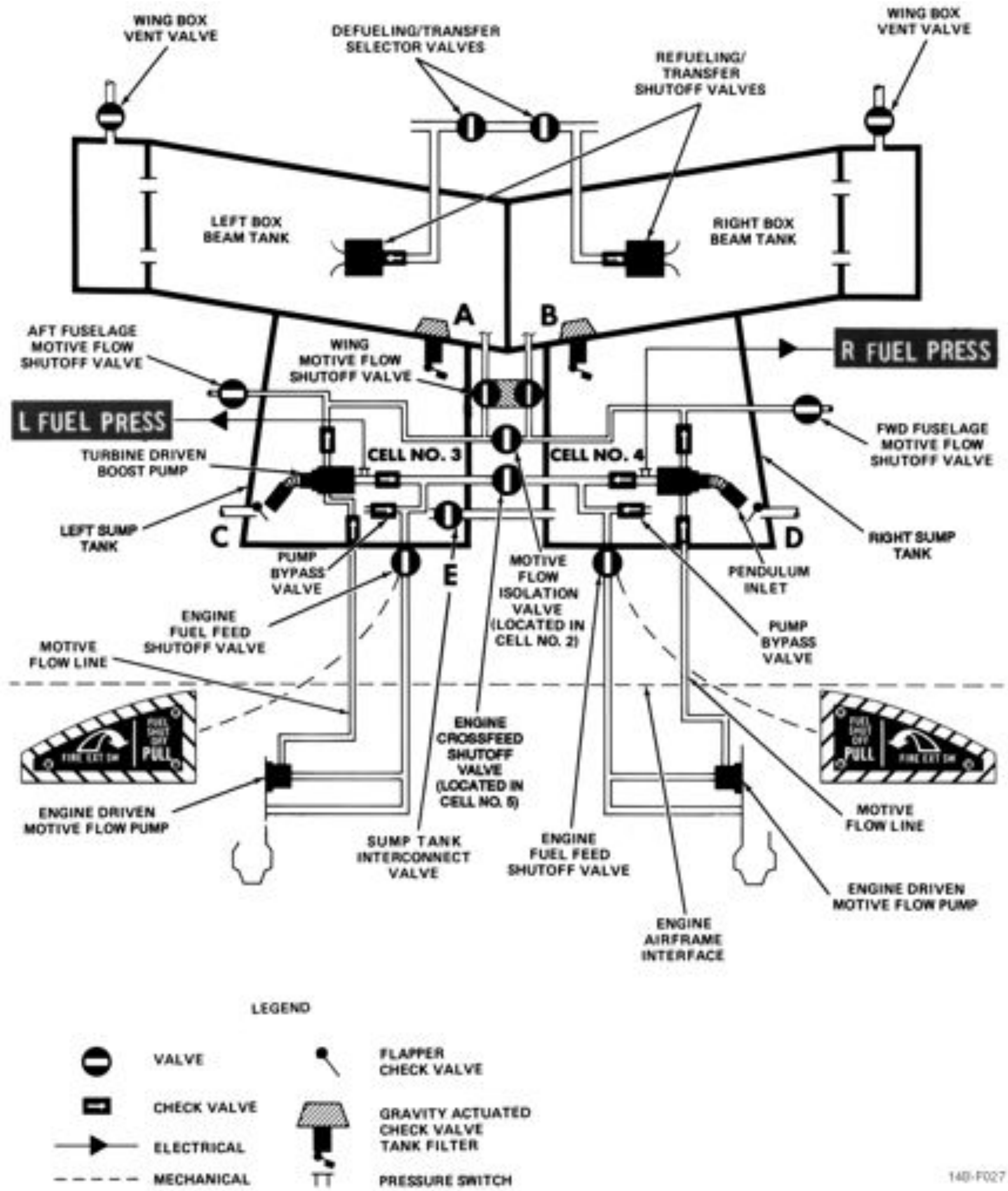


Figure 2-29. Engine Fuel Feed

is commanded open during low-fuel states and during fuel balancing when the FEED switch is selected FWD or AFT.

In a normal sequence, three situations can be defined:

1. Situation 1:

   a. Fuel in cell Nos. 2 and 5

   b. FEED switch in NORMAL

   c. Normal engine fuel flow (MIL thrust or less).

   Under these conditions, the sump tank interconnect valve is closed and the left and right systems are isolated. The transfer capacity into the box-beam tank exceeds the engine demand, ensuring a full box-beam tank. The pressure head at interconnect A or B, created by the higher vertical location of the fuel in the box-beam tank, is greater than that created at interconnect C or D by the fuel in either cell No. 2 or 5. Therefore, fuel to replenish the sump tanks will come from the box-beam tanks through interconnects A and B.

2. Situation 2:

   a. Fuel in cell Nos. 2 and 5

   b. FEED switch in NORM

   c. High-engine fuel demands (afterburner).

   Under these conditions, the sump tank interconnect valve is closed and the left and right systems are isolated. Engine fuel demand can exceed the transfer rate into the box-beam tank. If this occurs, the fuel level in the box-beam tank will start to drop; however, the box-beam tanks are not vented, resulting in a pressure drop above the declining fuel level. This reduced pressure lowers the total pressure at A and B below the pressure at C and D. Therefore, the majority of the fuel to replenish the sump tanks comes directly from fuselage cell Nos. 2 and 5 through interconnects C and D, respectively. The reduction in box-beam tank fuel quantity should not normally result in a feed-group quantity indication of less than 1,200 pounds. If the feed groups drop and then hold in the 1,200-pound range during a high-speed dash, the system is working normally.

3. Situation 3:

   a. Fuel in either cell No. 2 or 5 has been depleted.

   b. FEED switch in NORM.

   c. Any normal engine demand.

   When the low-level thermistor in either cell No. 2 or 5 is uncovered, both box-beam tanks are vented and the sump tank interconnect valve is opened. The two groups become a common system and will seek a common level to equalize the static pressure head. Fuel will flow through the open sump tank interconnect valve only as a function of differential pressure. With open vent valves, the fuel in both box-beam tanks has a positive vent pressure, forcing the fuel into the respective sump tank through interconnect A or B.

Fuel in the sump tank is picked up by the turbine-driven boost pump through a flexible pendulum pickup, boosted to greater than 10 psi, and fed to the engine through the engine feed line. Normally, the right boost pump only feeds the right engine and the left boost pump only feeds the left engine; however, the boost pump output lines are connected by a normally closed engine automatic crossfeed valve. If either boost pump output pressure falls below 9 psi, as indicated by the illumination of the appropriate FUEL PRESS caution light, the engine automatic crossfeed valve is commanded open. The engine automatic crossfeed valve allows fuel from the operating boost pump to supply pressurized fuel to the engine on the failed side. The engine automatic crossfeed valve is also opened when either of the low level thermistors in cell No. 2 or 5 is uncovered; however, if equal boost pump pressures exist, negligible flow will occur through the valve.

2.14.3.1 L/R FUEL PRESS Caution Light. Illumination of the L or R FUEL PRESS caution light results from a malfunction of the boost pump, failure of the motive flow pump, exhaustion of fuel, or fuel flow interruption. With illumination of the caution light, the engine automatic crossfeed valve is commanded open and the fuselage motive flow shutoff valve on the failed side is automatically closed. Because of the reduced pumping and transfer capacity while operating on a single boost pump, afterburner operation is restricted to altitudes below 15,000 feet. Fuel to both engines is supplied from the side with the operating boost pump; therefore, a fuel quantity imbalance will result. Use of the FEED switch to balance fuel quantity will override the low-fuel pressure signal to the fuselage motive flow shutoff valve, allowing normal fuel balancing procedures.

Illumination of both FUEL PRESS caution lights indicates the reduced (<9 psi) or loss of boosted fuel pressure to both engines. Fuel will continue to be supplied by suction feed; however, thrust settings should be minimized and afterburner used only in emergencies. Suction feed is drawn from an inlet at the bottom of the fuel cell that does not incorporate a flexible pendulum pickup.

CAUTION

With a left or right FUEL PRESS light, flight at zero or negative g should be avoided or engine fuel starvation may result.

With both FUEL PRESS caution lights illuminated, there is a potential that total loss of motive flow pressure has occurred due to both motive flow pumps not functioning. Total loss of motive flow pressure will preclude transfer of any remaining wing fuel or fuel dump and result in total segregation of the FWD/RIGHT and AFT/LEFT systems since motive flow provides the force to open the sump tank interconnect valve. Without motive flow pressure, all fuselage fuel transfer is by gravity, which makes the quantity of usable fuel a function of aircraft attitude. At cruise attitude, approximately 400 pounds of usable fuel will be trapped in the aft fuselage.

After illumination of both fuel pressure caution lights, any of the following events indicate that some motive flow pressure is available:

1. Wing fuel transfer

2. With the FEED switch in FWD or AFT and no transfer of external fuel:

   a. The feed group of the selected side remains full.

   b. Fuel migration from one side to the other.

2.14.3.2 Engine Fuel Feed During Afterburner Operations. High afterburner fuel consumption places extreme demands on the engine feed system. In addition, the g forces experienced with afterburner use, especially during unloaded accelerations ("bugouts") and low-g nose-high maneuvering, tend to reduce forward fuel transfer to cell No. 5 and the left engine sump tank (cell No. 3). When these conditions are sustained, fuel in cell No. 5 is depleted by both high-suction feed through the gravity transfer line (C) (Figure 2-30), and by reducing gravity fuel transfer from cell Nos. 6 and 7. Zero- or low-g (less than 0.5) flight tends to force the fuel remaining in cell No. 5 toward the aft wall of the tank or, at reduced fuel level, uncovers gravity transfer line (C) and allows air to be drawn into the sump tank. Continued zero- or low-g (less than 0.5) maneuvers will aggravate this condition and increase the probability of air ingestion. If air enters the boost pump and engine feed line, the fuel pressure light will illuminate. If the maneuver is continued, the left afterburner will blow out and subsequent left-engine flameout can occur. Right-engine flameout can follow after left-engine flameout because engine feed crossfeed operation will reduce the effective output of the right boost pump. Aircraft deceleration can further interrupt fuel transfer from cell No. 2 to the right sump through gravity transfer line (D) (Figure 2-31). Once initiated, this sequence can occur rapidly and is independent of total fuel state.

WARNING

- During zero or negative-g flight, the oil pressure light will normally illuminate and activate the MASTER CAUTION light. Subsequent illumination of a fuel pressure light may go unnoticed, allowing the pilot to continue the maneuver to the point of afterburner blowout and engine flameout.

- In the presence of a fuel pressure light, fuel demand must be reduced and positive g restored to prevent possible engine flameout.

2.14.3.3 Fuel Shutoff Handles. Individual engine fuel feed shutoff valves in the left and right feed lines at the point of nacelle penetration are connected by control cables to the FUEL SHUT OFF handles on the

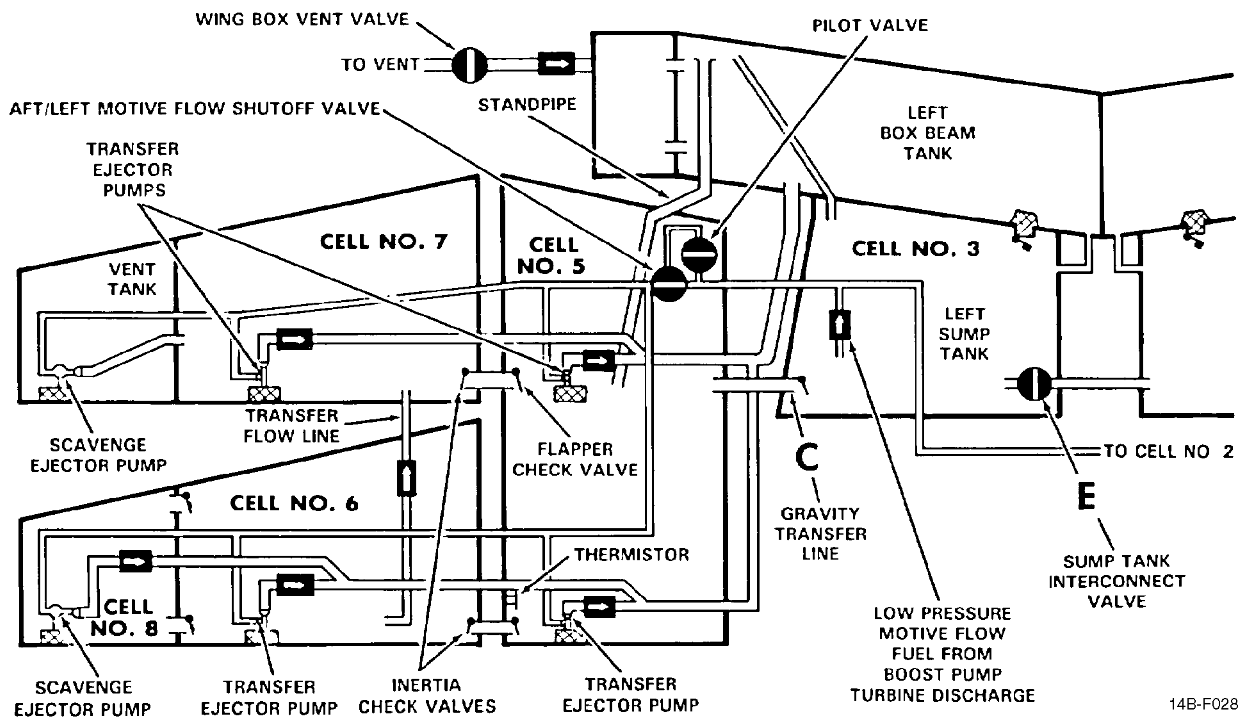


Figure 2-30. Aft Fuselage Fuel Transfer

pilot instrument panel. During normal operation, the handles should remain pushed in so that fuel flow to the engine fuel feed system is unrestricted. If a fire is detected in the engine nacelle, the pilot should pull (approximately 3 or 4 inches) the FUEL SHUT OFF handle on the affected side to stop the supply of fuel to the engine.

CAUTION

FUEL SHUT OFF handles should be used only in emergency situations. Damage to the fuel pumps and lines may result if the emergency fuel shutoff handle is used to secure an engine.

Note

Engine flameout will occur approximately 4 seconds after the FUEL SHUT OFF handle(s) is pulled with the throttle(s) at MIL. With lower power settings, time to flameout will increase (approximately 30 seconds at IDLE).

2.14.4 Fuel Transfer

2.14.4.1 Motive Flow Transfer. With the exception of the external tanks, which utilize bleed air, all fuel transfer is accomplished by gravity and motive flow. In motive flow, a relatively small amount of pressurized fuel moves at high speed through ejector pumps, using the Venturi effect to induce flow of the transfer fuel. The ejector pumps have no rotating parts or power requirements other than motive flow.

Like other elements of the fuel transfer system, motive flow transfer is initially segregated to right and left. The motive flow pump driven by the right engine provides motive flow and pressure to drive the right boost pump and to run the ejector transfer pumps in the forward fuselage and right wing. The motive flow pump driven by the left engine provides motive flow and

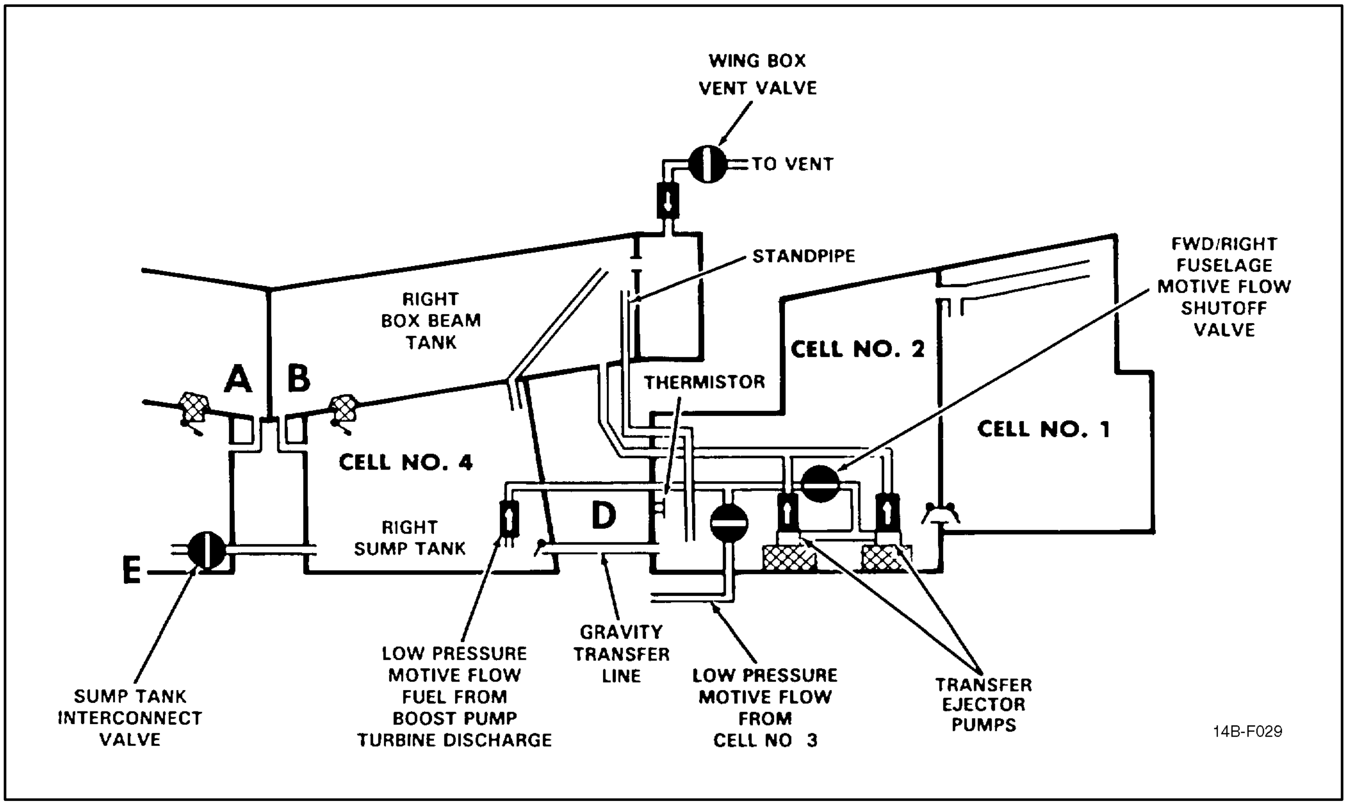


Figure 2-31. Forward Fuselage Fuel Transfer

pressure to drive the left boost pump and runs the ejector transfer pumps in the aft fuselage and left wing.

The path of the motive flow fuel is essentially the same for either side. Fuel from the engine feed line is pressurized by the engine-driven motive flow pump and initially routed through the boost pump turbine. The motive flow fuel is then routed through its respective transfer system. As the pressurized fuel passes through each ejector pump, it induces transfer fuel to flow along with the motive flow fuel. This combination of fuel eventually is transferred into the respective wing box-beam tank.

There are four valves that control motive flow transfer:

1. Motive flow isolation valve — Normally closed, but when the low-level thermistor in cell No. 2 or 5 is uncovered or the FEED switch is out of NORM, the valve is commanded open, providing a path for motive flow fuel from a normally operating side to cross over and power a malfunctioning opposite side.

2. Forward fuselage motive flow shutoff valve — Normally open except when the R FUEL PRESS caution light is illuminated or the FEED switch is in AFT. When the valve is closed, all motive flow transfer in the forward fuselage is shut off. If the valve is closed because of the R FUEL PRESS caution light, positioning the FEED switch to FWD will open the valve.

3. Aft fuselage motive flow shut-off valve — Normally open except when the L FUEL PRESS caution light is illuminated or the FEED switch is in FWD. When the valve is closed, all motive flow transfer in the aft fuselage is shut off. If the valve is closed because of the L FUEL PRESS caution light, positioning the FEED switch to AFT will open the valve.

4. Wing motive flow shut-off valve — The motive flow to each wing passes through separate paths in a single motive flow shutoff valve. The valve is normally open except when:

   a. The WING/EXT TRANS switch is in OFF or in AUTO with both left and right wing thermistors dry.

b. Weight is on wheels.

c. The REFUEL PROBE switch is in ALL EXTD.

In any case, the wing motive flow shutoff valve can be commanded open by selecting ORIDE on the WING/EXT TRANS switch.

2.14.4.2 Forward Fuselage Transfer. Fuel in cell No. 1 flows by gravity into cell No. 2 where two motive flow ejector pumps transfer it into the right-wing box-beam tank at approximately 18,000 pph. Fuel entering the box-beam tank beyond engine demands overflows through an overflow pipe back into cell No. 2. There is no fuel level control associated with fuselage motive flow transfer; therefore, the fuel will continue to circulate from cell No. 2 into the right box-beam tank and back through the overflow pipe. When the fuel in cell Nos. 1 and 2 is depleted, the motive flow ejector pumps are shut off by their own low-level floats. In the event of failure of the forward fuselage motive flow, the fuel can reach the right sump tank by gravity flow through interconnect D.

2.14.4.3 Aft Fuselage Transfer. Fuel in the aft fuselage is transferred forward by scavenge ejector pumps in cell No. 8 and the vent tank, single ejector pumps in cell Nos. 6 and 7 and two ejector pumps in cell No. 5. All aft motive flow transfer is into the left box-beam tank, producing a rate of approximately 36,000 pph. This flow rate is approximately twice that of the forward fuselage transfer rate because there are more motive flow ejector pumps in the aft transfer system. More fuel tanks and thus more motive flow ejector pumps are required in the aft transfer system than the forward transfer system because of the aircraft structural configuration. Like the forward fuselage, aft fuselage transfer does not have any high-level control associated with it. Excess fuel in the box-beam tank passes through an overflow pipe back into cell No. 5. When cell No. 5 is full, the fuel cascades into cell Nos. 6, 7, and 8. The aft fuselage fuel will continue to circulate until consumed by the engine. When their respective cell is empty, the motive flow ejector pumps will be shut off by their own low-level floats. The scavenge ejector pumps do not incorporate shutoff floats. In the event of loss of aft fuselage motive flow transfer, fuel may be gravity fed forward to cell No. 5 and eventually to the left sump tank through interconnect C.

2.14.4.4 Wing Transfer. Wing fuel is transferred by two motive flow ejector pumps located in each wing. To prevent overfilling the fuselage, entry of wing fuel into the box-beam tank is controlled by the refueling/transfer shutoff valve. In the forward fuselage, excess fuel overflows through an overflow pipe from the right box-beam tank into cell No. 2, and then cascades into cell No. 1. A high-level pilot valve senses when cell No. 1 is full and sends a signal to close the right refueling/transfer shutoff valve, preventing additional wing fuel from entering. When engine fuel consumption provides room in cell No. 1 for additional fuel, the high-level pilot valve will signal the refueling/transfer shutoff valve to open. The sequence is identical for the left box-beam tank and aft fuselage with the exception that the high-level pilot valve is located in cell No. 7 and controls the left refueling/transfer shutoff valve (see Figure 2-32 for wing and external tank fuel transfer).

Normally wing fuel can only transfer to the box-beam tank on its respective side except when the thermistor in either cell No. 2 or 5 is uncovered or the FEED switch is selected FWD or AFT. For either condition, the motive flow isolation valve opens, making motive flow pressure available to either wing from either engine and the two defuel/transfer selector valves open permitting fuel from either wing to transfer to either box-beam tank. Total loss of wing motive flow will preclude transfer of any remaining wing fuel. Failure of either high-level pilot valve or refueling/transfer shutoff valve to the closed position could cause a single-wing transfer failure. Selection of FWD or AFT on the feed switch opens the defuel/transfer selector valves allowing the trapped wing fuel to transfer to the opposite box-beam fuel tank.

Note

- Premature, automatic wing motive flow valve shutoff may occur because of formation of air bubbles in the wingtip fuel thermistors. Pilot selection of ORIDE with the WING/EXT TRANS switch will reenable fuel transfer.

- ORIDE transfer should not normally be used unless AUTO transfer fails to complete transfer of wing or external tank fuel. ORIDE use when the wing tanks are dry may allow air to enter the box-beam tanks, reducing the efficiency of gravity transfer to the sump tanks.

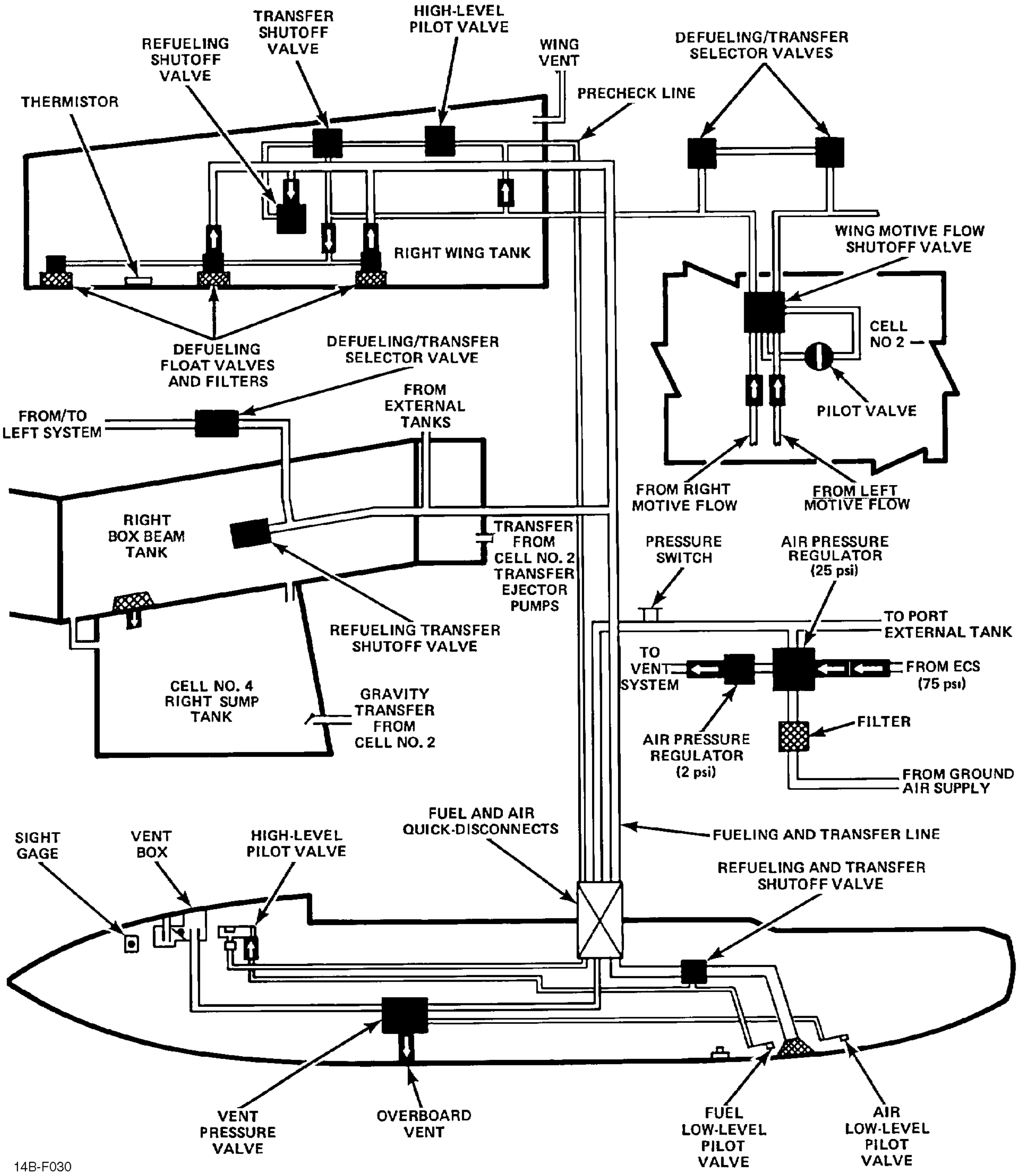


Figure 2-32. Wing and External Tank Fuel Transfer

Note

When the thermistor in either cell No. 2 or 5 is uncovered, the WING/EXT TRANS switch will be deenergized from OFF to AUTO. This automatic feature is to ensure all wing and external fuel has been transferred. After 5 seconds, the pilot may reset this switch to OFF.

A weight-on-wheels inhibit function prevents opening of the wing motive flow shutoff valve. To transfer wing fuel during ground operations, the WING/EXT TRANS switch must be set to ORIDE to bypass the weight-on-wheels function.

Activation of fuselage fuel dump automatically initiates wing fuel transfer in sequence after external tank transfer by automatically moving the WING/EXT TRANS switch to AUTO if in OFF. Positioning the REFUEL PROBE switch to ALL/EXTD also releases the solenoid holding the WING/EXT TRANS switch in OFF.

2.14.4.5 External Tank Transfer. External tank transfer is also controlled by the WING/EXT TRANS switch. When external tanks are installed, transfer from the wings and external tanks occurs concurrently. Transfer from the wings and external tanks cannot be accomplished separately; however, the external tanks should complete transfer before the wing tanks. External tank fuel is transferred by bleed air pressure regulated to 25 psi. Maximum transfer rate of each external tank is approximately 45,000 pph. External tank fuel transfer into the fuselage is controlled by the same valves that control wing transfer. Fuselage level is controlled by the refueling/transfer shutoff valves and, until both the defuel/transfer valves are commanded open, external tank fuel can only transfer into the box-beam tank located on the same side of the aircraft.

External tank transfer can be checked on the deck by placing the WING/EXT TRANS switch to ORIDE or selecting FLT GR UP with the MASTER TEST switch and noting depletion of external tank fuel quantity. In addition, when FLT GR UP is selected, the GO/NO GO light on the MASTER TEST panel is illuminated by a pressure switch in the aircraft pressure line leading to the external tanks and indicates status of line pressure.

Since FLT GR UP serves to bypass the landing gear down interlock in the external tank transfer circuit, the WING/EXT TRANS switch must remain in the AUTO (normal) position for this check.

Note

- Verifying tank operation by observing fuel transfer is both time consuming with a full fuselage fuel load and aggravates fuel slosh loads in the external tanks during catapult launch.
- Engine rpm above idle may be required to provide sufficient bleed air pressure for a satisfactory check.

2.14.4.6 Vent Valve Failure. The vent valves in the right and left box-beam tank are always commanded open with the sump tank interconnect valve, making the right and left feed groups a common system. This function occurs when the low-level thermistor in cell No. 2 or 5 is uncovered. To equalize the static pressure head at the interconnect valve, the fuel in the sump tanks will seek a common level. At matched engine demands, each engine will feed from its own side and negligible flow will occur across the sump tank interconnect valve. If a vent valve fails to open, the additional vent pressure on top of the fuel on the vented side creates a pressure differential between the left and right sump tanks and results in migration through the interconnect valve to the side with the inoperative vent valve. Therefore, sump tank replenishment of fuel to the side with the failed vent valve will come primarily from the opposite sump tank because the head pressure at the interconnect valve (E) may be higher than that at interconnects A, B, C, or D (Figure 2-29). A fuel quantity imbalance will occur with the side of the properly operating vent valve decreasing more rapidly than the malfunctioning side. The box-beam tank with the malfunctioning vent valve will eventually vent through the overflow pipe when the respective fuselage tank (cell No. 2 or 5) is empty. If for any reason the fuel is not transferred out of the respective fuselage tank, the imbalance will continue until the vented sump tank fuel quantity is low enough to uncover the interconnect valve and line (256 pounds approximately). This permits venting of the unvented side and permits use of the balance of the fuel in the sump tanks.

Vent valve malfunctions can create disconcerting fuel imbalances. Although engine operation is not affected and all of the fuel in the aircraft is available, afterburner use should be avoided when low-feed group fuel quantities are indicated. If both engine/boost pumps are operating, there is no advantage in using the cockpit fuel FEED switch to attempt to correct the imbalance. Positions other than NORM may simply aggravate the imbalance.

2.14.5 Fuel Quantity Balancing. Fuel quantity balancing is not normally required prior to completion of wing/external tank transfer or until one fuselage tape drops below 4,500 pounds. The procedure requires use of the FEED switch, which opens the sump tank interconnect valve, joining the FWD/RIGHT and AFT/LEFT systems. With a high quantity in the FWD/RIGHT group, the greater static head pressure, particularly in noseup attitudes, can cause overfilling of the AFT/LEFT group. To prevent this, the FEED switch should be returned to NORM before the AFT/LEFT tape reaches 6,200 pounds.

When the FEED switch is moved to select the high-fuel quantity side, the following occurs:

1. Sump tank interconnect valve opens and provides a fuel path between the right and left tanks.

2. Both box-beam tank vent valves open and provide equal vent pressure on top of the fuel in each box-beam tank, regardless of the fuel level.

3. Fuselage motive flow shutoff valve on the nonselected (low-fuel quantity) side closes and terminates the last source of transfer of that fuselage fuel into its respective box-beam tank.

4. Motive flow isolation valve opens and provides path for nonselected side motive flow pressure to reach the opposite side. Thus motive flow transfer should maintain a full box-beam tank on the selected side.

5. Both defuel/transfer selector valves open and permit either wing/external tank to transfer into either wing box-beam tank.

The higher static pressure head created by the full box-beam tank on the selected side results in the nonselected side engine feeding primarily from the sump tank interconnect rather than interconnecting A, B, C, or D. With both engines feeding from the fuel in primarily one side, the correction rate of the fuel quantity imbalance is essentially a function of engine demand.

WARNING

- During afterburner operations, NORM shall be selected. FWD or AFT could deplete fuel in sump tanks.

- Aircraft attitude will have a significant influence on the direction of fuel movement if FWD or AFT is selected. Nose-down attitude will transfer fuel forward, and noseup attitude will transfer fuel aft.

2.14.6 Fuel Transfer/Feed During Single-Engine Operation. Loss of an engine before the low-level thermistor in either cell No. 2 or 5 is uncovered will terminate all motive flow transfer on the failed side. External tank fuel will continue to transfer if room is available in the failed side fuselage tanks. If no pilot action is taken, the operating engine will feed only from its own side. This will lead to a fuel imbalance that can normally be corrected through the use of the fuel FEED switch. Selecting the high side (inoperative engine side) results in the following:

1. Selected side fuselage motive flow shutoff valve is opened. The valve was commanded closed when the FUEL PRESS caution light illuminated.

2. Operating side fuselage motive flow shutoff valve is closed and stops operating side fuselage fuel transfer into the box-beam tank.

3. Motive flow isolation valve opens. Operating side motive flow pressure now powers the inoperative side. Failed side fuselage fuel will begin transferring into its respective box-beam tank.

4. Sump tank interconnect valve opens and provides a path for the inoperative side fuel to reach the operating engine.

5. Wing box-beam tank vent valves open and equalize the pressure above the fuel in each wing box-beam tank permitting the higher static pressure created by the full-wing box-beam tank on the inoperative side to induce flow through the open sump tank interconnect valve to the operating engine.

6. Both defuel/transfer selector valves open and allow either wing or external tank fuel to transfer into either wing box-beam tank.

If no crew action is taken with the FEED switch, the same fuel system functions are automatically provided when the thermistor in either cell No. 2 or 5 is uncovered. Additional actions that will occur when the cell No. 2 or 5 thermistor is uncovered are:

1. Both right and left fuselage motive flow shutoff valves open, overriding any previous commands to close. Manual override of each valve is still provided through the FEED switch.
2. Engine crossfeed valve receives a redundant command to open. An initial command was provided when the FUEL PRESS caution light illuminates.
3. WING/EXT TRANS switch will automatically go to AUTO if originally in OFF. If desired, OFF can be reselected after 5 seconds.

2.14.6.1 Sump Tank Interconnect Valve Failure. The major fuel system consideration while operating with a single engine is that the sump tank interconnect valve opens when commanded. This constitutes the only path through which inoperative side fuselage fuel can reach the operating engine. While the probability of an inoperative sump tank interconnect valve is very low, the consequences of a malfunction under single-engine conditions are severe, particularly at landing fuel weights. With a failed-closed sump tank interconnect and full fuselage cells on the inoperative side, only the wing fuel on the inoperative side and external fuel can be transferred into the operating side fuselage. Attempts to transfer the fuel from the inoperative side with the FEED switch compound the problem when the motive flow isolation valve and inoperative side motive flow shutoff valve open. Operating side motive flow fuel, pumped through the open motive flow isolation valve to permit inoperative side wing and/or fuselage motive flow transfer, cannot be retrieved. Fuel migration is approximately 100 pounds per minute because of wing transfer, and approximately 200 pounds per minute for fuselage transfer. Coupled with a normal engine demand of approximately 100 pounds per minute, a balancing attempt will result in usable fuel in the operative side being depleted at approximately 400 pounds per minute.

Note

Operating side fuel remaining can be protected by pulling the FUEL SHUT OFF handle for the inoperative side and concurrently selecting the operative side on the FEED switch. This will eliminate a potential fuel-path across the engine automatic crossfeed valve, through the inoperative sump tank boost pump, into the inoperative side.

If the sump tank interconnect is failed closed, the following additional considerations apply.

With the FEED switch selected to the operating side:

1. Wing and external tank fuel from both sides will transfer into the operating side fuselage *if the inoperative side fuselage is full.*
2. If DUMP is selected, wing motive flow is automatically activated; therefore, approximately 100 pounds per minute of fuel available to the operating engine will be lost.

2.14.7 Fuel Dump. Figure 2-33 shows aircraft fuel system components associated with fuel dump operation. Fuel dump standpipes in the forward (cell No. 2) and aft (cell No. 5) fuselage tanks are connected to the fuel dump manifold at the dump shutoff valve. The manifold extends aft to the fuselage boattail. Actuation of the fuel DUMP switch to DUMP supplies power (dc essential No. 2) to open the solenoid-operated pilot valve, which ports motive flow fuel pressure to open the dump shutoff valve with weight off the main landing gear and the speedbrakes retracted.

The fuel DUMP switch circuit is deactivated on deck or with speedbrakes extended. Fuel dump with the speedbrakes extended is inhibited because of the resulting flow field disturbance, which would result in fuel impingement on the fuselage boattail and exhaust nozzles. The speedbrake switch is electrically bypassed during a combined hydraulic system failure, enabling the pilot to dump fuel when the speedbrakes are floating. The electrical bypass is accomplished whenever the combined pressure falls below 500 psi.

Note

- Dump operations with either engine in afterburner should be avoided since the fuel dump mast discharge will be torched.
- After terminating fuel dump, wait approximately 1 minute to allow residual fuel in the fuel dump line to drain before extending speedbrakes or lighting afterburners.

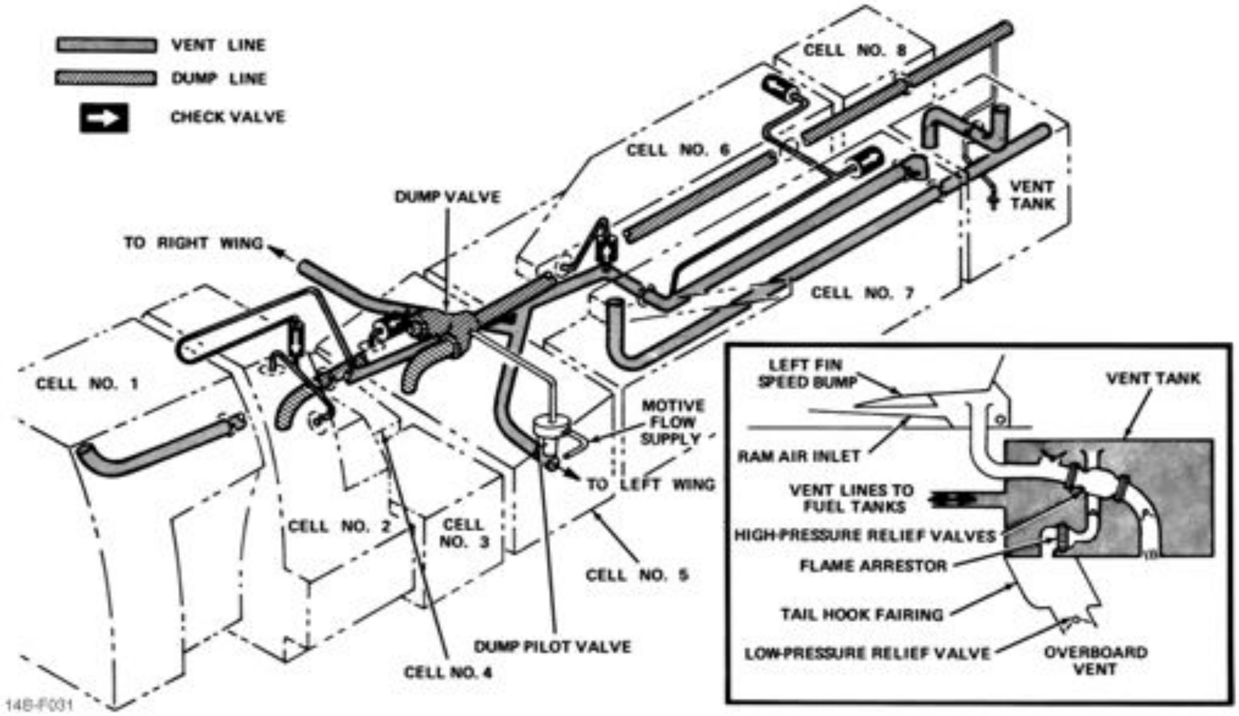


Figure 2-33. Fuel Vent and Dump

Fuel in the wings and external tanks is dumped by transferring to the fuselage. When the fuselage fuel-dump circuit is activated, wing and external tank transfer to the box-beam tanks is automatically initiated. Fuel dump is by gravity flow with a nominal discharge rate of 1,500 pounds per minute. The dump rate is affected by aircraft pitch attitude and total fuselage fuel quantity with discharge flow inhibited at nosedown conditions. The standpipes in the fuel cells control the minimum fuel-dump level in the tanks, which under normal operations (feed group full) is approximately 4,000 pounds.

2.14.8 Internal Tank Pressurization and Vent. The internal fuel vent system is shown in Figure 2-33. It is an open-vent-type system, pressurized by ram air and engine bleed air from the 25-psi external tank pressure system, which is reduced to 1.75 psi by a fuselage pressure regulator and distributed to all tanks through the fuselage vent system. This air is automatically supplied when the landing gear handle is UP or the WING/EXT TRANS switch is in ORIDE. When the WING/EXT TRANS switch is in OFF, the low-pressure bleed air is cut off.

In flight, the vent tank is maintained at a positive pressure up to 2.5 psi maximum. This pressure is fed by connecting lines to all internal tanks. These connecting lines are routed to provide venting to both the forward and aft end of each fuselage tank so it can function as both a climb and dive vent. Venting of the box-beam tanks is controlled by solenoid-operating valves that, when closed, provide suction transfer through the gravity flow paths in cell Nos. 2 and 5 to the sump tanks.

2.14.9 Fueling and Defueling. Figure 2-34 shows the refueling system. The aircraft is equipped with a single-point refueling system that enables pressure filling of all aircraft fuel tanks from a single receptacle. The receptacle is at the recessed ground refuel and defuel station, behind a quick-access door on the lower right side of the forward fuselage. The maximum refueling rate is 450 gpm at a pressure of 50

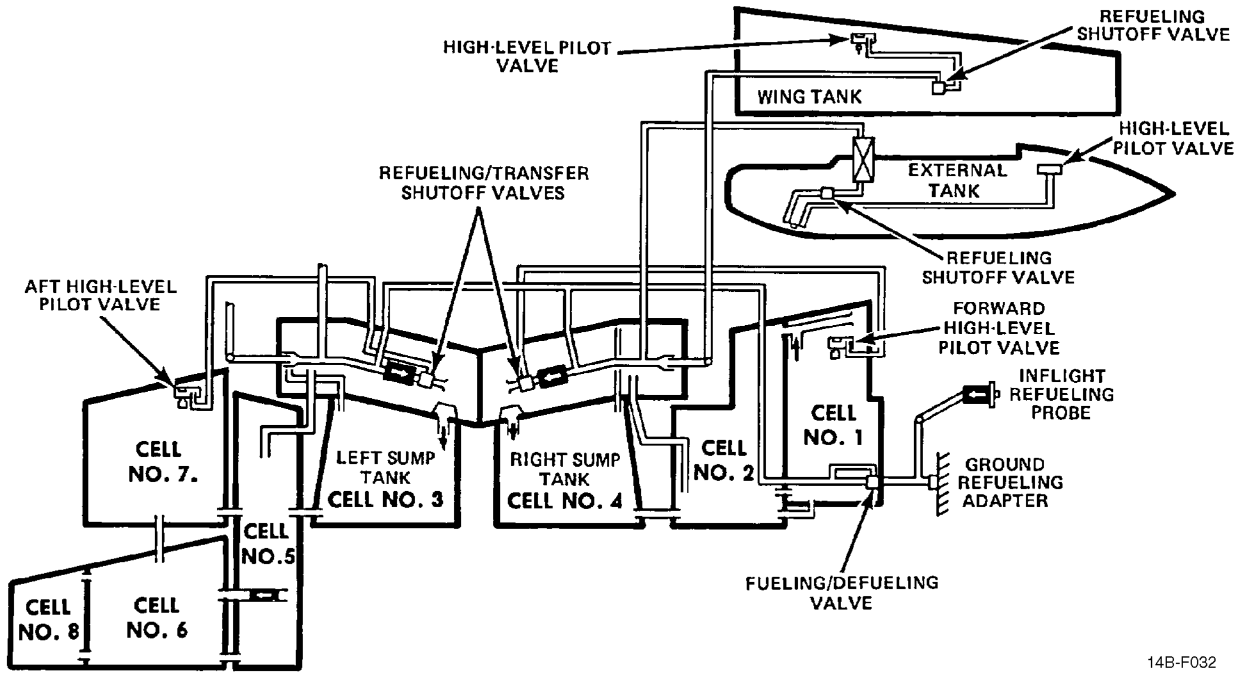


Figure 2-34. Refueling System

psi. Since ground and air refueling connections use a common manifold, the refueling sequence is the same.

Standpipes refuel the aft and forward fuselage tanks by overflow from the left and right box-beam tanks. A high-level pilot valve at the high point of the forward tank shuts off the fuselage refueling valve in the right box-beam tank when the forward tank group is full. Fuel flows from the left box-beam tank to cell No. 5, after which it overflows to the right side then the left side. A high-level pilot valve at the high point of the left box-beam tank and aft tank (cell No. 7) shuts off the fuselage refueling valve in the left box-beam tank when the aft tank group is full. Individual wing and external tank filling is accomplished by flow through a shutoff valve in each tank.

CAUTION

Gravity refueling of the aircraft fuel system should be accomplished only under emergency situations. While performing such an operation, avoid introducing contaminants into the fuel tanks or damaging the fuel quantity probes and wiring.

2.14.9.1 Precheck System. Ground refueling control is by two precheck selector valves and a vent pressure gauge adjacent to the refueling receptacle on the ground refuel and defuel panel. The precheck valves functionally test high-level pilot valve operation incident to ground pressure refueling; the valves separately check the pilot valves in the fuselage tanks and the wing and external tanks. In addition to this precheck function, the precheck valves can be used for ground selective refueling of only the fuselage or all tanks. Since the precheck valves, which are manually set by the ground-crew, port pressurized servo fuel to the high-level pilot valves and subsequently to the shutoff valves, no electrical power is necessary on the aircraft to perform ground refueling operations. Additionally, ground refueling control without engines running is completely independent of switch positioning on the fuel management panel. The direct-reading vent pressure indicator monitors pressure in the vent lines. The gauge consists of a pointer on a scale having two bands: one green and one red.

The green band indicates a safe pressure range (0 to 4 psi) and the red band indicates an unsafe range (4 to 8 psi).

CAUTION

During ground refueling operations, the direct-reading vent pressure indicator shall be observed and refueling stopped if pressure indicates in the red band (above 4 psi).

2.14.10 In-Flight Refueling

Note

Refer to Chapter 9 for in-flight refueling procedures.

The in-flight refueling system permits partial or complete refueling of the aircraft fuel tanks while in flight. The retractable refueling probe has an MA-2-type nozzle that is compatible with any drogue-type refueling system. A split refueling system is provided with fuel routed into the left and right box-beam tanks for initial replenishment of sump tank fuel. Selectable fuel management controls dictate the extent of further distribution to the wing tanks, external tanks, and/or fuselage tanks. The maximum refueling rate is approximately 475 gallons per minute at a pressure of 57 psi.

WARNING

To prevent fuel fumes from entering the cockpit through the ECS because of possible fuel spills during in-flight refueling, select L ENG air source.

CAUTION

Maximum airspeed for extension or retraction in flight of the refueling probe is 400 KIAS (0.8 IMN).

Note

- With the in-flight refueling probe extended, the pilot and RIO altimeter and airspeed and Mach indicators will show erroneous indications because of changes in airflow around the pitot static probes.
- Flight operations with in-flight refueling probe door removed are not recommended because of effects of water intrusion, exposure to elements, and structural fatigue to electrical hydraulic hardware assemblies. If operational necessity dictates, the in-flight refueling probe door may be removed to prevent damage, loss, or engine FOD.
- The RUDDER AUTH caution light may illuminate when the in-flight refueling probe is extended. Press the MASTER RESET button to reset the light.

2.14.10.1 In-Flight Refueling Probe. The retractable in-flight refueling probe is in a cavity on the right side of the forward fuselage section, immediately forward of the pilot vertical console panel.

Extension of the refueling probe is provided through redundant circuits by the REFUEL PROBE switch. A hydraulic actuator within the probe cavity extends and retracts the probe. The probe actuator is powered by the combined hydraulic system. It can be extended and retracted by means of the hydraulic handpump in the event of combined system failure.

CAUTION

Loss of combined pressure may indicate impending fluid loss. Without fluid in the combined system return line, the in-flight refueling probe will not extend with the handpump. Early extension of the refueling probe at the first indication of a combined system malfunction is recommended in a carrier environment.

Note

To extend or retract the refueling probe using the hydraulic handpump requires the refuel probe switch to be placed in EXT or RET (as appropriate), combined system fluid in the return line, and essential dc No. 2 electrical power. With a total loss of combined hydraulic pressure in flight, fluid trapped in the return line/handpump reservoir can be isolated exclusively for refueling probe extension if the landing gear handle is in the UP position. Extension of the refueling probe requires approximately 25 cycles of the pump handle.

Note

Probe retraction is not available if the FUEL P/MOTIVE FLOW ISOL V (P-PUMP) circuit breaker (RG1) is pulled.

2.14.10.2 Refueling Probe Transition Light. The red probe transition light immediately above the REFUEL PROBE switch illuminates whenever the probe-cavity forward door is not in the closed position. Since the closed-door position is indicative of both the probe retracted and extended position, the light serves as a probe transition indicator as well as a terminal status indicator. The probe external light illuminates automatically upon probe extension with the EXT LTS master switch ON.

2.14.10.3 In-Flight Refueling Controls. Regardless of fuel management panel switch positioning, at low-fuel states, the initial resupply of fuel is discharged into the left and right box-beam tanks. The split refueling system to the left and right engine feed group provides for a relatively balanced cg condition during refueling. Selective refueling of the fuselage or all fuel tanks is provided on the REFUEL PROBE switch with the probe extended. In FUS/EXTD, normal fuel transfer and feed is unaltered. This position is used for practice plug-ins, fuselage-only refueling, or return flight with a damaged wing tank. The ALL/EXTD shuts off wing and external drop tank transfer to permit the refueling of all tanks.

2.14.11 Hot Refueling. Hot refueling can be accomplished with the refueling probe extended or retracted. If the probe is extended, control of the tanks to be refueled is accomplished in the same manner as during inflight refueling. If the probe is not extended, select WING/EXT TRANS switch to OFF to refuel all tanks. Select ORIDE to refuel the fuselage only.

2.14.12 Automatic Fuel Electrical Controls

2.14.12.1 Automatic Low-Level Wing Transfer Shutoff. A thermistor is located at the low point in each wing cell. When both are uncovered, a discrete electrical signal is generated; through a control, the wing motive flow shutoff valve is energized and closes, terminating all wing transfer. If either or both thermistors are again submerged, wing transfer resumes.

Failure of this override system could result in a wing transfer failure. Selection of WING/EXT TRANS switch to ORIDE removes all power from the wing motive flow shutoff valve, permitting it to open.

2.14.12.2 Automatic Fuel Low-Level Override. Under normal operating conditions, the forward and right fuselage tank complex is isolated from the aft and left tank. This is necessary for proper longitudinal cg control and battle-damage conditions. However, as fuel depletion progresses to the point of sump tank only remaining, it becomes mandatory that the tanks be connected to maintain an equal balance. To accomplish this, two thermistors are located at the low points in cell Nos. 2 and 5. When either is uncovered (approximately 1,700 to 2,000 pounds per side) the following operations are electrically performed.

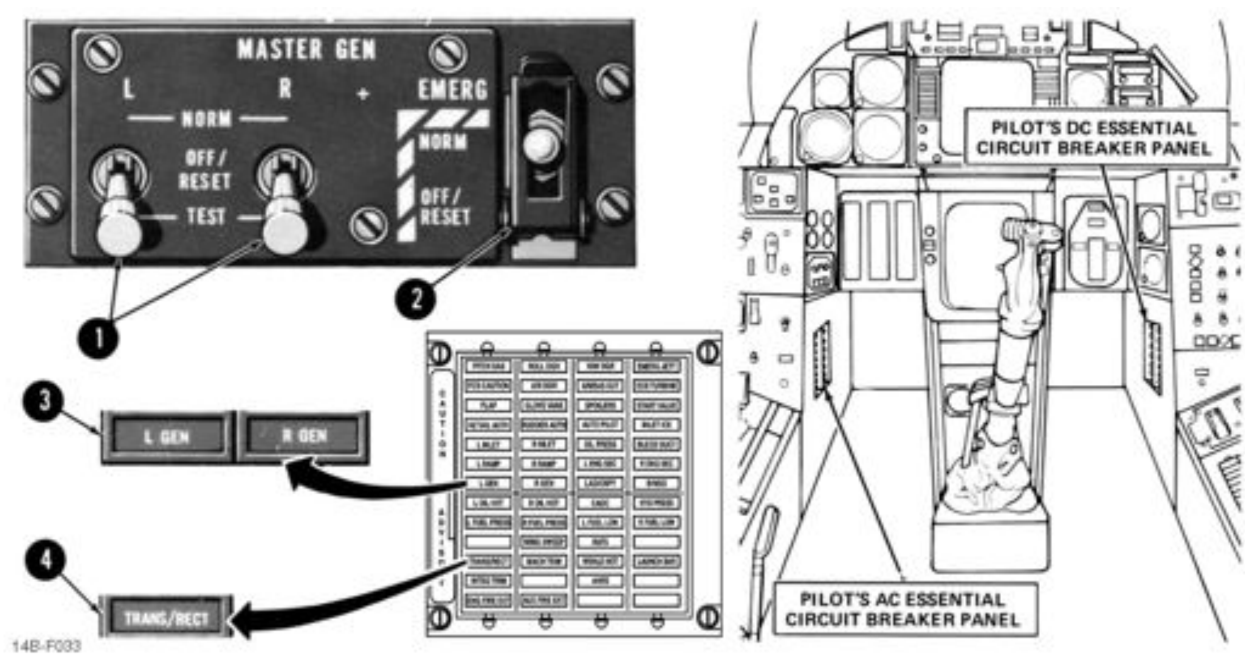
1. Sump tank interconnect valve is opened.
2. Motive flow isolation valve is opened.
3. Box-beam vent valves are opened.
4. Engine crossfeed valve is opened.
5. WING/EXT TRANS switch is energized to move from OFF to AUTO. This signal is maintained for 5 seconds.
6. Defuel transfer selector valves are opened.

WARNING

Uncovering either thermistor in cell No. 2 or 5 will only move the WING/EXT TRANS switch from OFF to AUTO but under no circumstances will it override a wing transfer failure.

2.15 ELECTRICAL POWER SUPPLY SYSTEM

In normal operation, ac power is supplied by the engine-driven generators. This ac power is converted by two transformer-rectifiers into dc power (refer to FO–7). One generator is capable of assuming the full ac power load and one T/R is capable of assuming the full DC power load. Additionally, a hydraulic-driven emergency generator provides an independent backup supply of both ac and dc power for electrical operation of essential buses. Ground operation of all electrically powered equipment is provided through the supply of external ac power to the aircraft. Switching between power supply systems is automatically accomplished without pilot action; however, sufficient control is provided for the flightcrew to selectively isolate power sources and distribution in emergency situations. See Figure 2-35 for a functional description of the control switches. All electrical circuits are protected by circuit breakers accessible in flight to the pilot and RIO.



NOMENCLATURE	FUNCTION	
1 MASTER GEN switch (lock lever)	NORM —	Connects the generator to the main buses through the line contact.
	OFF/RESET —	Disconnects generators from the buses. Reset the generator if tripped by an overvoltage, undervoltage, or fault condition.
	TEST —	The generators are energized but are not connected to the buses. Provides a means to analyze a system malfunction indicated by a generator caution light when an attempt to reset a generator is unsuccessful.
2 EMERG generator switch	NORM —	Safety guard down. Emergency generator is automatically connected to the essential buses If both DC power sources fail.
	OFF/RESET —	Safety guard must be lifted. Disconnects the emergency generator from the essential buses. Resets the generator if tripped by an undervoltage or underfrequency condition.
3 L GEN and R GEN caution lights	GEN caution lights are on the pilot's caution/advisory light panel. Each light is tied to its respective main ac contact and is powered by the essential bus no. 2. Illumination of the L GEN or R GEN caution light indicates that the corresponding generator is not operating due to a fault in the generator, generator control unit, or electrical distribution system.	
4 TRANS/RECT advisory light	A TRANS/RECT advisory light is on the lower half of the pilot's caution/advisory indicator panel. Illumination of the TRANS/RECT advisory light indicates that the operable transformer-rectifier is powering the total DC load, or that a dual transformer-rectifier failure has occurred.	

Figure 2-35. Generator Panel

2.15.1 Normal Electrical Operation

2.15.1.1 Main Generators. Two engine-driven, oil-cooled IDGs produce the normal 115- to 200-volt, 400 Hz, three-phase ac electrical power. The normal rated output of each generator is 75 kVA, which is sufficient to individually assume the complete electrical load of the aircraft. Each main ac generator is controlled by a separate switch on the pilot MASTER GEN control panel. Indication of a main power supply malfunction is provided by a L GEN and R GEN caution light. The IDG oil system is used for cooling as well as lubricating the IDG. The oil is normally cooled by the IDG air/oil cooler and returned to the constant speed drive for recirculation. When AB is used, additional cooling is provided by the AB fuel/oil cooler before returning to the IDG. Should an excessive amount of heat be developed in an IDG, a thermally (390 °F) actuated device automatically decouples the input shaft from the remainder of the CSD, protecting both the CSD and generator. There are no provisions for recoupling the IDG unit in flight.

CAUTION

> Failure of the weight-on-wheels circuit to the in-flight mode while on the deck will cause the loss of ECS engine compartment air ejector pumps, causing a subsequent IDG disconnect and illumination of the GEN light.

2.15.1.1.1 Generator Control Units. Generator output voltage and frequency are individually monitored by GCUs, which prevent application of internally generated power to the aircraft bus system until the generator output is within prescribed operating limits. With the main generator switch in NORM, the applicable generator is self-excited so that, during the engine start cycle, it automatically comes on the line at approximately 60-percent rpm under normal load conditions. Likewise, during engine shutdown, the GCU automatically trips the generator off the line as the power output decreases below prescribed limits at approximately 55 percent.

During normal operations, the generator control switches remain in NORM continuously. However, subsequent to an engine shutdown, stall, or flameout in flight where the GCU has tripped the generator off the line, the reattainment of normal engine operation will not automatically reset the generator unless the engine speed decreases below about 30-percent N_2 rpm. If a transient malfunction or condition causes the generator to trip, the generator must be manually reset by cycling the applicable generator control switch to OFF/RESET then back to NORM.

When normal reset cannot be accomplished, TEST on the generator control switch allows the generator to be excited but not connected to the aircraft buses. In test, a CSD, generator, or GCU failure causes the GEN light to remain illuminated. If the light goes out, the problem is in the distribution system.

2.15.1.2 Transformer-Rectifiers. Two transformer rectifiers convert internal or external ac power to 28-Vdc power. A single TRANS/RECT advisory light on the pilot advisory panel provides failure indication for one or both transformer-rectifiers. No flightcrew control is exercised over transformer-rectifier operation aside from controlling the ac power supply or circuit breakers for the power converters. The transformer-rectifiers have a rated output of 100 amperes each. Each unit is capable of assuming the complete dc electrical load of the aircraft. Forced air cooling is provided with engines running to dissipates the heat generated by the power converters.

2.15.1.3 External Power. Ground power is applied through a receptacle just aft of the nosegear. The pilot has control over external power application only through hand signals to the plane captain. An external power monitor prevents application of external power that is not within tolerances and disconnects external power from the buses if undervoltage, overvoltage, underfrequency, overfrequency, or phase reversal occurs. Power can be reapplied to the aircraft by pressing the reset button adjacent to the receptacle, provided it is within prescribed limits. External electrical power is automatically inhibited from VDIG, PMDIG, AICS, APX-76, CADC, and CSDC without external air-conditioning connected to the aircraft. When the left generator comes on line during start, it automatically disconnects external power. Although there is no direct cockpit indication of external power being applied after one generator is operating, the HYD TRANSFER PUMP will not operate if the external power plug is still in the aircraft receptacle.

2.15.2 Electrical Power Distribution. Electrical power is distributed through a series of buses. Under normal operation, the ac generator power distribution is split between the left and right main ac buses. Failure of either main ac generator trips a tie connector to connect both buses to the operative generator. If the bus tie fails to trip when the generator goes bad, the respective transformer-rectifier will not be powered and the indication of this double failure will be a L GEN or R GEN caution light and a TRANS/RECT advisory light. The left and right main ac buses in turn supply ac power directly to the respective transformer-rectifiers, and the left main ac bus also supplies power to both essential ac buses under normal operation.

External power is distributed through the aircraft electrical system in the same manner as main generator power. Like the main ac generators, dc power distribution from the two transformer-rectifiers under normal operations is split between the left and right main dc buses. Failure of either transformer-rectifier trips the respective tie contact to connect both main dc buses to the operative transformer-rectifier. The TRANS/RECT advisory light provides a direct indication of dc bus tie status. An interruption-free dc bus interconnects the left and right main dc buses to provide a continuous source of dc power with failure of either main ac generator and/or transformer-rectifier. The left main dc bus additionally supplies power to both essential de buses under normal operations. Power to the DFCS bus is normally supplied from the interruption-free dc bus; however, with an output failure from both transformer-rectifiers, the DFCS bus load is automatically transferred to the essential No. 2 bus. Loss of main dc power automatically activates the emergency generator. The emergency generator is electrically inhibited by a solenoid control valve energized by the left main dc bus. Operation of the generator is automatically initiated, connecting to the essential buses, with the loss of the left main dc bus, regardless of other sources of ac or dc power. Total loss of ac or dc power will consequently result in the loss of the left main dc bus and therefore activation of the emergency generator. This, in turn, trips power transfer relays to change essential ac and dc bus loading from the left main ac and dc buses to the emergency generator, regardless of main generator output status.

2.15.2.1 Circuit Breakers. Individual circuit protection from an overload condition is provided by circuit breakers that are all located in the cockpits for accessibility in flight. The appropriate circuit breaker will pop out and isolate a circuit that draws too much current, thus preventing equipment damage and a possible fire.

CAUTION

Popped circuit breakers should not be reset more than once nor held depressed unless the associated equipment is absolutely required by operational necessity. A popped circuit breaker indicates an equipment malfunction or an overload condition. Repeated resets or forced depressions of popped circuit breakers can result in equipment damage and/or serious electrical fire.

Cockpit circuit breaker panels are shown on FO–8 and FO–9. Circuit breakers in the pilot cockpit comprise the majority of those required for essential aircraft systems. The circuit breakers are arranged in rows and are oriented so that the white-banded shaft of popped breakers is readily visible for flightcrew surveillance. Panels, rows, and columns of breakers are identified to facilitate breaker location and designation. Placards adjacent to the breakers identify individual circuit breakers by affected components; amperage ratings are indicated on top of each circuit breaker.

2.15.2.1.1 Circuit Breaker Location. The alphanumeric system for locating circuit breakers in the aircraft is as follows.

The panels in the RIO cockpit are labeled 1 through 8, starting left aft and proceeding clockwise (see Figure 2-36.) Thus, panels 1 to 4 are on the RIO's left and panels 5 to 8 are on his right. The pilot left- and right-knee panels are designated L and R, respectively. The first digit in the three-part locater is the alphanumeric, that identifies the circuit breaker panel.

The second part is a letter that designates the row in which the circuit breaker will be found. The top row is designated A, the next row lower is B, etc.

The third part is a number that designates the column in which the circuit breaker will be found. The innermost column of each panel 1, 2, 7, and 8 or aftmost column on each panel 3, 4, 5, 6 L and R is designated "1," the next outboard/forward column is "2," etc.

3F6	AC ESS BUS NO. 2 FDR PH A
4F1	AC ESS BUS NO. 2 FDR PH B
4F4	AC ESS BUS NO. 2 FDR PH C
2I4	ACM LT/SEAT ADJ/STEADY POS LT
4B6	ACM PNL LT/INS SYNC
6D5	ACM PNL PWR
3C6	AHRS PH A
4C1	AHRS PH B
4C5	AHRS PH C
LF2	AICS L
2I5	AICS L HTR
7E2	AICS L LKUP PWR/EMER GEN TEST
6A6	AICS L RAMP STOW
LG2	AICS R
2I8	AICS R HTR
7E1	AICS R LKUP PWR/ANTI-SKID
6A5	AICS R RAMP STOW
8A4	AIM-54 MSL
8G4	AIM-7 L BATT ARM
8G3	AIM-7 R BATT ARM
RC2	AIR SOURCE CONTR
8B6	ALE-39 CHAFF/FLARE DISP
8B5	ALE-39 SEQ 1 & 2 SQUIBS
7C8	ALPHA COMP/PEDAL SHAKER
4B3	ALPHA HTR
6C1	ALQ-126 DECM
1C2	ALQ-126 PH A
1C5	ALQ-126 PH B
1C6	ALQ-126 PH C
8C1	ALQ-167 STA 1 & 6
1I4	ALR-67 CMPTR
2F2	ALR-67 RCVR PH A
2H3	ALR-67 RCVR PH B
2I10	ALR-67 RCVR PH C
6B6	ALT LOW WARN
8D1	AMC BIT/R DC TEST
8G1	AMCS ENABLE
8F5	AN/ALR-67 CONT
3D7	AN/ARA-50
7D6	AN/ARA-50
1D2	AN/AWG-9 CMPTR PH A
1D5	AN/AWG-9 CMPTR PH B
1D6	AN/AWG-9 CMPTR PH C
2D1	AN/AWG-9 PUMP 3 PH
2G3	ANIAWG-9 PUMP PH A
2G6	AN/AWG-9 PUMP PH B
2G7	AN/AWG-9 PUMP PH C
8H6	AN/AWW-4
1B3	AN/AWW-4 PH A
1C4	AN/AWW-4 PH B
1B6	AN/AWW-4 PH C
3C3	ANGLE OF ATTK IND AC
7E3	ANGLE OF ATTACK IND DC
4F5	ANL ATTK TOTAL TEMP HTR
7C1	ANN PANEL PWR
7F3	ANN PILOT PANEL AUX PWR/TR-ADVSY
8C2	ANN PNL/DDI DIM CONTR
8G2	ANT LOCK EXCIT
1F2	ANT SVO HYD PH A
1F4	ANT SVO HYD PH B 2
1F5	ANT SVO HYD PH B 1
1F6	ANT SVO HYD PH C
2I1	ANTICOLL/SUPP POS/POS LTS
7C2	ANTI-ICE RAIN RPL/HK CONT
RG2	ANTI-ICE/ENG/PROBE
7E1	ANTI-SKID/R AICS LKUP PWR
7E7	APN-154
5C4	APX-72 AC
6F7	APX-72 DC
8I6	APX-72 TEST SET
7C7	ARA-63 ILS DC
3A6	ARA-63 ILS PH A
4A3	ARA-63 ILS PH B
4A5	ARA-63 ILS PH C
6B3	ARC-159 NO. 1
6D1	ARC-159 NO. 2
8D7	ARMT GAS INGEST PWR
4E6	AS/ARA48 ANT
1J2	ASW-27 AC
8G6	ASW-27 (DC)/DDI
LA3	AUTO PITCH DRIVE TRIM
2G6	AUTO THROT
8B7	AUTO THROT DC
7G3	AUX FLAP/FLAP CONTR
6B7	AWG-15 DC
5B5	AWG-15 PH A NO. 1
5B4	AWG-15 PH A NO. 2
5D5	AWG-15 PH B NO. 1
5D4	AWG-15 PH B NO. 2
5F5	AWG-15 PH C NO. 1
5F4	AWG-15 PH C NO. 2
3D3	BARO ALTM AC
7C6	BARO ALT/TURN SLIP
4F6	BDHI INST PWR/TACAN AC
7E8	BDHI/TACAN DC
7F6	BINGO/OXY CAUTION

Figure 2-36. Circuit Breaker Alphanumeric Index (Sheet 1 of 5)

7F2	BLEED AIR/L OIL HOT
4A4	BLEED DUCT AC
8D5	BRAKE ACCUM SOV
7A1	CABIN PRESS
7C5	CAN/LAD CAUTION/EJECT CMD IND
8D4	CDNU
LA2	CHAN 1 CADC PH A
LB2	CHAN 1 CADC PH B
LC2	CHAN 1 CADC PH C
LH2	CHAN 2 CADC
3D1	COMB HYD PRESS IND
8A5	CONTR/DISPL SUBSYS
1G2	CONTR/DISPLAY PH A
1G3	CONTR/DISPLAY PH B
1G6	CONTR/DISPLAY PH C
8D2	COUNTING ACCEL/TARPS/FEMS
7D5	CSDC
3B7	CSDC PH A
4B2	CSDC PH B
4B5	CSDC PH C
6B5	DC ESS NO. 1 FDR
7A2	DC ESS NO. 2 BUS FDR
7G7	DC L TEST/RUDDER TRIM
8D1	DC R TEST/AMC BIT
2G7	DDI AC
8C2	DDI/ANN PNL DIM CONTR
8G6	DDI DC ASW-27
7B1	DFCS BUS FDR
7D8	DISPLAY PWR
RD1	DUMP/FUEL FEED
8E7	DYHR UNIT
7D4	ECS TEMP CONTR DC
1J6	EGI SDC
6C3	EIG NO. 1
6C2	EIG NO. 2
5F3	EIG WHT LTS
7C5	EJECT CMD IND/CAN-LAD CAUTION
8H4	ELEC COOLING
6B2	EMERG FLT HYD AUTO
6B1	EMERG FLT HYD MAN
7E2	EMER GEN TEST/L AICS LKUP PWR
8I2	EMERG GEN CONTR
RB1	ENG ANTI-ICE/VALVES
4C6	ENG L OIL PRESS
7D1	ENG OIL COOL
RG2	ENG/PROBE/ANTI-ICE
4D6	ENG R OIL PRESS
7G8	ENG SEC
7F10	ENG STALL TONE
6A4	ENG STALL WARN LT
RE1	ENG START
7A5	EXHAUST NOZZLE/R ENG AFT CONT
7G10	EXT LT CONTR
8D2	FEMS/COUNTING ACCEL
7C4	FIRE L DET LT
6C5	FIRE L EXT
7C3	FIRE R DET LT
6C4	FIRE R EXT
7G3	FLAP CONTR/AUX FLAP
3E3	FLAP IND/TAIL/RUDDER
RE2	FLAP/SLAT CONTR SHUT-OFF
LD1	FLT CONTR AUTH AC
RF2	FLT CONTR AUTH DC
2A1	FLT HYD BACKUP PH A
2B1	FLT HYD BACKUP PH B
2C1	FLT HYD BACKUP PH C
3D2	FLT HYD PRESS IND
2H2	FORM/TAXI LT
RD1	FUEL FEED/DUMP
7F7	FUEL LOW CAUTION
RC1	FUEL MGT PNL
RG1	FUEL P/MOTIVE FLOW ISOL V (P-PUMP)
7F1	FUEL PRESS ADVSY
3F2	FUEL QTY IND AC
7D3	FUEL QTY IND DC
7E4	FUEL TRANS ORIDE
7F9	FUEL VENT VALVE
7F5	GEN L CAUTION
7F4	GEN R CAUTION
8F4	GND PWR/COOLING INTERLK
7G1	GND ROLL BRAKING/SPOILER POS IND
8D6	GND TEST BRAKE ACCUM SOV
8C3	GUN ARMED POWER
8B3	GUN CLR/GUN CONTR PWR DC
2H5	GUN CONTR PWR AC
8B3	GUN CONTR PWR DC/GUN CLR
8I3	GYRO PWR
1B1	HSD/ECMD PH A
1B4	HSD/ECMD PH B
1B7	HSD/ECMD PH C
8C4	HUD CAMERA DC

Figure 2-36. Circuit Breaker Alphanumeric Index (Sheet 2)

1F1	HUD CAMERA PH A
1D4	HUD CAMERA PH B
1E5	HUD CAMERA PH C
3C7	HUD PH A
4C2	HUD PH B
4C4	HUD PH C
1A1	HV PWR SUP PH A
1A2	HV PWR SUP PH B
1A3	HV PWR SUP PH C
7E6	HYD PRESS IND
7G11	HYD PUMP SPOILER CONTR
7E5	HYD VALVE CONTR
LD3	ICE DET
6F3	ICS NFO
6F2	ICS PILOT
2G3	IFF A/A AC
8F6	IFF A/A DC
7C7	ILS ARA-63 DC
3A6	ILS ARA-63 PH A
4A3	ILS ARA-63 PH B
4A5	ILS ARA-63 PH C
7G9	INBD SPOILER CONTR
4B6	INS SYNC/ACM PNL LT
5D3	INST BUS FDR
2I6	INST LT
1I2	INTEG TRIM AC
8F3	INTEG TRIM DC
4A2	INTRF BLANKER
8I1	INTRPT FREE DC BUS FDR NO. 1
8C6	INTRPT FREE DC BUS FDR NO. 2
6E3	JETT 1
6E2	JETT 2
7D7	JULIET 28
LF2	L AICS
2I5	L AICS HTR
7E2	L AICS LKUP PWR/EMER GEN TEST
6A6	L AICS RAMP STOW
8G4	L AIM-7 BATT ARM
7G7	L DC TEST/RUDDER TRIM
7A4	L ENG AFT CONT/ARMT/RATS IND
5A4	L ENG BACK-UP IGN
4C6	L ENG OIL PRESS
7C4	L FIRE DET LT
6C5	L FIRE EXT
7F5	L GEN CAUTION

1A5	L MAIN XFMR/RECT
7F2	L OIL HOT/BLEED AIR
3E6	L PH A TEST/P. ROLL TRIM
4E2	L PH B TEST/P. ROLL TRIM
4E5	L PH C TEST/P. ROLL TRIM
4D1	L PITOT STATIC HTR
3B1	L TIT IND
8F7	LANTIRN POD PWR
7A3	LCH BAR NLG STRUT ADVSY
2H10	LIQUID COOLING CONTR AC
8B4	LIQUID COOLING CONTR DC 3
LD2	MACH TRIM AC
RD2	MACH TRIM DC
LE2	MANUV FLAP/WG SWP DRIVE NO. 2
6B4	MASTER ARM
8H5	MASTER TEST
8A7	MCAP MDL
8H3	MECH FUZING STA 1/8
8H2	MECH FUZING STA 3/4
8H1	MECH FUZING STA 5/6
7G5	MLG HANDLE RLY NO. 1
7G4	MLG HANDLE RLY NO. 2
6F5	MLG SAFETY REL NO. 1
6F4	MLG SAFETY RLY NO. 2
8D3	MONITOR BUS CONTR
8I5	MOTOR FIRE A
8I4	MOTOR FIRE B
1G1	MSL AUX PH A
1G4	MSL AUX PH B
1G7	MSL AUX PH C
8A1	MSL AUX SUBSYS
2G2	MSL HTR PH A
2G5	MSL HTR PH B
2G8	MSL HTR PH C
8B1	NAV EGI
1I3	NAV PWR SUP PH A
1I5	NAV PWR SUP PH B
1I6	NAV PWR SUP PH C
2I2	NFO CONSOLE LT
7A3	NLG STRUT LCH BAR ADVSY
RB2	NOSE WHEEL STEER
5F6	NVG FLOOD LT
7F2	OIL L HOT/BLEED AIR
7D2	OIL R HOT
8C5	OUTBD SPOILER CONTR
2B2	OUTBD SPOILER PUMP

Figure 2-36. Circuit Breaker Alphanumeric Index (Sheet 3)

7F6	OXY/BINGO CAUTION
3F3	OXY QTY IND
7C8	PEDAL SHAKER/ALPHA COMP
3E6	P. ROLL TRIM/L PH A TEST
4E2	P. ROLL TRIM/L PH B TEST
4E5	P. ROLL TRIM/L PH C TEST
RA2	P. ROLL TRIM/SPD BK ENABLE
3E6	PH A L TEST/P. ROLL TRIM
2H1	PH A R TEST
4E2	PH B L TEST/P. ROLL TRIM
2H4	PH B R TEST
4E5	PH C L TEST/P. ROLL TRIM
2H8	PH C R TEST
2I3	PILOT CONSOLE LT
5A1	PILOT INST LT
LB1	PITCH A AC
7B7	PITCH A DC
LH1	PITCH B AC
7B3	PITCH B DC
4D1	PITOT L STATIC HTR
4D2	PITOT R STATIC HTR
7E3	PLT ANN PNL AUX PWR/TR-ADVSY
2I1	POS/ANTICOLL/SUPP POS LTS
RG2	PROBE/ENG/ANTI-ICE
4F2	PROBE LT
8C7	PTID DC
LG2	R AICS
2I8	R AICS HTR
7E1	R AICS LKUP PWR/ANTI-SKID
6A5	R AICS RAMP STOW
8G3	R AIM-7 BATT ARM
8D1	R DC TEST/AMC BIT
7A5	R ENG AFT CONT/EXHAUST NOZZLE
5A3	R ENG BACK UP IGN
3C2	R ENG N2 TACH
4D6	R ENG OIL PRESS
7C3	R FIRE DET LT
6C4	R FIRE EXT
7F4	R GEN CAUTION
2E3	R MAIN XFMR RECT
7D2	R OIL HOT
2H1	R PH A TEST
2H4	R PH B TEST
2H8	R PH C TEST
4D2	R PITOT STATIC HTR
3B2	R TIT IND

5D6	RADAR ALTM
8A3	RADAR SUBSYS NO. 1
8A2	RADAR SUBSYS NO. 2
7C2	RAIN REPL/ANTI-ICE CONTR/HKCONTR
8G7	RECCE ECS CONT/LANTIRN POD PWR
2C4	RECCE/LANTIRN PWR 3 PH
2G4	RECON ECS CONT AC
2B1	RECON HTR PWR PH A
1F4	RECON POD
8F7	RECON POD CONTR
8F2	RECON POD DC PWR NO. 1 [1]
8F1	RECON POD DC PWR NO. 2 [1]
7B4	ROLL A DC
LB3	ROLL A/YAW M
LA1	ROLL B AC
7B2	ROLL B DC
7G7	RUDDER TRIM/L DC TEST
3E7	RUDDER TRIM PH A
4E1	RUDDER TRIM PH B
4E4	RUDDER TRIM PH C
3E3	RUDDER/TAIL/FLAP IND
2I4	SEAT ADJ/ACM LT/STEADY POS LT
1E2	SEMI REG PWR SUP PH A
1E4	SEMI REG PWR SUP PH B
1E6	SEMI REG PWR SUP PH C
1J6	SIGNAL DATA CONVERTER
1H1	SOL PWR SUP PH A
1H5	SOL PWR SUP PH B
1H7	SOL PWR SUP PH C
RA2	SPD BK/P-ROLL TRIM ENABLE
7G11	SPOILER CONTR HYD PUMP
7G9	SPOILER CONTR INBD
8C5	SPOILER CONTR OUTBD
7G1	SPOILER POS IND/GND ROLL BRAKING
8E4	STA 1 AIM-9 COOL PWR
6D4	STA 1 AIM-9 REL PWR
2G1	STA 1 BOL PWR
6C7	STA 1 REL PWR A
6C6	STA 1 REL PWR B
8E6	STA 1A AIM-9 PWR
2H7	STA 1A AIM-9 PWR PH B
8E5	STA 1B AIM-9 PWR
2H9	STA 1B AIM-9 PWR PH C
1E1	STA 1/8 AIM-7 PH A
1E3	STA 1/8 AIM-7 PH B
1E7	STA 1/8 AIM-7 PH C
6D7	STA 2, 3, & 4 REL PWR A
6D6	STA 2, 3, & 4 REL PWR B

Figure 2-36. Circuit Breaker Alphanumeric Index (Sheet 4)

8H7	STA 3 NO. 1 DC
8D5	STA 4 NO. 1 DC
8I7	STA 5 NO. 1 DC
8G5	STA 6 NO. 1 DC
8H2	STA 3/4 MECH FUZING
1D1	STA 3/6 AIM-7/AIM-54 PUMP PH A
1D3	STA 3/6 AIM-7/AIM-54 PUMP PH B
1 D7	STA 3/6 AIM-7/AIM-54 PUMP PH C
1C1	STA 4/5 AIM-7 PH A
1C3	STA 4/5 AIM-7 PH B
1C7	STA 4/5 AIM-7 PH C
6E7	STA 5, 6, & 7 REL PWR A
6E6	STA 5, 6, & 7 REL PWR B
8E1	STA 8 AIM-9 COOL PWR
6D3	STA 8 AIM-9 REL PWR
2G4	STA 8 BOL PWR
6E5	STA 8 REL PWR A
6E4	STA 8 REL PWR B
8E3	STA 8A AIM-9 PWR
2I7	STA 8A AIM-9 PWR PH B
8E2	STA 8B AIM-9 PWR
2I9	STA 8B AIM-9 PWR PH C
7F8	STARTER VALVE LT/THRUST LIM
5A5	STBY ATTD IND PH A
5C5	STBY ATTD IND PH B
2I4	STEADY POS LT/ACM LT/SEAT ADJ
2I1	SUPP POS/ANTICOLL/POS LTS
3D6	TACAN ARM-84
7E8	TACAN/BDHI
4F6	TACAN/BDHI INST PWR
3E3	TAIL/RUDDER/FLAP IND
2H2	TAXI/FORM LT
1H2	TCS PH A
1H3	TCS PH B
1H6	TCS PH C
8A6	TCS SEL
4D4	TEMP CONT AC
7D4	TEMP CONTR ECS DC
7F3	TR-ADVSY/PLT ANN PNL AUX PWR
6F6	UHF CONTR
4D5	UTILITY LT
3B6	VDI PH A
4B1	VDI PH B
4B4	VDI PH C
LE2	WG SWP DR NO. 2/MANUV FLAP
7G6	WHEELS POS IND
2H6	WHITE FLOOD LT
3B3	WING POS IND AC
7G2	WING POS IND DC
LE1	WING SWEEP DRIVE NO. 1
7C2	WSHD AIR/ANTI-ICE/HK CONTR
8B2	WSHLD DEFOG CONTR
1A5	XFMR RECT L MAIN
2E3	XFMR RECT R MAIN
7B6	YAW A DC
7B5	YAW B DC
LC1	YAW A AC
LC3	YAW B AC
LB3	YAW M/ROLL A
3F7	26 VAC BUS FDR
1B2	28 VDC PWR SUP PH A
1B5	28 VDC PWR SUP PH B
1B8	28 VDC PWR SUP PH C

EFFECTIVITY

1 TARPS aircraft only.

2 Labeled RECON POD on TARPS aircraft.

3 TARPS aircraft with ALQ-167 pod circuit breaker is labeled LIQ CLG/ALQ-167 CONTR DC.

Figure 2-36. Circuit Breaker Alphanumeric Index (Sheet 5)

Note

- Panel No. 1 row A, the column numbering is different from rows B to J.

- Panel No. 2 rows A to F, the column numbering is different from rows G to I.

2.15.3 Degraded Electrical Operation

2.15.3.1 Emergency Generator. The emergency generator provides a limited but independent backup source of ac (5 kVA or 1 kVA, 115/200 volts) and dc (50 amperes, 28 volts) power for flight-essential components. It is driven by combined system hydraulic pressure.

With normal combined hydraulic system operation, the emergency generator powers the essential ac and dc No. 1 and No. 2 buses and the DFCS dc bus in the 5 kVA mode. Operation of the generator is automatically initiated with the loss of dc left main bus even if other dc buses remain energized. Approximately 1 second elapses from the time of automatic initiation before the generator delivers rated power to flight essential ac and dc buses. This delay will force the DFCS computers into a power-up BIT sequence, requiring a master reset to regain spoilers, SAS, and ARI functions.

WARNING

The spoiler actuators are mechanically biased to the retracted position in order to cause the spoilers to retract in the event that the command signal from the DFCS is lost (i.e., DFCS power failure). If this bias is reversed, the affected spoiler will extend instead of retracting when the command signal is lost. A DFCS power failure coupled with a reversed spoiler bias will result in a fully deployed spoiler. All unaffected spoilers will remain retracted and will not respond to flight control inputs until the DFCS command signals are restored.

Note

- DFCS synchronization can take up to 2 seconds following a power interrupt. If the MASTER RESET pushbutton is depressed during the synchronization time, an additional depression of the MASTER RESET pushbutton will be required to restore spoiler functionality.

- Do not press and hold the MASTER RESET pushbutton. Pressing and holding the MASTER RESET pushbutton during the synchronization time will have no effect since the DFCS computers only recognize the leading edge of the pulse from the MASTER RESET pushbutton, and not the fact that the button is continuously depressed.

Pilot control of the emergency generator is through the guarded EMERG switch on the MASTER GEN control panel. The emergency generator is electrically inhibited by a solenoid control valve energized by the left main dc bus.

With the switch in NORM, operation of the generator is automatically initiated, connecting to the essential buses, with the loss of the left main dc bus, regardless of other sources of ac or dc power. Total loss of ac or dc power will consequently result in the loss of the left main dc bus and activation of the emergency generator.

The OFF/RESET switch position provides the pilot with the capability of isolating emergency electrical power from the aircraft buses (as in the case of an electrical fire) or resetting the generator.

2.15.3.1.1 Emergency Power Distribution. An emergency generator control unit monitors the emergency generator output. If it senses that the emergency generator cannot supply power within the proper frequency and voltage tolerances, the control unit disconnects the ac essential No. 2, dc essential No. 2, and dc DFCS buses from the emergency generator (1 kVA mode). It is possible that this could happen if the combined hydraulic system is not operating normally. If combined hydraulic pressure subsequently recovers, the emergency generator switch must be cycled through OFF/RESET and back to NORM to regain the 5 kVA mode, restoring power to the essential No. 2 and DFCS buses. The DFCS computers will respond with a power up BIT sequence, requiring a MASTER RESET to regain spoilers, SAS, and ARI functions.

The exact hydraulic pressure at which the emergency generator is unable to power all three buses is dependent on the load placed on the generator and can vary from 2,000 to 1,100 psi indicated. If the emergency generator is required and there is a hydraulic emergency that could lower combined system operating pressure, the ac essential No. 2, dc essential No. 2, and dc DFCS buses can be powered with lower hydraulic pressure by securing non-essential equipment in order to reduce the electrical load and to maintain DFCS functionality.

Note

When the emergency generator is operating with one main hydraulic system inoperative, large hydraulic flow requirements for flight controls may cause loss of the ac essential No. 2, dc essential No. 2, and dc DFCS buses. To regain these buses, the emergency generator switch must be cycled through OFF/RESET to NORM after the hydraulic pressure recovers.

2.15.3.1.2 Emergency Generator Test. An operational check of the emergency generator can be accomplished anytime the combined system is pressurized and at least one main generator is on line by selecting EMERG GEN on the MASTER TEST switch and depressing the switch. This provides 28 Vdc to activate the emergency motor-generator and checks the tie contactors by connecting electrical power to the essential ac and dc buses. The GO light on the MASTER TEST panel indicates a satisfactory check. A malfunction in the emergency generator operation is indicated by the NO GO light.

Note

During the emergency generator test the essential ac No. 2 bus is switched between the left main and emergency generator. The DFCS computers detect this as a loss of ac power and perform a power-up BIT sequence when the emergency generator test is completed. A MASTER RESET is required to regain SAS and ARI functions.

2.16 HYDRAULIC POWER SUPPLY SYSTEMS

The aircraft employs two main, independent, engine-powered hydraulic systems, supplemented by two electro hydraulic power modules, a bidirectional transfer unit, and a cockpit hand pump. The systems are pressurized to 3,000 psi and use MIL-H-83282 hydraulic fluid circulated through stainless steel and titanium lines. Hydraulic fluid is cooled by heat exchangers that use ejector air on deck. Hydraulic power system controls and indicators are shown in Figure 2-37. The components serviced by each hydraulic power system are shown in FO–10.

2.16.1 Flight and Combined Systems

2.16.1.1 Engine-Driven Pumps. The flight and the combined systems are each pressurized by engine driven pumps. The flight hydraulic system pump is driven by the right engine and the combined hydraulic system pump by the left engine. Each of the main systems is normally pressurized to 3,000±100 psi anytime the respective engine is operating.

2.16.1.2 Hydraulic Pressure Light. A HYD PRESS caution light illuminates when the discharge pressure from either engine-driven hydraulic pump falls below 2,100 psi; thereafter, the light goes out when pressure in both systems via the engine-driven pumps exceeds 2,400 psi. If the HYD PRESS caution light has been illuminated by low pressure in one main system, pressure failure in the other system will not cause the MASTER CAUTION light to illuminate again. The COMB and FLT gauges on the hydraulic pressure indicator reflect system pressure provided by either the engine driven pumps or the hydraulic transfer pump. With both systems normally pressurized to 3,000 psi, the gauge needles form a horizontal line.

Note

High-rate lateral movements may illuminate the HYD PRESS light when engines are at idle power.

2.16.1.3 Hydraulic Transfer Pump (Bi-Directional Pump). To assure the continuance of main system hydraulic pressure with an engine or engine-driven pump inoperative, a second source of pressure is provided by the hydraulic transfer pump. This unit consists of two hydraulic pumps, one in each of the main hydraulic systems, interconnected by a common mechanical shaft. Thus, a pressure deficiency in one system is automatically augmented using pressure in the other system as the motive power. The result is bidirectional transfer of energy without an interchange of system fluid. The efficiency of the pump is such that a 3,000-psi system on one side will pressurize the other system to approximately 2,400 to 2,600 psi.

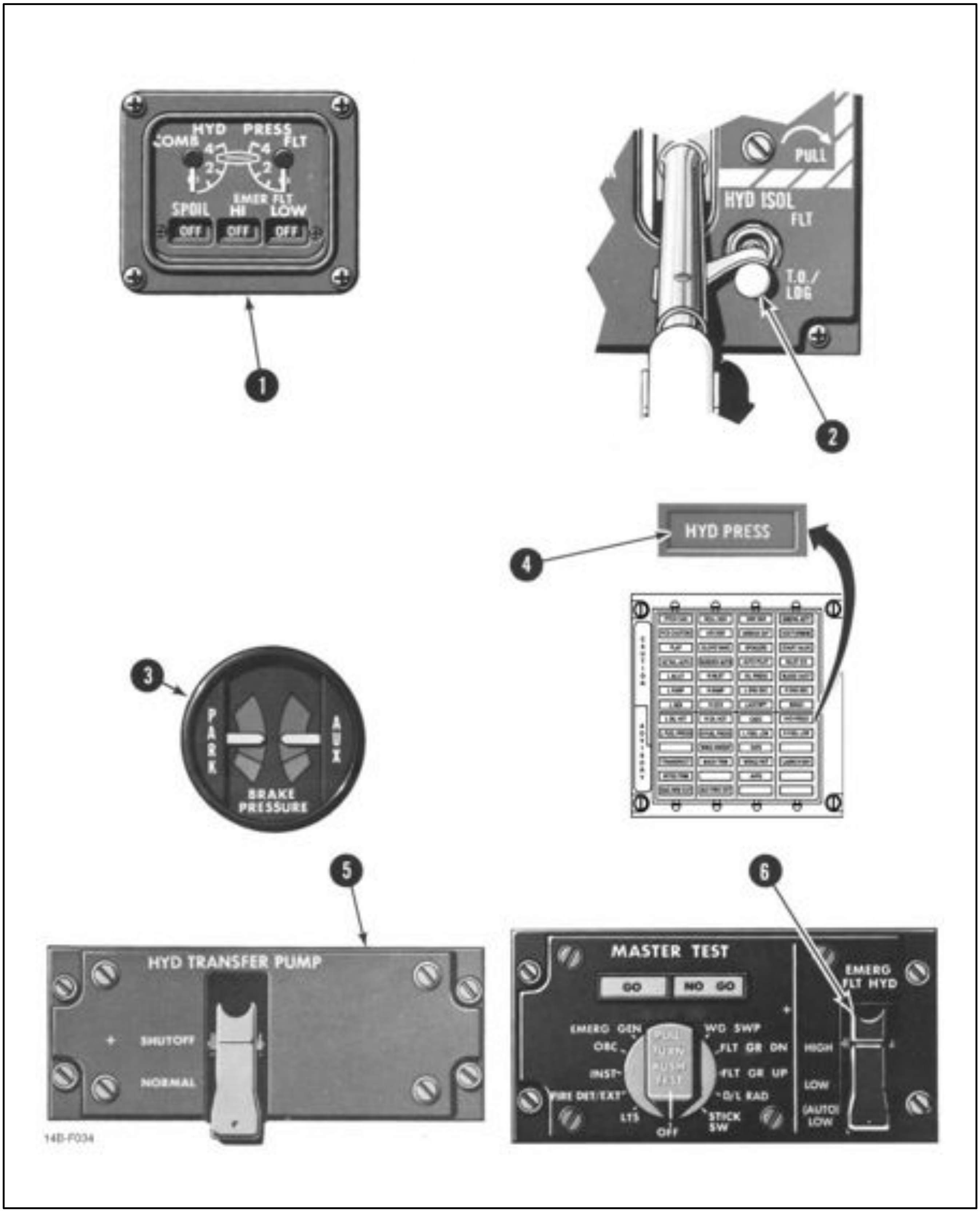


Figure 2-37. Hydraulic System Controls and Indicators (Sheet 1 of 2)

NOMENCLATURE	FUNCTION	
1 HYD PRESS Indicator	COMB and FLT —	Indicates pump discharge pressure on each engine, normally 3,000 psi, or hydraulic transfer pressure approximately 2,400 psi.
	SPOIL —	When the outboard spoiler hydraulic module is pressurized (1,950 to 2,050 psi) the ON flap appears. Pressure below 1,900 to 1,800 psi: the OFF flag appears.
	EMER FLT — HI LOW	When pressure from the backup flight control hydraulic module reaches 500±50 psi the ON flap appears. Pressure below 350±50 psi: the OFF flag appears.
2 HYD ISOL switch	FLT —	Combined system hydraulic pressure is shut off to landing gear, nosewheel steering, antiskid, and wheel brakes.
	T.O./LDG —	Hydraulic pressure is available to all combined system components.
3 BRAKE PRESSURE gage	AUX —	Green segment indicates hydraulic pressure (2,150±50 to 3,000 psi) in the auxiliary brake accumulator; auxiliary braking may be applied by ruddertoe pedals (approximately 13 to 14 applications available). Red segment indicates 1,900 to 2,150 psi (approximately 5 applications available).
	PARK —	Green segment Indicates hydraulic pressure (2,150±50 to 3,000 psi) in the parking brake accumulator; The parking/emergency brake handle must be pulled to apply emergency braking (approximately 3 applications available). Red segment indicates 1,900 to 2,150 psi.
4 HYD PRESS caution light	Illuminates when hydraulic pressure from either engine-driven pump is below 2,100 psi. It will go out with pressure In both systems at 2,400 psi or above, if pressure is provided by engine-driven pumps.	
5 HYD TRANSFER PUMP switch	SHUTOFF —	Guard must be lifted. Shuts off hydraulic transfer pump. Should be activated when hydraulic pressure drops below 500 psi and does not rise again within 5 seconds.
	NORMAL — (Guarded)	Safety guard down. Pressure loss below 2,100 psi in one hydraulic system activates hydraulic transfer pump to supply pressure from the other system.
6 EMERG FLT HYD switch	HIGH —	Guard must be lifted. Activates the power module (high speed mode) bypassing flight and combined 2,100-psi switches.
	LOW —	Guard must be lifted. Activates the backup power module (low-speed mode) bypassing flight and combined 2,100-psiswitches.
	AUTO (LOW) —	Safety guard down. The backup flight control system is automatically activated (low-speed mode) when pressure in both the flight and combined systems is less than 2,100 psi.

Figure 2-37. Hydraulic System Controls and Indicators (Sheet 2)

To prevent damage to the hydraulic transfer pump with the loss of system fluid on one side and to conserve hydraulic power in the remaining good system, the pump is automatically secured when pressure less than 500 psi is detected on either side of the pump for 10 seconds. In addition, the pilot can manually shut off the hydraulic transfer pump by lifting the guarded HYD TRANSFER PUMP switch, located aft on the right outboard console.

CAUTION

If pressure in either system remains below 500 psi for 5 seconds, immediately lift the guard and select SHUTOFF with the HYD TRANSFER PUMP switch. Failure of the hydraulic transfer pump to automatically shut off after 10 seconds below 500 psi may cause the driving system to cavitate and overheat.

With ground electrical power connected to the aircraft, the hydraulic transfer pump is deactivated and can only be energized by a switch on the ground check panel. Normally, with both engines running, the hydraulic transfer pump is off. However with less than 2,100-psi hydraulic pump discharge pressure from either system, the pump will automatically come on and supply hydraulic power to the faulty system. The pilot has no direct control over the direction of pump flow; the system automatically shifts in the direction that supplemental power is required. Because of the location of the flight and combined system pressure switches, the pressurization contribution of the hydraulic transfer pump is reflected on the hydraulic pressure indicator and may produce slight pressure fluctuations. Failure of either hydraulic system (<2,100 psi) will cause the HYD PRESS caution light to illuminate and remain illuminated with operation of the hydraulic transfer pump. If the failed system discharge pressure is restored to normal operating pressure (>2,400 psi) by the engine-driven pump, this HYD PRESS light will go out and the hydraulic transfer pump will shut off.

2.16.1.4 Cockpit Handpump. A manually operated pump handle is provided as a supplementary source of power for ground operations with engines shut down and as a backup for the loss of combined system pressure to operate the in-flight refueling probe or charge the brake accumulator. It is an extendable handle in the pilot cockpit between the left console and ejection seat. Forward and aft stroking of the handpump operates a double-acting wobble pump. The pump, which draws fluid from the combined system return line, recharges wheelbrake accumulator pressure when the landing gear handle is down. It also serves as a backup means of extending/retracting the in-flight refueling probe by placing the refuel probe switch in the desired position (EXT or RET).

The handpump is the only means of pressurizing the radome fold actuator, an operation that must be manually selected and the radome unlocked on deck from the nose wheel-well. The operation rate using the handpump power source is a function of the number of components selected. The recommended rate of operation is approximately 12 cycles per minute (a cycle is a complete forward and aft movement of the pump handle).

2.16.2 Hydraulic Power Distribution. The distribution of hydraulic power in the flight and combined systems is shown in FO–10. Except for the left empennage control surfaces, the flight system services only those components on the right side of the aircraft and does not penetrate into the wings. The combined system distribution is more extensive throughout the aircraft, yet its services are predominantly concentrated to the left side and extend to the inboard sections of the movable wing panels and to the landing gear. Although the flight and combined systems are completely independent of each other, in certain components, both pressure sources are used without an interchange of fluid. Both systems operate in parallel to supply power for operation of the primary flight control surfaces (except spoilers) and stability augmentation actuators. If one system fails, the other can continue to supply pressure for operation (with reduced power capability of such components). If either or both main hydraulic systems should fail, backup sources provide the capability for safe return flight and landing.

Major components in the combined and flight hydraulic power supply systems are shown in FO–10. Each system has a piston-type reservoir and filter module in the sponson aft of the main landing gear strut on the respective side (combined, left; flight, right). Protrusion of mechanical pins on each filter module indicates a clogged filter.

2.16.2.1 Hydraulic Priority Valves. The combined and flight hydraulic systems each incorporate two priority valves (1,800 psi and 2,400 psi) shown in FO–10. Hydraulic fluid will not pass through the one-way priority valves unless the input pressure exceeds the cracking threshold of the valve. Basically, the 2,400-psi priority valves give priority of the individual engine-driven pump discharge pressure to the primary flight controls (horizontal tails, rudders, inboard spoilers) and stability augmentation actuators. Conversely, the 1,800 psi priority valves give priority to the remaining systems on the other side (inlet ramps, wing sweep, etc.) with pressure supplied by the hydraulic transfer pump. Under such circumstances, the pilot should be aware of the hydraulic energy available and demands of the various system components. Large and abrupt control commands can rapidly consume total energy with the engine(s) at IDLE speed. For example, during a single-engine landing rollout if excessive horizontal tail movements are commanded, the nosewheel steering and wheelbrake operation could be temporarily lost.

2.16.2.2 Normal Hydraulic Isolation. The combined system incorporates isolation circuits to limit distribution of flight essential components. With the LDG GEAR handle UP, normal isolation may be selected by the pilot to prevent loss of hydraulic fluid in the event of material failure or combat damage to the isolated systems. Normal isolation electrically shuts off hydraulic pressure to wheelbrakes, antiskid, landing gear, and nosewheel steering. It is activated by placement of the HYD ISOL switch to FLT on the landing gear panel. Placement of the gear handle to DN mechanically cams the HYD ISOL switch to T.O./LDG or the pilot can manually select it before lowering the landing gear. Such action returns all combined-system components to normal operation.

2.16.3 Outboard Spoiler System. The outboard spoilers are powered by a separate closed-loop system, independent of the main hydraulic systems (see Figure 2-38). An electrohydraulic power module supplies hydraulic pressure for outboard spoiler deflection and provides a backup power source for the main flaps and slats. Outboard spoiler operation is electrically inhibited at wing-sweep angles greater than 62° and the power module is deactivated at wing-sweep angles greater than 65°.

A thermal cutout circuit secures the system in the event of overheating. Normal operation is automatically restored when fluid temperature falls below the prescribed limit. The thermal cutout circuit is disabled with the gear handle down and weight off wheels to prevent over temperature shutdowns during takeoff or landing. To avoid overheating caused by prolonged ground operations, the outboard power module is deactivated with the flap handle up when on internal electrical power with weight on wheels.

Electrical power for the outboard spoiler system motor is supplied from the right main ac bus. The module can be activated using external ac electrical power. With the module pressurized, the ON flag appears in the SPOIL window at the bottom of the hydraulic pressure indicator; otherwise, an OFF indication is displayed in the window.

Reservoir servicing level is shown by an indicator rod protruding from the integral power package. A fluid temperature gauge that registers current and retained peak system temperatures is on the power module. Protrusion of a red-tipped pin on the integrated filter package is an indication of a clogged filter.

2.16.3.1 Flap and Slat Backup Operation. Although normal operation of the main flap and slat segments is powered by a combined system motor on the flap and slat gearbox, an auxiliary motor powered by the outboard spoiler system is geared to the same shaft to provide for emergency operation (retraction and extension) of the main flaps and slats at a reduced rate. Failure of combined system pressure activates the auxiliary motor to drive the flap and slat gearbox when selected by the normal flap handle or maneuvering flap thumbwheel.

2.16.4 Backup Flight Control System. The backup flight control system consists of a two-speed electrohydraulic power module that provides fluid energy to operate the horizontal tails and rudders at a reduced rate (see Figure 2-39). Emergency power provides sufficient pitch, roll, and yaw control for return flight and landing with both main hydraulic power systems inoperative.

Return flow from the combined side of the rudder and stabilizer actuators is first used to ensure the BFCM reservoir is filled. When filled, a reservoir bypass valve opens that allows return flow to the combined system. A priority valve connects the BFCM return to the aircraft combined system return. When the combined

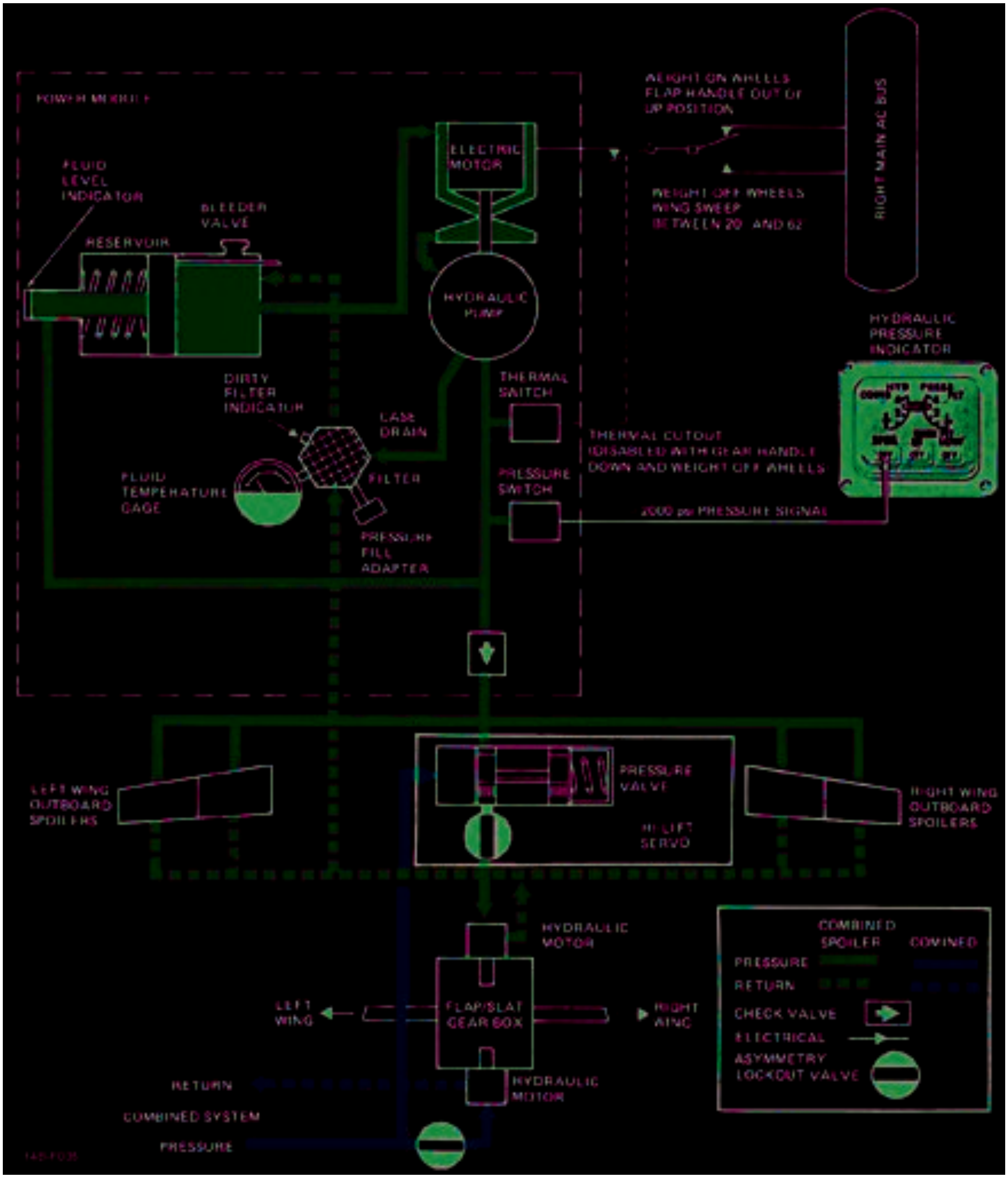


Figure 2-38. Outboard Spoiler System

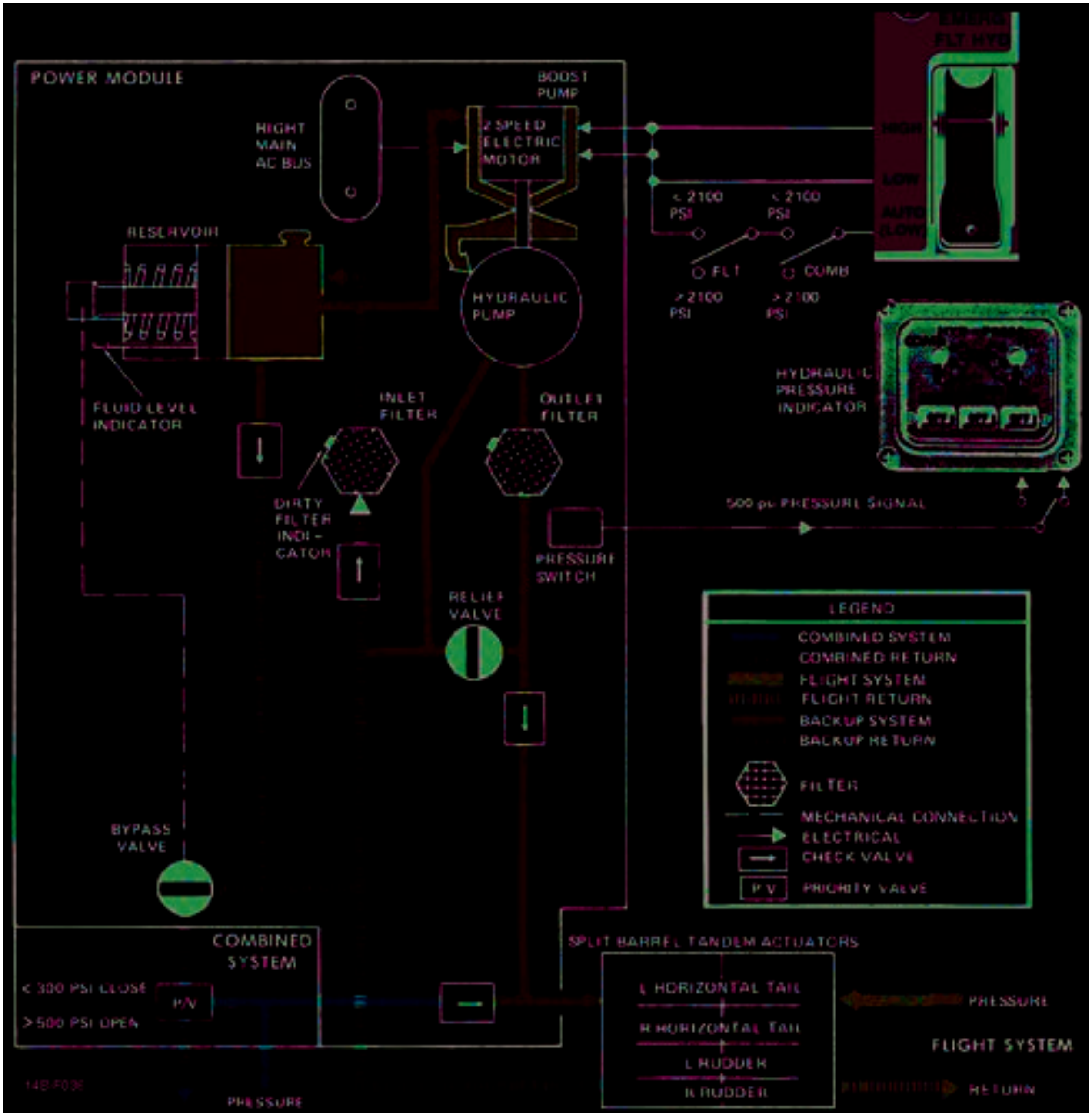


Figure 2-39. Backup Flight Control System

system pressure falls below 300 psi, the priority valve closes, isolating the BFCM return from the combined system return. When the combined pressure exceeds 500 psi, the priority valve opens allowing the backup system return to flow into the combined system return. A check valve isolates backup system pressure from the combined system when the BFCM is energized.

2.16.4.1 Backup Flight Control Operation. The module may be operated in two modes: emergency and ground test. In the emergency mode, the module is controlled by the EMERG FLT HYD switch on the MASTER TEST panel. The switch has three positions: AUTO (LOW), HIGH, and LOW mode. Electric power to the motor is supplied by the right main ac electrical bus through the FLT HYD BACKUP PH A (2A1), PH B (2C1), and PH C (2E1) circuit breakers located on the right main ac circuit breaker panel (No. 2) in the rear cockpit. Loss of both engine-driven electrical generators eliminates in-flight use of the module.

CAUTION

Never use the three-phase circuit breakers (PH A, PH B, and PH C) to start or shut off backup module as damage to the motor may result. These circuits must be engaged prior to any system test.

Automatic control of the module is provided by the closing of both flight and combined hydraulic system pressure switches. Since the switches are set at 2,100 psi, both flight and combined hydraulic system pressures must drop below 2,100 psi before the module is turned on in the auto (low) mode. Once in this automatic mode of operation, the module cannot be turned off unless either or both flight and combined systems are pressurized above 2,400 psi. The EMERG FLT HYD switch is used to select the LOW or HIGH mode. Either of these positions overrides the circuitry of the auto (low) mode and the module will remain on even if either or both system pressures become pressurized above 2,400 psi. When the module pump reaches 500 psi, the on flag appears in the selected window at the bottom of the hydraulic pressure indicator.

WARNING

When operated in conjunction with zero combined system pressure, some backup module hydraulic fluid will be forced out by thermal expansion. The module will remain fully serviced and operate normally as long as the elevated temperatures are maintained. Once operating, the module should not be turned off in flight without combined system pressure available to reservice it. Doing so would result in fluid contraction and an underserviced condition that could prevent subsequent pump operation.

CAUTION

If either the flight or the combined hydraulic system pressure drops below 2,100 psi without illuminating the HYD PRESS caution light the auto (low) mode of the backup flight control system may be inoperative.

2.16.4.2 Ground Operations. Ground checks of the backup module are performed by the pilot using the EMERG FLT HYD switch. Before performing ground checks, the reservoir should be serviced by pressurizing the combined hydraulic system. Both hydraulic system pressures should indicate zero in order to fully test independent operation of the module.

CAUTION

A 180 °F thermal cutoff switch is bypassed when the backup module is selected on with the EMERG FLT HYD switch. Prolonged ground operation in the emergency mode will result in module burnout.

CAUTION

Since flight control demands can exceed backup module capability, all surface demands must be performed slowly and cautiously in order not to exceed the output rate of the system. Excessive system demands will cause the pump to cavitate and the motor to overheat. Checks should be made slowly enough to ensure continuous on indication in the hydraulic pressure indicator.

2.16.4.2.1 Ground Test Mode. The ground test mode of operation is controlled by the AUX HYD CONT switch on the ground test panel in the rear cockpit. In this mode, the module operates in the high mode only. Ground test from the rear cockpit is electrically inhibited when the aircraft is on internal electrical power. For ground inspection purposes, protrusion of a red-tipped button on either the inlet or outlet filter cases is a positive indication of a dirty filter. Both such indications may be observed through an access door on the underside of the aft fuselage.

CAUTION

The ground test mode incorporates a solenoid valve that allows the backup module to pressurize the entire combined hydraulic system. If the combined and brake accumulators are not fully charged (brake pressure indicator at top of green) or if the combined system is not fully serviced, the reservoir will be depleted and the motor will cavitate and overheat. This could result in motor failure prior to activation of the thermal cutoff switch.

In the low-speed mode, the system can operate indefinitely and should be used for maximum range and endurance. Emergency power (high mode) provides a maximum unloaded horizontal tail-deflection rate approximately one fourth of that available from a fully powered hydraulic system (10° per second versus 36° per second). The maximum deflection rate available will decrease as airloads increase.

CAUTION

Prolonged use (approximately 8 minutes cumulative time) of the BFCM in the high mode may result in a failure of the module.

2.17 PNEUMATIC POWER SUPPLY SYSTEMS

The pneumatic power supply systems consist of three independent, stored pneumatic pressure sources for normal and auxiliary operation of the canopy and for emergency extension of the landing gear. The high-pressure bottles for normal canopy operation and another for the emergency landing gear extension are ground-charged through a common filter connection in nose wheelwell to 3,000 psi at 70 °F ambient temperature. Individual bottle pressure is registered on separate gauges on the right side of the nose wheelwell. An auxiliary canopy-open N_2 bottle, filter valve, and gauge are on the turtleback behind the cockpit to allow opening the canopy from the cockpit or ground. Charges may be compressed air; however, pressurized dry nitrogen is preferred because of its low moisture content and inert properties.

2.17.1 Normal Canopy Control. The bottle that supplies a pressurized charge for normal operation of the canopy is on the right side of the forward fuselage, inboard of the air refuel probe cavity. Expenditure of bottle pressure for normal operation of the canopy is controlled by three (pilot, RIO, and ground) canopy control handles. A fully charged bottle provides approximately 10 complete cycles (open and close) of the canopy before reaching the minimum operating pressure of 225 psi.

2.17.2 Auxiliary Canopy Open Control. The auxiliary canopy air bottle supplies a pneumatic charge to translate the canopy aft so that the counterpoise action of the canopy actuator facilitates opening. It is on the turtleback behind the canopy hinge line.

Activation of the auxiliary mode can be effected from either of the three (pilot, RIO, or ground) canopy control handles. After activation of the auxiliary open mode, the control system will not return to the normal mode of operation (canopy will lower but will not translate forward) until the auxiliary selector valve on the aft canopy deck is manually reset (lever in vertical position). Servicing of the auxiliary canopy air bottle is through the small access panel immediately behind the canopy on the turtleback. The reservoir is normally serviced to 3,000 psi at 70 °F ambient temperature. A fully charged bottle provides more than 20 operations in the auxiliary open mode. Minimum preflight pressure is 800 psi.

2.17.3 Emergency Gear Extension. The bottle that supplies the pneumatic force for a single emergency extension of the landing gear is on the right side of the nose wheelwell. Expenditure of bottle pressure is controlled by a twist-pull operation of the landing gear handle. Minimum bottle pressure for accomplishing emergency extension of the gear to the down-and-locked condition is 1,800 psi. Normal preflight bottle pressure is 3,000 psi at 70 °F.

Note

- Emergency extension of the landing gear shall be logged in the maintenance action form.
- Once the landing gear is extended by emergency means, it cannot be retracted while airborne and must be reset by maintenance personnel.
- Use of emergency gear extension results in loss of nosewheel steering.

2.18 STANDARD CENTRAL AIR DATA COMPUTER

Note

The acronyms SCADC and CADC are used interchangeably throughout this manual.

The SCADC is functionally interchangeable with the CADC 1166B/A with one difference: the SCADC software incorporates the static error source correction curve required for the true values of Mach number, airspeed, and altitude.

The CADC is a single-processor, digital computer with a separate independent analog backup wing-sweep channel. It is capable of making yes and no decisions, solving mathematical problems, and converting outputs to either digital or analog form as required by each aircraft system. The CADC gathers, stores, and processes pitot pressure, static pressure, total temperature and angle-of-attack data from the aircraft airstream sensors (see Figure 2-40). It performs wing sweep and flap and slat schedule computations, limit control and electrical interlocks, failure detection, and systems test

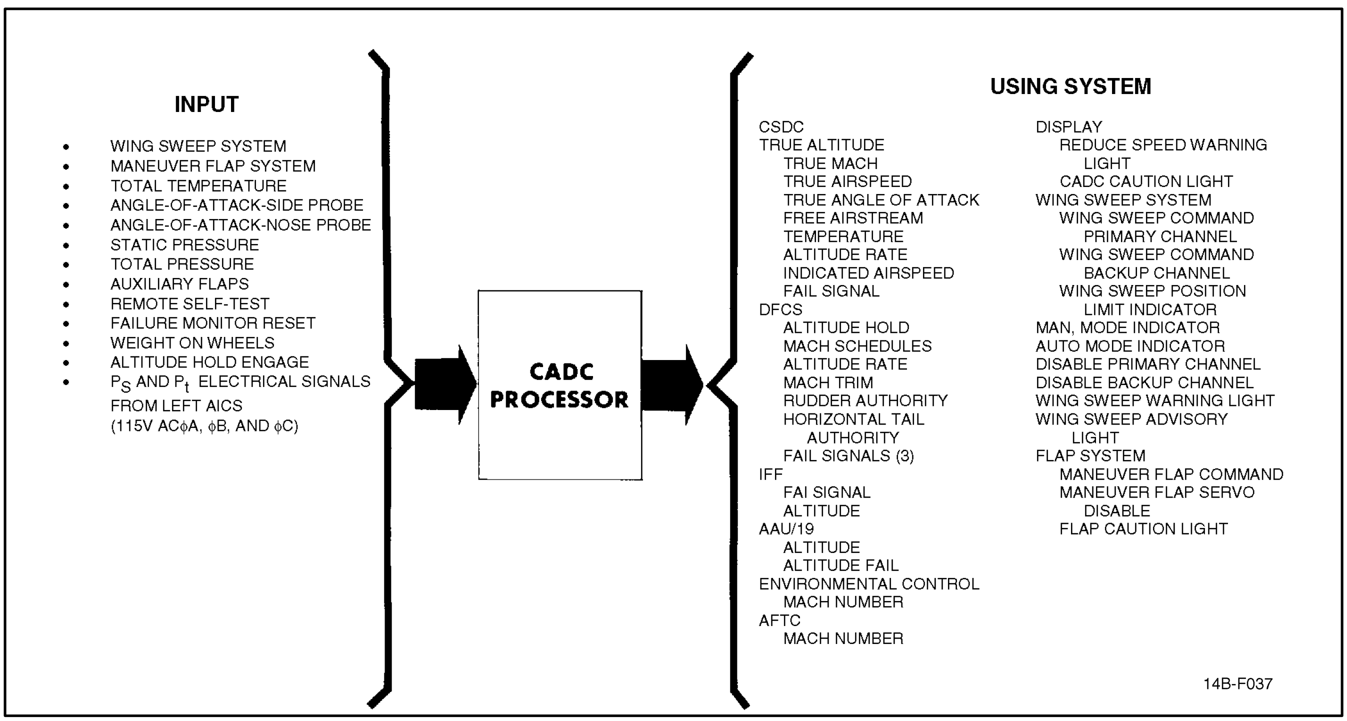


Figure 2-40. CADC Functional Relationships

logic. Major systems that depend on all or part of these CADC functions are shown in Figure 2-41.

2.18.1 CADC Tests

2.18.1.1 Built-In Test. BIT capabilities provide continuous monitoring of the CADC and its inputs and outputs. The failure indicator matrix (Figure 2-42) tabulates the functions that are monitored and associated fail indications.

2.18.1.2 Onboard Checkout. The CADC performs a self-test during OBC only with weight on wheels. When OBC is initiated, normal air data inputs are locked out and in their place constants from the computer memory are received. Self-test detected failures may be manually reset by pressing the MASTER RESET pushbutton.

Pressing the MASTER RESET pushbutton for 1 second resets transient failures in the CADC. Activating the master reset circuit recycles the failure detection process in the CADC. This recycling process puts off the caution, advisory, and warning light(s) and may take as long as 10 seconds to check out the status of the system. If a failure exists, the light(s) will illuminate again. If a transient failure existed, the light(s) will remain off.

The following caution, advisory, and warning lights are activated by the CADC:

CADC	REDUCE SPEED
FLAP	WING SWEEP (advisory) *
GLOVE VANE	WING SWEEP (warning)**

* If the WING SWEEP advisory light does not recycle when MASTER RESET pushbutton is depressed, the light is activated by the wing flap and glove-vane controller.

** If the WING SWEEP warning light does not recycle when MASTER RESET pushbutton is depressed, the light is activated by the emergency WINGSWEEP handle being out of detent.

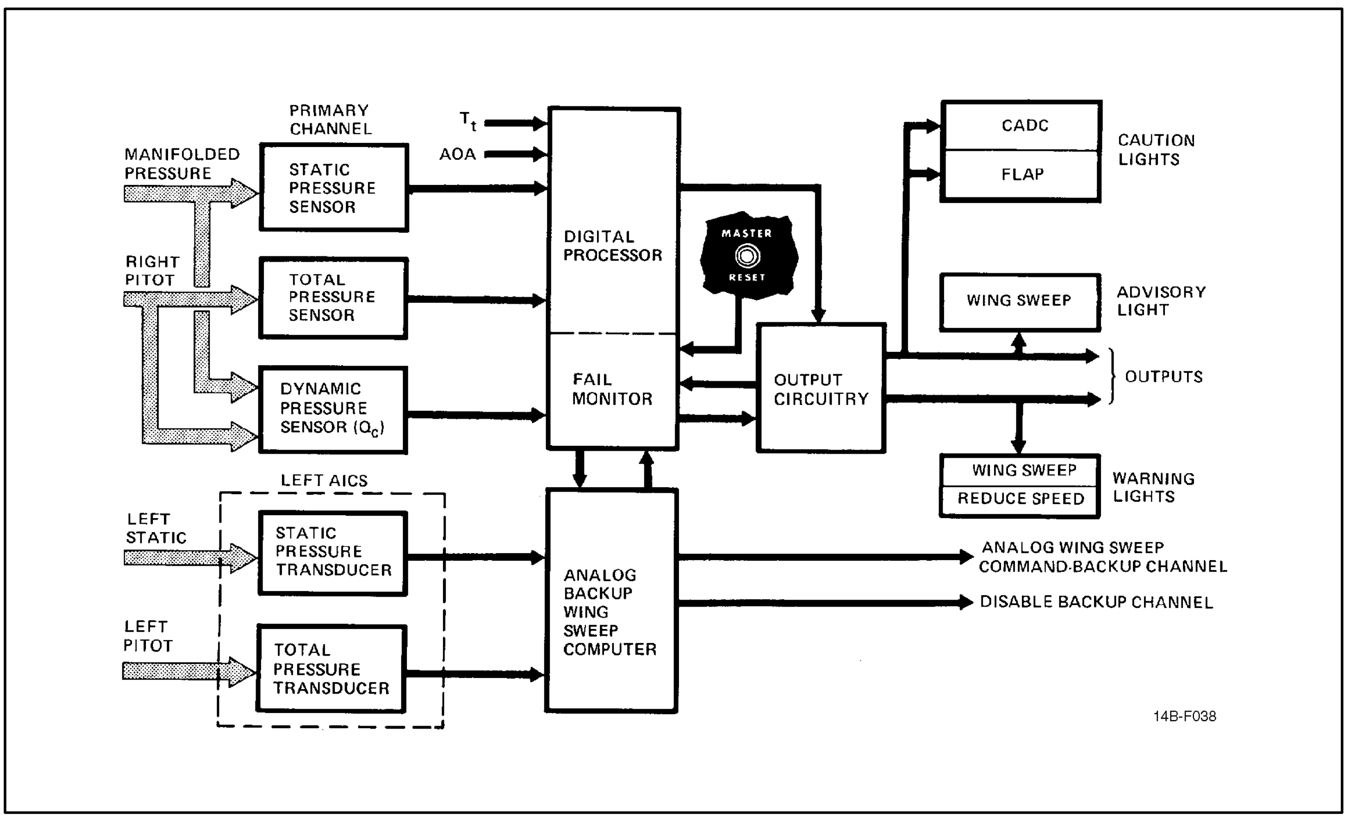


Figure 2-41. CADC Processor

FAILURE \ INDICATION	CADC	Wing Sweep Advisory	Wing Sweep Warning	Flap	Reduce Speed	Rudder Auth	HZ Tail Auth	Mach Trim	REMARKS
CADC — P_S/P_t SENSOR COMPARE DIGITAL PROCESSOR	●	●		●	●	●	●	●	WING-SWEEP LIMIT BUG MAY BE INACCURATE, MAXIMUM SAFE MACH INDICATOR MAY BE INACCURATE, MANEUVER FLAPS, INOPERATIVE, ALTIMETER TO STANDBY.
CADC WING-SWEEP COMMAND (SINGLE FAILURE)	●	●							
CADC WING-SWEEP COMMAND (DUAL FAILURE)	●	●	●						AUTO WING SWEEP INOPERATIVE
WING SWEEP (SINGLE FAILURE)		●							
WING SWEEP (DUAL FAILURE)		●	●						AUTO WING SWEEP INOPERATIVE
CADC MANEUVER FLAP COMMAND	●			●					MANEUVER FLAPS VIA THUMBWHEEL INOPERATIVE
MANEUVER FLAP — COMMAND AND SERVO MISCOMPARE				●	*				MANEUVER FLAPS VIA THUMBWHEEL INOPERATIVE
MANEUVER FLAP — HYDRAULIC VALVE AND/OR ACTUATOR MISCOMPARE				●	*				
MANEUVER FLAP — HANDLE AND/OR HYDRAULIC VALVE MISCOMPARE				●					
AUXILIARY FLAP AND MANEUVER FLAP MISCOMPARE				●					
AUXILIARY FLAP ASYMMETRY				●					
CADC RUDDER OR STABILIZER COMMAND AUTHORITY	●					●	●		
ANGLE-OF-ATTACK SIGNAL	●								ANGLE-OF-ATTACK DISPLAY NOT PRESENT ON HUD DURING LANDING MODE
TOTAL TEMPERATURE SIGNAL	●								AUTO PILOT CAUTION LIGHT ILLUMINATES IF IN ALTITUDE HOLD. ALTITUDE HOLD WILL BE DISENGAGED VERTICAL SPEED NOT PRESENT ON HUD DURING TAKEOFF AND LANDING MODE
CADC WING SWEEP INDICATOR OUTPUT	●								WING SWEEP INDICATOR INACCURATE
ECS FAILURE AND MACH > 0.25.	●								CABIN TEMPERATURE MAY RISE AFTER LANDING. COOLING AIR ADVISORY LIGHT MAY ILLUMINATE
ECS FAILURE AND MACH > 0.4.	●								
CADC DIGITAL DATA TO CSDC	●								ALTITUDE AND MACH NOT DISPLAYED ON HUD. ANGLE-OF-ATTACK DURING LANDING DISPLAY NOT ON HUD. DURING TAKEOFF AND LANDING VERTICAL SPEED NOT ON HUD.
ALTITUDE HOLD OUTPUT ALTITUDE RATE OUTPUT	●								AUTO PILOT CAUTION LIGHT ILLUMINATES IF IN ALTITUDE HOLD ALTITUDE HOLD WILL BE DISENGAGED
MACH TRIM OUTPUT	●							●	
ALTITUDE TO PRESSURE ALTIMETERS	●								ALTIMETERS SWITCH TO STANDBY

* REDUCE SPEED LIGHT WILL ILLUMINATE IF AIRSPEED >225 KIAS AND FLAPS ARE GREATER THAN 4°

Figure 2-42. CADC Processor Indicators

Three independent CADC fail signals drive the DFCS failure detection circuits. If these signals exist, the DFCS will illuminate the following lights:

1. CADC fail signal to pitch computer: no light

2. CADC fail signal to yaw computer: RUDDER AUTH and HZ TAIL AUTH

3. CADC fail signal to roll computer: MACH TRIM, FCS CATION and ARI DGR.

Note

- If autopilot is engaged the AUTOPILOT light will illuminate when CADC input to the pitch computer is failed. If ACL is engaged, ACLS/AP lights will also illuminate.

- Pressing MASTER RESET pushbutton will also update the wing-sweep, flap, and glove-vane commands to their respective feedback signals. As a result, there may be movement in the wings, maneuver flaps and glove-vanes when MASTER RESET pushbutton is depressed.

2.19 WING-SWEEP SYSTEM

The variable geometry of the wing-sweep system provides the pilot with considerable latitude for controlling wing lift and drag characteristics to optimize aircraft performance over a broad flight spectrum.

Under normal operating conditions, the wings are automatically positioned to the optimum sweep angle for maximum maneuvering performance. The pilot can selectively position the wings at sweep angles aft of optimum.

A mechanical backup control system is provided for emergency and oversweep operations. Details of the wing-sweep system are shown on FO–11.

The outboard location of the wing pivot reduces the change in longitudinal stability as a function of wingsweep angle. Two independently powered, hydromechanical screwjack actuators, mechanically interconnected for synchronization, position the wings in response to pilot or CADC commands. In flight, the wings can be positioned between 20° and 68° wing leading-edge sweep angle. On the deck, the range is extended aft to 75° (oversweep position) to reduce the span for spotting. Such authority results in a variation of wing span from approximately 64 to 33 feet.

Cavities above the engine nacelles and the midfuselage accommodate the inboard portions of the wing panels as they sweep aft. Sealing of the underside is by a wiper seal and airbag. The bag is pressurized by engine bleed air. Airbag pressure is released during oversweep to avoid overloading of the flap mechanism. An overwing fairing encloses the wing cavity and provides a contoured seal along the upper surface of the wing for the normal range of in-flight sweep angles. The left and right overwing fairing actuators are pressurized by the combined and flight hydraulic systems, respectively.

2.19.1 Wing-Sweep Performance. Maximum wing-sweep rate (approximately 15° per second) is adequate for most transient flight conditions; however, wing-sweep rate can be significantly reduced or stalled by negative-g or large positive-g excursions. Sufficient capability has been provided in the system, consistent with the sustained performance capabilities of the aircraft. Failure of either the combined or flight hydraulic systems permits the wings to move at a reduced rate.

CAUTION

Slower than normal wing sweep cycling times may also be indicative of a failed hydraulic wing sweep motor or an impending failure. With aircraft on the ground and both FLT and COMB hydraulic power, the time to sweep the wings from 68° to 20° should not exceed 9 seconds.

Note

The overwing fairings and flaps are susceptible to a high frequency (60 cycles per second) low-amplitude oscillation that can be felt in cockpit. This overwing fairing and flap buzz is normal and is influenced by rigging of the fairings and air in the hydraulic systems.

Note

Overwing fairing and flap buzz is usually encountered between 0.9 and 1.4 IMN.

2.19.2 Wing-Sweep Modes. Normal control of the wing-sweep position in AUTO, AFT, FWD, and BOMB modes is by the four-way wing-sweep switch on the inboard side of the right throttle grip (Figure 2-43). As an emergency mode of control, changes in wing-sweep position can be selected manually with the emergency WING SWEEP handle on the inboard side of the throttle quadrant. The handle is connected directly to the wingsweep hydraulic valves. The command source for positioning the wings depends upon the module selected by the pilot or, in certain cases, is automatically selected. Electrical and mechanical wing-sweep command paths are shown on FO–11. Wing-sweep modes are shown in Figure 2-44.

WARNING

The emergency wingsweep handle can be moved independent of the wings and wing-sweep indicators when no hydraulic power and/or electrical power are on the aircraft. Care must be taken to accurately determine the position of the emergency wingsweep handle prior to application of hydraulic power. Inadvertent wingsweep to the position selected by the emergency wingsweep handle may occur, resulting in potential damage to the aircraft. When positioning the wings during ground operation other than pilot poststart or postlanding checklist procedures, use the emergency wingsweep handle to minimize the possibility of moving the wings inadvertently.

Note

- When positioning the wings, do not command opposite direction until wings have stopped in original commanded position (all sweep modes) to increase motor life.
- The optimum wing position (triangular index) and the AUTO/MAN flags may be unreliable when the CADC caution light is illuminated.

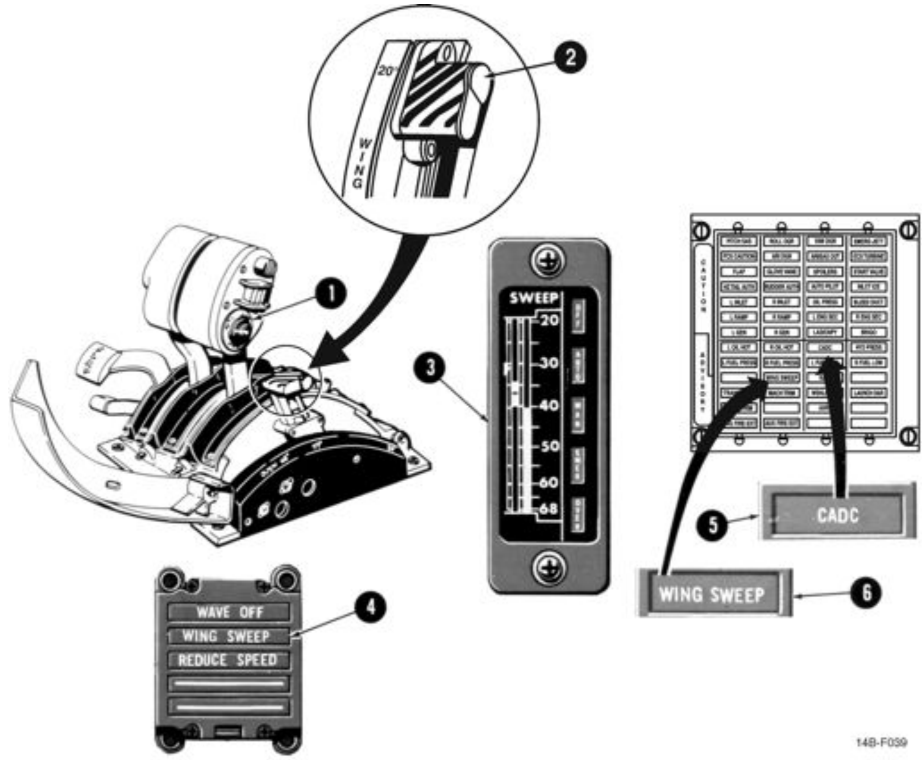
2.19.2.1 Auto Mode. Selection of the auto mode is made by placing the four-way wing-sweep switch in the upper detented position (AUTO) that permits the CADC wing-sweep program to position the wings automatically. The program positions the wings primarily as a function of Mach number but includes pressure altitude biasing. Wing position is scheduled to the optimum sweep angle for developing maximum maneuvering performance. In addition to providing an automatic wing positioning function, the programmer also defines the forward sweep limit that cannot be penetrated using any of the other electrical (manual or bomb) modes. The forward sweep limiter prevents electrical mispositioning of the wings from a wing structure standpoint.

Pilot selection of the auto mode or automatic transfer from the manual mode causes the AUTO flag to appear in the wing-sweep indicator. Once in the auto mode, the four-way WING SWEEP switch can be in the center position without changing the command mode.

2.19.2.2 Manual Mode. The manual wing-sweep mode is commanded by selecting AFT or FWD from the neutral position of the wing-sweep switch, driving the wings in the commanded direction to any wing-sweep position aft of the automatic program. The switch is spring loaded to return to the center position. Manual command mode exists unless the wing-sweep program is intercepted, at which point transfer to the auto mode is automatic. Indication of the existing mode is provided by the AUTO and MAN flags in the wingsweep indicator.

2.19.2.3 Bomb Mode. Bomb mode is selected by moving the WING SWEEP switch to the down (BOMB) position. With the switch in BOMB, the following occurs:

1. Wing-sweep indicator shows MAN flag.
2. If wing sweep is less than 55°, wings will drive to 55°.



NOMENCLATURE	FUNCTION
(1) Wing sweep switch	AUTO — Wing sweep angles are determined by CADC according to wing sweep program. Detented switch position. BOMB — Wings are positioned at 55° or further aft if commanded by the CADC program. Detented switch position. AFT/FWD — The pilot can select AFT or FWD wing positions within limits imposed by the wing sweep program. Switch is spring-loaded to the center position. When the forward limit is intercepted, the mode is transferred to AUTO.
(2) Emergency WING SWEEP handle	Provides a mechanical means of wing sweep control that overrides the CADC program commands. Wing sweep angles between 20° and 68° are unrestricted except for flap interlocks. Oversweep 75° is provided with weight-on-wheels, horizontal stabilizer authority restricter in reduced range, and air bag pressure dumped.
(3) Wing SWEEP indicator	Displays (from right to left) actual wing sweep position, commanded position and wing sweep program position, which is the maximum forward angle at present airspeed and attitudes. Indicator windows show the operating mode.
(4) WING SWEEP warning light	Indicates failure of both wing sweep channels and/or disengagement of spider detent. Wing sweep positioning is required using the emergency wing sweep handle.
(5) CADC caution light	Indicates hardware failure and/or that certain computations of the air data computer are unreliable. Illumination of WING SWEEP warning and/or advisory light determines pilot action.
(6) WING SWEEP advisory	Indicates failure of a single channel in the system. Illumination of both WING SWEEP advisory and CADC caution light indicates failure of one channel in CADC.

Figure 2-43. Wing-Sweep Controls and Indicators

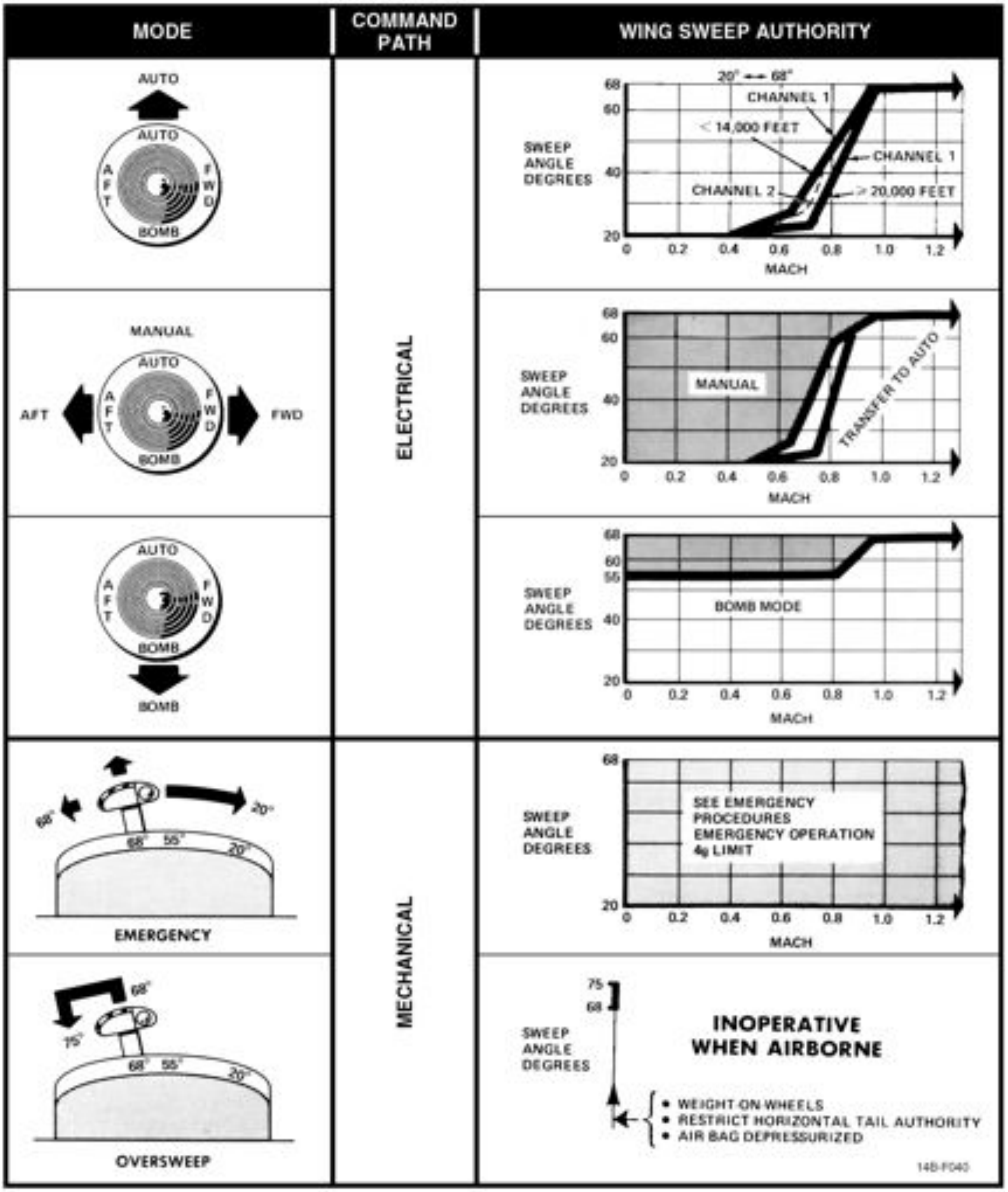


Figure 2-44. Wing-Sweep Modes

3. If wing sweep is greater than 55°, wings will not move.
4. If maneuver flaps are extended, they will retract and wings will sweep to 55°.

As the aircraft accelerates and the auto wing-sweep schedule is intercepted, the wings will follow the auto schedule even though the switch remains in bomb mode. Upon decelerating, the wings will sweep forward to 55° and stop.

2.19.2.4 Emergency Mode. During normal mode operation of the wing-sweep system, the wing-sweep control drive servo drives the hydraulic valve command input through a spider detent mechanism. The emergency handle under a transparent guard is moved in parallel with the servo output. The emergency mode provides an emergency method of controlling wing sweep. It bypasses the normal command path of the fly-by-wire system (CADC and control drive servo loop).

To select emergency mode, the handle must be extended vertically and the guard should be moved out of the way before the handle is operated. Vertical extension of the emergency handle provides for better accessibility and leverage. The detent is not disengaged by raising the handle vertically. An initial fore or aft force of up to 30 pounds breakout and 13 pounds maximum is necessary for operation.

The spider detent is reengaged if the handle is repositioned to the detent (servo) position.

The emergency WING SWEEP handle incorporates locks at approximately 4° increments between 20° and 68°. These locks are provided to eliminate random wing movement in the emergency mode should electrical system transients be experienced. When the locks are engaged, wing movement is inhibited provided that wings match handle position. The wing-sweep locks eliminate the need for the installation or activation of wing-sweep servo cutout switches. Locks are engaged by raising the handle 1 inch from the stowed position. In order to bypass the locks and select a wing position, the handle is raised an additional 1 inch (2 inches from stowed) and moved to the desired position. The handle is spring loaded to return to the lock position when released. The handle can be raised from 20° to 68° and oversweep but can only be returned to the stowed position at 20° and oversweep. This feature is intended to prevent inadvertent engagement of the auto mode, commanding the wings to spread causing possible damage to the aircraft or injury to personnel in a confined area. The handle is spring loaded toward the stowed position but requires depressing the release button on the inboard side of the lever in order to return the handle to the stowed position.

CAUTION

- Except for wing flap (main and auxiliary) and oversweep interlocks in the control box, the emergency mode does not prevent pilot mispositioning of the wings from a structural standpoint.
- If operating in the emergency wing-sweep mode, positively confirm flaps/slats indicate fully retracted prior to attempting aft wing sweep.

Since the wing-sweep program acts as a forward limiter only for the normal modes of operation, the pilot must follow the following schedule in the emergency mode:

0.4 IMN — 20°

0.7 IMN — 25°

0.8 IMN — 50°

0.9 IMN — 60°

1.0 IMN — 68°

When operating in the emergency mode, pulling the WING SWEEP DRIVE NO. 1 (LE1) and WG SWP DR NO. 2/MANUV FLAP (LE2) circuit breakers on the pilot left knee panel assures that the electrical command path cannot interfere with the emergency mode.

2.19.2.5 Oversweep Mode (75°). The wing oversweep mode allows sweeping the wings aft of 68° to 75° during on-deck operation only, thereby reducing the overall width of the aircraft for deck spotting. At 75°, the wing trailing edge is over the horizontal tail surface.

With the wings at 68°, oversweep can be initiated by raising the emergency WING SWEEP handle to its full extension and holding. Raising the handle releases air pressure from the wing-seal airbags and activates the horizontal tail authority system, restricting the surface deflections to 18° trailing edge up and 12° trailing edge down. During motion of the horizontal stabilizers, the HZ TAIL AUTH caution light is illuminated. When the horizontal tail authority restriction is accomplished (approximately 15 seconds), the HZ TAIL AUTH caution light will go off and the OVER flag on the wing-sweep indicator will be visible. This advises the pilot that the oversweep interlocks are free, allowing movement of the emergency WING SWEEP handle to 75° and stow.

The EMER and OVER flags on the wing-sweep indicator will be visible.

CAUTION

- Failure of the oversweep interlocks while trying to achieve oversweep may result in damage to either the wingtip and horizontal tail trailing edge of the maneuver flap actuator or both.
- If unusual resistance is encountered while attempting to put the wings into oversweep, continued aft pressure on the WING SWEEP handle may cause failure of the wing-sweep actuator.
- Avoid stick movements with the wings in oversweep and the HZ TAIL AUTH light illuminated and/or the OVER flag not displayed in the wing-sweep indicator.

The reverse process takes place when sweeping forward from oversweep. However, there is no need to hold the emergency handle in the raised position at 68°. Motion out of oversweep is completed (wing-seal airbag pressure established and horizontal tail authority restriction removed) when both the OVER flag and the HZ TAIL AUTH caution lights are off. Six seconds later, the WING SWEEP advisory light will illuminate. Upon engagement of the spider detent by further unsweeping the emergency handle, MASTER RESET pushbutton is pressed to clear both WING SWEEP advisory and warning lights, thus activating the electrical command circuits of the wing-sweep system.

CAUTION

When coming out of oversweep and a 68° wing position is desired, the wings should be moved forward to approximately 60° and then back to 68°.

2.19.3 Wing-Sweep Interlocks. Automatic limiting of wing-sweep authority is provided under normal in-flight control modes to prevent mispositioning of the wings at conditions that could result in the penetration of structural boundaries. Wing-sweep interlocks within the CADC are shown in Figure 2-45. Wing sweep is also electrically inhibited at normal accelerations less than –0.5g.

2.19.3.1 Flap and Slat Wing-Sweep Control Box. Electromechanical (auxiliary flaps, oversweep enable) and mechanical (main flap) interlocks in the control box limit aft wing-sweep commands at 21°, 15°, 50°, and 68°. Interlocks in the control box are shown in Figure 2-45. These interlocks, which serve as a backup to the electronic interlocks in the CADC, are imposed on both the normal and the emergency inputs to the control box and assure noninterference between movable surfaces and the fuselage.

2.19.4 Wing-Sweep System Test

2.19.4.1 Continuous Monitor. The command and execution of the wing-sweep system is continually monitored by a failure detection system. The failure detection system in the CADC governs the change from wing-sweep channel 1 to channel 2 or the disabling of wing-sweep channel 1 or 2 by switching the respective control drive servo off. A single-channel failure in the wing-sweep electrical command path is indicated by illumination of the WING SWEEP advisory light followed by normal operation on the remaining channel. Failure of the remaining channel is indicated by illumination of the WING SWEEP warning light, after which wing-sweep control must be exercised through the emergency WING SWEEP handle.

Transient failures in the CADC can be reset by pressing the MASTER RESET pushbutton, which recycles the failure detection system.

2.19.4.2 Preflight Check. A preflight check of the wing-sweep system to assure proper operation of the electrical command circuits without moving the wings

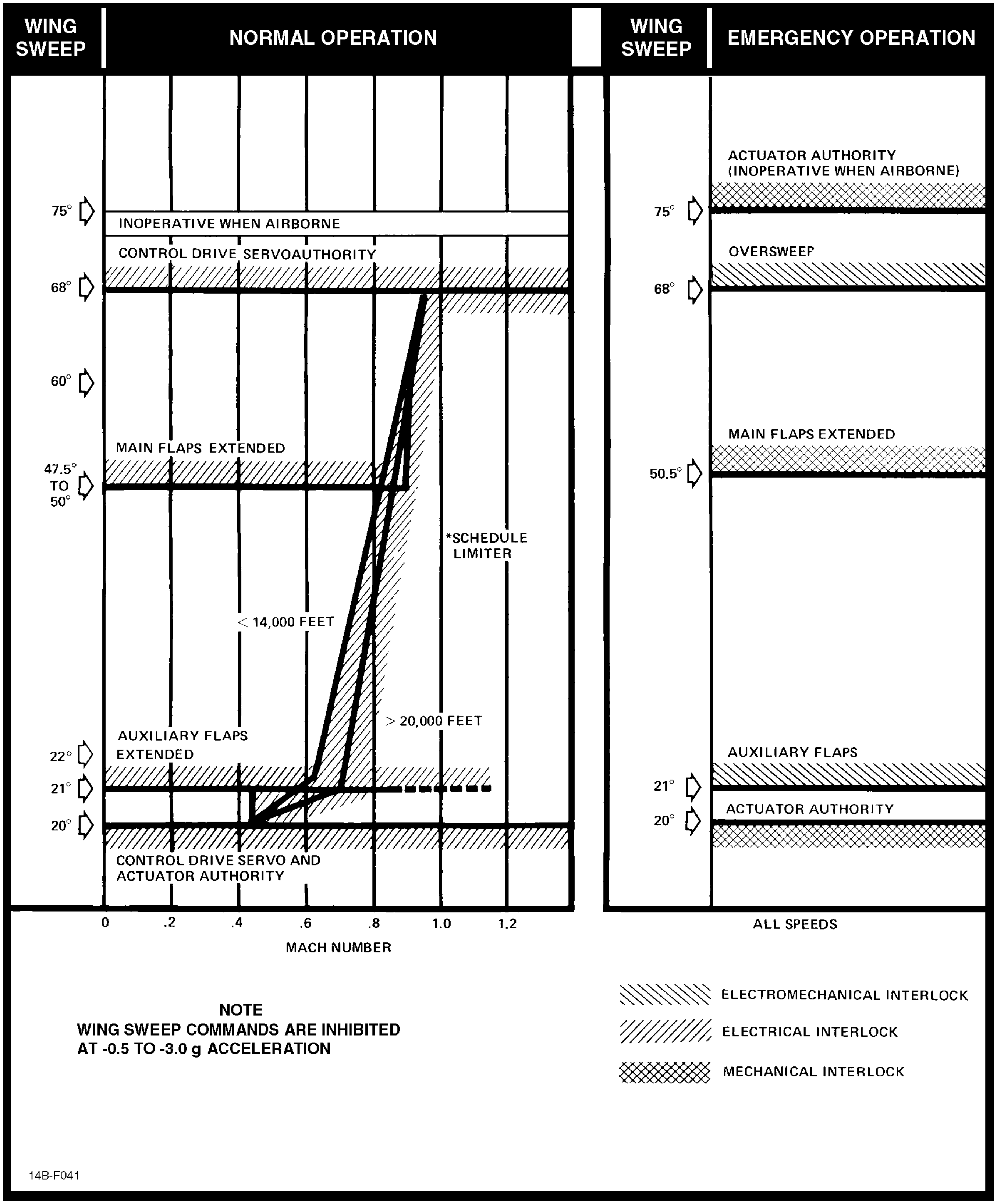


Figure 2-45. Wing-Sweep Interlocks

should be accomplished after starting engines while the wings are in oversweep (75°).

1. Set wing-sweep mode switch to AUTO.

Note

The CADC caution light will illuminate and test will not run if AUTO is not selected on the wing-sweep switch.

2. Press MASTER RESET pushbutton.
3. Set MASTER TEST switch to WG SWP.
4. Monitor test by observing:
   a. Wing-sweep limit pointer drives to 44°.
   b. Illumination of the WING SWEEP advisory light and FLAP caution light and the REDUCE SPEED warning light.

Note

The WING SWEEP advisory light will illuminate 3 seconds after test starts, then go off and illuminate again at 8 seconds into test.

   c. At end of test (approximately 25 seconds) the limit pointer will drive to 20° and above lights will go off.
5. Set MASTER TEST switch to OFF.

Note

Ignore illumination of RUDDER AUTH caution or MACH TRIM advisory lights and motion of the control stick if they occur during the test.

2.20 FLAPS AND SLATS

The flaps and slats form the high-lift system, which provides the aircraft with augmented lift during the two modes of operation: take off or landing and maneuvering flight. The flaps are of the single-slotted type, sectioned into three panels on each wing. The two outboard sections are the main flaps utilized during both modes of operation. The inboard section (auxiliary flap) is commanded only during takeoff or landing. The slats consist of two sections per wing mechanically linked to the main flaps. Flaps down greater than 10° enables the wheels warning light interlock, and greater than 25° enables direct lift control.

2.20.1 Flap and Slat Controls. Pilot controls for flap and slat takeoff, landing, and maneuvering modes are illustrated in Figure 2-46.

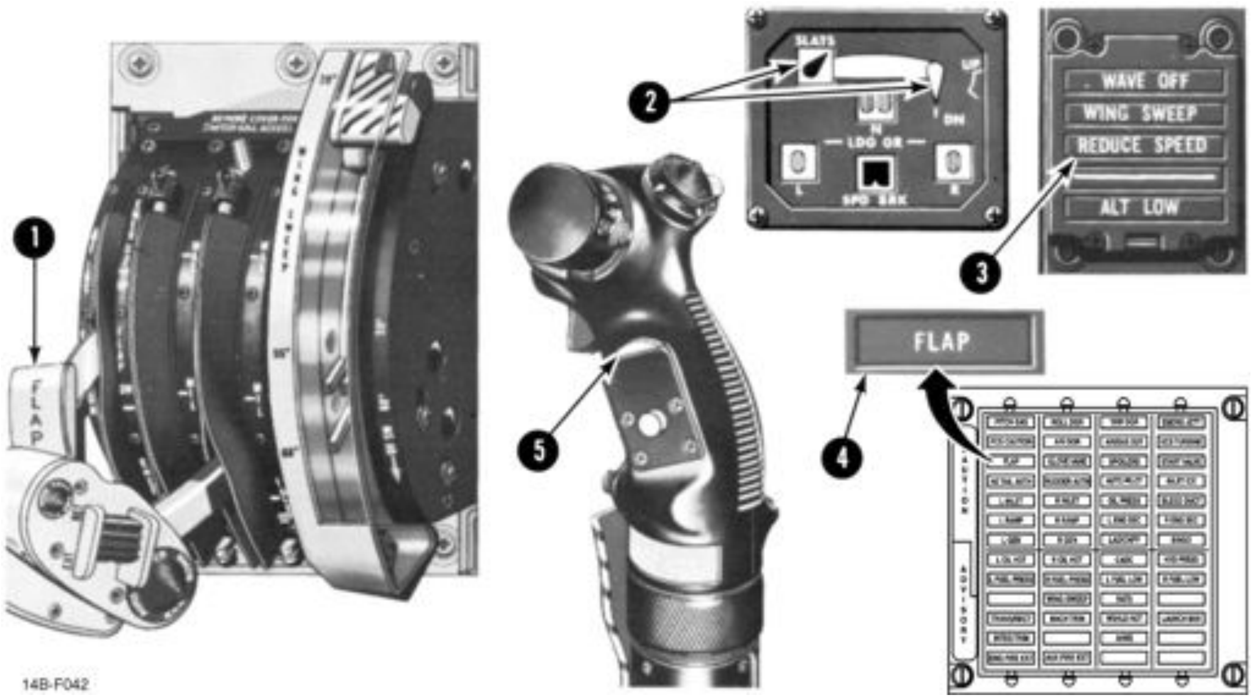
2.20.1.1 FLAP Handle. The FLAP handle, located outboard of the throttles, is used to manually command flaps and slats to the takeoff and landing position. Flap handle commands are transmitted by control cable to the flap and slat and wing-sweep control box where they are integrated with CADC electromechanical inputs to command proper flap and slat position.

2.20.1.1.1 Emergency Flaps. EMER UP enables the pilot to override any electromechanical commands that may exist because of malfunction of the CADC. To position the flaps, move the FLAP handle to the end of the normal travel range, then move handle outboard and continue moving to extreme EMER UP. While moving handle, forces may be higher than normal. EMER DN has no function.

CAUTION

- Reversal of flap direction while flaps are in motion will damage the flexible drive-shafts between the main flap and slat gearbox and the flap and slat drive sequencer.
- A slip clutch assembly is installed between the combined system forward flap hydraulic motor and the center gearbox assembly. While this will relieve some stall torque on the hydraulic motor, extremely fast reversals of flap direction while flaps are in motion may result in eventual failure of the flap and slat flexible driveshaft.

2.20.1.2 Maneuver Flap and Slat Thumbwheel. The maneuver flap and slat thumbwheel is located on the left side of the stick grip and is spring loaded to the center position. With LDG GEAR and FLAP handles up, automatic CADC flap and slat positioning can be overridden with pilot thumbwheel inputs to partially or fully extend or retract the maneuvering flaps and slats; however, the next time angle of attack crosses an extension or retraction threshold, the automatic command will again take precedence, unless manually overridden again. Manual thumbwheel command is a proportional command.



NOMENCLATURE	FUNCTION	
(1) FLAP handle	UP —	Normal retraction of main and auxiliary flaps.
	DN —	Normal extension of main and auxiliary flaps.
	EMER UP —	Emergency retraction of main flaps to full up overriding any electromechanical command faults.
	EMER DN —	No function.

Figure 2-46. Flap and Slat Controls and Indicators (Sheet 1 of 2)

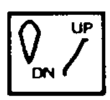
NOMENCLATURE	FUNCTION
(2) Flap and Slats Indicator	 — Power off; maneuver slats extended  — Slats extended (17°). Slats position is an electrical pickoff of right slat position only.  — Slats retracted (0°).  — Flaps full up (0°). Flap position is pickoff from hydraulic motor for main flaps only.  — Maneuver flaps down (10°).  — Flaps full down (35°) 14B-F043
(3) REDUCE SPEED warning light	Main flap comparator failures with flaps not retracted and airspeed >225 KIAS (see Figure 2-41). Maximum safe Mach exceeded (2.4 M). Total temperature exceeds 388 °F.
(4) FLAP caution light	Disagreement between main and/or AUX flap position (10-second light) or asymmetry lockout (3-second light). CADC failure. WG SWP DR NO. 2/MANUV FLAP (LE2) circuit breaker pulled.
(5) Maneuver flap and slat thumbwheel	Forward — Commands maneuver flaps and slats to retract. Neutral — Automatic CADC program. Aft — Commands maneuver flaps and slats to extend.

Figure 2-46. Flap and Slat Controls and Indicators (Sheet 2)

2.20.2 Main Flaps. The main flaps on each wing consist of two sections, simultaneously driven by four mechanical actuators geared to a common flap driveshaft. Each wing incorporates a flap asymmetry sensor and flap overtravel switches for both the extension and retraction cycles.

Cove doors, spoilers, eyebrow doors, and gusses operate with the flaps to form a slot to optimize airflow over the deflected flap. The cove doors are secondary surfaces along the underside of the wing forward of the flap (Figure 2-47). As the flaps pass 25° deflection, a negative command received from the DFCS depresses the spoilers to –4 1/2° to meet with the cove doors. Because the spoilers do not span the entire wing as do the flaps, gusses inboard and outboard of the spoilers perform the flap-down function of the spoilers. With the flaps retracted, the eyebrow doors, which are the forward upper surface of the flaps, are spring loaded in the up position to close the gap between the trailing edge of the spoiler or guss and the leading edge of the flaps. Mechanical linkage retracts the eyebrow door when the flaps are lowered to provide a smooth contour over the upper surface of the deflected flap.

2.20.3 Auxiliary Flaps. The auxiliary flaps are inboard of the main flaps and are powered by the combined hydraulic system. The actuator is designed to mechanically lock the auxiliary flaps when in the up position. In the event of high dynamic-pressure conditions, a bypass valve within each control valve opens causing the auxiliary flap to be blown back, thus avoiding possible structural damage. During loss of electrical power, the control valve is spring loaded to retract, retracting the auxiliary flaps within 1 minute. The auxiliary flaps use cove doors, eyebrow doors, and gusses identical in purpose and operation with those associated with the main flaps.

2.20.4 Slats. The slats on each wing are divided into two sections, both of which are driven simultaneously by a single-slat driveshaft. The slats are supported and guided by seven curved tracks.

2.20.5 Flap and Slat Operation

Note

- There is no automatic flap/slat retraction.
- With flaps extended by the FLAP handle and an airspeed of 225 KIAS or greater, the REDUCE SPEED light will illuminate.

2.20.5.1 Normal Operation. The main flap and slat portion of the high-lift system is positioned with a dual redundant hydromechanical servo loop in response to the FLAP handle command. The auxiliary flap is a two-position control surface powered by the combined hydraulic system. With the FLAP handle exceeding 5° deflection, the auxiliary flaps fully extend. Conversely, they retract for a FLAP handle position equal to or less than 5°. The torque of the flap and slat drive hydraulic motor is transmitted by flexible driveshafts to each wing.

2.20.5.2 Degraded Operation. In the event of a combined hydraulic system failure, outboard spoiler module fluid is automatically directed to a backup hydraulic motor to lower main flaps and slats only. In the event of main flap asymmetry greater than 3°, slat asymmetry greater than 4°, or flap surface overtravel, the flap and slat system is disabled. Flaps and slats will remain in the position they were in when failure or malfunction occurred. The auxiliary flaps are automatically commanded to retract. There is no asymmetry protection for the auxiliary flaps.

2.20.5.3 Flap Wing Interlocks. The main flap and auxiliary flap commands are interlocked electrically and mechanically with the wing sweep to prevent flap fuselage interference. An electrical interlock in the CADC and a mechanical command in the wing-sweep control box prevent wing sweep aft of 22° with auxiliary flaps extended. In a similar manner, upon extension of the main flaps, the wings are electrically and mechanically limited to wing-sweep angles less than 50°. The FLAP handle is mechanically prevented from moving to the down position if wing position is aft of 50°. If flaps are lowered with wings between 21° and 50°, main flaps will extend but auxiliary flaps will remain retracted.

CAUTION

If flaps are extended with wings between 21° and 50°, auxiliary flap extension is inhibited and a large down-pitch trim change will occur.

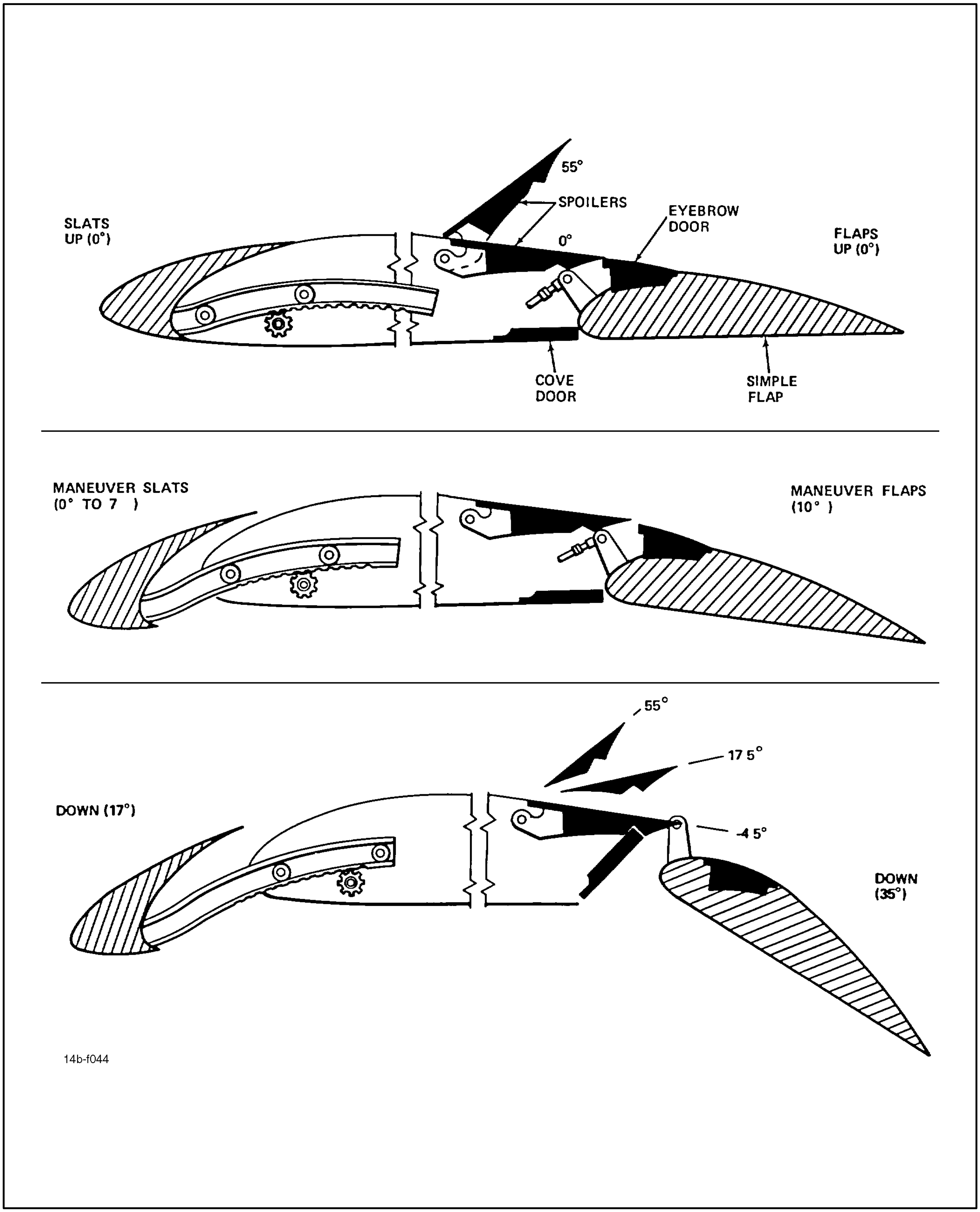


Figure 2-47. Wing Control Surfaces

CAUTION

Pulling the FLAP/SLAT CONTR SHUT-OFF circuit breaker (RE2) will eliminate flap overtravel protection, could eliminate mechanical or electrical main and auxiliary flap interlocks, and may allow the wings to be swept with the flaps partially or fully down in the wing-sweep emergency mode.

2.20.5.4 Maneuver Flap and Slat Mode. The main flaps can be extended to 10° with the slats extended to 7° within the altitude and Mach envelope shown in Figure 2-48.

Maneuver flaps and slats are automatically extended and retracted by the CADC as a function of angle of attack and Mach number (Figure 2-49). The schedule commands full maneuver flaps and slats as soon as the slatted wing maneuvering efficiency exceeds that of the clean wing.

Note

CADC maneuver flap commands are automatically reset when the flap handle is placed down greater than 2°, wing-sweep bomb mode is selected or maneuver flaps are commanded to less than 1° by the CADC because of dynamic pressure.

The angle-of-attack input to the CADC from the alpha computer is inhibited and will retract the maneuver devices if they are extended when the LDG GEAR handle is lowered. This is to ensure that the maneuver devices are retracted before lowering the FLAP handle. Maneuver devices' extended condition is indicated by a SLATS barberpole and an intermediate (10°) flap position.

CAUTION

If maneuver devices are not retracted prior to lowering the FLAP handle, a rapid reversal of the flaps will occur with possible damage to the flap system.

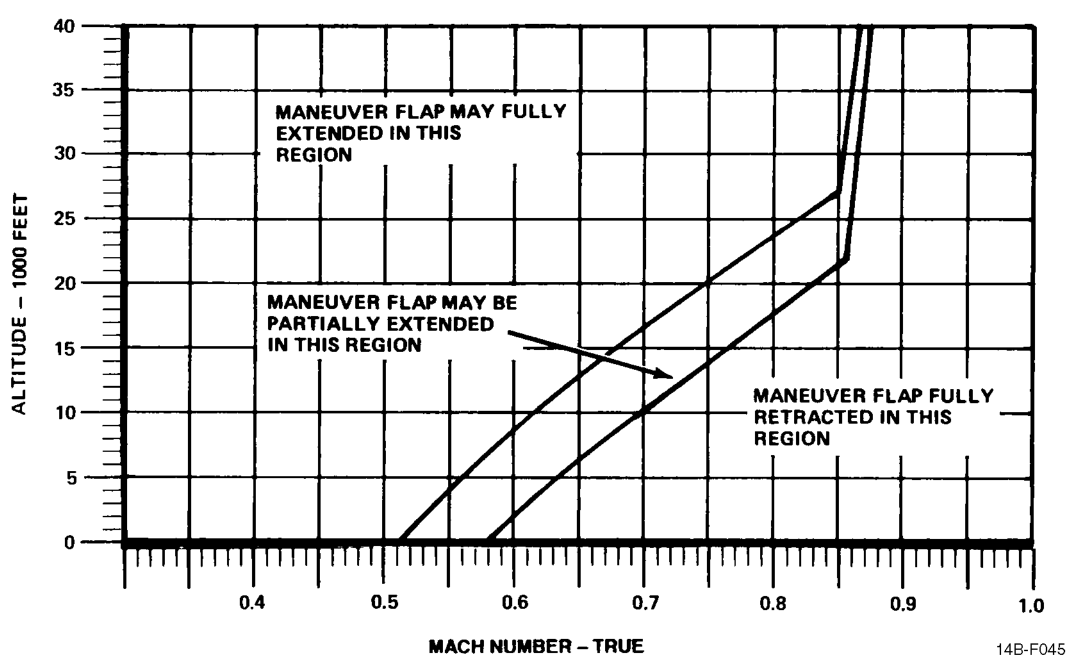


Figure 2-48. Maneuver Flap Envelope

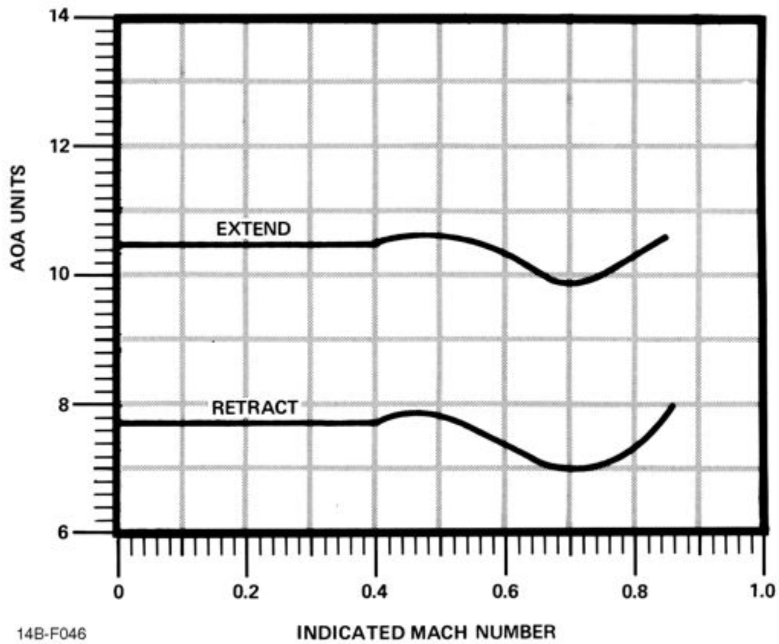


Figure 2-49. Maneuver Slat/Flap Automatic Schedule for CADC

2.21 SPEEDBRAKES

The speedbrakes consist of three individual surfaces: one upper and two lower panels on the aft fuselage between the engine nacelles (Figure 2-50). As a drag control device, the speedbrakes may be infinitely modulated on the extension cycle, but the retraction cycle is a single step. Operating time for full deflection is approximately 2 seconds. Hydraulic power is supplied by the combined hydraulic system (non isolation circuit), and electrical power is through the essential No. 2 dc bus with circuit overload protection on the pilot right circuit breaker panel (SPD BK/P-ROLL TRIM ENABLE) (RA2).

2.21.1 Speedbrake Operation. Pilot control of the speedbrakes is effected by use of the three-position speedbrake switch on the inboard side of the right throttle grip (Figure 2-51). Automatic retraction of the speedbrakes occurs with placement of either or both throttles at MIL or loss of electrical power.

To avoid fuel impingement on the fuselage boattail and nozzles, fuel dump operations are prevented with the speedbrakes extended.

Note

- Loss of combined hydraulic pressure with the speedbrakes retracted or extended will cause the speedbrakes to move to a floating position.
- The speedbrake switch is electrically bypassed during a combined hydraulic system failure, enabling the pilot to dump fuel when the speedbrakes are floating or modulating. The electrical bypass is accomplished whenever the combined pressure falls below 500 psi.
- Do not extend the speedbrakes in flight within 1 minute (nominal) after terminating fuel dump operations to allow residual fuel in the dump mast to drain.
- A throttle must be held in MIL (or greater) for approximately 3 seconds in order for the automatic function to completely retract the speedbrake. Anything less will cause partial retraction.

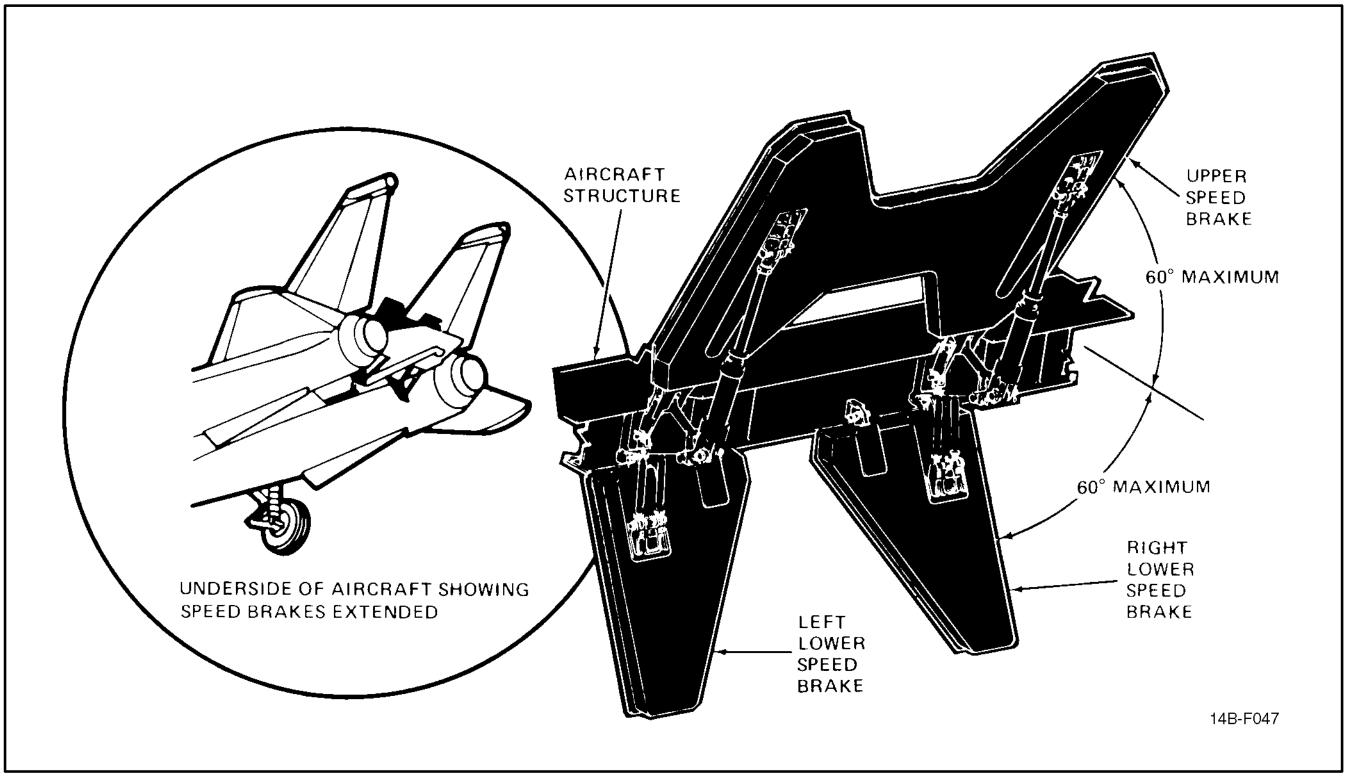


Figure 2-50. Speedbrakes

The speedbrakes will start to blow back (close) at approximately 400 knots and will continue toward the closed position as airspeed increases to prevent structural damage. A reduction in airspeed will not automatically cause the speedbrakes to extend to the originally commanded position.

2.22 FLIGHT CONTROL SYSTEMS

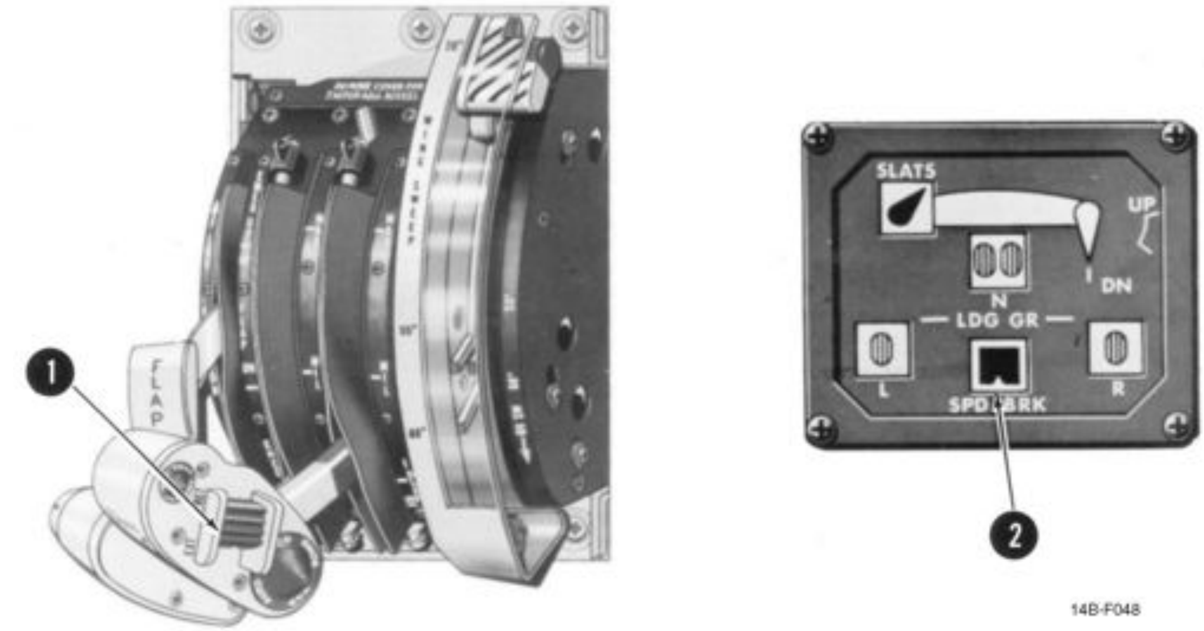
Flight control is achieved through an irreversible hydraulic power system operated by a control stick and rudder pedals. Aircraft pitch is controlled by symmetrical deflection of the horizontal stabilizers. Roll control is effected by differential stabilizer deflections and augmented by spoilers at wing-sweep positions less than 62°. Directional control is provided by dual rudders. During power approach maneuvers, the aircraft flight-path can be controlled through symmetric spoiler displacement by the pilot selecting direct lift control. Control surface indicators are shown in Figure 2-52.

The horizontal stabilizer and rudders are powered by the flight and combined hydraulic systems and controlled by pushrods and bellcranks. A third independent flight control hydraulic power source is provided by the backup module.

Sufficient control for safe return and field landing is provided to the stabilizer and rudder actuators by the backup flight control module should both the combined and flight hydraulic systems fail. Spoiler control is effected by an electrohydraulic, fly-by-wire system and powered by the combined hydraulic system and outboard spoiler module.

The DFCS includes a stability augmentation system, an autopilot, and auxiliary control functions for spoiler control, rudder authority control, lateral stick authority control, Mach trim compensation, and enhanced high AOA and approach flight characteristics.

2.22.1 Longitudinal Control. Longitudinal control (Figure 2-53) is provided by symmetric deflection of independently actuated horizontal stabilizer slabs. Control stick motion is transmitted to the stabilizer power actuators by pushrods and bellcranks to dual tandem actuators independently powered by the flight and combined hydraulic systems. The power actuators control the stabilizers symmetrically for longitudinal control and differential for lateral control. This is accomplished by mechanically summing pitch and roll commands at the pitch-roll mixer assembly. Nonlinear stick-to-stabilizer gearing provides appropriate stick sensitivity for responsive and smooth control. Longitudinal system authority is shown in Figure 2-54.



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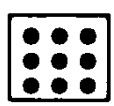
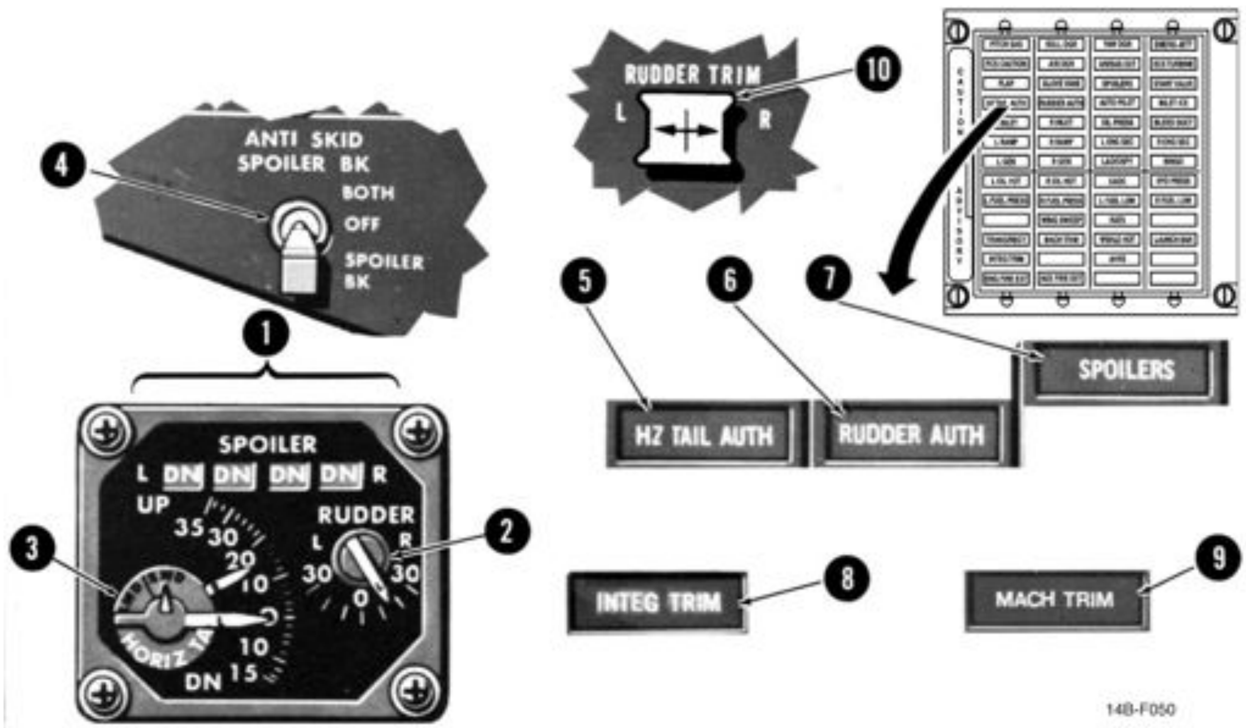
NOMENCLATURE	FUNCTION	
(1) Speed brake switch	EXT —	Momentary position used for partial or full extension. When released, switch returns to center (hold) position.
	RET —	Normal position of switch. Retracts and maintains speed brakes closed.
(2) Flap and Slats Indicator		— Partial extension (hold).
		— Full extension (60°).
		— Full retracted position
		— Speed brakes power is off.
	14B-F049	
	Note Automatic retraction of speed brakes occurs when either or both throttles are at MIL.	

Figure 2-51. Speedbrake Control and Indicator



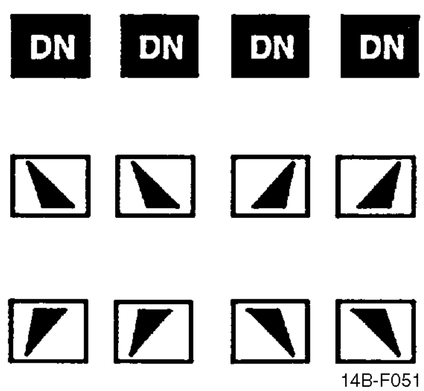
NOMENCLATURE	FUNCTION
1 SPOILER position indicators **Note** A right inboard or outboard spoiler position indicator showing one position higher than the corresponding spoiler's actual position indicates a possibility of ground-roll braking in flight and loss of spoiler symmetry protection due to a failed zero degree switch.	 — Spoilers down (flush with wing surfaces) — Either spoiler of the appropriate pair is extended more than 0°. — Both spoilers of the appropriate pair at a dropped position 0 – 4 1/2° below wing surface.
2 RUDDER position indicator	Individual rudder pointers marked R (right) and L (left) display the trailing-edge position of the rudders in degrees (0 to 30).
3 HORIZONTAL tall stabilizers position indicator	Indicated by two pointers marked R (right) and L (left) on a scale 35° up and 15° down. Scale is graduated in 2° increments. The inner pointer indicates left wing down or right wing down (differential stabilizer position).

Figure 2-52. Control Surface Indicators (Sheet 1 of 2)

NOMENCLATURE	FUNCTION
4 ANTI SKID SPOILER BK switch	BOTH — Antiskid. Spoiler brakes operate with weight on wheels and throttles at IDLE. OFF — Antiskid and spoiler brakes inoperative with weight on wheels. SPOILER BK — Spoiler brakes operate with weight on wheels and both throttles at IDLE. Antiskid is deactivated.
5 HZ TAIL AUTH caution light	Failure of lateral tall authority actuator to follow schedule or CADC failure.
6 RUDDER AUTH caution light	Disagreement between command and position, failure of rudder authority actuators to follow schedule, or CADC failure. **Note** The RUDDER AUTH caution light may illuminate when the in flight refueling probe is extended. Press the MASTER RESET button to reset the light.
7 SPOILERS caution light	Spoiler system failure, causing a set of spoilers to be locked down.
8 INTEG TRIM advisory light	Discrepancy between input command signal and actuator position or an electrical power loss within the computer
9 MACH TRIM advisory light	Failure of Mach trim actuator to follow schedule. **Note** Transient failures involving HZ TAIL AUTH, RUDDER AUTH, or SPOILERS caution lights and INTEG TRIM and MACH TRIM advisory lights can be reset by pressing the MASTER RESET pushbutton.
10 Rudder trim switch	Controls the electromechanical actuator that varies the neutral position of the mechanical linkage for rudder trim.

Figure 2-52. Control Surface Indicators (Sheet 2)

2.22.1.1 Longitudinal Feel. Artificial feel devices in the control system provide the pilot with force cues and feedback. A spring-loaded cam and roller assembly produces breakout force when the stick is displaced from neutral trim and provides increasing stick forces proportional to control stick displacement. Control stick forces, proportional to normal acceleration (g forces) and pitch acceleration are produced by fore and aft bobweights. Aircraft overstress from abrupt stick inputs is prevented by an eddy current damper that resists large, rapid control deflections.

2.22.1.2 Longitudinal Trim. Longitudinal trim is provided by varying the neutral position of the cam and roller feel assembly with an electromechanical screw-jack actuator. The manual pitch trim button on the stick is a five-position switch that is spring loaded to the center (off) position (Figure 2-55). The fore-and-aft switch positions produce corresponding nosedown and noseup trim, respectively. The manual trim switch is deactivated when the autopilot is engaged.

2.22.1.3 Mach Trim. Mach trim control is provided by the DFCS and is continuously engaged to provide automatic Mach trim compensation during transonic and supersonic flight. A failure of Mach trim compensation is indicated by the MACH TRIM advisory light. Transient failures can be reset by depressing the MASTER RESET pushbutton.

The manual and DFCS automatic trim and Mach trim actuator is installed in parallel with the flight control system. Trim actuation produces a corresponding stick and control surface movement.

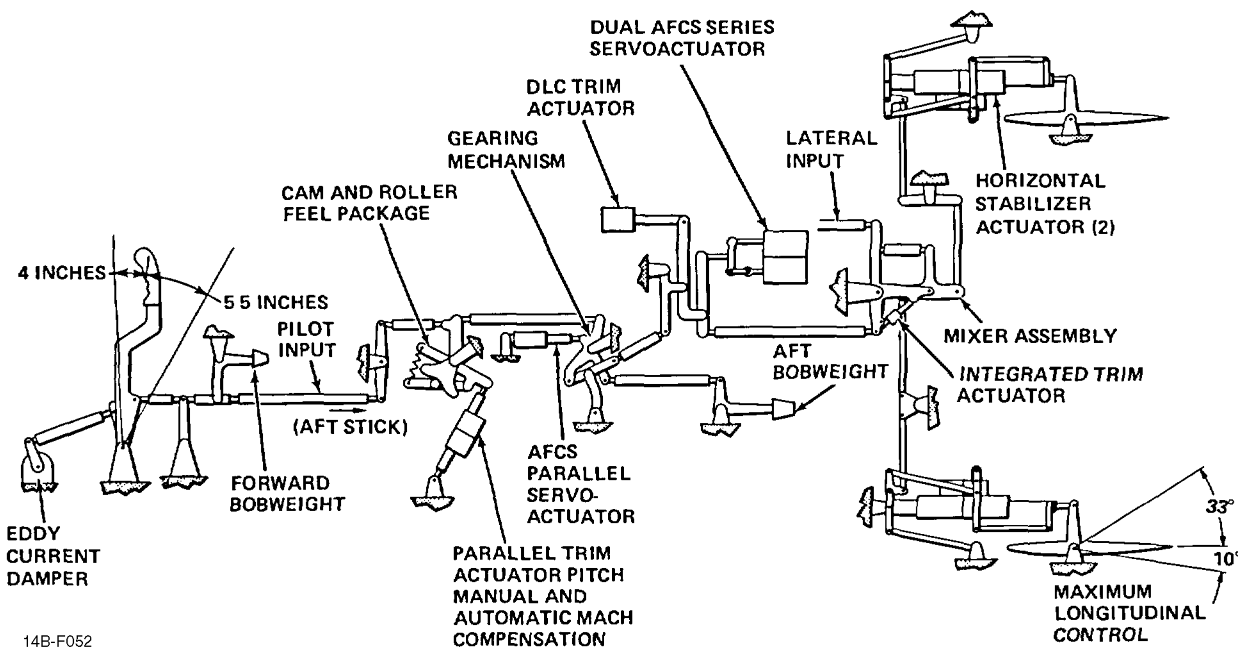


Figure 2-53. Longitudinal Control System

2.22.2 Integrated Trim System. The ITS is incorporated to eliminate longitudinal trim changes caused by the extension and retraction of flaps and speedbrakes. Disagreement of command position removes power from the motor and illuminates the INTEG TRIM advisory light. Transient failures can be reset by pressing the MASTER RESET pushbutton. ITS schedules are shown in Figure 2-56.

CAUTION

When the AIM-54 weapon rail pallet(s) is installed, the speedbrake compensation schedule in the integrated trim computer changes. If less than four AIM-54 missiles are carried on the weapon rails, the ITS may overcompensate for the speedbrake trim change. In the worst case (low altitude, between 0.7 and 0.8 IMN, pitch SAS off, and weapon rails without AIM-54 missiles) the ITS can cause an incremental 2g nosedown trim change when the speedbrake is extended. Under these conditions with the pitch SAS engaged, maximum trim change is reduced to approximately 1g.

2.22.2.1 Preflight. The ITS is automatically energized with hydraulic and electrical power applied. It can be checked by operating flaps or speedbrakes and observing a change in indicated stabilizer position.

2.22.3 Lateral Control. Lateral control (Figure 2-57) is effected by differential displacement of the horizontal stabilizers and augmented by wing spoilers at wing-sweep positions of less than 62°. A ±l/2-inch stick deadband is provided to preclude spoiler actuation with small lateral stick commands. The spoilers are commanded to the flush-down (0°) position at wing sweeps greater than 62°, and roll control is provided entirely by differential stabilizer. At wing sweeps of 65° and greater the hydraulic power to the spoiler actuators is cut off, locking the spoilers in the 0° position. Lateral stick commands are transmitted by pushrods and bellcranks to the independent stabilizer power actuators and electrically to the spoiler actuators. Lateral system authority is tabulated in Figure 2-58.

2.22.3.1 Lateral Feel. An artificial feel system provides the pilot with force cues and feedback. The lateral feel mechanism is a spring roller cam assembly with a neutral stick position detent and a constant stick deflection force gradient.

COCKPIT CONTROL			STABILIZER SURFACE		PARALLEL TRIM	
ACTUATION	MODE	MOTION	AUTHORITY	RATE	AUTHORITY	AVERAGE RATE
Control Stick	Manual	4 inches forward 5.5 Inches aft	10° TED 33° TEU	36° per second	9° TED 18° TEU	1° per second
DFCS	Series (SAS)	None	±3°	20° per second	—	—
	Parallel Automatic Carrier Landing (ACL only)	4 inches forward 5.5 inches aft	10° TED 33° TEU	36° per second	9° TED 18° TEU	0.1° per second
Maneuver Flap Integrated Trim System (ITS) and DLC Thumbwheel	Series	±45° DLC Thumbwheel Mode	8.4° TED Maximum	36° per second	—	—
		±45° Maneuver Flap Mode	±3°	3° per second	—	—

Figure 2-54. Longitudinal System Authority

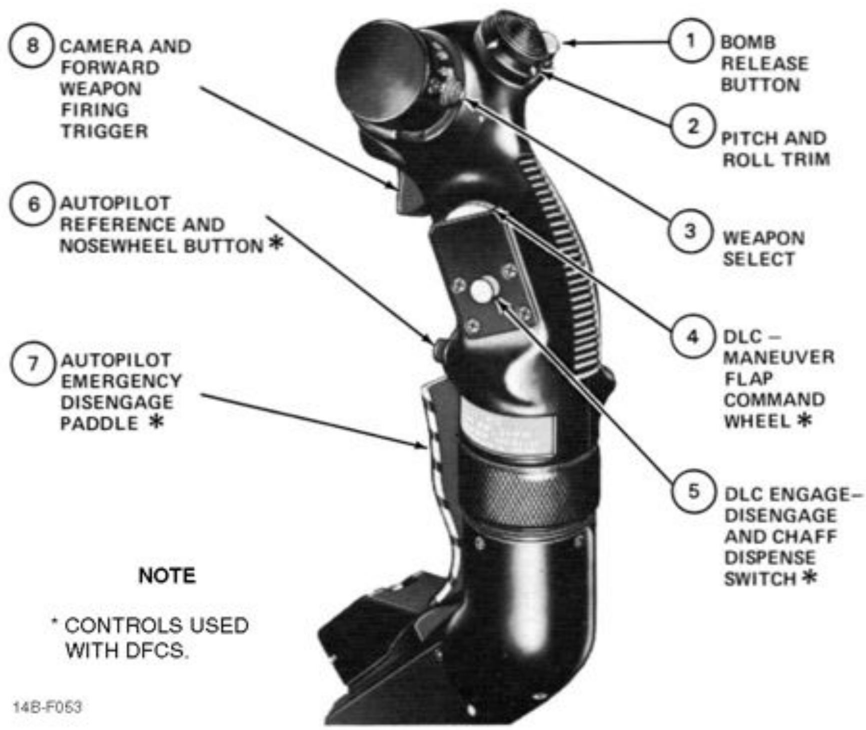
2.22.3.2 Lateral Trim. Lateral trim is by differential deflection of the horizontal stabilizers. The wing spoilers are not actuated for lateral trim control. Trim is provided by adjusting the neutral position of the spring roller cam feel assembly with an electromechanical screwjack. Left or right deflection of the roll trim button on the stick grip produces corresponding stick movement and left or right wing-down trim, respectively. The normal stick grip trim switch is inoperative when the autopilot is engaged.

Note

With lateral trim set at other than 0°, maximum spoiler deflection is reduced in the direction of applied trim.

2.22.4 Spoiler Control. Four spoiler control surfaces (Figure 2-59) on the upper surface of each wing augment roll control power and implement aerodynamic ground-roll braking. The inboard spoilers also provide DLC. The inboard and outboard spoilers are powered and controlled by separate hydraulic and electrical command systems. The DFCS monitors each spoiler panel individually. The pitch computer and outboard spoiler module control the outboard spoilers; and the roll computer and the combined hydraulic system control the inboard spoilers. (Refer to digital flight control system in FO–12).

2.22.4.1 Lateral Control Stops. To limit the torsional fuselage loads, variable lateral control authority stops are installed. The lateral stick stops vary according to dynamic pressure airloads from full stick authority at low Q, to one-half stick throw limits at high-Q conditions. Failure of the lateral stick stops is indicated by the HZ TAIL AUTH caution light. Transient failures can be reset with the MASTER RESET pushbutton. Failure of the stops in the one-half stick position does limit low-Q rolling performance; however, ample roll control is available for all landing conditions and configurations. Failure in the open condition with SAS on requires the pilot to manually limit stick deflection at higher speeds to avoid exceeding fuselage torsional load limits, because lateral stops do not limit SAS authority.



NOMENCLATURE	FUNCTION
1 Bomb release button	Pilot control for release of stores. In aircraft with the weapons rail defense electronic countermeasures (DECM) chaff adapter, the bomb release button is used to dispense chaff.
2 Pitch and roll trim button	Spring-loaded to (center) off position. Up and down positions control pitch trim and left and right positions control roll trim. Manual trim is inoperative during autopilot operation.
3 Weapon Selector switch	SP or PH — Selects Sparrow or Phoenix missiles. SW — Selects Sidewinder missiles. GUN — Selects gun. OFF — Inhibits all weapon selection by the pilot.
4 Maneuver flap, slat, and DLC command thumbwheel	Spring-loaded to a neutral position. With DLC engaged: Forward rotation extends spoilers; aft rotation retracts spoilers. With gear and flaps up: Forward rotation retracts maneuvering flaps/slats; aft rotation extends maneuvering flaps/slats.
5 DLC engage, disengage, and chaff switch	Momentary depression of the switch with flaps greater than 25° down, throttle less than MIL, and no failures in spoiler system engages DLC. With flaps up, switch will dispense chaff or flares. DLC is disengaged by momentarily pressing the switch, raising the flaps, or advancing either throttle to MIL.

Figure 2-55. Control Stick and Trim (Sheet 1 of 2)

NOMENCLATURE	FUNCTION
6 Autopilot reference and nosewheel steering pushbutton	With weight on wheels, nosewheel steering can be engaged by depressing switch momentarily. Weight off wheels and autopilot engaged, switch engages compatible autopilot modes. The switch also disengages ACL mode.
7 Autopilot emergency disengage paddle	Disengages all autopilot modes and DLC. Releases all autopilot switches. Depressing the paddle switch reverts throttle system from AUTO or BOOST mode to MAN mode and reverts engines to SEC mode only while depressed and with weight on wheels.
8 Camera and forward weapon firing trigger	Pilot control of CTVS, gun camera, and/or forward firing weapons. First detent of trigger starts gun camera and cockpit television sensor (CTVS).

Figure 2-55. Control Stick and Trim (Sheet 2)

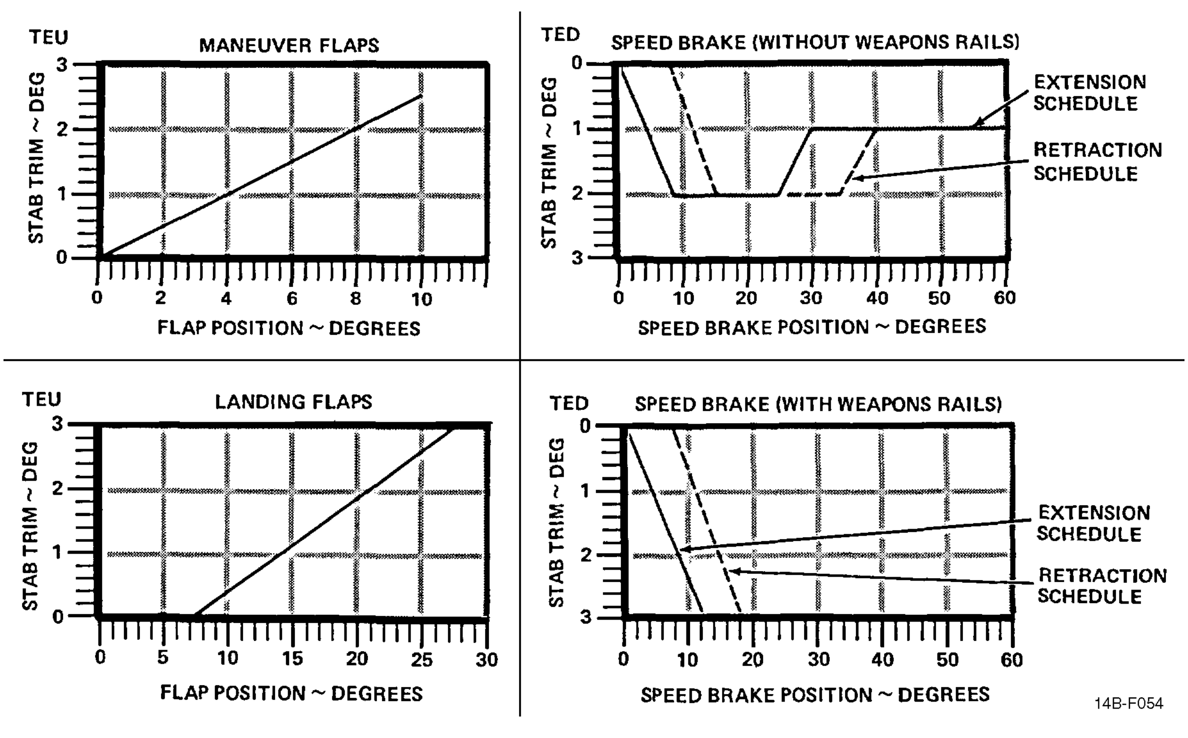


Figure 2-56. Integrated Trim Schedules

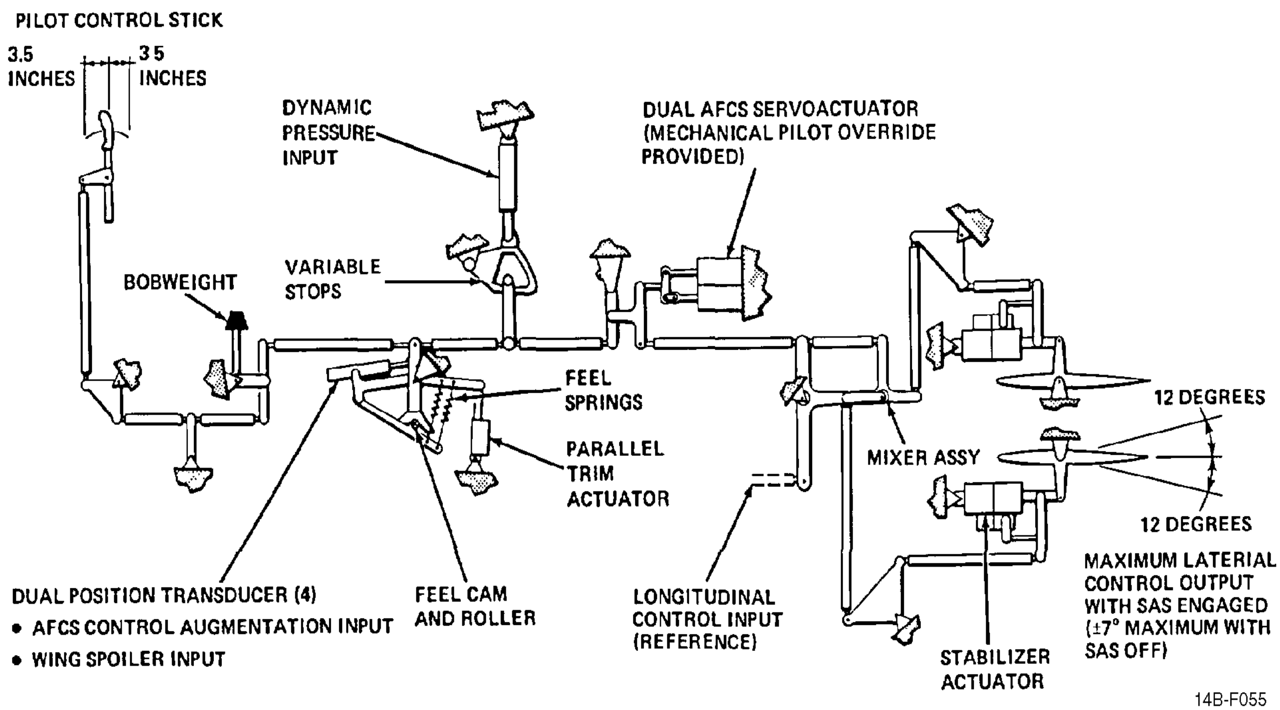


Figure 2-57. Lateral Control System

The inboard spoilers are controlled and monitored by the ROLL A and PITCH A computer segregations respectively. The outboard spoilers are controlled and monitored by the PITCH B and YAW B computer segregations respectively. Hydraulic actuation of the servo actuators is controlled by electric servo valves at the actuator and commanded by control stick displacement. The aircraft has two spoiler gearing curves called cruise and power approach. Cruise spoiler gearing is the schedule that spoilers follow in the clean configuration and is shown in Figure 2-60. Power approach is the schedule that spoilers follow with the flaps down greater than 25° and is shown in Figure 2-60 (DLC engaged). The power approach spoiler gearing schedule is modified to provide predictable roll response with lateral stick deflection and is shown in Figure 2-60 (DLC engaged). To provide the appropriate spoiler gearing for all landing configurations, the DFCS uses the power approach spoiler gearing whenever the landing gear or main flaps are down. With DLC engaged in the power approach mode, the inboard spoilers are positioned from the normal –4.5° to +17.5° position. Lateral stick inputs result in the spoilers extending on one side in the direction of stick displacement and depressing toward the landing flaps down drooped (–4.5°) stowed position on the other side. This is the primary reason for better roll response in the landing configuration with DLC engaged.

2.22.4.2 Lateral Trim. As mentioned earlier, lateral trim is provided by adjusting the neutral position of the stick. This movement of the neutral position has an effect on the amount of spoiler deflection available. That is, as lateral trim is applied away from the neutral trim position, maximum spoiler deflection is reduced in the same direction (right trim — less right wing spoilers deflection).

WARNING

Full slat asymmetry (17°) can result in an out-of-control situation at 15 units AOA or greater even with 55° of spoilers available.

CONTROL SURFACE	COCKPIT CONTROL			SURFACE		PARALLEL TRIM	
	ACTUATION	**MODE**	**MOTION**	**AUTHORITY**	**RATE**	**AUTHORITY**	**RATE**
Differential Stabilizer	Control Stick	Manual	3.5 inches left 3.5 inches right	±7°	36° per second	±3	3/8° per second
	DFCS	Series	None	±5°	33° per second	—	—
Inboard and Outboard Spoilers	Control Stick	Manual 62°	3.5 inches left 3.5 inches right	±55°	250° per second	None	None
	DFCS (ACL) (Inboard only)	Series	None	15° maximum 8° neutral	250° per second	None	None
	DLC/ Maneuver Flap (Inboard only)	Manual	DLC/ Maneuver Flap Command Thumb-wheel ±45°	inbd only 17.5° neutral –4.5° down +55° up	125° per second (minimum)	None	None
	Ground-Roll Braking Armed, Weight-on-Wheels	Series	None	55° up	250° per second	None	None
*Lateral Stops	Control Stick Restricted	Manual	1.75 inches left 1.75 inches right	±3-1/2° Diff. Stabilizer **28° Spoiler	36° per second 250° per second	—	—

* Programmed by CADC (Horizontal Tail Authority) as a function of dynamic pressure.

** Maximum SAS off deflection limits with full lateral stops engaged.

Figure 2-58. Lateral System Authority

Full lateral trim in the same direction as lateral stick displacement will still provide approximately 25° to 35° of spoiler deflection to counteract an asymmetric flap and slat condition (see Figure 2-60). This is sufficient to control full-flap asymmetry with symmetrically down slats.

2.22.4.3 Ground-Roll Braking. Aerodynamic ground-roll braking is provided by symmetric deflection of all spoilers to +55°. Ground-roll braking is controlled by the ANTI SKID SPOILER BK switch on the pilot left vertical console. The three-position switch allows optional selection of BOTH (spoiler brake and wheel antiskid braking), SPOILER BK (spoiler brake only), or OFF where neither spoilers nor antiskid is armed. With SPOILER BK or BOTH selected, two conditions are required to actuate the spoilers:

1. Weight on wheels.
2. Both throttles at idle.

Failure to satisfy any one of the above conditions will cause the spoilers to return to the down position.

CAUTION

Ground-roll braking may fail to extend spoilers on touchdown due to a momentary miscompare of the weight-on-wheels switches. MASTER RESET should restore normal ground-roll braking operation.

Note

During initial spoiler brake operation, it is normal for the indicators in the SPOILER window to momentarily flip-flop.

2.22.4.4 Spoiler Failure. Spoiler monitoring is accomplished by directly comparing the commanded spoiler position with the actual spoiler position. When a miscompare is detected, the affected individual

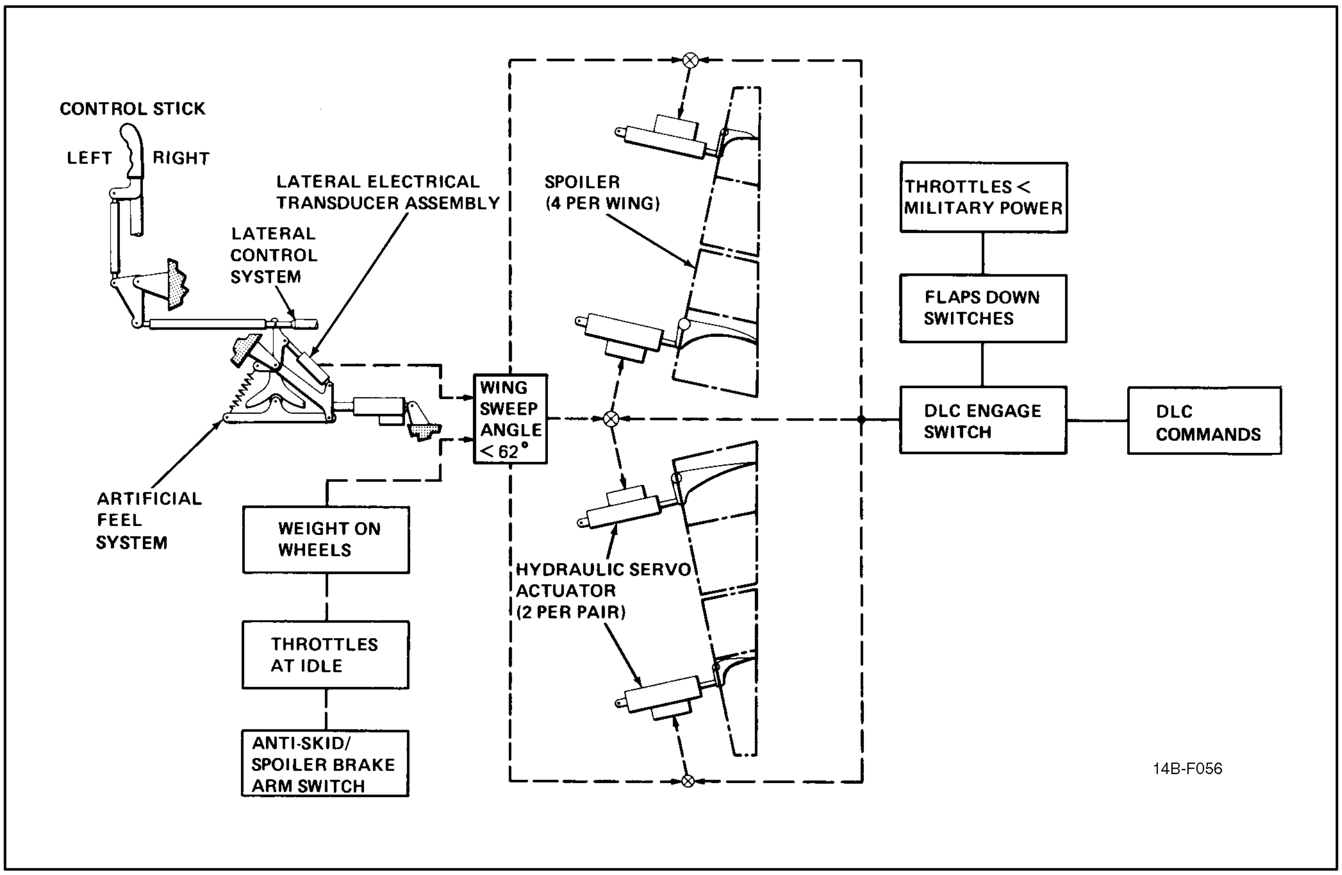


Figure 2-59. Spoiler Control System

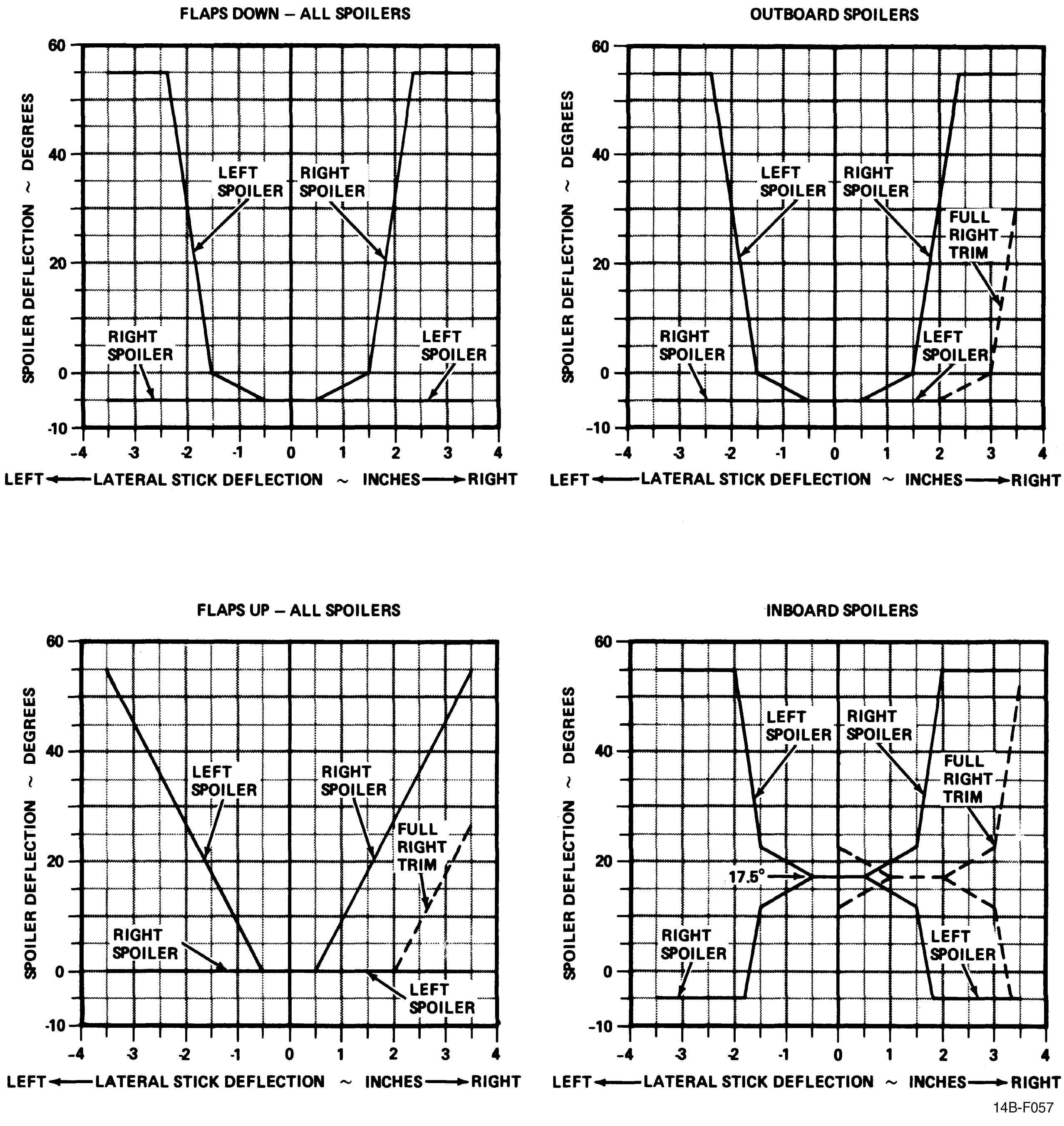


Figure 2-60. Spoiler Gearing Schedule

spoiler panel and the corresponding spoiler panel on the opposite wing are commanded to –4 1/2° and the SPOILERS caution light is illuminated. Transient spoiler failures can be reset by depressing the MASTER RESET pushbutton. If the affected spoiler panel is mechanically stuck-up, the DFCS automatically restores normal operation of the opposite spoiler panel within 2 sec.

WARNING

The spoiler actuators are mechanically biased to the retracted position in order to cause the spoilers to retract in the event that the command signal from the DFCS is lost (i.e., DFCS power failure). If this bias is reversed, the affected spoiler will extend instead of retracting when the command signal is lost. A DFCS power failure coupled with a reversed spoiler bias will result in a fully deployed spoiler. All unaffected spoilers will remain retracted and will not respond to flight control inputs until the DFCS command signals are restored.

Note

- DFCS synchronization can take up to 2 seconds following a power interrupt. If the MASTER RESET pushbutton is depressed during the synchronization time, an additional depression of the MASTER RESET pushbutton will be required to restore spoiler functionality.
- Do not press and hold the MASTER RESET pushbutton. Pressing and holding the MASTER RESET pushbutton during the synchronization time will have no effect since the DFCS computers only recognize the leading edge of the pulse from the MASTER RESET pushbutton, and not the fact that the button is continuously depressed.
- On deck, when the flap handle is cycled to UP, the outboard spoiler module is shut down. This will cause the outboard spoilers to remain extended if activated. If this occurs, position the flap handle to DN and deactivate the spoilers. This may also cause the spoiler indicators to inaccurately indicate a droop or down position. If this occurs, position the flap handle to DN and move the control stick laterally to correct spoiler indicators.

2.22.4.5 Spoiler Test. Proper spoiler operation is verified when IBIT is run during startup if wings are at 20° and flaps are down. See Chapter 41.

2.22.5 Yaw Control. Yaw control (Figure 2-61) is effected by twin rudders, one on each vertical tail. The rudder pedals adjust through a 10-inch range in 1-inch

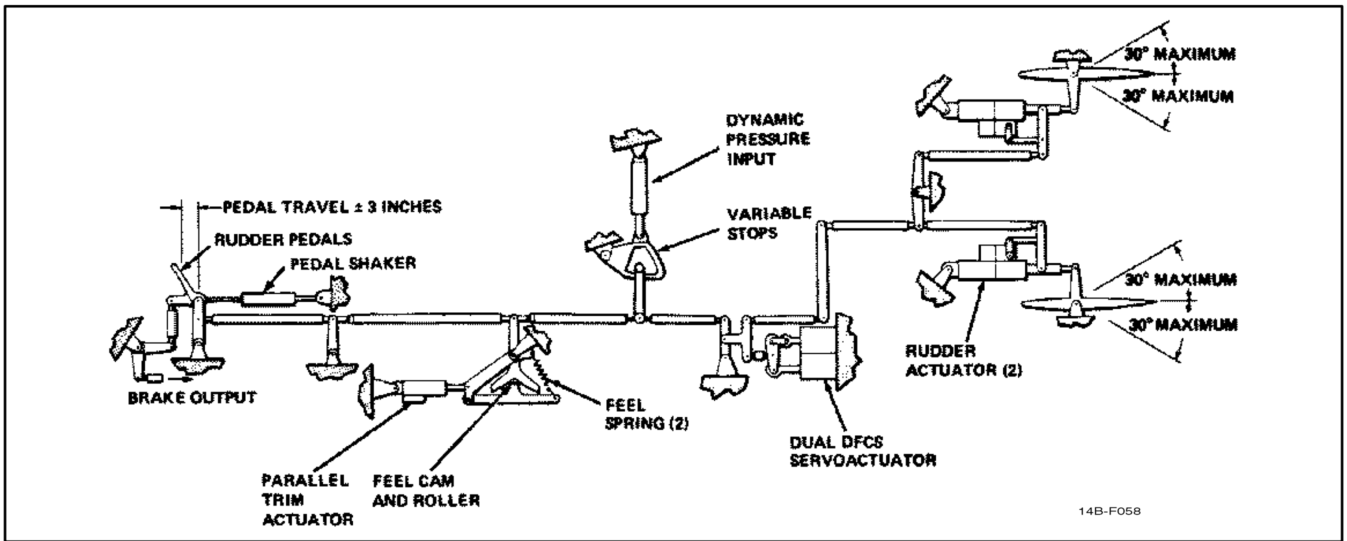


Figure 2-61. Yaw Control System

increments with the adjust control on the lower center pedestal forward of the control stick.

Yaw commands are transmitted mechanically from the rudder pedals to the rudder power actuators by pushrods and bellcranks. Tandem power actuators are powered independently by the flight and combined hydraulic systems. Yaw system authority is tabulated in Figure 2-62.

2.22.5.1 Rudder Feel. Artificial feel is provided with a spring roller-cam mechanism similar to the longitudinal and lateral feel systems.

Rudder force with pedal deflection is nonlinear with a relatively steep gradient about the neutral detent and gradually decreases with increased pedal travel.

2.22.5.2 Rudder Trim. Rudder trim is effected by varying the neutral position of the feel assembly with an electromechanical screwjack actuator. Rudder trim control is actuated by a three-position switch on the left console outboard of the throttle quadrant. Left (L) and right (R) lateral switch movement commands left and right rudder trim respectively. The switch is spring loaded to the center off position. Trim actuation produces an associated movement of the rudder pedals, rudders, and rudder indicator.

2.22.5.3 Rudder Authority Stops. Rudder authority control stops limit rudder throws in the high-Q flight environment. Rudder deflection limits are scheduled by the CADC, commencing at about 250 KIAS. Above approximately 400 KIAS, the stops are fully engaged, restricting manual rudder deflection to 9.5°. Disagreement between command and position removes power from the motor and illuminates the RUDDER AUTH caution light.

CAUTION

A CADC failure may drive the rudder authority stops to 9.5°. This condition should be determined prior to making a single-engine or crosswind landing. With the 9.5° stops in, rudder control may be insufficient to maintain directional control with single engine afterburner operation or during crosswind conditions. Nosewheel steering authority is greatly reduced with the 9.5° stops engaged.

2.22.5.4 Rudder Pedal Shaker. The rudder pedal shaker operates during IBIT and in flight when the landing gear is extended and angle of attack is above approximately 20 units. Rudder pedal shaker will deactivate once the angle of attack is reduced below approximately 19 units.

COCKPIT CONTROL			RUDDER SURFACE		PARALLEL TRIM	
ACTUATION	MODE	MOTION	AUTHORITY	RATE	AUTHORITY	AVERAGE RATE
Rudder Pedals	Manual (unrestricted)	3 inches left, 3 inches right	±30° maximum	106° per second	7°	1.13° per second
	*Manual (restricted)	1 inches left 1 Inches right	±9.5° minimum	106° per second	7°	1.13° per second
DFCS	Series	None	*±19°	80° per second	—	—
*Stops programmed by CADC (rudder authority) as a function of dynamic pressure.						

Figure 2-62. Yaw System Authority

WARNING

The aircraft flying qualities in the landing configuration will provide little feedback to the pilot that the aircraft has exceeded optimum AOA without operable rudder shakers, which can result in high AOA and excessive sink rates in the low altitude landing environment.

Note

- The rudder pedal shaker operates using consolidated AOA from the DFCS. This AOA may be as much as ±2 units different than observed on the cockpit AOA indicator.

- The rudder pedal shaker will be inoperative with a YAW B failure.

2.22.6 Direct Lift Control. During landing approaches, the spoilers and horizontal stabilizers can be controlled simultaneously to provide vertical glidepath correction without changing engine power setting or angle of attack. Only the inboard spoilers are used for DLC.

Before DLC can be engaged, the following conditions are required:

1. Flaps down greater than 25°.

2. Throttles less than MIL power.

3. Inboard spoilers operational.

4. Pitch B and Yaw B computer segregations operational.

5. Operable combined hydraulic pump.

2.22.6.1 DLC Operation. DLC is engaged with the control stick DLC switch and commanded by the thumbwheel. The thumbwheel is spring loaded to a neutral position. Forward rotation of the wheel extends spoilers and aft rotation retracts them proportionally to the degree of thumbwheel rotation. Absolute spoiler deflection is dependent upon lateral stick position (see Figure 2-60). DLC control is provided by the yaw computer.

Upon engagement of DLC, the roll computer extends the inboard spoilers from the landing flaps down drooped (–4.5°) position to 17.5° above the flush (0°) position. The pitch computer displaces the trailing edges of the horizontal stabilizers 2.75° down from their trim position. If thumbwheel control is rotated fully forward, the inboard spoilers extend to 55° and the stabilizer trailing edges remain at 2.75°. This increases the rate of descent. If the thumbwheel control is rotated fully aft, the spoilers retract to their –4.5° position and the stabilizer trailing edges return to the trim position. This decreases the rate of descent.

2.23 DIGITAL FLIGHT CONTROL SYSTEM

The DFCS (FO–12) augments the aircraft natural damping characteristics and provides automatic commands for control of attitude, altitude, heading, and approach modes selected by the pilot. All DFCS functions are integrated into the primary flight control system.

The DFCS also provides an Up and Away Automatic Rudder Interconnect (UA-ARI) to enhance departure resistance, spin recovery and high angle of attack flying qualities, and a Power Approach Automatic Rudder Interconnect (PA-ARI) to enhance the landing approach flying qualities. The DFCS consists of three computers, one computer for each axis (pitch, roll, and yaw). Each computer has two distinct and independent processors called channels or segregations (one “A” and one “B” channel per axis), each controlling one of the dual series servoactuators. All channels share data through cross channel data links.

A BIT capability is provided to exercise in-flight monitoring and to conduct an automatic operational readiness test for preflight checks. DFCS rates and authorities are tabulated in Figure 2-63.

2.23.1 Stability Augmentation System. Stability augmentation is provided for all three aircraft axes (pitch, roll, and yaw) and is controlled by the three STAB AUG switches on the upper half of the DFCS control panel (DCP) (Figure 2-64). SAS is engaged by placing these switches to ON during normal poststart procedures. The PITCH, ROLL, and YAW STAB AUG switches are manually operated toggle switches mechanically held in the selected ON or OFF position.

The pitch SAS incorporates a pitch rate feedback function that is reduced as airspeed is increased above 650 KIAS. This is necessary to maintain adequate control system stability and is not noticeable. The roll

SAS is independent with the landing gear up, at low angle of attack (less than 15 units), and at supersonic flight conditions. At all other conditions, the roll SAS is part of the UA-ARI and PA-ARI. Similar to the pitch SAS, the roll rate feedback is reduced as airspeed is increased above 300 KIAS. With the landing gear down, the yaw SAS is becomes part of the PA-ARI.

All SAS switches should remain ON during flight. Deselection of either the ROLL or YAW SAS switch will disable the affected SAS axis and all ARI functions, and illuminate the ARI/SAS OUT caution light. Deselection of the PITCH SAS switch will disable the pitch SAS, but no caution light will illuminate since no restriction exist for PITCH SAS OFF.

WARNING

Maneuvering with YAW SAS OFF or inoperative shall not be conducted above 15 units AOA with landing gear retracted.

Note

Depressing the paddle switch does not disable the pitch and roll SAS. If problems are suspected with any SAS axis, the appropriate STAB AUG switch must be manually selected OFF. Depressing the paddle switch will disengage the autopilot and DLC inflight and revert the throttles to MANUAL mode on deck.

2.23.1.1 DFCS Control Panel/Fault Display. The DFCS control panel (Figure 2-64), located on left side console, includes all the controls for the DFCS and an LED alphanumeric fault display with the associated INC and DEC pushbuttons to control display operation. This fault display is intended for ground use only to assist in the troubleshooting and repair of the DFCS and related components.

2.23.1.2 Up and Away Automatic Rudder Interconnect (UA-ARI). The UA-ARI is selected when the landing gear handle is up and provides several functions designed to improve high angle of attack flying qualities and departure resistance (Figure 2-65). These include:

- Differential Stabilizer Fadeout
- Lateral Stick-to-Rudder Interconnect (LSRI)
- Low airspeed/high angle of attack cross control (LSXC)
- Wing Rock Suppression
- Spin Recovery Function.

These functions are active throughout the subsonic flight envelope and are scheduled with Mach number and angle of attack (Figure 2-65). The effects of these functions on flight characteristics are discussed in Chapter 11.

Note

The primary AOA input for control law scheduling is based on degrees AOA provided by the ARI alpha nose-probe vice units AOA as displayed on the cockpit AOA indicator provided by the ADD AOA side-probe. Descriptions of control law functions are written in units AOA, but it should be noted that the correlation between units and degrees AOA is a function of Mach number.

AXIS	ACTUATOR	SURFACE	AUTHORITY	SURFACE RATE
Pitch	Dual Series SAS	Stabilizer	±3°	20° per second
	ITS	Stabilizer	±3°	3° per second
	Parallel (ACL only)	Stabilizer	10° TED 33° TEU	36° per second
	Parallel Trim	Stabilizer	10° TED 18° TEU	0.1° per second
Roll	Dual Series	Differential Stabilizer	±5°	33° per second
		Spoilers (ACL)	15° maximum	250° per second
Yaw	Dual Series	Rudder	±19°	80° per second

Figure 2-63. DFCS Rates and Authorities

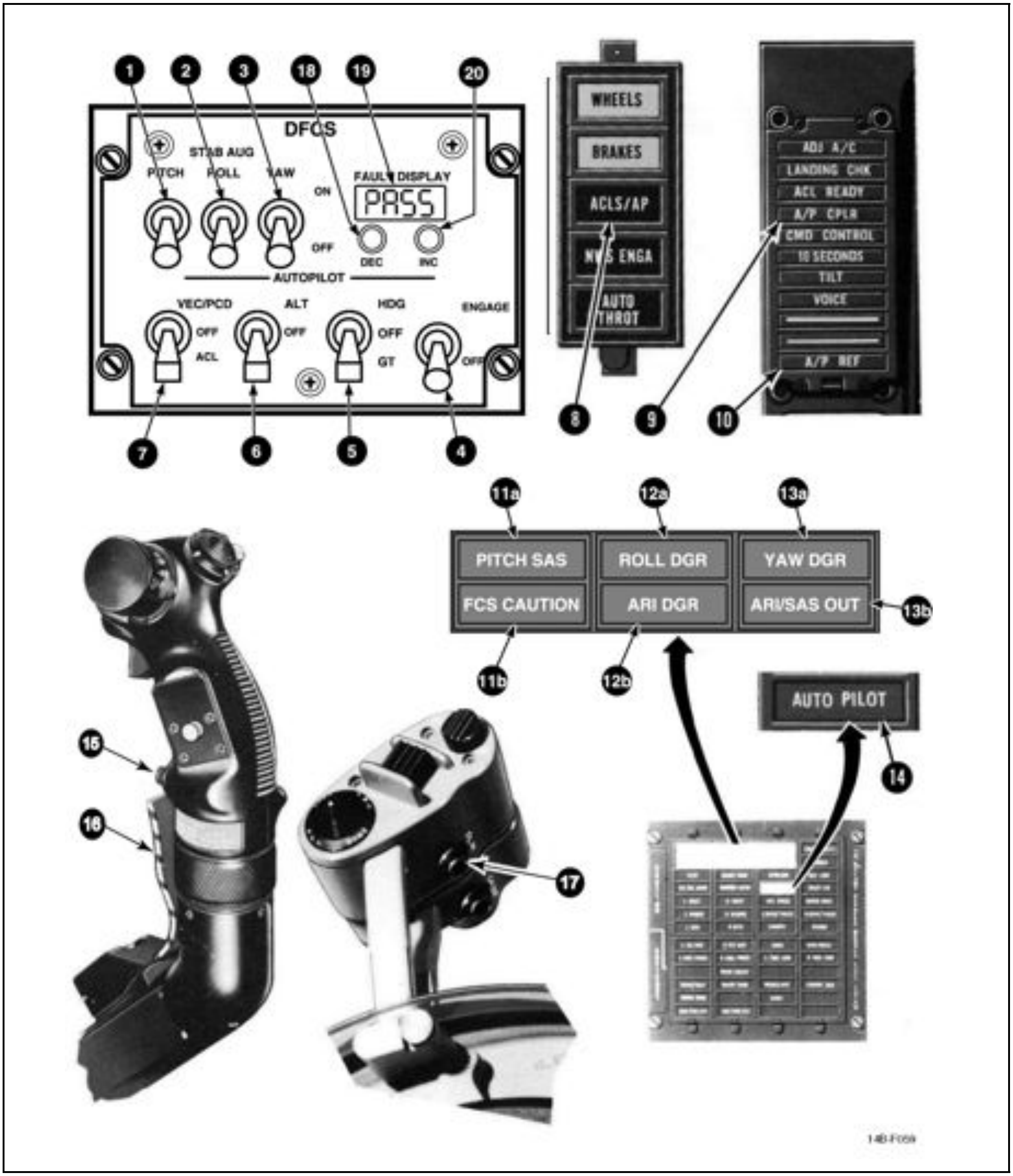


Figure 2-64. DFCS Controls and Indicators (Sheet 1 of 3)

NOMENCLATURE	FUNCTION
1 PITCH STAB AUG engage switch	Engages dual channel pitch stability augmentation.
2 ROLL STAB AUG engage switch	Engages dual channel roll stability augmentation.
3 YAW STAB AUG engage switch	Engages dual channel yaw stability augmentation.
4 AUTOPILOT ENGAGE — OFF switch	ENGAGE — Engages autopilot. PITCH, ROLL, and YAW SAS switches must be engaged. No warmup required. Engages attitude hold. Requires weight off wheels. OFF — Disengages autopilot.
5 HDG-OFF-GT switch	HDG — Autopilot will lock on constant aircraft heading when aircraft is less than ±5 roll. OFF — Disengages heading hold and ground track. GT — Selects autopilot ground tracking computed at time of engagement using inertia navigation system (INS) data. Engaged by nosewheel steering pushbutton. Engaged by nosewheel steering pushbutton.
6 ALT-OFF switch	ALT — Autopilot will maintain barometric altitude. Engaged by nosewheel steering pushbutton. OFF— Disengages altitude mode.
7 VEC/PCD-OFF-ACL	VEC/PCD — Autopilot roll axis commands steer aircraft using data link signals for vectoring. If the precision course direction (PCD) discrete is present both roll and pitch axis commands are used. Engaged by nosewheel steering pushbutton. OFF — Disengages VEC/PCD and ACL modes. ACL — Autopilot will accept data link signals for carrier landing, using spoilers for roll and parallel servo for pitch. Only pitch commands are transmitted to stick movement. Engaged and disengaged by nosewheel steering pushbutton.
8 ACLS/AP caution light	Autopilot and automatic carrier landing system (ACLS) mode disengaged.
9 A/P CPLR warning light	Indicates the aircraft can be coupled to the ACL system for a mode I or mode IA approach. A/P CPLR remains illuminated in conjunction with the CMD CTRL warning light after coupling is accomplished.
10 A/P REF warning light	Autopilot mode is selected but is not engaged. (Except attitude and heading hold).
11a PITCH SAS caution light	Indicates inoperative pitch channel or pitch SAS failure.
11b FCS CAUTION caution light	Indicates DFCS failure has occurred. If no other lights are illuminated, indicates loss of redundancy only (subsequent failure may result in loss of significant DFCS functionality).
12a ROLL DGR caution light	Indicates inoperative roll channel and degraded roll authority.
12b ARI DGR caution light	Indicates degraded ARI performance. If caused by loss of a Mach number signal, LSXC and wing rock suppression functions will be inoperative.
13a YAW DGR caution light	Indicates inoperative yaw channel and degraded yaw authority.
13b ARI/SAS OUT cautionlight	Indicates loss of either Roll or Yaw SAS and all ARI functions. Will be illuminated if either the ROLL STAB AUG or YAW STAB AUG switches are selected off.

Figure 2-64. DFCS Controls and Indicators (Sheet 2)

NOMENCLATURE	FUNCTION
14 AUTOPILOT caution light	Indicates failure of one or more of pilot relief modes.
15 Autopilot reference and nosewheel steering pushbutton	Engages the ALT, GT, ACL or VEC/PCD autopilot mode selected. Autopilot must be engaged and compatible autopilot modes selected. Also disengages ACL mode. Requires weight off wheels.
16 Autopilot emergency disengage paddle	Disengages all autopilot modes and releases all autopilot switches.
17 PLM pushbutton	With the A/P CPLR warning light illuminated and the VEC/PCD ACL switch latched in the ACL position, depressing the PLM pushbutton disengages the ACL mode and autopilot.
18 DEC pushbutton	With weight on wheels, depressing the DEC pushbutton scrolls backward through logged DFCS fault codes.
19 DFCS fault display	With weight on wheels, the DFCS fault display yields three categories of fault codes including: currently existing failures (FAIL), in flight detected failures (FLT), and IBIT detected failures (IBIT).
20 INC pushbutton	With weight on wheels, depressing the INC pushbutton scrolls forward through logged DFCS fault codes.

Figure 2-64. DFCS Controls and Indicators (Sheet 3)

The differential stabilizer fadeout function reduces the amount of differential stabilizer the pilot can command as angle of attack and Mach number are increased. Below ~15 units angle of attack, the pilot can command up to the maximum ±12° differential stabilizer authority. Above ~30 units angle of attack, the differential stabilizer is limited to a maximum of ±2° deflection (except when overridden by activation of LSXC or spin recovery functions). As Mach number is increased, the differential stabilizer is faded out at a lower AOA. This reduces the effects of kinematic coupling and results in less adverse sideslip with lateral stick deflection as angle of attack is increased and reduces the tendency for lateral control induced departures.

The LSRI function gradually applies coordinating rudder with lateral stick as angle of attack is increased above approximately 15 units AOA. A maximum of ±19° coordinating rudder is provided by the LSRI above approximately 23 units AOA. This results in the desired roll response with lateral stick input alone at elevated AOA.

The LSXC function provides a means to override the differential stabilizer fadeout and LSRI functions when CADC Mach number is below 0.4 and angle of attack is above approximately 30 units. At these conditions, the pilot can command up to ±10° differential stabilizer deflection in the direction of lateral stick and up to ±30° rudder deflection in the direction of commanded rudder. Because rudder effectiveness is diminished above 30 units angle of attack, the LSXC function is necessary to provide adequate roll/yaw maneuvering capability at extreme angles of attack. When LSRI is no longer effective, the aircraft can still be rolled through LSXC by manually applying greater than 1.75 inch of rudder pedal in the direction of the desired roll, and greater than 1 inch lateral stick in the opposite direction. This will create an adverse yaw response causing the aircraft to roll/yaw in the same direction as the rudder input.

The wing rock suppression function uses roll rate feedback to command the differential stabilizer and rudder to damp lateral-directional oscillations from between 20 to 30 units AOA. This results in smoother tracking capability for the majority of the maneuvering flight envelope. Wing rock suppression is disabled when a pedal input greater than 2 in. is applied or CADC Mach number is above 0.77 to prevent the system from applying inadvertent cross control inputs and allow the pilot to roll the aircraft with rudder inputs alone.

The spin recovery function applies full SAS authority of up to ±19° rudder and up to ±5° differential stabilizer to oppose yaw rate during a departure. The spin recovery function is activated when angle of attack is above ~30 units and yaw rate is above 20°/sec. The spin recovery inputs are in addition to the pilot's mechanical inputs, providing full control surface authority for departure recovery (±30° rudder opposite roll/yaw and ±12° differential stabilizer into roll/yaw).

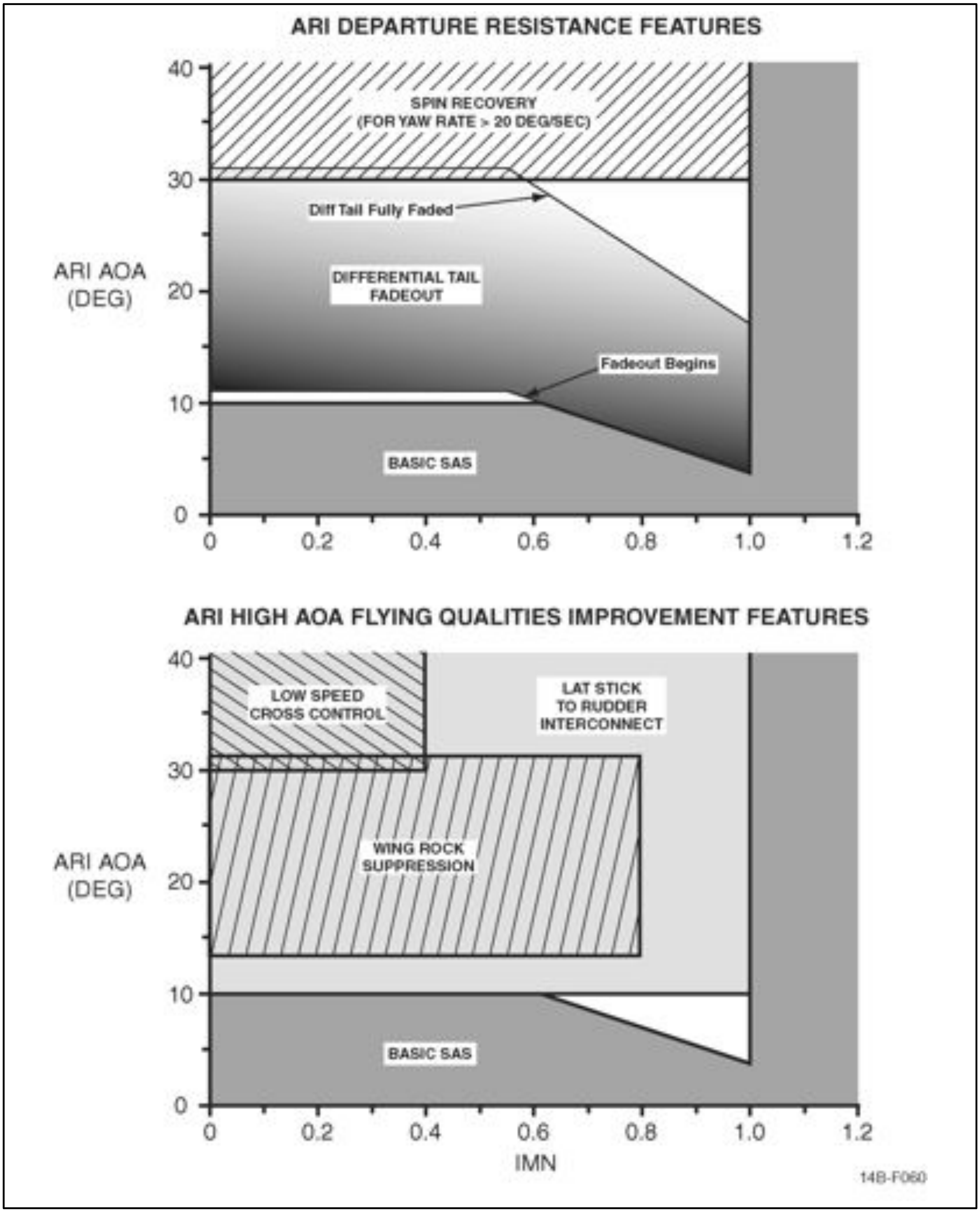


Figure 2-65. DFCS Up and Away ARI Functions

Misapplied pilot recovery inputs are limited to ±11° pro-spin rudder and ±2° pro-spin differential stabilizer.

2.23.1.3 Power Approach ARI. The PA-ARI is selected when the landing gear handle is down and provides roll rate command, LSRI, Dutch roll damping, and spiral mode stabilization functions. In addition, the spoiler gearing has been modified for 0.1 inch lateral stick spoiler breakout to improve roll sensitivity and predictability.

The roll rate command function tailors differential stabilizer to maintain a constant lateral stick to roll rate relationship. This is achieved by comparing the roll rate command (based upon lateral stick position as measured from trimmed position) to the actual roll rate, then increasing or decreasing the differential stabilizer deflection to maintain the commanded roll rate. The control gains are designed to provide approximately 20°/sec roll rate per inch of lateral stick deflection from trim.

Note

The PA-ARI will perceive a lateral trim offset as an uncommanded roll rate and will attempt to reduce roll rate to zero with the stick in the trimmed position. As a result, it is possible to have the stick offset due to lateral trim with zero roll rate. Because the pilot's roll rate command is based upon lateral stick position from a trimmed position, it may be necessary to select ROLL SAS OFF, trim the airplane, and then reselect the ROLL SAS ON. The same procedure may be necessary to trim an airplane with a lateral store asymmetry, trapped wing fuel, etc.

The LSRI function gradually fades in coordinating rudder with lateral stick as angle of attack is increased above ~10 units AOA. This minimizes adverse yaw response from lateral stick only inputs, greatly enhancing heading and centerline capture during lineup corrections. At normal approach conditions (15 units angle of attack, flaps down), up to ±19° coordinating rudder is provided by the LSRI. Raising the flaps decreases the amount of coordinating rudder available.

The Dutch roll damping function provides sideslip rate feedback to the rudder to reduce directional nose wandering during approach. Airplane roll rate, yaw rate, lateral acceleration, Mach number, and angle of attack are used to calculate sideslip rate. At normal approach conditions, the sideslip rate feedback to rudder provides a deadbeat Dutch roll response.

The spiral mode stabilization function provides yaw rate feedback to the differential stabilizer to reduce bank angle excursions during stabilized turns. At normal approach conditions, the yaw rate feedback to differential stabilizer provides an essentially neutral spiral mode.

2.23.1.4 Aircraft Sensors. The DFCS uses the aircraft sensor inputs distributed to the various computer channels as shown in Figure 2-66. The DFCS distributes sensor inputs to all computer channels through cross channel data link (CCDL) communication. Each computer channel compares like sensor data (for example, yaw rate A, B, and M) to determine validity of each input and then consolidates the good inputs. The consolidated sensor inputs are then used to generate output commands. This provides an additional level of monitoring and redundancy.

Note

Loss of a computer segregation or individual cross channel data link will result in loss of sensor information provided by the affected segregation or link and illuminate the appropriate caution/advisory lights.

The aircraft sensors are supplemented by a pitch/roll voter monitor and air data redundancy management algorithm to provide a fail-operational capability following a single sensor failure. Following a second sensor failure, the DFCS reverts to a fail-safe configuration.

2.23.1.4.1 Pitch/Roll Voter Monitor. The pitch/roll voter monitor (PQVM) algorithm provides triple redundancy for the existing duplex pitch and roll rate gyro sensors. The PQVM operates by calculating aircraft pitch and roll attitudes from three axis rate information and comparing this against pitch and roll attitudes supplied by the EGI. If a pitch or roll rate sensor miscompare occurs, the PQVM algorithm is used to select the remaining good sensor signal. The monitor does not provide additional rate information for averaging with the sensor signals. Since only pitch and roll attitude are available from the EGI, the effectiveness of the monitor depends on aircraft attitude. The monitor is incapable of detecting pitch rate failures with the wings near vertical (±90° bank angle) or roll rate failures with the fuselage near vertical (±90° pitch angle).

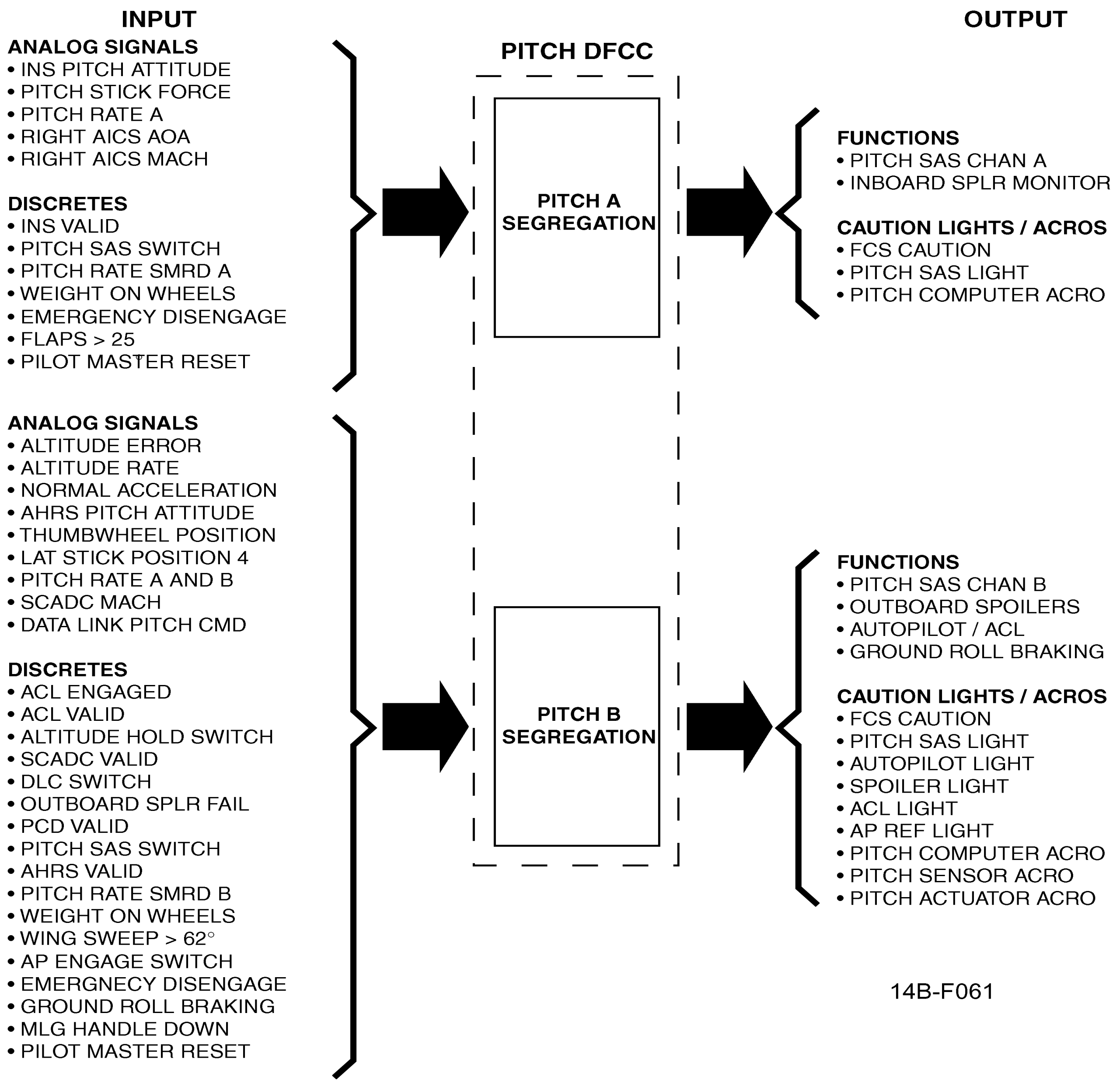


Figure 2-66. DFCS Pitch DFCC Interfaces and Control Functions (Sheet 1 of 3)

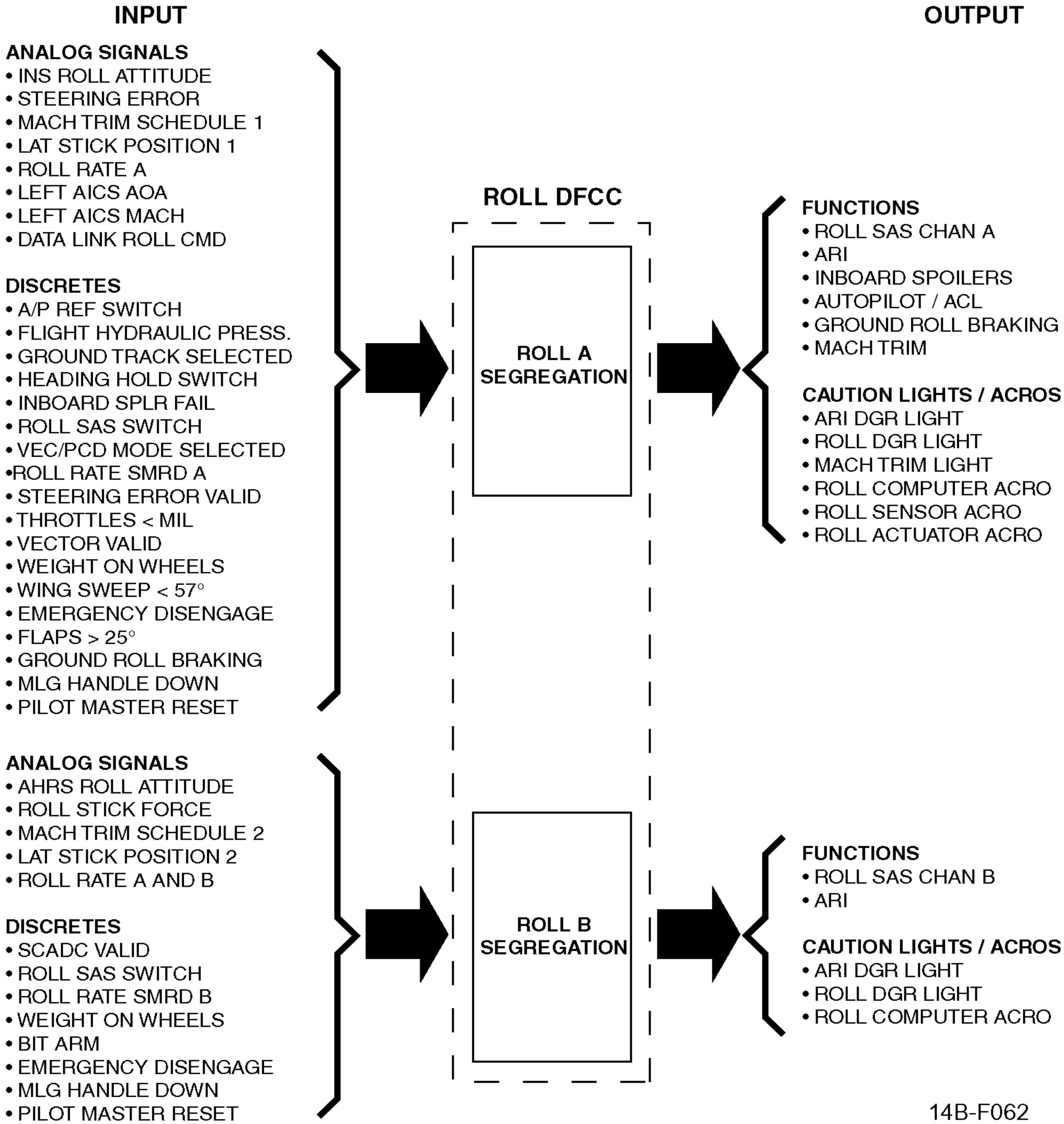


Figure 2-66. DFCS Roll DFCC Interfaces and Control Functions (Sheet 2)

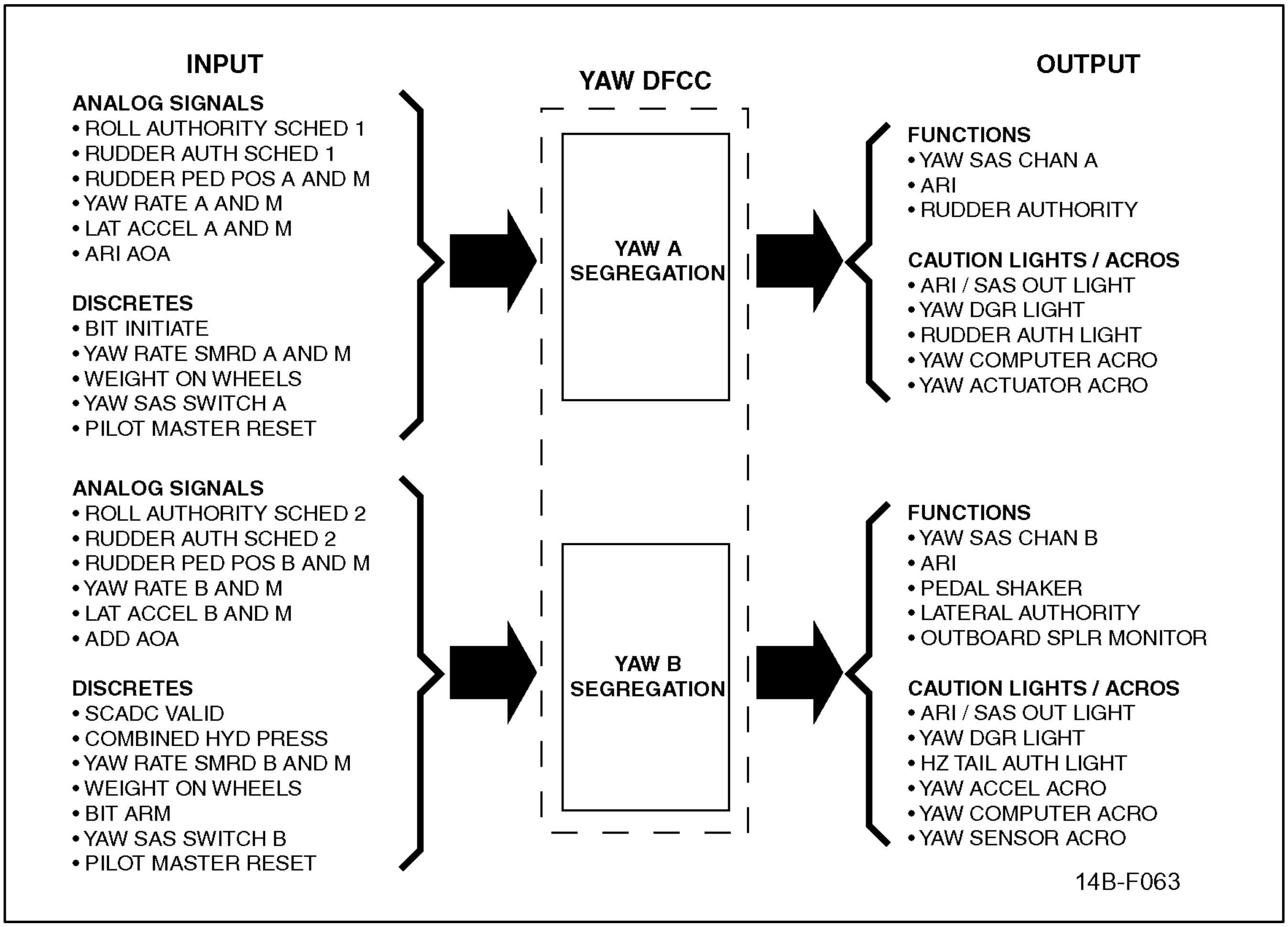


Figure 2-66. DFCS Roll DFCC Interfaces and Control Functions (Sheet 3)

Note

Transient EGI attitude failures will result in a PQVM miscompare. This will be indicated by an FCS CAUTION light accompanied by PS and RS acronyms. Depressing the MASTER RESET pushbutton will restore normal PQVM operation and clear the failure indications. Failed velocity information from the EGI does not affect operation of the PQVM function.

2.23.1.4.2 Angle of Attack/Mach Redundancy Management. The primary angle of attack (AOA) input is provided by the ARI alpha nose-probe (AOA range 0° to +37°). The fuselage-mounted ADD AOA side-probe (AOA range –4° to +24° for Mach <0.4) is used for comparison and as a backup AOA source in the event of a detected failure of the ARI AOA input. Although two AICS AOA inputs are available (AOA range 0° to +30° for Mach >0.5), significant sideslip-induced errors distort these measurements as a function of their locations on either side of the fuselage. Location of sensor probes is discussed in paragraph 2.31 (Pitot Static System). A sideslip estimation routine, based upon lateral acceleration, differential stabilizer, and rudder position, is implemented to select the upwind AICS AOA source. This AICS AOA is utilized as a triplex monitor to vote out a failed ARI or ADD AOA (first AOA fault), but is not of sufficient accuracy to be used as a primary source for control law gain scheduling. In the event of a subsequent miscompare between the remaining AOA sources (second AOA fault), the ARI control laws are reverted to fail-safe fixed values for AOA. First AOA miscompares are indicated by an FCS CAUTION light and PS acronym. Second AOA miscompare are indicated by FCS CAUTION, ROLL DGR, ARI DGR, and ARI/SAS OUT caution lights and PS acronym with the landing gear handle up and FCS CAUTION, ARI DGR caution lights and PS acronym with the landing gear handle down.

CAUTION

Pulling the Alpha computer circuit breaker will result in loss of the primary AOA source. This may degrade DFCS performance as the backup ADD AOA is subject to sideslip-induced errors. For the DFCS to operate properly, the Alpha computer should not be disabled.

The primary Mach number input is provided by the CADC calculated from the left and right pitot-static probe inputs. Total and static pressure data (Mach number) inputs from the left and right AICS programmers are used for comparison. Similar to the AOA implementation, the upwind AICS Mach number is selected based upon estimated sideslip and is compared with the CADC Mach number. When the estimated sideslip angle is less than 2°, the Mach calculations from both the left and right AICS programmers are cross checked to determine pressure validity. An AICS cross check miscompare (first Mach fault) results in a loss of Mach redundancy and is indicated by an FCS CAUTION light and PS acronym. Mach scheduling functions are still being performed using the CADC Mach number. A single Mach miscompare between the CADC Mach number and the upwind AICS Mach number results in a default Mach number being set and is indicated by FCS CAUTION, ARI DGR caution lights and PS acronym. Any subsequent Mach failure (second Mach fault) results in the UA control laws configuring to a fail-safe degraded mode and is indicated by PITCH SAS, FCS CAUTION, ROLL DGR, ARI DGR, and ARI/SAS OUT caution lights and PS acronym with the landing gear handle up. Subsequent Mach failures do not further degrade the PA control laws and are indicated by an FCS CAUTION, ARI DGR lights and PS acronym with the landing gear handle down.

CAUTION

Pulling either AICS programmer circuit breakers (LF2 or LG2) will result in DFCS air data failures and degraded control system capability. This will be indicated by one or more of the following caution lights depending on flight condition: FCS CAUTION, PITCH SAS, ROLL DGR, and ARI DGR. Once the AICS circuit breaker is reset, depressing MASTER RESET should restore normal operation and clear the failure indications.

Note

- Extremely aggressive maneuvering at high AOA or intermittent CADC problems may result in a transient AOA or Mach miscompare. Depressing the MASTER RESET pushbutton will restore normal operation and clear the failure indications for all single failure situations. Dual failure of either the Mach or AOA inputs is not resettable with MASTER RESET.

- With a dual AOA or Mach failure set, lowering the landing gear handle will result in the PITCH SAS (Mach only), ROLL DGR, and ARI/SAS OUT lights extinguishing. This does not imply the dual failure is no longer present, only that the impact of the dual failure on PA control functions are less severe than on the UA control functions due to the more confined operational flight envelope.

2.23.1.5 Sensor Failures. First sensor input failures are indicated by the FCS CAUTION light and the appropriate acronym (PS, RS, YS, or AM). An FCS CAUTION light with no other lights indicates a loss of sensor redundancy with no loss of functionality. The only single sensor failure to light more than the FCS CAUTION light is a single Mach miscompare that is indicated by FCS CAUTION, ARI DGR caution lights and PS acronym. With a single Mach miscompare, the LSXC and wing rock suppression functions will be lost. Depressing the MASTER RESET pushbutton should clear transient first sensor failures and failure indications. Second sensor failures result in loss of functions in the affected axis. The affected axis will be indicated by a PITCH SAS, ROLL DGR, or YAW DGR caution light. For failures affecting either the roll or yaw axis, all ARI functions may be lost. Partial loss or degrade of the ARI is indicated by an ARI DGR caution light. Complete loss of the ARI is indicated by the ARI/SAS OUT light. For second AOA, Mach, or roll rate sensor failures the spin recovery function is retained even though the ARI/SAS OUT light is illuminated.

DFCS failure indications and effects are summarized in Figure 2-67. The DCP fault codes are listed in alpha-numeric order followed by their classification to the IBIT and/or OFP fault group(s). The IBIT fault group includes fault codes generated by the IBIT self-test and will be identified in the DCP FAULT DISPLAY following the "IBIT" group header. The OFP fault group includes fault codes generated by the PBIT and/or ABIT self-test(s) and will be identified in the DCP FAULT DISPLAY following the "FAIL" and/or "FLT" group header. The failure indication and potential functions lost are listed for each individual fault code. The associated caution lights and maintenance file acronyms are listed for each fault code in addition to any applicable notes. In certain cases, potential functions lost for multiple failures (also known as a dual faults or second faults) have been identified.

2.23.1.6 Digital Flight Control Computers. The DFCS consists of three computers, one for each axis (pitch, roll, and yaw) (Figure 2-66). Each computer has two distinct channels/segregations (A and B), each in turn controlling one of the dual series servoactuators in the respective axis. The DFCS uses cross channel data link communication to provide redundancy management so that a miscompare between the A and B channels of a given axis cannot result in a loss of the entire axis. Each A channel (for example, pitch A) is monitored by every B channel (pitch B, roll B, and yaw B) and conversely each B channel is monitored by every A channel. As a result of this monitoring structure, loss of a single channel will only result in loss of functions controlled by that channel and the corresponding series servoactuator, rather than the entire axis (sensor information provided by the affected channel will also be lost). Loss of a second channel will significantly degrade DFCS performance or result in a complete loss of all DFCS functions. Computer failure effects and cockpit indications are summarized in Figure 2-67.

2.23.1.6.1 Flight Control Computer Reset. Each computer channel is independently powered and can be disabled by pulling the appropriate DC or AC circuit breaker. In general, there should be no need to cycle DFCS circuit breakers. If power is removed from a channel and then restored, the pilot must depress MASTER RESET to restore full DFCS functionality. If power is removed from two or more of the "same letter" channels/segregations, most or all of the DFCS functions will be lost. Restoring power will cause the DFCS to execute a Power On Reset (POR) and the system will re-initialize interpreting the current sensor information as valid. This can create a potentially hazardous situation under conditions where a dual sensor failure occurred prior to restoring power. When the DFCS re-initializes, it is possible for the failed signals to be interpreted as valid and the remaining good signal to be interpreted as invalid. Therefore, careful consideration should be given before executing a POR airborne, since it can result in erroneous DFCS commanded control deflections.

When a POR is performed on deck, the DC cbs (ROLL A, YAW B, and YAW A) are generally used to avoid inadvertently inducing additional faults. A MASTER RESET is required to extinguish the resulting DFCS caution lights following restoration of power.

Note

- The DFCS computers take up to 2 seconds to synchronize following restoration of power. Depression of the MASTER RESET pushbutton during this time will have no effect on the DFCS. Another depression of the MASTER RESET pushbutton following completion of the synchronization time will be required to restore DFCS functionality.

- Do not press and hold the MASTER RESET pushbutton. Pressing and holding the MASTER RESET pushbutton during the synchronization time will have no effect since the DFCS computers only recognize the leading edge of the pulse from the MASTER RESET pushbutton, and not the fact that the button is continuously depressed.

An IBIT must always be run following a POR on deck to ensure full system capability is restored.

Note

Both roll rate gyros are powered through ROLL B AC cb, while both pitch rate gyros are powered through PITCH A AC cb. Removing DFCS Pitch A or Roll B computer channel AC power via one of these circuit breakers for more than approximately 15 seconds either on deck or airborne can result in latched dual rate sensor faults requiring a POR to clear.

DCP Code	IBIT Group	OFP Group	Failure Indication/*Functions lost*	PITCH SAS	FCS CAUTION	ROLL DGR	ARI DGR	YAW DGR	ARI/SAS OUT	SPOILERS	MACH TRIM	HZ TAIL AUTH	RUDDER AUTH	AUTOPILOT	ACLS A/P	Pitch Computer	Pitch Sensor	Pitch Actuator	Roll Computer	Roll Sensor	Roll Actuator	Yaw Computer	Yaw Sensor	Yaw Actuator	Accelerometer	Notes
115V	I		115 V_{AC} aircraft power supply out of tolerance fault. *Loss of one or more computer segregation(s). No IBIT capability.*	x	x	x	x	x	x							x			x			x				
28DC	I		28 V_{DC} aircraft power supply out of tolerance fault. *Loss of one or more computer segregation(s). No IBIT capability.*	x	x	x	x	x	x							x			x			x				
AC28	I	O	Alpha computer/pedal shaker 28 V_{DC} power supply input fault. *Loss of primary AOAC alpha source/redundancy, default to ADD alpha source. Loss of rudder pedal shaker.*		1												1									1:WOW
AD01		O	Air data computer (CADC) general fault. *Loss of WRS, LSXC, Mach trim, lateral & rudder authority actuators, and autopilot. No IBIT capability.*		3		3				x	x	x	1	2		3									1:AP engd, 2:ACL engd, 3:WOW
AD02	I		Mach schedule (pitch) signal from CADC fault. *Loss of WRS, LSXC, and autopilot.*		x		x							1			x									1:AP engd
AD03		O	Air data computer valid input (pitch) fault. *Loss of autopilot. No IBIT capability.*											1	2											1:AP engd, 2:ACL engd
AD04		O	Air data computer valid input (roll) fault. *Loss of WRS, LSXC, and Mach trim. No IBIT capability.*		3		3				x			1	2		3									1:AP engd, 2:ACL engd, 3:WOW
AD05		O	Air data computer valid input (yaw) fault. *Loss of lateral & rudder authority actuators. No IBIT capability.*									x	x													
AD06		O	Mach trim schedule input fault. *Loss of Mach trim actuator.*								x															
AD07		O	Lateral authority schedule input fault. *Loss of lateral authority actuators.*									x														
AD08		O	Rudder authority schedule input fault. *Loss of rudder authority actuators.*										x													
AD09	I		Autopilot altitude error signal from CADC fault. *Degraded autopilot altitude hold mode.*											1												1:AP engd
AD10	I		Autopilot altitude rate signal from CADC fault. *Degraded autopilot altitude hold mode.*											1												1:AP engd
AD11	I		Mach trim schedule 1 signal from CADC fault. *Loss of Mach trim actuator.*								x															
AD12	I		Mach trim schedule 2 signal from CADC fault. *Loss of Mach trim actuator.*								x															
AD13	I		Lateral authority schedule 1 signal from CADC fault. *Loss of lateral authority actuator.*									x														
AD14	I		Lateral authority schedule 2 signal from CADC fault. *Loss of lateral authority actuator.*									x														
AD15	I		Rudder authority schedule 1 signal from CADC fault. *Loss of rudder authority actuator.*										x													
AD16	I		Rudder authority schedule 2 signal from CADC fault. *Loss of rudder authority actuator.*										x													
AHR1		O	Attitude and heading reference system invalid input fault. *Loss of autopilot with IMU failure (backup mode).*											1												1:AP engd & IMU failed
AHR2		O	Attitude and heading reference system pitch synchro input fault. *Loss of autopilot with IMU failure (backup mode).*											1												1:AP engd & IMU failed
AHR3		O	Attitude and heading reference system roll synchro input fault. *Loss of autopilot with IMU failure (backup mode).*											1												1:AP engd & IMU failed

Figure 2-67. DFCS Failure Modes and Indications (Sheet 1 of 12)

DCP Code	IBIT Group	OFP Group	Failure Indication/*Functions lost*	PITCH SAS	FCS CAUTION	ROLL DGR	ARI DGR	YAW DGR	ARI/SAS OUT	SPOILERS	MACH TRIM	HZ TAIL AUTH	RUDDER AUTH	AUTOPILOT	ACLS A/P	Pitch Computer	Pitch Sensor	Pitch Actuator	Roll Computer	Roll Sensor	Roll Actuator	Yaw Computer	Yaw Sensor	Yaw Actuator	Accelerometer	Notes
AICX		O	Disagreement between left and right AICS fault. *Loss of pitch SAS and degraded roll SAS > 600 kts.*	1	2	1											2									1:> 600 knts, 2:WOW
AOAC	I	O	ARI angle of attack sensor fault. *Loss of primary AOAC alpha source/redundancy, default to ADD alpha source.*		1												1									1:WOW
AOAL		O	Left AICS angle of attack sensor fault. *Loss of tertiary AICS alpha source/redundancy.*		1												1									1:WOW
AOAR		O	Right AICS angle of attack sensor fault. *Loss of tertiary AICS alpha source/redundancy.*		1												1									1:WOW
AOAT	I	O	ADD angle of attack sensor fault. *Loss of secondary ADD alpha source/redundancy.*		1												1									1:WOW
APCA	I		Normal accelerometer sensor fault. *Degraded autothrottle APC, autopilot altitude hold, and ACL modes.*											1	1											1:AP engd
APCS	I		Scheduled outputs to approach power compensator fault. *Degraded autothrottle APC mode.*																							
CA28	I	O	Flight controls authority 28 V_{DC} power supply input fault. *Loss of lateral & rudder authority actuators.*									x	x													
CSDC	I		Steering error signal from CSDC fault. *Loss of autopilot heading hold, ground track hold, and VEC/PCD modes. Degraded autopilot ACL mode.*											1												1:AP engd
DCP1		O	DFCS control panel Pitch SAS switch fault. *Pitch SAS switch failure default to ON position. No IBIT capability.*		1													1								1:Pitch SAS switch Off
DCP2		O	DFCS control panel Roll SAS switch fault. *Roll SAS switch failure default to ON position. No IBIT capability.*			1	1		1												1					1:Roll SAS switch Off
DCP3		O	DFCS control panel Yaw SAS switch fault. *Yaw SAS switch failure default to ON position. No IBIT capability.*				1	1	1															1		1:Yaw SAS switch Off
DCP4	I	O	DFCS control panel Autopilot switch fault. *Autopilot switch failure default to OFF position unless cycled OFF/ON.*											1	2											1:AP engd, 2:ACL engd
DLCT	I		DLC thumb-wheel sensor fault. *Degraded DLC thumbwheel.*														x									
DLT1	I	O	DLC trim servo fault. *Loss of DLC actuator. No autopilot ACL mode.*											1	2			x								1: AP engd, 2: ACL engd
DLT2		O	DLC trim servo isolation fault. *Loss of Pitch B computer segregation. No IBIT capability.*	x	x		1			x				x		x	x	x		x						1:WOW
DPSL	I		Left AICS delta pressure (angle of attack) sensor fault. *Degraded tertiary AICS alpha source/ redundancy.*		x												x									
DPSR	I		Right AICS delta pressure (angle of attack) sensor fault. *Degraded tertiary AICS alpha source/ redundancy.*		x												x									
EDPS		O	Emergency disengage paddle switch discrete input fault. *Paddle switch failure default to engaged — no DLC, autopilot. No IBIT capability.*											1	2											1:AP engd, 2:ACL engd

Figure 2-67. DFCS Failure Modes and Indications (Sheet 2)

DCP Code	IBIT Group	OFP Group	Failure Indication/*Functions lost*	PITCH SAS	FCS CAUTION	ROLL DGR	ARI DGR	YAW DGR	ARI/SAS OUT	SPOILERS	MACH TRIM	HZ TAIL AUTH	RUDDER AUTH	AUTOPILOT	ACLS A/P	Pitch Computer	Pitch Sensor	Pitch Actuator	Roll Computer	Roll Sensor	Roll Actuator	Yaw Computer	Yaw Sensor	Yaw Actuator	Accelerometer	Notes
FLAP		O	Flaps down discrete input fault. *Flap switch failure default to flaps down. Loss of DLC, autopilot ACL mode. Flaps down spoiler gains. Possible loss of IBIT capability.*											1	2											1: AP engd, 2: ACL engd
GRBS		O	Ground-roll braking system discrete input fault. *Loss of ground-roll braking. Possible loss of IBIT capability.*																							
HT28		O	Lateral authority actuator 28 V_{DC} power supply fault. *Loss of lateral authority actuator.*									x														
HZTA	I	O	Lateral authority actuator fault. *Loss of lateral authority actuator.*									x														
IMU1		O	Inertial measurement unit INS invalid input fault. *Loss of pitch/roll rate redundancy (autopilot operates in AHRS).*		x									1	2		x			x						1: AP engd, 2: ACL engd
IMU2		O	Inertial measurement unit pitch synchro input fault. *Loss of pitch/roll rate redundancy (autopilot operates in AHRS).*		x									1	2		x			x						1: AP engd, 2: ACL engd
IMU3		O	Inertial measurement unit roll synchro input fault. *Loss of pitch/roll rate redundancy (autopilot operates in AHRS).*		x									1	2		x			x						1: AP engd, 2: ACL engd
IMU4		O	Inertial measurement unit PQVM fault. *Loss of pitch/roll rate redundancy (autopilot operates in AHRS).*		x									1	2		x			x						1: AP engd, 2: ACL engd
LAT1	I	O	Lateral accelerometer channel A fault. *Loss of lateral acceleration redundancy (2nd fault loss of yaw SAS/ARI).*		x																				x	
LAT2	I	O	Lateral accelerometer channel B fault. *Loss of lateral acceleration redundancy (2nd fault loss of yaw SAS/ARI).*		x																				x	
LAT3	I	O	Lateral accelerometer channel M fault. *Loss of lateral acceleration redundancy (2nd fault loss of yaw SAS/ARI).*		x																				x	
LDG1		O	Main landing gear input 1 fault. *Loss of main landing gear position redundancy (2nd fault defaults to UA mode).*																	x						
LDG2		O	Main landing gear input 2 fault. *Loss of main landing gear position redundancy (2nd fault defaults to UA mode).*																	x						
LDG3		O	Main landing gear input 3 fault. *Loss of main landing gear position redundancy (2nd fault defaults to UA mode).*																	x						
MACL		O	SCADC to AICS Mach miscompare while left AICS was selected. *Loss of WRS, LSXC, autopilot. Loss of pitch SAS and degraded roll SAS > 600 kts.*	1	2	1	2										2									1: > 600 knts, 2: WOW
MACR		O	SCADC to AICS Mach miscompare while right AICS was selected. *Loss of WRS, LSXC, autopilot. Loss of pitch SAS and degraded roll SAS > 600 kts.*	1	2	1	2										2									1: > 600 knts, 2: WOW
MRS1		O	Master reset switch input 1 fault. *Loss of master reset switch redundancy (2nd fault defaults to OFF position).*																							
MRS2		O	Master reset switch input 2 fault. *Loss of master reset switch redundancy (2nd fault defaults to OFF position).*																							

Figure 2-67. DFCS Failure Modes and Indications (Sheet 3)

DCP Code	IBIT Group	OFP Group	Failure Indication/*Functions lost*	PITCH SAS	FCS CAUTION	ROLL DGR	ARI DGR	YAW DGR	ARI/SAS OUT	SPOILERS	MACH TRIM	HZ TAIL AUTH	RUDDER AUTH	AUTOPILOT	ACLS A/P	Pitch Computer	Pitch Sensor	Pitch Actuator	Roll Computer	Roll Sensor	Roll Actuator	Yaw Computer	Yaw Sensor	Yaw Actuator	Accelerometer	Notes
MRS3		O	Master reset switch input 3 fault. *Loss of master reset switch redundancy (2nd fault defaults to OFF position).*																							
MT28	I	O	Mach trim 28 V_{DC} power supply input fault. *Loss of Mach trim actuator.*								x															
MTRM	I	O	Mach trim actuator fault. *Loss of Mach trim actuator.*								x															
PC01		O	Pitch A computer AC export power supply fault. *Loss of Pitch A computer segregation.*	x	x	3	4			x				1	2	x	x	x		x	x					1: AP engd, 2: ACL engd, 3: > 600 knts, 4: WOW
PC02		O	Pitch B computer AC export power supply fault. *Loss of Pitch B computer segregation.*	x	x		1			x				x		x	x	x		x						1: WOW
PC03	I		Pitch A computer 28 V_{DC} power supply monitor fault. *Probable loss of Pitch A computer segregation.*	x	x	x	x	x	x							x										
PC04	I		Pitch B computer 28 V_{DC} power supply monitor fault. *Probable loss of Pitch B computer segregation.*	x	x	x	x	x	x							x										
PC05		O	Pitch A computer general fault. *Loss of Pitch A computer segregation.*	x	x	3	4			x				1	2	x	x	x		x	x					1: AP engd, 2: ACL engd, 3: > 600 knts, 4: WOW
PC06		O	Pitch B computer general fault. *Loss of Pitch B computer segregation.*	x	x		1			x				x		x	x	x		x						1: WOW
PC07	I		Pitch A computer general fault. *Probable loss of Pitch A computer segregation.*	x	x	x	x	x	x							x										
PC08	I		Pitch B computer general fault. *Probable loss of Pitch B computer segregation.*	x	x	x	x	x	x							x										
PC09	I		Probable Pitch A computer isolation fault. *Loss of Pitch A computer segregation isolation capability.*	x	x	x	x	x	x							x										
PC10	I		Probable Pitch B computer isolation fault. *Loss of Pitch B computer segregation isolation capability.*	x	x	x	x	x	x							x										
PC11		O	Pitch A from Pitch B computer CCDL fault. *Degraded/failed Pitch A computer segregation.*	x	x					1						x										1: DLC or GRB engd
PC12		O	Pitch B from Pitch A computer CCDL fault. *Degraded/failed Pitch B computer segregation.*	x	x					3				1	2	x	x	x								1: AP engd, 2: ACL engd, 3: Flaps up
PC13		O	Pitch A from Roll B computer CCDL fault. *Degraded/failed Pitch A computer segregation.*		x																					
PC14		O	Pitch B from Yaw A computer CCDL fault. *Degraded/failed Pitch B and/or Yaw A computer segregation.*		x												1									1: WOW
PC15		O	Pitch A from Yaw B computer CCDL fault. *Degraded/failed Pitch A computer segregation.*		x																					
PC16		O	Pitch B from Roll A computer CCDL fault. *Degraded/failed Pitch B computer segregation.*	3	x					4				1	2		x									1: AP engd, 2: ACL engd, 3: > 600 knts, 4: Flaps up or GRB engd

Figure 2-67. DFCS Failure Modes and Indications (Sheet 4)

DCP Code	IBIT Group	OFP Group	Failure Indication/*Functions lost*	PITCH SAS	FCS CAUTION	ROLL DGR	ARI DGR	YAW DGR	ARI/SAS OUT	SPOILERS	MACH TRIM	HZ TAIL AUTH	RUDDER AUTH	AUTOPILOT	ACLS A/P	Pitch Computer	Pitch Sensor	Pitch Actuator	Roll Computer	Roll Sensor	Roll Actuator	Yaw Computer	Yaw Sensor	Yaw Actuator	Accelerometer	Notes
PC17	I		Pitch A computer ±12 V_{DC} exported power supply fault. *Degraded autopilot modes.*											1												1:AP engd
PC18	I		Pitch B computer ±12 V_{DC} exported power supply fault. *Degraded DLC thumbwheel.*														x									
PC19	I		Pitch computer consolidated exported power supply fault. *Loss of pitch SAS, autopilot, and roll rate redundancy.*	x	x												x									
PC20	I		Servo isolation fault in Pitch A computer. *Loss of Pitch A computer segregation isolation capability.*	x	x	x	x	x	x							x										
PC21	I		Servo isolation fault in Pitch B computer. *Loss of Pitch B computer segregation isolation capability.*	x	x	x	x	x	x							x										
PC22	I		Pitch A computer ground test input fault. *No immediate loss of function.*	x	x	x	x	x	x							x										
PC23	I		Pitch B computer spoiler servo amplifier fault. *Loss of outboard spoiler actuator(s).*							x								x								
PC24	I		Pitch computer gyro input fault. *Loss of pitch rate redundancy.*		x												x									
PC26	I		Pitch computer autotrim command monitor fault. *No immediate loss of function.*											1												1:AP engd
PC35	I		Pitch A computer consolidated exported power supply monitor fault. *Loss of pitch SAS, autopilot, and roll rate redundancy.*	x	x	x	x	x	x							x										
PC36	I		Pitch B computer consolidated exported power supply monitor fault. *Loss of pitch SAS, autopilot, and roll rate redundancy.*	x	x	x	x	x	x							x										
PC37	I		Pitch A computer 115 V_{AC} power supply monitor fault. *Loss of Pitch A computer segregation.*	x	x	x	x	x	x							x										
PC38	I		Pitch B computer 115 V_{AC} power supply monitor fault. *Loss of Pitch B computer segregation.*	x	x	x	x	x	x							x										
PC39	I		Probable Pitch A computer interface BIT circuit fault. *Probable loss of Pitch A computer segregation.*		x									1			x			x						1:AP engd
PC40	I		Probable Pitch B computer interface BIT circuit fault. *Probable loss of Pitch B computer segregation.*		x									1	1					x						1:AP engd
PC41	I		Pitch A computer AC analogue input interface fault. *Loss of IMU pitch attitude and autopilot pitch stick force.*		x									1			x			x						1:AP engd
PC42	I		Pitch B computer AC analogue input interface fault. *Loss of AHRS pitch attitude, roll stick position redundancy, and pitch datalink command.*		x									1	1					x						1:AP engd
PC45		O	Pitch computer consolidated exported power supply fault. *Loss of pitch SAS and roll rate (PQVM) redundancy.*	x	x									1	2		x									1:AP engd, 2:ACL engd
PGY1	I	O	Pitch gyro channel A fault. *Loss of pitch rate redundancy (2nd fault possible loss of pitch SAS, autopilot, and roll rate redundancy).*		x												x									
PGY2	I	O	Pitch gyro channel B fault. *Loss of pitch rate redundancy (2nd fault possible loss of pitch SAS, autopilot, and roll rate redundancy).*		x												x									
PGY4	I	O	Pitch gyro channel A SMRD fault. *Loss of pitch rate redundancy (2nd fault possible loss of pitch SAS, autopilot, and roll rate redundancy).*		x												x									

Figure 2-67. DFCS Failure Modes and Indications (Sheet 5)

DCP Code	IBIT Group	OFP Group	Failure Indication/*Functions lost*	PITCH SAS	FCS CAUTION	ROLL DGR	ARI DGR	YAW DGR	ARI/SAS OUT	SPOILERS	MACH TRIM	HZ TAIL AUTH	RUDDER AUTH	AUTOPILOT	ACLS A/P	Pitch Computer	Pitch Sensor	Pitch Actuator	Roll Computer	Roll Sensor	Roll Actuator	Yaw Computer	Yaw Sensor	Yaw Actuator	Accelerometer	Notes
PGY5	I	O	Pitch gyro channel B SMRD fault. *Loss of pitch rate redundancy (2nd fault possible loss of pitch SAS, autopilot, and roll rate redundancy).*		x												x									
PGY7	I		Pitch gyro common mode fault. *Loss of pitch SAS, autopilot, and roll rate redundancy.*	x	x												x									
POR		O	In-flight power on reset. *POR indicates transient AC and/or DC power interruption to computers in OFP resulting in total loss of DFCS functionality.*	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	
PPA	I	O	Pitch parallel actuator fault. *Loss of autopilot ACL mode.*											x	x			x								
PSA1	I	O	Pitch series servo channel A fault. *Degraded pitch SAS due to loss of single pitch SAS actuator (2nd fault possible loss of pitch SAS).*	x														x								
PSA2	I	O	Pitch series servo channel B fault. *Degraded pitch SAS due to loss of single pitch SAS actuator (2nd fault possible loss of pitch SAS).*	x														x								
PSA3		O	Pitch series servo channel A isolation fault. *Loss of Pitch computer segregation.*	x	x	3	4			x				1	2	x	x	x		x	x					1:AP engd, 2:ACL engd, 3:> 600 knts, 4:WOW
PSA4		O	Pitch series servo channel B isolation fault. *Loss of Pitch B computer segregation.*	x	x		1			x				x		x	x	x		x						1: WOW
PTRM	I	O	Pitch autotrim actuator fault. *Degraded autopilot modes.*											x	1			x								1:ACL engd (OFP only)
RC01		O	Roll A computer AC export power supply fault. *Loss of Roll A computer segregation.*	3	x	x	x			x	x			1	2		x		x	x	x					1:AP engd, 2:ACL engd, 3:> 600 knts
RC02		O	Roll B computer AC export power supply fault. *Loss of Roll B computer segregation.*		x	x	x				x			1	2		3		x	x	x					1:AP engd, 2:ACL engd, 3:WOW
RC03	I		Roll A computer 28 V_{DC} power supply monitor fault. *Probable loss of Roll A computer segregation.*	x	x	x	x	x	x										x							
RC04	I		Roll B computer 28 V_{DC} power supply monitor fault. *Probable loss of Roll B computer segregation.*	x	x	x	x	x	x										x							
RC05		O	Roll A computer general fault. *Loss of Roll A computer segregation.*	3	x	x	x			x	x			1	2		x		x	x	x					1:AP engd, 2:ACL engd, 3:> 600 knts
RC06		O	Roll B computer general fault. *Loss of Roll B computer segregation.*		x	x	x				x			1	2		3		x	x	x					1:AP engd, 2:ACL engd, 3:WOW
RC07	I		Roll A computer general fault. *Probable loss of Roll A computer segregation.*	x	x	x	x	x	x										x							
RC08	I		Roll B computer general fault. *Probable loss of Roll B computer segregation.*	x	x	x	x	x	x										x							
RC09	I		Probable Roll A computer isolation fault. *Loss of Roll A computer segregation isolation capability.*	x	x	x	x	x	x										x							
RC10	I		Probable Roll B computer isolation fault. *Loss of Roll B computer segregation isolation capability.*	x	x	x	x	x	x										x							
RC11		O	Roll A from Roll B computer CCDL fault. *Degraded/failed Roll A computer segregation.*		x	x					x			1	2				x	x	x					1:AP engd, 2:ACL engd
RC12		O	Roll B from Roll A computer CCDL fault. *Degraded/failed Roll B computer segregation.*		x	x					x								x							

Figure 2-67. DFCS Failure Modes and Indications (Sheet 6)

DCP Code	IBIT Group	OFP Group	Failure Indication/*Functions lost*	PITCH SAS	FCS CAUTION	ROLL DGR	ARI DGR	YAW DGR	ARI/SAS OUT	SPOILERS	MACH TRIM	HZ TAIL AUTH	RUDDER AUTH	AUTOPILOT	ACLS A/P	Pitch Computer	Pitch Sensor	Pitch Actuator	Roll Computer	Roll Sensor	Roll Actuator	Yaw Computer	Yaw Sensor	Yaw Actuator	Accelerometer	Notes
RC13		O	Roll A from Yaw B computer CCDL fault. *Degraded/failed Roll A computer segregation.*		x																					
RC14		O	Roll B from Pitch A computer CCDL fault. *Degraded/failed Roll B computer segregation.*		x	1																				1:> 600 knts
RC15		O	Roll A from Pitch B computer CCDL fault. *Degraded/failed Roll A computer segregation.*		x					3				1	2					x						1:AP engd, 2:ACL engd, 3: DLC or GRB engd
RC16		O	Roll B from Yaw A computer CCDL fault. *Degraded/failed Roll B computer segregation.*		x																					
RC17	I		Roll A computer internal power supply fault. *Loss of Roll A computer segregation.*	x	x	x	x	x	x										x							
RC18	I		Roll B computer ±12 V_{DC} exported power supply fault. *Degraded autopilot modes.*											1												1:AP engd
RC19	I		Roll computer consolidated exported power supply fault. *Loss of roll SAS/ARI, autopilot, and pitch rate redundancy.*		x	x	x		x											x						
RC20	I		Servo isolation fault in Roll A computer. *Loss of Roll A computer segregation isolation capability.*	x	x	x	x	x	x										x							
RC21	I		Servo isolation fault in Roll B computer. *Loss of Roll B computer segregation isolation capability.*	x	x	x	x	x	x										x							
RC22	I		Roll A computer ground test input fault. *No immediate loss of function.*	x	x	x	x	x	x										x							
RC23	I		Roll A computer spoiler servo amplifier fault. *Loss of inboard spoiler actuator(s).*							x											x					
RC24	I		Roll computer gyro input fault. *Loss of roll rate redundancy.*		x															x						
RC27	I		Roll computer Mach trim actuator isolation fault. *No immediate loss of function.*								x															
RC28	I		Roll computer Mach trim current monitor fault. *Probable loss of Roll A computer segregation.*								x															
RC35	I		Roll A computer consolidated exported power supply monitor fault. *Loss of roll SAS/ARI, autopilot, and pitch rate redundancy.*	x	x	x	x	x	x										x							
RC36	I		Roll B computer consolidated exported power supply monitor fault. *Loss of roll SAS/ARI, autopilot, and pitch rate redundancy.*	x	x	x	x	x	x										x							
RC37	I		Roll A computer 115 V_{AC} power supply monitor fault. *Loss of Roll A computer segregation.*	x	x	x	x	x	x										x							
RC38	I		Roll B computer 115 V_{AC} power supply monitor fault. *Loss of Roll B computer segregation.*	x	x	x	x	x	x										x							
RC39	I		Probable Roll A computer interface BIT circuit fault. *Probable loss of roll A computer segregation.*		x									1	1		x			x						1:AP engd
RC40	I		Probable Roll B computer interface BIT circuit fault. *Probable loss of Roll B computer segregation.*		x									1						x						1:AP engd
RC41	I		Roll A computer AC analogue input interface fault. *Loss of IMU roll attitude, roll stick position redundancy, and roll datalink command.*		x									1	1		x			x						1:AP engd
RC42	I		Roll B computer AC analogue input interface fault. *Loss of AHRS roll attitude, roll stick position redundancy, and autopilot roll stick force.*		x									1						x						1:AP engd

Figure 2-67. DFCS Failure Modes and Indications (Sheet 7)

DCP Code	IBIT Group	OFP Group	Failure Indication/*Functions lost*	PITCH SAS	FCS CAUTION	ROLL DGR	ARI DGR	YAW DGR	ARI/SAS OUT	SPOILERS	MACH TRIM	HZ TAIL AUTH	RUDDER AUTH	AUTOPILOT	ACLS A/P	Pitch Computer	Pitch Sensor	Pitch Actuator	Roll Computer	Roll Sensor	Roll Actuator	Yaw Computer	Yaw Sensor	Yaw Actuator	Accelerometer	Notes
RC45		O	Roll computer consolidated exported power supply fault. *Loss of roll SAS/ARI, autopilot, and pitch rate redundancy (PQVM fault).*		x	x	x		x					1	2					x						1:AP engd, 2:ACL engd
RCP1		O	Roll stick position input 1 fault. *Loss of roll stick position redundancy (2nd fault loss of roll SAS/ARI and spoilers).*		x															x						
RCP2		O	Roll stick position input 2 fault. *Loss of roll stick position redundancy (2nd fault loss of roll SAS/ARI and spoilers).*		x															x						
RCP3		O	Roll stick position input 3 fault. *Loss of roll stick position redundancy (2nd fault loss of roll SAS/ARI and spoilers).*		x															x						
RD28		O	Rudder authority $28V_{DC}$ power supply input fault. *Loss of rudder authority actuator.*										x													
RGY1	I	O	Roll gyro channel A fault. *Loss of roll rate redundancy (2nd fault possible loss of roll SAS/ARI, autopilot, and pitch rate redundancy).*		x															x						
RGY2	I	O	Roll gyro channel B fault. *Loss of roll rate redundancy (2nd fault possible loss of roll SAS/ARI, autopilot, and pitch rate redundancy).*		x															x						
RGY4	I	O	Roll gyro channel A SMRD fault. *Loss of roll rate redundancy (2nd fault possible loss of roll SAS/ARI, autopilot, and pitch rate redundancy).*		x															x						
RGY5	I	O	Roll gyro channel B SMRD fault. *Loss of roll rate redundancy (2nd fault possible loss of roll SAS/ARI, autopilot, and pitch rate redundancy).*		x															x						
RGY7	I		Roll gyro common mode fault. *Loss of roll SAS/ARI, autopilot, and pitch rate redundancy.*		x	x	x		x											x						
RPP1		O	Rudder pedal position sensor input 1 fault. *Loss of rudder pedal position redundancy (2nd fault loss of ARI functions).*		x																		x			
RPP2		O	Rudder pedal position sensor input 2 fault. *Loss of rudder pedal position redundancy (2nd fault loss of ARI functions).*		x																		x			
RPP3		O	Rudder pedal position sensor input 3 fault. *Loss of rudder pedal position redundancy (2nd fault loss of ARI functions).*		x																		x			
RSA1	I	O	Roll series servo channel A fault. *Degraded roll SAS due to loss of single roll SAS actuator (2nd fault possible loss of ARI functions).*			x	x														x					
RSA2	I	O	Roll series servo channel B fault. *Degraded roll SAS due to loss of single roll SAS actuator (2nd fault possible loss of ARI functions).*			x	x														x					
RSA3		O	Roll series servo channel A isolation fault. *Loss of Roll A computer segregation.*	3	x	x	x			x	x			1	2		x		x	x	x					1:AP engd, 2:ACL engd, 3:> 600 knts
RSA4		O	Roll series servo channel B isolation fault. *Loss of Roll B computer segregation.*		x	x	x				x			1	2		3		x	x	x					1:AP engd, 2:ACL engd, 3:WOW
RUDA	I	O	Rudder authority actuator fault. *Loss of rudder authority actuator.*										x													
SHKR		O	Rudder pedal shaker fault. *Loss of rudder pedal shaker.*																							
SP1L	I	O	No. 1 left spoiler actuator fault. *Loss of spoiler actuator.*							x				1	1						x					1:ACL engd

Figure 2-67. DFCS Failure Modes and Indications (Sheet 8)

DCP Code	IBIT Group	OFP Group	Failure Indication/*Functions lost*	PITCH SAS	FCS CAUTION	ROLL DGR	ARI DGR	YAW DGR	ARI/SAS OUT	SPOILERS	MACH TRIM	HZ TAIL AUTH	RUDDER AUTH	AUTOPILOT	ACLS A/P	Pitch Computer	Pitch Sensor	Pitch Actuator	Roll Computer	Roll Sensor	Roll Actuator	Yaw Computer	Yaw Sensor	Yaw Actuator	Accelerometer	Notes
SP1R	I	O	No. 1 right spoiler actuator fault. *Loss of spoiler actuator.*							x				1	1						x					1:ACL engd
SP2L	I	O	No. 2 left spoiler actuator fault. *Loss of spoiler actuator.*							x				1	1						x					1:ACL engd
SP2R	I	O	No. 2 right spoiler actuator fault. *Loss of spoiler actuator.*							x				1	1						x					1:ACL engd
SP3L	I	O	No. 3 left spoiler actuator fault. *Loss of spoiler actuator.*							x				1	1			x								1:ACL engd
SP3R	I	O	No. 3 right spoiler actuator fault. *Loss of spoiler actuator.*							x				1	1			x								1:ACL engd
SP4L	I	O	No. 4 left spoiler actuator fault. *Loss of spoiler actuator.*							x				1	1			x								1:ACL engd
SP4R	I	O	No. 4 right spoiler actuator fault. *Loss of spoiler actuator.*							x				1	1			x								1:ACL engd
SPSL	I		Left AICS static pressure sensor fault. *Degraded tertiary AICS alpha/Mach source/redundancy.*		x		x										x									
SPSR	I		Right AICS static pressure sensor fault. *Degraded tertiary AICS alpha/Mach source/ redundancy.*		x		x										x									
TPSL	I		Left AICS total pressure sensor fault. *Degraded tertiary AICS alpha/Mach source/redundancy.*		x		x										x									
TPSR	I		Right AICS total pressure sensor fault. *Degraded tertiary AICS alpha/Mach source/ redundancy.*		x		x										x									
WOW1		O	Weight-on-wheels input 1 fault. *Loss of weight-on-wheels redundancy (2nd fault default W-off-W, loss of GRB).*														x									
WOW2		O	Weight-on-wheels input 2 fault. *Loss of weight-on-wheels redundancy (2nd fault default W-off-W, loss of GRB).*																	x						
WOW3		O	Weight-on-wheels input 3 fault. *Loss of weight-on-wheels redundancy (2nd fault default W-off-W, loss of GRB).*																				x			
WSP1		O	Wingsweep input to Pitch computer fault. *Loss of inboard spoilers with flaps up.*																							
WSP2		O	Wingsweep input to Roll computer fault. *Loss of outboard spoilers with flaps up.*																							
YC01		O	Yaw A computer AC export power supply fault. *Loss of Yaw A computer segregation.*		x		x	x				x	x				1					x	x	x	x	1:WOW
YC02		O	Yaw B computer AC export power supply fault. *Loss of Yaw B computer segregation.*		x		x	x		x		x	x	1	1		2	x				x	x	x	x	1:ACL engd, 2:WOW
YC03	I		Yaw A computer 28 V_{DC} power supply monitor fault. *Probable loss of Yaw A computer segregation.*	x	x	x	x	x	x													x				
YC04	I		Yaw B computer 28 V_{DC} power supply monitor fault. *Probable loss of Yaw B computer segregation.*	x	x	x	x	x	x													x				
YC05		O	Yaw A computer general fault. *Loss of Yaw A computer segregation.*		x		x	x				x	x				1					x	x	x	x	1:WOW
YC06		O	Yaw B computer general fault. *Loss of Yaw B computer segregation.*		x		x	x		x		x	x	1	1		2	x				x	x	x	x	1:ACL engd, 2:WOW
YC07	I		Yaw A computer general fault. *Probable loss of Yaw A computer segregation.*	x	x	x	x	x	x													x				

Figure 2-67. DFCS Failure Modes and Indications (Sheet 9)

DCP Code	IBIT Group	OFP Group	Failure Indication/*Functions lost*	PITCH SAS	FCS CAUTION	ROLL DGR	ARI DGR	YAW DGR	ARI/SAS OUT	SPOILERS	MACH TRIM	HZ TAIL AUTH	RUDDER AUTH	AUTOPILOT	ACLS A/P	Pitch Computer	Pitch Sensor	Pitch Actuator	Roll Computer	Roll Sensor	Roll Actuator	Yaw Computer	Yaw Sensor	Yaw Actuator	Accelerometer	Notes
YC08	I		Yaw B computer general fault. *Probable loss of Yaw B computer segregation.*	x	x	x	x	x	x													x				
YC09	I		Probable Yaw A computer isolation fault. *Loss of Yaw A computer segregation isolation capability.*	x	x	x	x	x	x													x				
YC10	I		Probable Yaw B computer isolation fault. *Loss of Yaw B computer segregation isolation capability.*	x	x	x	x	x	x													x				
YC11		O	Yaw A from Yaw B computer CCDL fault. *Degraded/failed Yaw A computer segregation.*		x			x				x	x									x		x		
YC12		O	Yaw B from Yaw A computer CCDL fault. *Degraded/failed Yaw B computer segregation.*		x			x				x	x									x	x		x	
YC13		O	Yaw A from Pitch B computer CCDL fault. *Degraded/failed Yaw A computer segregation.*		x																					
YC14		O	Yaw B from Roll A computer CCDL fault. *Degraded/failed Yaw B computer segregation.*		x					1																1:Flaps up
YC15		O	Yaw A from Roll B computer CCDL fault. *Degraded/failed Yaw A computer segregation.*		x																					
YC16		O	Yaw B from Pitch A computer CCDL fault. *Degraded/failed Yaw B computer segregation.*		x					1																1:Flaps up
YC17	I		Yaw A computer ±12 V_{DC} exported power supply fault. *Loss of yaw rate and lateral accelerometer redundancy.*		x																		x		x	
YC18	I		Yaw B computer ±12 V_{DC} exported power supply fault. *Loss of yaw rate and lateral accelerometer redundancy.*		x																		x		x	
YC19	I		Yaw computer exported ’M’ channel power supply fault. *Loss of yaw rate and lateral accelerometer redundancy.*		x																		x		x	
YC20	I		Servo isolation fault in Yaw A computer. *Loss of Yaw A computer segregation isolation capability.*	x	x	x	x	x	x													x				
YC21	I		Servo isolation fault in Yaw B computer. *Loss of Yaw B computer segregation isolation capability.*	x	x	x	x	x	x													x				
YC22	I		Yaw B computer ground test input fault. *No immediate loss of functionality.*	x	x	x	x	x	x													x				
YC24	I		Yaw computer gyro input fault. *Loss of yaw rate redundancy.*		x																		x			
YC25	I		Yaw computer accelerometer input fault. *Loss of lateral accelerometer redundancy.*		x																				x	
YC29	I		Yaw computer rudder authority actuator isolation fault. *No immediate loss of functionality.*										x													
YC30	I		Yaw computer rudder authority current monitor fault. *Probable loss of Yaw A computer segregation.*										x													
YC31	I		Yaw computer lateral authority actuator isolation fault. *No immediate loss of functionality.*									x														
YC32	I		Yaw computer lateral authority actuator current monitor fault. *Probable loss of Yaw B computer segregation.*									x														
YC33	I		Yaw computer 28 V_{DC} power supply discrete input fault. *No immediate loss of functionality.*									x	x													
YC34	I		Yaw computer rudder pedal shaker fault. *Loss of rudder pedal shaker.*																					x		
YC35	I		Yaw A computer exported ’M’ channel power supply monitor fault. *Loss of yaw rate and lateral acceleration redundancy.*	x	x	x	x	x	x													x				

Figure 2-67. DFCS Failure Modes and Indications (Sheet 10)

DCP Code	IBIT Group	OFP Group	Failure Indication/*Functions lost*	PITCH SAS	FCS CAUTION	ROLL DGR	ARI DGR	YAW DGR	ARI/SAS OUT	SPOILERS	MACH TRIM	HZ TAIL AUTH	RUDDER AUTH	AUTOPILOT	ACLS A/P	Pitch Computer	Pitch Sensor	Pitch Actuator	Roll Computer	Roll Sensor	Roll Actuator	Yaw Computer	Yaw Sensor	Yaw Actuator	Accelerometer	Notes
YC36	I		Yaw B computer exported ’M’ channel power supply monitor fault. *Loss of yaw rate and lateral acceleration redundancy.*	x	x	x	x	x	x													x				
YC37	I		Yaw A computer 115 V_{AC} power supply monitor fault. *Loss of Yaw A computer segregation.*	x	x	x	x	x	x													x				
YC38	I		Yaw B computer 115 V_{AC} power supply monitor fault. *Loss of Yaw B computer segregation.*	x	x	x	x	x	x													x				
YC39	I		Probable Yaw A computer interface BIT circuit fault. *Probable loss of Yaw A computer segregation.*		x																		x			
YC40	I		Probable Yaw B computer interface BIT circuit fault. *Probable loss of Yaw B computer segregation.*		x																		x			
YC41	I		Yaw A computer AC analogue input interface fault. *Loss of rudder pedal position redundancy.*		x																		x			
YC42	I		Yaw B computer AC analogue input interface fault. *Loss of rudder pedal position redundancy.*		x																		x			
YC43		O	Yaw M AC export power supply fault. *Loss of yaw rate and rudder pedal position redundancy.*		x																		x			
YC44		O	Yaw M AC power supply monitor fault. *No immediate loss of functionality.*																							
YC45		O	Yaw computer consolidated exported power supply fault. *Loss of yaw rate and lateral accelerometer redundancy. Possible loss of ADD alpha redundancy.*		x																		x		x	
YGY1	I	O	Yaw gyro channel A fault. *Loss of yaw rate redundancy (2nd fault possible loss of yaw SAS/ARI, autopilot, and pitch/roll rate redundancy).*		x																		x			
YGY2	I	O	Yaw gyro channel B fault. *Loss of yaw rate redundancy (2nd fault possible loss of yaw SAS/ARI, autopilot, and pitch/roll rate redundancy).*		x																		x			
YGY3	I	O	Yaw gyro channel M fault. *Loss of yaw rate redundancy (2nd fault possible loss of yaw SAS/ARI, autopilot, and pitch/roll rate redundancy).*		x																		x			
YGY4	I	O	Yaw gyro channel A SMRD fault. *Loss of yaw rate redundancy (2nd fault possible loss of yaw SAS/ARI, autopilot, and pitch/roll rate redundancy).*		x																		x			
YGY5	I	O	Yaw gyro channel B SMRD fault. *Loss of yaw rate redundancy (2nd fault possible loss of yaw SAS/ARI, autopilot, and pitch/roll rate redundancy).*		x																		x			
YGY6	I	O	Yaw gyro channel M SMRD fault. *Loss of yaw rate redundancy (2nd fault possible loss of yaw SAS/ARI, autopilot, and pitch/roll rate redundancy).*		x																		x			
YSA1	I	O	Yaw series servo channel A fault. *Degraded yaw SAS due to loss of single yaw SAS actuator (2nd fault possible loss of ARI functions).*				x	x																x		
YSA2	I	O	Yaw series servo channel B fault. *Degraded yaw SAS due to loss of single yaw SAS actuator (2nd fault possible loss of ARI functions).*				x	x																x		
YSA3		O	Yaw series servo channel A isolation fault. *Loss of Yaw A computer segregation.*		x		x	x				x	x				1					x	x	x	x	1:WOW

Figure 2-67. DFCS Failure Modes and Indications (Sheet 11)

DCP Code	IBIT Group	OFP Group	Failure Indication/*Functions lost*	PITCH SAS	FCS CAUTION	ROLL DGR	ARI DGR	YAW DGR	ARI/SAS OUT	SPOILERS	MACH TRIM	HZ TAIL AUTH	RUDDER AUTH	AUTOPILOT	ACLS A/P	Pitch Computer	Pitch Sensor	Pitch Actuator	Roll Computer	Roll Sensor	Roll Actuator	Yaw Computer	Yaw Sensor	Yaw Actuator	Accelerometer	Notes
YSA4		O	Yaw series servo channel B isolation fault. *Loss of Yaw B computer segregation.*		x		x	x		x		x	x	1	1		2	x				x	x	x	x	1: ACL engd, 2: WOW

Note:

Abbreviations: autopilot (AP), automatic carrier landing (ACL), direct lift control (DLC), ground-roll braking (GRB), inertial measurement unit (IMU), weight-off-wheels (WOW). This table shows failure indications and functions lost for single faults only. Multiple faults may yield additional failure indications and functions lost. Functions lost due to degrade/failure of computer segregation(s) identified below.

Computer Segregation Failure Functions Lost:

Pitch A Pitch A SAS actuator, inboard spoilers, DLC, AOA/Mach redundancy (no AICR AOA/Mach), WRS, LSXC, autopilot. Loss of pitch SAS, degraded roll SAS > 600 kts. No IBIT capability.

Pitch B Pitch B SAS actuator, outboard spoilers, DLC, GRB, Mach failure (no SCADC Mach), WRS, LSXC, autopilot. Autothrottle APC degraded. No IBIT capability.

Roll A Roll A SAS actuator, inboard spoilers, DLC, GRB, Mach trim, AOA/Mach redundancy (no AICL AOA/Mach), WRS, LSXC, autopilot. Loss of pitch SAS, degraded roll SAS > 600 kts. No IBIT capability.

Roll B Roll B SAS actuator, Mach trim, autopilot. Mach failure (no SCADC Mach), WRS, LSXC. No IBIT capability.

Yaw A Yaw A SAS actuator, lateral/rudder authority actuators, AOA redundancy (no ARI AOA), DCP display (POR acro), rudder pedal shaker. No IBIT capability.

Yaw B Yaw B SAS actuator, outboard spoilers, DLC, lateral/rudder authority actuators, AOA redundancy (no ADD AOA), rudder pedal shaker. No IBIT capability.

Figure 2-67. DFCS Failure Modes and Indications (Sheet 12)

The only situation in which an airborne POR should be considered is when a DFCS failure has resulted in unsuitable controllability for landing approach (i.e., complete loss of spoilers and asymmetric load condition). In this case, the risk of potential uncommanded SAS inputs is outweighed by the risk of attempting landing with marginal or uncontrollable flying qualities at approach speed.

2.23.2 Voltage Monitoring. The DFCS monitors voltage levels internally and no longer requires the VMCU. When a low voltage condition of 88.5 volts ac or less or a high voltage condition of 126.5 volts ac or more is detected, the computer channel detecting the abnormal voltage will be isolated and its associated functions will be lost. Failure indications for an isolated computer channel are shown in Figure 2-67. Depressing MASTER RESET will restore normal system operation once the voltage is within allowable limits.

Similar to the ac power, when dc voltage drops below 11.0 volts, the affected computer channel will be isolated and the associated functions will be lost. Depressing MASTER RESET will restore normal system operation once the voltage is within allowable limits.

2.23.3 Autopilot. The autopilot is controlled by four switches on the lower half of the DFCS control panel (Figure 2-64), and the autopilot reference and nosewheel steering pushbutton on the stick grip. With all three SAS axes engaged, autopilot operation is commanded by placing the ENGAGE/OFF switch to ENGAGE. No warmup period is required. The autopilot may be engaged with the aircraft in any attitude. If, however, aircraft attitude exceeds ±30° in pitch and ±60° in roll, the autopilot will automatically return the aircraft to these limits. Normally, the EGI is the prime reference and AHRS a backup.

2.23.3.1 DFCS Series Actuators. The series actuator is a dual-channel servoactuator that is controlled and commanded by the DFCS computers to provide a low-authority input that can be mechanically overridden by the pilot. Each servo of the dual actuator is monitored to provide failure detection and automatic shutdown of a malfunctioning actuator channel. The remaining functional channel will continue to provide half authority in the affected axis. In the yaw axis, the output commands are doubled to provide normal yaw SAS response up to the authority of the remaining yaw series servoactuator (±9.5°). Autopilot modes may be engageable but will have reduced authority. A dual pitch series servoactuator failure results in loss of the pitch SAS. A dual roll or yaw series servoactuator failure results in loss of the affected SAS and all ARI functions. With landing gear retracted, the roll SAS will be disabled whenever ARI functions are lost. This is to minimize risk of departure if a dual failure occurs during aggressive maneuvering.

Pitch series servoactuator failures are indicated by the PITCH SAS caution light and PA acronym. Roll series servoactuator failures are indicated by the ROLL DGR, ARI DGR caution lights and RA acronym for a first failure and ROLL DGR, ARI DGR, ARI/SAS OUT caution lights and RA acronym for a second failure. Yaw series servoactuator failures are indicated by the YAW DGR, ARI DGR caution lights and YA acronym for a first failure and YAW DGR, ARI DGR, ARI/SAS OUT caution lights and YA acronym for a second failure. With landing gear handle up, the ROLL DGR caution light will also be illuminated indicating inhibited UA roll SAS. Series servoactuator failure affects and cockpit indications are summarized in Figure 2-67.

Note

Taxiing with one engine shut down and the HYD TRANSFER PUMP off may illuminate the PITCH SAS, ROLL DGR, ARI DGR, and YAW DGR caution lights.

2.23.3.2 DFCS Pitch Parallel Actuator. The DFCS pitch parallel actuator is a single-channel electrohydraulic servoactuator that provides automatic longitudinal control during mode I and mode IA ACLS approaches. Pitch commands received by the data link are supplied to the parallel actuator via the DFCS pitch computer. As a safety feature, the parallel actuator system contains a mechanical force link that is designed to disconnect the actuator from the control system when excessive force (greater than 90 pounds) is encountered at the actuator control rod, thus uncoupling the autopilot from the ACL system. Upon ACL engagement, the parallel actuator centers itself automatically as a function of stick position, pitch rate, and pitch attitude. Coupling with the aircraft out of trim or in a climb or descent will result in improper centering of the parallel actuator and decreased actuator authority in one direction. This will greatly increase the probability of uncoupling during the approach since the actuator may command the control system against the physical stop in the direction of reduced authority and disconnect the force link. Similarly, it is possible for the force link to disconnect during pilot OBC if longitudinal trim is not properly set prior to OBC commencement. Once the force link is disconnected, further mode I or mode IA approaches will be impossible until the force link is reset by maintenance.

CAUTION

- It is absolutely imperative that the aircraft be trimmed hands-off in level, on-speed, wings level flight with landing checks complete prior to coupling in order to achieve proper centering of the pitch parallel actuator. Engagement of ACL in any other flight condition will seriously degrade mode I/IA flight characteristics and may result in a force link disconnect. The recommended method for coupling is to engage ACL after 15 to 30 seconds of flight in the landing configuration with attitude and altitude hold engaged to utilize the DFCS automatic pitch trim system.

- Commencement of OBC with longitudinal trim set below zero units with flaps up or 3 units nose up with the flaps down may most likely result in a force link disconnect when the control stick hits the forward stop during pitch parallel actuator checks.

2.23.3.3 Automatic Pitch Trim. Automatic pitch trim is used in all autopilot pitch modes to trim the aircraft in order to minimize pitch transients when disengaging autopilot functions. The pitch servo position is monitored to drive the aircraft pitch trim motor at one-tenth manual trim rate. The pilot manual trim button on the control stick is inoperative during all autopilot operations.

2.23.3.4 Autopilot Emergency Disengage. Operation of the autopilot emergency disengage paddle on the control stick (Figure 2-64). disengages the autopilot and DLC. Depressing the paddle with weight on wheels reverts throttle system from the auto or boost mode to the manual mode and reverts the engines to SEC mode only while depressed.

Note

> The AUTO PILOT light may or may not illuminate when the autopilot is disengaged with the autopilot emergency disengage paddle.

2.23.4 Pilot Relief and Guidance Modes

2.23.4.1 Control Stick Steering. With the autopilot engaged, the aircraft may be maneuvered using control stick steering. In control stick steering mode, the DFCS automatically synchronizes to the new attitude.

2.23.4.2 Attitude Hold. Attitude hold is selected by setting the AUTO-PILOT ENGAGE switch to ENGAGE. To change attitude, use control stick steering. Reengagement is achieved by releasing pressure on the stick. The autopilot will hold pitch attitudes up to ±30° and bank angles up to ±60°. EGI failure will cause mode disagreement and the engage switch will return off. The mode may be reengaged using AHRS as a reference.

2.23.4.3 Heading Hold. Heading (HDG) hold is engaged by setting the HDG-OFF-GT switch to HDG. After maneuvering the aircraft to the desired reference heading, release the control stick at a bank angle of less than ±5°. The autopilot will then hold the aircraft on the desired heading. Heading reference is obtained from the AHRS via the CSDC(R).

2.23.4.4 Ground Track. To engage ground track, set the HDG-OFF-GT switch to GT. When the A/P REF warning light (on left side of the vertical display indicator) illuminates, press the nosewheel steering pushbutton on the control stick grip. When the A/P REF warning light goes off, the mode is engaged.

Disengagement will occur if more than 1-1/2 pounds lateral stick force is applied and will be indicated by the A/P REF light. The ground-track mode may be reengaged by releasing the stick force and pressing the nosewheel steering pushbutton.

Ground-track steering computations are performed by the weapon system computer, based on inputs from the CSDC(R), EGI, and AHRS. The computer output, in the form of ground-track error signals, is processed in the CSDC(R), which generates steering commands to the autopilot roll axis. Bank angles are limited to ±30°. Failure of the EGI or AHRS will cause loss of ground-track steering.

Note

> Performing BIT sequence 2 with ground track (GT) engaged will cause the DFCS AUTO PILOT caution light to illuminate, which may cause the ground-track mode to disengage.

2.23.4.5 Altitude Hold. Altitude hold mode is engaged by setting the ALT-OFF switch to ALT. When the A/P REF warning light illuminates, press the nosewheel steering pushbutton when at the desired altitude. This will engage the altitude hold mode and the A/P REF warning light will go off. Applying 10 pounds of longitudinal stick force will cause the A/P REF warning light to illuminate. The mode may be reengaged by depressing the nosewheel steering pushbutton on the stick grip, when at the desired altitude, and observing that the A/P REF warning light goes off. Altitude hold should not be engaged during any maneuvers requiring large, rapid, pitch trim changes because of limited servo authority and slow automatic trim rate. Disengagement of altitude hold is accomplished by applying 10 pounds or more longitudinal stick force or by placing the ALT-OFF switch to OFF.

Note

- Do not actuate in-flight refueling probe with altitude hold engaged because of large transients in pitot-static systems sensed by the CADC.
- Altitude hold performance in the landing configuration with cg forward of 12 percent will be degraded due to rapid limiting of servo-actuator authority. Aircrew should avoid aggressive power or bank angle changes in this condition or undesirable pitch attitudes may result (without decoupling of AUTOPILOT switch).

2.23.4.6 Data Link Vector — Precision Course Direction. This mode is engaged by placing the VEC/PCD switch to VEC/PCD and pressing the nosewheel steering pushbutton. Mode engagement is evidenced by the A/P REF warning light going off.

Disengagement of the mode is accomplished by application of stick forces of 7-1/2 pounds lateral or 10 pounds longitudinal, or by placing the VEC/PCD switch to OFF. If the switch is left in VEC/PCD, the A/P REF warning light will illuminate and the mode may be reengaged by depressing the autopilot reference and nosewheel steering pushbutton.

Determination of whether data link or precision course direction signals are present is made in the DFCS pitch and roll computers in response to inputs from the data-link converter and CSDC(R). If the data-link vector discrete is present, the autopilot roll axis will respond to data-link heading commands and bank angle authority will be limited to ±30°.

When the PCD discrete is present, the autopilot roll and pitch axes will respond to data-link commands.

2.23.4.7 Automatic Carrier Landing. The DFCS incorporates ACLS software with control laws provide a vertical rate (h-dot) command system with integrated direct lift control (DLC). These control laws provide corrections for glidepath deviations commanded directly by horizontal stabilizer and DLC through altitude rate "h-dot" feedback. Since the F-14 DFCS does not have a direct altitude rate input from the EGI, the DFCS has incorporated the normal accelerometer (Nz) sensor to derive a pseudo vertical rate feedback signal by sensing motion in the vertical axis. This normal accelerometer is the same sensor used in the autothrottle approach power compensator (APC) system and the autopilot altitude hold mode.

ACLS control of the aircraft is achieved through the autopilot by pitch parallel servo actuator and DLC commands in pitch and spoiler commands in roll. The pitch parallel actuator is utilized to command the control stick and horizontal stabilizers to provide a large amplitude, low frequency control response. The integrated "blended" DLC is utilized to provide a small amplitude, high frequency control response. This system is significantly more capable than previous versions of compensating for varying engine response, winds, and/or deck motion. The DFCS continues to provide roll control through the spoilers only and does not capitalize on the full benefits of the automatic rudder interconnect (ARI). The lateral axis is the primary limitation of the F-14 DFCS ACLS and must be closely monitored for any unacceptable course deviations during the approach.

Note

If the pitch parallel actuator force link is mechanically disconnected, the A/P REF light indicating ACL mode engagement may go out when coupling is attempted, but the aircraft will not respond to SPN-46 commands and the autopilot will then uncouple from the ACLS when the first pitch commands are received.

The F-14 DFCS ACLS control laws require the incorporation of a software upgrade in the AN/SPN-46 Automatic Carrier Landing System.

Note

ACLS mode I/IA approaches are authorized for F-14 DFCS aircraft incorporating OFP 4.4 or subsequent only.

CAUTION

DFCS software OFP 4.4 is not compatible with AN/SPN-42 systems. ACLS mode I/IA approaches are only authorized with AN/SPN-46 systems.

2.23.4.7.1 ACL Operation. Prior to ACLS engagement, the aircraft should be in the landing gear down, full flaps, speedbrakes extended approach configuration with direct lift control (DLC), autothrottle approach power compensator (APC), and autopilot altitude hold mode engaged.

WARNING

ACLS mode I/IA approaches are not authorized with the THROTTLE MODE switch in MANUAL.

Note

The AWG-9 should be in STBY or PULSE search to avoid beacon interference problems.

With a valid ACLS coupler discrete (A/P CPLR light), the autopilot can be armed in the ACL mode with the A/P REF light illuminated, indicating that a pilot relief mode (in this case, ACL) has been selected, but not engaged (altitude hold mode will automatically disengage). The pilot can then couple the autopilot ACL mode to the data link by means of the autopilot reference pushbutton on the control stick, at which time, if the DFCS is functioning properly and the ACL mode interlocks are satisfied, the AP REF light will be extinguished. The pilot should report coupled and the controller will then send a discrete command control message that illuminates the CMD CONTROL light. The Naval Tactical Data System (NTDS) begins transmitting ACLS data-link pitch and bank commands to the aircraft. The autopilot actuates the appropriate control surface to execute the desired command, while the autothrottle APC maintains approach angle of attack by controlling the throttle setting.

Note

- Application of more than 2 to 3 pounds of stick force while attempting to couple will cause the AUTOPILOT caution light to illuminate and coupling cannot be accomplished. It is imperative that any stick force be avoided while depressing the autopilot reference pushbutton to preclude illumination of the AUTO-PILOT caution light.

- In the autopilot ACL mode, the ACLS control laws utilize DLC to augment glideslope control. DLC engaged is an interlock requirement for the ACL mode. DLC disengagement during an approach will result in automatic downgrade.

- When the ACL mode is engaged, the DLC neutral spoiler position is shifted from 17.5° to 8°. In the event of a downgrade, the DLC neutral spoiler position will return to 17.5° This slight transient will occur over a 1 sec fade-in schedule so as not to result in any perceptible change in aircraft energy and/or rate of descent during the approach.

- Between the time the autopilot ACL mode is engaged (A/P REF light extinguished) and transition to command control (CMD CONTROL light illuminated), the aircraft may experience a slight altitude deviation of less than 100 feet. Normal system operation should correct for this deviation prior to tip-over.

- Care should be taken not to couple above glideslope. If above glideslope or reference altitude when initial pitch commands are sent, the resulting nose down correction may cause a force link disconnect resulting in automatic decouples and an inability to perform mode I/IA approaches until maintenance action is performed.

- Care should be taken not to couple after tip over or prior to tip over with greater than 500 foot per minute rate of climb or descent. If coupling is attempted after tip over, degraded system performance should be expected, possibly requiring a PTO no later than 200 feet or 1/2 mile on final. If excessive climb/descent rate is established prior to coupling, system control authority may be insufficient to arrest the trend and capture reference altitude.

The ACL mode (and autopilot) will be automatically disengaged by loss of any aircraft autopilot or ACL mode interlock requirement, if the information stored in the data link is not updated within any 2-second period, or the aircraft exceeds the flightpath control envelope. The DFCS will revert to basic stability augmentation and the pilot can continue the descent in mode II or mode III.

WARNING

If the autopilot/ACLS uncouples after approach commencement, do not attempt to recouple with the CMD CONTROL light illuminated. To do so could cause abrupt attitude changes and a possible force link disconnect. The pilot should verbally instruct the approach controller, “downgrade to mode II.” Upon downgrading, the CMD CONTROL light should go out. The ACL READY and A/P CPLR lights must be reilluminated prior to any attempt at recoupling.

Until 12.5 seconds from touchdown, the landing system commands the aircraft to follow a stabilized glideslope. Inside of 12.5 seconds, the landing system commands the aircraft to follow the vertical movement of the intended touchdown point. As a result, some deviations from the FLOLS glideslope will be noted with large pitching deck motions.

Between 12.5 and 1.5 seconds from touchdown, the approach controller sends an automatic waveoff discrete if any part of the carrier-based equipment fails and up to 5 seconds from touchdown if the aircraft exceeds the AN/SPN-46 flightpath control envelope. Waveoff signals may also be issued by the final controller between lock-on and touchdown and the landing signal officer between 1 mile and touchdown. Approaches must be waved off at weather minimums (200-feet altitude and 1/2-mile visibility) if the pilot cannot see the meatball.

At 1.5 seconds from touchdown, the landing system freezes the vertical rate command and sends a bank command to return the aircraft to a wings-level attitude. The DFCS follows these commands to touchdown, unless the pilot elects to disengage from the ACL mode via pilot takeover.

CAUTION

If the pilot and/or LSO recognizes a course drift immediately prior to or at command freeze, the pilot will be required to make a lateral correction to prevent unacceptable deviation from centerline.

Pilot takeovers (PTO) may be desired/required during ACLS approaches. In the case of an ACLS mode IA approach the PTO shall be executed prior to 200-feet altitude and 1/2-mile. All approaches must be waved off at precision approach weather minimums if the pilot cannot see the meatball. The recommended method for a PTO is via the autopilot reference pushbutton located on the control stick to disengage the ACL mode and the CAGE/SEAM pushbutton on the throttle to disengage autothrottle APC. An alternative method to disengage the ACL mode is via the PLM pushbutton. Another method to disengage the ACL mode is via the manual deselection of the ACL or AUTOPILOT switches. Manual deselection of the THROTTLE MODE switch will disengage the autothrottle APC. Manual deselection of these switches may be difficult to accomplish, especially during the final stages of the approach. The paddle switch will disengage the ACL mode and autopilot, but will also disengage DLC. As a last resort, overriding the control stick with 10 pounds longitudinal or 7 pounds lateral control stick force will disengage the ACL mode and 11 pounds of force per throttle will disengage the autothrottle APC. If the aircraft bolters or if the pilot decides to go around, the autopilot/ACL mode is disengaged automatically by weight-on-wheels or overriding the control stick, as the pilot enters the bolter/waveoff pattern. If the aft longitudinal stick force method is used at or inside the in-close position, the pilot must avoid over-rotation. The waveoff technique described in Chapter 8 applies.

WARNING

A PTO initiated by autothrottle APC disengagement with large power additions prior to uncoupling from ACLS will result in large nose down commands. A force link disconnect may occur if the control stick hits the forward stop.

CAUTION

The paddle switch will disengage the autopilot. Use of the paddle switch to disengage DFCS for mode IA landing is not recommended since DLC will also be disengaged. The pitch and roll SAS switches will remain engaged.

Note

- The paddle switch will revert throttles to MANUAL mode with weight-on-wheels.
- The paddle switch, control stick forces, or loss of any aircraft ACL mode interlock will illuminate the MASTER CAUTION light, AUTOPILOT caution light, and ACLS/AP caution ladder light.

ACL mode disengagement via the autopilot reference pushbutton or PLM pushbutton will illuminate the ACLS/AP caution ladder light, but not the MASTER CAUTION and AUTOPILOT caution lights. The PLM pushbutton commands the radar to pilot lock-on mode when the A/P CPLR light is not illuminated. However, when the A/P CPLR light is illuminated, selection of the PLM pushbutton disengages the ACL mode. ACL mode disengagement via control stick forces or the emergency disengage paddle will illuminate the MASTER CAUTION light, the AUTOPILOT caution light, and the ACLS/AP caution ladder light. Manually disengaging the ACL mode and/or AUTOPILOT switches will illuminate the ACLS/AP caution ladder light, but not the MASTER CAUTION and AUTOPILOT caution lights.

2.23.5 DFCS Test. The DFCS has several self-test modes. These include power-up BIT (PBIT), initiated BIT (IBIT), and automatic BIT (ABIT). The results of these tests are indicated by the illumination of applicable caution lights, maintenance file acronyms, and DFCS control panel (DCP) fault display codes.

2.23.5.1 DFCS Power-Up BIT (PBIT). A DFCS power-up BIT is an automatic function of the DFCS that is initiated when power is initially applied to the aircraft. Power-up BIT is completed in approximately 2 seconds. Following a successful power-up BIT, the flight control computers will synchronize and enter the operational flight program mode following depression of the MASTER RESET pushbutton. Failure of power-up BIT will result in illumination of caution lights and DCP fault display codes associated with the failed computer(s) that will not reset with MASTER RESET. The failed computer(s) will remain isolated and will not enter the operational flight program mode.

2.23.5.2 DFCS Initiated BIT (IBIT). A DFCS Initiated BIT is a thorough preflight indication of DFCS performance and can be obtained during poststart OBC or a DFCS BIT. All SAS switches must be engaged, weight-on-wheels, flaps extended greater than 25° or wings swept aft of 62°, and ANTI-SKID SPOILER BK switch OFF. If one of these interlocks is not satisfied the DFCS will not enter the IBIT ARM state. The AUTOPILOT switch must be engaged to test autopilot functions and can only be engaged in the IBIT ARM state.

Longitudinal trim should be greater than 0° for flaps up and greater than 3° for flaps down. The MASTER TEST switch must be selected to "IBIT ARM" by raising and rotating to the "OBC" or "DFCS BIT" position. The DCP fault display will alternate between an "IBIT" and "ARM" indication to confirm that IBIT is in the armed state. The AUTOPILOT switch can be engaged at this time in order to test autopilot functions during IBIT. If the INC or DEC pushbuttons are depressed in the IBIT ARM state the DCP will indicate any existing fault display codes. In this case, the DFCS is still in the IBIT ARM mode and the depression of a MASTER RESET will restore the IBIT ARM codes to the fault display, but is not required. A DFCS IBIT test sequence will commence upon depression of the MASTER TEST switch in the "DFCS BIT" position, or a complete OBC encompassing all aircraft functions may be subsequently initiated by the RIO with the MASTER TEST switch in the "OBC" position.

The DFCS IBIT sequence will commence with the following: The DCP fault display will alternate between an "IBIT" and "RUN" during the entire IBIT run sequence. All ten DFCS caution lights (including the HZ TAIL AUTH, RUD AUTH, and SPOILERS lights) will illuminate and the ACLS/AP and AP REF lights will flash once per second to serve as an indication that IBIT is running. The IBIT sequence will continue with the pitch trim check (slow longitudinal stick motion), pitch SAS actuator check (no longitudinal stick motion), the pitch parallel actuator check (rapid longitudinal stick motion), the individual spoiler operation check (from right to left), and the roll and yaw SAS actuator checks. DFCS IBIT concludes with disengagement of the AUTOPILOT switch, activation of the rudder pedal shaker check, and illumination of an alternating test pattern to test all pixels of the DCP LED fault display.

Premature termination of the IBIT sequence will cause the ACLS/AP and AP REF lights to stop flashing and leave all other DFCS caution lights illuminated. The DCP fault display will indicate "ABRT" when IBIT is terminated prematurely.

Following completion of a successful IBIT, all DFCS caution lights will be extinguished, the AUTOPILOT switch will be OFF, and the DFCS will automatically enter the operational flight program mode. The DCP will display a "PASS" indication in the DCP fault display.

Following an IBIT with one or more failures, caution lights and acronyms for the detected failures will be displayed. The DCP fault display will indicate "NO GO" and fault codes for the specific failed WRAs can be viewed using the INC and DEC pushbuttons. The DFCS will automatically enter the operational flight program, even though IBIT has detected failures. Depression of the MASTER RESET pushbutton will extinguish caution lights and acronyms, but will not clear DCP IBIT fault codes. Any discrepancies detected by IBIT may still exist even though caution lights have been extinguished with MASTER RESET. Another

IBIT must be completed to ensure proper system operation.

CAUTION

Following an IBIT, a MASTER RESET will clear the IBIT caution/advisory light failure indications, but will not clear the FAULT DISPLAY IBIT codes. This does not indicate that the failures detected during IBIT are resolved. The DFCS should not be considered fully operational. Only the successful completion of another IBIT can verify proper system operation.

Note

Spoiler actuator IBIT tests are run only with the wings forward and flaps down. During IBIT, spoilers are deflected individually, one at a time starting with the right no. 4 spoiler.

If the pitch parallel actuator is functioning properly, large longitudinal control stick deflections should be observed during IBIT. An IBIT with the flaps down requires a longitudinal trim of 3° or more noseup; an IBIT with the wings at 68° requires not less than 0° noseup. A pitch parallel actuator force link disconnect during IBIT is indicated by illumination of the AUTOPILOT caution light, a PA acronym, and the absence of large control stick deflections. It is possible for the force link to be partially disconnected; that is, disconnected mechanically while electrical continuity is maintained. If this has occurred, the AUTOPILOT caution light or PA acronym may be absent after IBIT, but no large stick deflection will be observed. The implications of this condition are the same as for a total disconnect (no ACL capability).

2.23.5.3 DFCS Automatic BIT (ABIT). A DFCS Automatic BIT provides continuous failure monitoring of the DFCS. Test coverage for ABIT is not as extensive as IBIT and should not be used as a replacement for performing a pre-flight IBIT. ABIT failures will be recorded in a maintenance data store and are listed on the DCP fault display following the “FAIL” and “FLT” headers. Depending on the severity of the problem detected, functionality may be lost and the appropriate caution/advisory lights illuminated and acronyms displayed.

2.23.6 DFCS Control Panel Fault Reporting. The DFCS control panel (DCP) incorporates an LED alphanumeric fault display. This fault display is intended for ground use only to assist in the troubleshooting and repair of the DFCS and related components. The DCP will not display any fault data with weight off wheels. DFCS operational DCP system display codes are listed in Figure 2-68. The fault display will group faults into three categories: currently existing faults (FAIL), faults detected in flight (FLT), and faults that are detected during initiated BIT (IBIT). Fault codes will be displayed in order by repeated depression of the INC pushbutton. Current failures will be displayed first followed by in-flight detected failures, and any IBIT detected failures. This will be indicated by “FAIL” followed by any current failures, then “FLT” followed by any in-flight logged failures, and finally by “IBIT” followed by failures detected during the last executed IBIT. If there are no failures in a particular group that group’s header will not be displayed. When all faults have been displayed, “END” will be displayed. The INC or DEC pushbuttons may be used to scroll forward or backward through the fault codes. If no failures have been logged, depression of the INC or DEC pushbutton will display a “GO” indication.

2.23.6.1 Current Faults. On the ground, currently existing faults are indicated by a combination of caution/advisory lights and acronyms. After momentary depression of the INC or DEC pushbutton, the current fault codes will be listed following the “FAIL” header. The current faults are logged in volatile memory and will be lost following removal of system power. If faults exist when the aircraft goes weight off wheels, they are added to the in-flight fault listing.

2.23.6.2 In-flight Detected Faults. In-flight faults will be logged and stored in chronological order. During the normal startup or shutdown sequence, depressing the INC or DEC pushbuttons will indicate if any in-flight faults were logged. In-flight faults will be listed following the “FLT” header. Each particular fault code will only be displayed once regardless of the number of failures recorded during the flight, unless a POR is recorded in which case the sequence is allowed to repeat previously listed codes. In-flight faults remain in memory until manually cleared by the pilot or ground crew. To avoid confusion, in-flight faults should be cleared just prior to each flight. Loss of system power does not remove FLT faults from memory to enable reference by maintenance personnel during postflight troubleshooting.

2.23.6.3 IBIT Detected Faults. Successful completion of IBIT is indicated by the absence of caution/advisory lights and acronyms. A "PASS" indication will also be displayed on the DCP. Depressing MASTER RESET will then blank the display (or will return to alternating "IBIT" and "ARM" if all IBIT interlocks are still valid). IBIT detected faults are indicated by the appropriate caution/advisory lights and acronyms, and a "NOGO" indication on the DCP. After momentary depression of the INC or DEC pushbutton, fault codes from the most recent IBIT run will be listed following the "IBIT" header. The IBIT faults are logged in volatile memory and will be lost following removal of system power.

2.23.6.4 Clearing Fault Indications. Simultaneous and continuous depression of the INC and DEC pushbuttons for 7 sec will clear any logged FLT fault codes. This will be indicated by a steady "CLR" message for 3 sec followed by a flashing "CLR" message for 4 sec. Once all FLT fault codes are cleared, all center segments "----" will be illuminated and the INC and DEC pushbuttons can then be released. IBIT faults can only be cleared by the completion of a successful IBIT "PASS", a power on reset, or loss of system power. Current FAIL faults can be cleared from the display by depressing MASTER RESET once the fault no longer exists or loss of system power.

CAUTION

Following an IBIT, a MASTER RESET will clear the IBIT caution/advisory light failure indications, but will not clear the FAULT DISPLAY IBIT codes. This does not indicate that the failures detected during IBIT are resolved. The DFCS should not be considered fully operational. Only the successful completion of another IBIT can verify proper system operation.

2.24 LANDING GEAR SYSTEMS

The aircraft has fully retractable, tricycle landing gear operated by combined hydraulic pressure in the normal mode of operation and a stored source of pressurized nitrogen for emergency extension. The landing gear retract forward so that airloads and gravity assist on emergency extension. Air-oil shock struts with oil metering pins reduce landing loads transmitted to the airframe, and the struts are fully extended with the gear in the wells. All landing gear doors remain open with the gear extended.

CODE	REMARKS
ARM	IBIT is armed awaiting BIT initiate (alternates between "IBIT" and "ARM").
RUN	Indication that IBIT is running (alternates between "IBIT" and "RUN").
ABRT	IBIT has aborted before it completed.
PASS	IBIT passed without any failures.
NOGO	IBIT completed with failures.
GO	No current, in-flight, or IBIT failures have been logged.
FAIL	Failures following this code are current fault indications.
FLT	Failures following this code were logged during flight.
IBIT	Failures following this code were logged during the most recent IBIT run.
END	Failure list end has been reached.
CLR	Failure clearing sequence has been started.
----	Indicates completion of clearing sequence.

Figure 2-68. DFCS DCP System Display Codes

2.24.1 Landing Gear Handle. The landing gear handle mechanically positions the landing gear valve for normal operation. Pulling the handle mechanically selects emergency extension of the gear using the pneumatic backup source. Both modes of gear operation can be accomplished without electrical power except for the gear position indication, which requires dc essential No. 2 bus power. Gear downlock actuators incorporate internal mechanical finger locks that maintain the downlock inserted position in the absence of hydraulic pressure. The landing gear handle contains other interlocks that are discussed under their respective systems such as weapons firing, jettison systems, APC, Mach lever, maneuvering flaps, and ground power system test panel.

Design limit landing sink speed for the aircraft is 25.3 feet per second (nominal landing sink speed is about 11 feet per second). Normal and emergency controls and displays associated with operation of the landing gear are shown in Figure 2-69.

2.24.2 Main Landing Gear. Each main landing gear shock strut consists of an upper outer cylinder and a lower internal piston that has a maximum stroke of 25 inches. A hard step (31,000 pounds required for further compression) in the strut air curve provides a consistent 4-inch stroke remaining in the ground static condition. A sidebrace link is mechanically extended from the inboard side of the strut outer cylinder to engage in a nacelle fitting and thus provides additional side-load support for ground operations.

The path of the wheel assembly is controlled by the dragbrace as it folds (jackknifes upwards) during gear retraction and unfolds during extension. The fully extended shock strut and jackknifed dragbrace retracts forward and rotates the wheel assembly 90° to lie flat in the wheelwell. Inboard, outboard, and aft main gear doors are individually actuated closed in sequence to provide fairing for the retracted gear. An uplock hook on the shock strut engages a roller in the wheel to hold the gear in the retracted position. The main landing gear actuator on the inboard side of the shock strut retracts and extends the gear assembly.

The gear downlock actuator, mounted at the dragbrace kneepin, extends to prevent unlocking (jack-knifing) of the dragbrace. Hydraulic pressure must be supplied to the downlock actuator in order to retract it against the spring action of the integral locking mechanism. A paint stripe across the dragbrace kneepin provides an external visual indication of the dragbrace locked condition. A ground lock device clamps onto the downlock actuator rod for safetying the main gear.

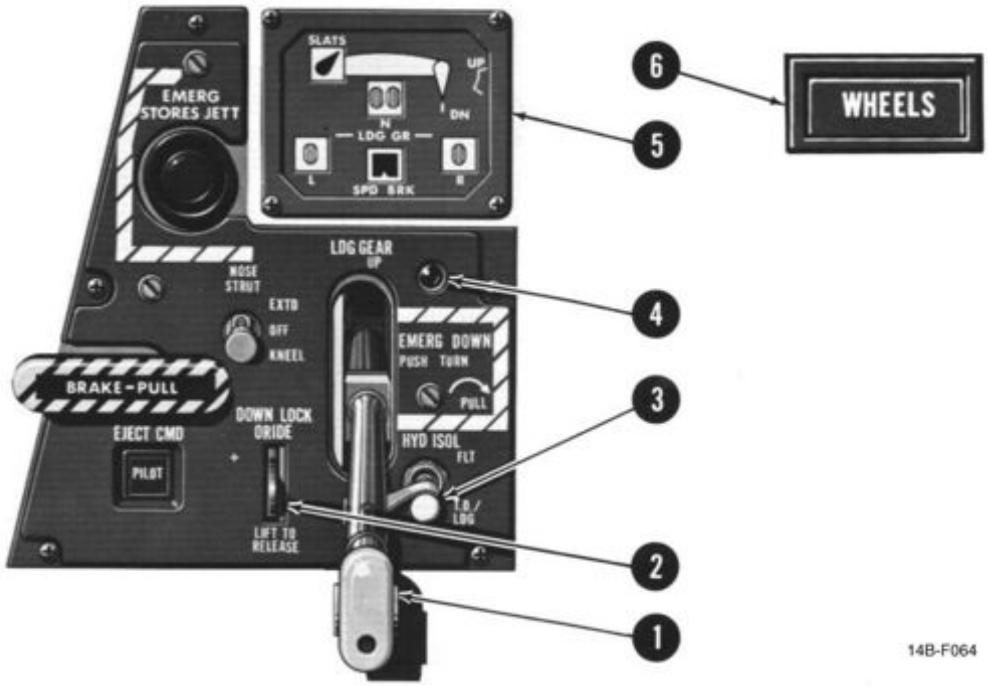
Maximum strut extension and wheel alignment are controlled by torque arms that incorporate cam-operated microswitches to detect a weight-on-wheels condition (greater than 5 inches of strut compression). The single split-type wheel assembly incorporates thermal fuse blow plugs and a pressure relief device to prevent over-inflation of the tire.

CAUTION

- Illumination of indexer lights does not indicate that the main landing gear are clear of the runway. Raising the gear before a positive rate of climb is established will result in blown main tires.

- Illumination of indexer and approach lights is not an indication of gear down and locked.

2.24.3 Nose Landing Gear. The dual-wheel nose landing gear has a shock strut consisting of an outer cylinder and a lower internal piston that has a maximum stroke of 18 inches. During normal ground operations, the strut is fully extended. Pilot control is provided to kneel the strut (4 inches of stroke remaining) for catapult operations. During retraction, the fully extended nose strut is rotated forward by the retract actuator into the well and enclosed by two forward and two aft doors. The forward doors are operated by a separate actuator that also engages the gear uplock, whereas the two aft doors are mechanically linked to the shock strut. An uplock hook actuator engages a roller on the lower piston to hold the gear and doors in the retracted position. During extension, the telescoping dragbrace compresses so that a downlock actuator mechanically locks the inner and outer barrel to form a rigid member for transmission of loads to the airframe.



NOMENCLATURE	FUNCTION
1 LDG GEAR handle	Normal — UP and DN overcenter action provides normal retraction and extension by the combined hydraulic system. Emergency — Down-push-turn clockwise pull action provides emergency extension of all gear by a compressed nitrogen charge.
2 DOWN LOCK ORIDE lever	Down — Weight-on-wheels indication, prevents gear handle being retracted without pilot override (raising lever). Up — Weight-off-wheels indication, does not inhibit pilot raising gear handle. Automatic operation by electrical solenoid.
3 HYD ISOL switch	FLT — Combined system hydraulic pressure is shut off to the landing gear, nosewheel steering and wheel brakes. T.O./LDG — Switch is automatically placed in this position with gear handle down. Combined hydraulic pressure is available to all components.
4 Landing gear transition light	On whenever gear and door positions (including main landing gear sidebrace actuators) do not correspond to handle position. Out when gear and doors are locked in position selected by handle.

Figure 2-69. Landing Gear Controls and Indicators (Sheet 1 of 2)

NOMENCLATURE	FUNCTION
(5) LDG GR indicator	 — Landing gear down and locked (except main landing gear sidebrace actuator). — Unsafe gear or power off indication. — Landing gear retracted and doors closed. 14B-F065
(6) WHEELS warning light	Flashes with flaps down more than 10°, either throttle below approximately 85 percent, and any landing gear not down and locked. Will not illuminate with a gear transition light and landing gear indicating safe gear down. Approach lights and indexer will illuminate when the LDG GEAR handle is placed in the down position, but this is not an indication of gear down and locked.

Figure 2-69. Landing Gear Controls and Indicators (Sheet 2)

Note

- There is no foolproof visual check of the nose landing gear locked-down status. Neither the downlock mechanism, which is concealed in the fuselage, nor insertion of the ground lockpin will provide a positive indication of gear-locked status. In flight, the pilot must normally rely on his indicator. Visual determination of nose landing gear unlocked status is assisted by a red band painted on the nose landing gear dragbrace. If red is visible, the nosegear is not locked.

- An additional sequencing switch in series with the existing down-and-locked switch provides the pilot with a positive indication of nosegear position. If the nose landing gear is unsafe in the down position because of premature deployment of the nose landing gear locking pin, nosegear indicator will indicate unsafe and transition light will illuminate.

Maximum strut extension and wheel steering angle are controlled by torque arms interconnecting the steering collar and the lower piston. The split-type wheel assembly incorporates tire pressure relief device to prevent overinflation of the tire. Additional hardware on the nose landing gear include the launch bar, holdback fitting, approach lights, nosewheel steering actuator, and taxi light. The wheel axles incorporate recessed holes for attachment of a universal tow bar with maximum steering angle of ±120°.

CAUTION

Restrict nosewheel deflection to ±90° to prevent structural damage to nosegear steering unit.

2.24.4 Landing Gear Normal Operation. The landing gear handle is mechanically connected to the landing gear valve that directs combined hydraulic fluid into the gear-up and gear-down lines and provides a path for return flow. In the down position, the handle mechanically sets the hydraulic isolation switch to provide hydraulic pressure for gear operation. The handle is electromechanically locked in the down position with weight on wheels to prevent inadvertent gear retraction. Pilot override of the solenoid-operated handle lock can be effected by lifting the downlock lever next to the gear handle. Vertical movement of the gear handle causes a corresponding up and down selection of the landing gear with the combined hydraulic system pressurized. Three flip-flop indicators provide a position display for each of the landing gear, and a gear transition light on the control panel illuminates anytime the gear position and handle do not correspond. In addition, a WHEELS warning light alerts the pilot if the landing gear is not down with flaps deflected greater than 10° and either or both throttles set for less than approximately 85-percent rpm.

CAUTION

- Unless attempting fast-cycle trouble-shooting for gear that indicates unsafe nosegear down, transition light illuminated, wait for gear to completely transition (15 seconds with normal hydraulic pressure) before recycling the landing gear handle. When fast-cycling the gear handle, the pilot must immediately return gear handle to down position to avoid damaging the main landing gear doors and inducing a possible combined hydraulic or brake system failure.
- Maximum landing gear tire speed is 190 KIAS.
- The WHEELS warning light will NOT illuminate with a gear transition light and landing gear indicating safe gear down.

2.24.4.1 Landing Gear Handle Up. Placement of the landing gear handle to UP actuates the landing gear valve that ports hydraulic pressure to the downlock actuators, gear retract actuators, and in sequence to the door and uplock actuators. The gear shock strut and door uplocks are hydraulically operated into a mechanical over-center position. An UP indication is displayed on the gear position indicators when the gear are in the uplock and all doors closed.

2.24.4.2 Landing Gear Handle Down. Placement of the LDG GEAR handle to DN actuates the gear control module to port hydraulic pressure to the door uplocks, door actuators, and the strut uplocks. The landing gear are hydraulically extended and assisted by gravity and airloads. A gear-down symbol (wheel) is displayed on the gear position indicators when the gear downlocks are in the locked position. The gear transition light will go out when the main gear sidebrace links are engaged.

Note

With the main gear downlock inserted but the sidebrace link not engaged, landing sink speed is restricted to 8 feet per second. Minimize yaw and sideslips on touchdown and rollout.

2.24.5 Emergency Gear Extension. Although emergency gear extension can be initiated with the landing gear control handle in any position, it is preferable that the LDG GEAR handle be placed in DN before actuating the emergency extension system.

CAUTION

The landing gear handle must be held in the fully extended emergency position for a minimum of 1 second to ensure complete actuation of the air release valve. Approximately 55 pounds pull force is required to fully actuate the emergency nitrogen bottle. The pulling motion should be rapid and continuous to ensure the air release valve goes completely over center to the locked position. The landing gear handle will be loose (fore and aft) in its housing as an indication of complete extension of the handle. An incomplete handle motion could cause partial porting of gaseous fluid, initiating the emergency dump sequence. Interruption of handle motion without completing the overcentering action of the valve could cause the extending gears to contact and damage the strut doors.

The emergency landing gear nitrogen bottle is located in the nose wheelwell. Normal preflight bottle pressure is 3,000 psi at 70 °F. Minimum bottle pressure for accomplishing emergency extension to the down-and-locked position is 1,800 psi.

Pneumatic pressure is directed by separate lines to power open the gear door actuators in sequence, release the gear uplock actuators, pressurize the nosegear actuator to extend the gear (main gear free fall), and pressurize the downlock actuators. A normal gear-down indication is achieved upon emergency gear extension.

Following emergency gear extension, nosewheel steering is disabled. Once the landing gear is extended by emergency means, it cannot be retracted while airborne and must be reset by maintenance personnel.

CAUTION

- Emergency extension of the landing gear shall be logged in the maintenance action form.
- To facilitate in-flight refueling probe extension when the landing gear has been blown down, raise landing gear handle to give priority to the refueling probe system.

2.25 WHEELBRAKE SYSTEM

The wheelbrake system provides power boost hydraulic control of the multiple disk-type main wheelbrakes using pressurized fluid in the landing gear down line from the combined hydraulic system. Individual or collective wheelbrake control can be modulated by depression of the rudder toe pedals or collective; unmodulated brake control is available with the parking brake. An electrohydraulic antiskid system is provided that operates in conjunction with the normal wheelbraking mode. Wheelbrake controls are shown in Figure 2-70.

Brake pedal and parking brake control motions are mechanically transmitted to the power brake module together with the antiskid valve. Separate hydraulic lines transmit normal and emergency fluid pressure from the power brake module to the left and right wheelbrake assemblies. The normal and emergency lines input fluid to the brake shuttle valve at each brake assembly, and brakes are applied as a function of normal or emergency line fluid pressure. Two wear-indicator pins on the brake piston housing measure lining wear for preflight inspection. For new brakes, these pins extend approximately 1/2-inch above the piston housing. When the pin is flush with the piston housing with the parking brake applied, the brake assembly is worn to the point of replacement.

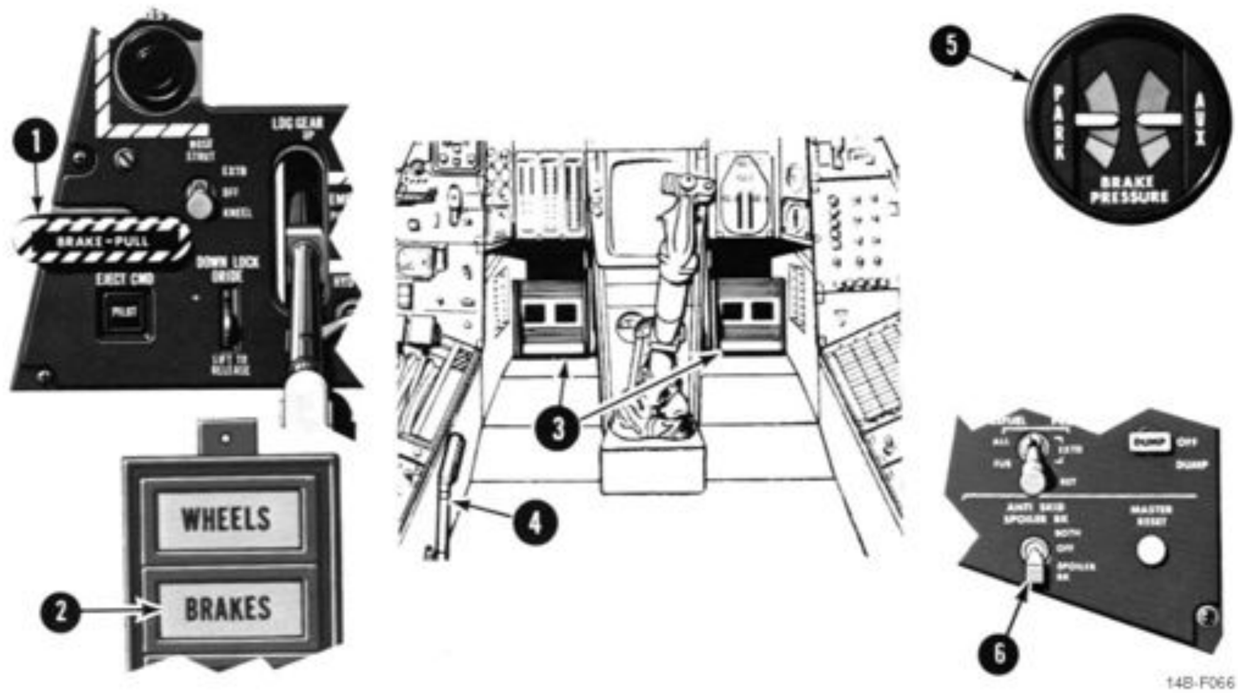
Four thermal relief plugs are mounted in each main wheel assembly to relieve tire pressure and thus avert a blowout caused by hot brakes if the local wheel temperature exceeds 428 °F.

The capacities of the wheelbrake assemblies are sufficient to restrain the aircraft in a static condition on a dry surface with 20-percent AB set on both engines. The minimum hydroplaning speed for the main tires on a wet runway is approximately 90 knots.

2.25.1 Brake Characteristics. Because carbon brakes contain solid disk-shaped carbon rotors and stators, they cannot shingle. The thermal characteristics prevent them from fusing together during or following heavy braking.

Carbon brakes may produce a sudden increase in brake torque as brake pedal force is smoothly increased. This can produce grabbing at low brake-pedal force inputs. This grabbing is caused by excessive air in the combined hydraulic system. Open-loop bleeding of the combined hydraulic system by maintenance personnel will reduce the amount of air in the system and should eliminate any associated grabbing. If grabby brakes are experienced, smooth modulation to higher braking forces is easily accomplished after the initial grabbing. The sudden increase in torque is most noticeable at moderate to slow taxi speeds. As groundspeed increases, the kinetic energy of the aircraft increases and the effect of the sudden torque increase is significantly reduced. Normal braking technique should be used during normal rollout.

The pilot must apply maximum pressure on the brake pedals to hold the aircraft static at MIL. If carbon brakes have been heated up by a full-stop landing, and for about 45 minutes thereafter, they will probably not hold the aircraft static with military power set on both engines even with the parking brake set. In this case, 75 to 100 pounds of pedal force will hold the aircraft static with afterburner set on one engine and idle power set on the other. In all cases, holding the aircraft static at high power settings depends on adequate runway and tire conditions. Degraded conditions such as wet runways or worn tires may result in tire skid at high power settings.



	NOMENCLATURE	FUNCTION	
1	Parking brake handle	Forward —	Parking brake released. Modulated braking action available with brake pedal depression.
		Aft —	Parking brake set. No modulation of control, locks both main wheelbrakes.
2	BRAKES warning light	Indicates parking brake handle is pulled, antiskid has failed, or operation is in auxiliary brake mode when brake pedals are depressed.	
3	Brake pedals	Press top of rudder pedals to command normal or auxiliary braking.	
4	Hand pump	Recharges auxiliary and parking brake accumulators with gear handle down. With the refueling probe switch in EXT or RET, provides emergency extension or retraction of refueling probe regardless of the gear handle position. With the gear handle down, priority is given to the brake accumulator.	
5	BRAKE PRESSURE gauge	Provides pilot indication of brake accumulator pressure remaining that is indicative of auxiliary and emergency brake cycles remaining.	
6	ANTI SKID SPOILER BK switch	BOTH —	Antiskid and spoiler brakes operative with weight on wheels and both throttles in IDLE.
		OFF —	Antiskid and spoiler brakes inoperative.
		SPOILER BK —	Spoiler brakes operate with weight on wheels and both throttles IDLE. Antiskid is deactivated.

Figure 2-70. Wheelbrake Controls and Indicators

The dynamic torque (or ability to stop an aircraft in motion) is approximately equal at the same hydraulic supply pressure. Therefore, normal pedal force should be used during normal stops. However, as the brakes heat up during heavy braking, the dynamic torque brakes do not noticeably change.

CAUTION

When the antiskid system becomes inoperative at 15 knots during a maximum-effort stop, carbon brakes can lock the wheels. Therefore, pedal pressure should be relaxed as the aircraft decelerates through 15 knots during a maximum-effort antiskid stop.

2.25.2 Normal Braking. In the normal mode of operation, wheelbrake application is modulated by brake pedal depression using pressurized fluid from the combined hydraulic system through the brake module and through the normal brake line to the brake assembly. In the normal mode of operation, the brake pressure gauge indication should continue to indicate a full charge on the brake accumulators since this fluid energy is maintained by the combined hydraulic system. Normal combined system operations can result in pressure excursions that will be trapped in the brake system. This can cause the brake pressure indicators to read beyond the full range of the gauges. This will not affect system performance.

CAUTION

- After heavy or repeated braking or if hot brakes are suspected, allow a 5- to 10-minute cooling period with the gear extended before retracting the gear.

- If heavy braking is used during landing or taxiing followed by application of the parking brake, normal brake operation may not be available following release of the parking brake if the brakes are still hot. Check for normal brake operation after releasing the parking brake and prior to commencing taxiing.

2.25.3 Antiskid. The antiskid system operates electrohydraulically in conjunction with the normal mode of wheelbrake operation to deliver maximum wheelbraking upon pilot command without causing a skid. Essential No. 2 bus dc power for antiskid operation is supplied through the ANTI SKID/R AICS L KUP PWR circuit breaker (7E1) and controlled by the ANTI SKID SPOILER BK switch (Figure 2-70). When energized, approximately 200 milliseconds are required for antiskid system warmup. Individual wheel rotational velocity is sensed by skid detectors mounted in the wheel hubs and transmitted to the skid control box. The control box detects changes in wheel deceleration and reduces fluid pressure in the normal brake lines to both wheels simultaneously to prevent a skid.

With the antiskid system armed in flight, the touchdown circuit in the control box prevents braking until weight is on both main gears and the wheels have spun up, regardless of brake pedal application. The antiskid system is inoperative at ground speeds of less than 15 knots. During maximum-effort antiskid braking, expect a rough, surging deceleration. When the ANTI SKID SPOILER BK switch is in BOTH during low-speed taxi (less than 10 knots for more than a few seconds), subsequent acceleration of the aircraft through approximately 15 knots will cause a temporary loss of brakes lasting from 2 to 10 seconds. Should this happen, use of the brakes can be regained instantly by turning antiskid OFF. To preclude this possibility, antiskid must be OFF during taxi.

WARNING

Failure of the weight-on-wheels switch results in a continuous-release signal with antiskid selected. Normal braking is available with antiskid off.

During landing rollout as the aircraft approaches taxi speed (approximately 15 knots), release brake pressure and deselect antiskid. This will preclude the possibility of antiskid remaining operative and causing a loss of braking effectiveness.

CAUTION

Failure to release brake pressure prior to deselecting antiskid may result in blown tires.

The antiskid system is inoperative when the wheelbrakes are in the auxiliary or parking modes of operation since the emergency brake lines bypass the brake valve. If an electrical failure occurs in the antiskid system or if hydraulic pressure is withheld from either brake for greater than 1.2 seconds by the control box, the system automatically becomes inoperative and illuminates the BRAKES warning light with the ANTI SKID SPOILER BK switch in BOTH.

2.25.3.1 Antiskid Ground Test. During ground operation, a self-test of the antiskid system can be initiated on the face of the control box with the system energized, parking brake handle released, and the aircraft in a ground static condition. Before taxiing (chocks in place) but after releasing the parking brake and while the pilot presses the toe pedal brakes, the plane captain should press the antiskid test pushbutton on the control box in the nose wheel well. Approximately 10 seconds is required for self-test, which checks the operational status of the control box, brake valve, and wheel sensors. Any discrepancies detected will be displayed by the BIT flags on the face of the control box (Figure 2-71).

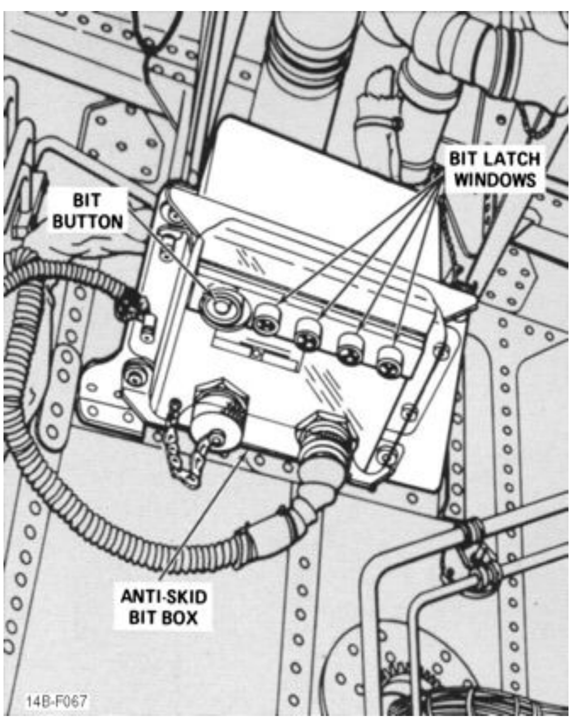


Figure 2-71. Antiskid BIT Box

A valid BIT test requires that three criteria be met: the BIT flags on the face of the control box must check good, the pilot must feel both brakes release during BIT test, and the BRAKES warning light must not remain illuminated. A flash of the BRAKES light coinciding with brake pedal thumps during the antiskid BIT check is acceptable.

WARNING

Before initiating antiskid self-test by pressing the antiskid pushbutton on the control box, ensure that the aircraft chocks are in place. Initiation of antiskid self-test will release aircraft brakes.

2.25.4 Auxiliary Brake. Two different auxiliary brake systems are presently incorporated in the aircraft. Entry into the auxiliary brake mode is the same for both systems. Transfer of normal brake operation to the auxiliary mode is automatic without the requirement for pilot action upon the loss of combined hydraulic system pressure. Both auxiliary braking systems have two brake accumulators that provide pressure for auxiliary and parking brake modes of operation when combined hydraulic system is not available. Accumulators deliver 3,000 psi when fully charged by the combined hydraulic system or hydraulic handpump (with the gear handle down only). When the combined hydraulic system pressure decreases below 1,425 psi, the shuttle valve in the power brake module shifts the brake system to the auxiliary brake mode.

Approximately 13 to 14 full dual-brake applications are available in the auxiliary mode. A dual pneumatic BRAKE PRESSURE gauge on the front cockpit (center pedestal) shows auxiliary and parking brake accumulator pressures on individual dials. Full capability operations of the brake accumulators in the auxiliary modes of operation are predicated on the system serviced with a nitrogen precharge of 1,900±50 psi. The green band of the dial indicates pneumatic pressure between 3,000 psi at the top of the band to 2,150 psi; the red band indicates pneumatic pressures between 2,150 psi and 1,900 psi at the bottom of the band. Approximately five auxiliary brake applications are available in the red band. Once the auxiliary braking system is depleted, braking must be accomplished by the emergency/parking brake. Three applications of the parking brake are available.

With either auxiliary brake system, additional braking can be achieved only by pulling the parking brake handle aft. If the shuttle valve in the power brake modules does not return to the normal position with combined hydraulic pressure greater than 2,000 psi, the BRAKES caution light will illuminate when a brake pedal is depressed. In this instance the wheelbrake accumulators can be recharged only by the hydraulic handpump with the landing gear handle down. Pilot manual isolation or system automatic isolation of the combined hydraulic system cuts off the supply of combined hydraulic pressure to the power brake module so that depression of the brake pedals will cause depletion of the brakes accumulator charge.

WARNING

- Even though braking action is available at accumulator pressures less than 3,000 psi, braking force is proportional to pressure remaining. Red-band pressure (1,900 psi) is sufficient to hold the brakes locked with aircraft stationary in all deck conditions; however, rolling motion greatly increases pressure requirements. Accumulator pressure of up to 2,100 psi may be required to stop a moving aircraft in a 4° deck roll. In deck rolls greater than 6°, 3,000 psi may not be sufficient to stop a moving aircraft.

- Complete loss of hydraulic fluid through the wheelbrake hydraulic lines will render parking brake ineffective.

2.25.5 BRAKES Warning Light. The BRAKES warning light will illuminate whenever auxiliary brake pressure is applied to the brakes via the brake pedals, indicating the combined hydraulic system pressure is not available to the brakes and cautioning the pilot to monitor brake application with the auxiliary brake pressure indicator. A postlight is installed above the BRAKE PRESSURE gauge to illuminate the dial.

Note

The postlight requires electrical power. Brake riders on carrier night respot must use a flashlight to check the cockpit BRAKE pressure gauge.

2.25.6 Parking Brake. The parking brake mode provides a means for collective locking of the wheelbrakes to maintain a ground static position during normal operations or during emergency conditions. Aft movement of the parking handle provides for unmodulated porting of accumulator fluid pressure through emergency lines to the shuttle valve at the wheelbrake assembly. In the parking brake mode, the rudder pedals have no effect on wheelbrake operation. Pushing the parking brake handle forward releases wheelbrake pressure and the power brake module reverts to the normal and auxiliary braking mode. When auxiliary mode braking action is no longer available by depression of the rudder pedals, sufficient accumulator fluid pressure remains for a minimum of three parking brake applications.

CAUTION

Normal brakes are not available with parking brake handle pulled. If parking brake accumulator pressure is depleted, aircraft brakes are isolated from brake pedal master cylinders. Parking brake handle must be pushed in to restore normal brake operation.

Note

The AUX brake and parking brake pressure indicator should be pumped into the green band before breaking down and moving the aircraft without combined hydraulic power. The indicator should be maintained in the green band until the aircraft is secured. Full 3,000-psi pressure is required if conditions are severe (greater than 4° roll, wet brakes, etc.).

In the absence of a pressurized, combined hydraulic system, the wheelbrake accumulators can only be recharged by the pilot hydraulic handpump with the landing gear handle in the down position.

WARNING

Complete loss of hydraulic fluid through the wheelbrake hydraulic lines will render parking brake ineffective.

2.25.7 Wheel Antirotation. During the initial phase of the landing gear retraction cycle, pressurized fluid from the gear-up lines is directed to the power brake module to displace the normal metering valves to stop main wheel rotation before the wheels enter the wells. This feature is not provided for the nose wheels.

CAUTION

Illumination of indexer lights is not a positive indication that the main landing gear is clear of the runway. Raising the gear before a positive rate of climb is established will result in blown main tires.

2.26 NOSEWHEEL STEERING SYSTEM

The electrohydraulic nosewheel steering system provides for on-deck aircraft directional control, nosewheel shimmy damping, and nosewheel centering. The power unit is located on the lower portion of the nose landing gear strut outer cylinder that, through a ring gear, controls the directional alignment and damping of the lower piston assembly.

Combined hydraulic system pressure is the motive power used for steering and centering. Electrical power is supplied from the essential dc bus with circuit protection by the NOSE WHEEL STEER/AFCS circuit breaker (RB2) on the pilot right knee panel. Hydraulic pressure is derived from the gear-down line such that steering control is disabled subsequent to emergency extension of the landing gear (Figure 2-72).

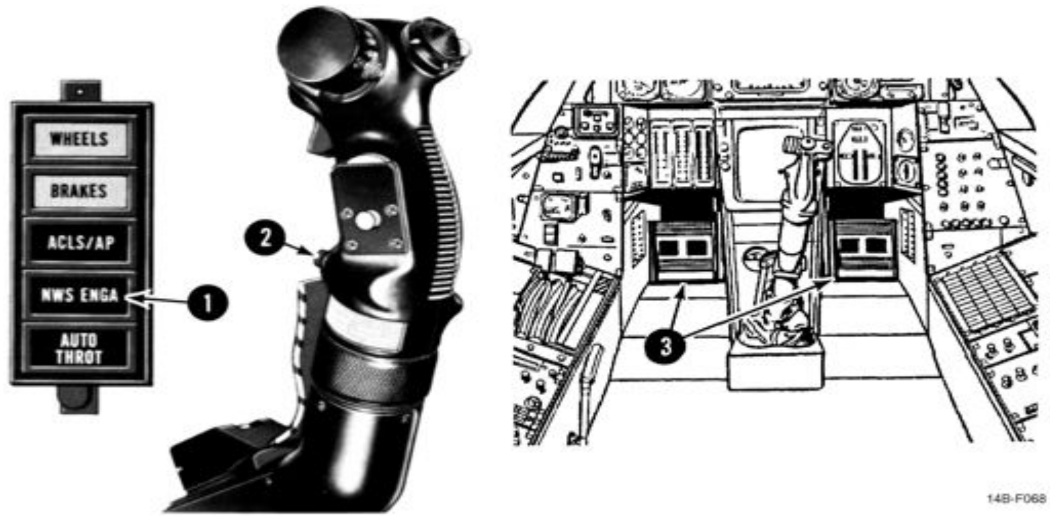
Note

If nosewheel steering is inoperative, the emergency gear extension air release valve may be tripped, which will prevent gear retraction.

2.26.1 Nosewheel Steering Control. Nosewheel steering control during ground operations is energized by momentarily pressing the autopilot reference and nosewheel steering pushbutton on the lower forward side of the pilot stick grip (see Figure 2-72). The system cannot be engaged without weight on wheels. The system will remain engaged until weight is off wheels, electrical power is interrupted, or the pushbutton switch is pressed again. Engagement of nosewheel steering is indicated by illumination of the NWS ENGA caution light. An automatic nosewheel steering system disengage feature is provided. If this feature has been activated by cycling the hook on deck with the throttles at idle, then the nosewheel steering will be disengaged and the NWS ENGA light extinguished when the launch bar is lowered. The nosewheel steering automatic disengage feature is deactivated if the nosewheel steering button is depressed.

With the system engaged, nosewheel steering is controlled by rudder pedal position. Centering is unaffected by directional trim displacement. Maximum steering authority is 70° either side of neutral, and the nosewheel can swivel a maximum of 120° about the centered position. With greater weight on the nosewheel (wings forward, high gross weight, etc.), the steering torque can only turn nosewheel +5° with the aircraft static. However, only a slight forward movement will provide the pilot with full power-steering authority. In a full pedal deflection turn using nosewheel steering, the aircraft pivots about a point between the main gear such that the inboard main wheel rolls backward. Under this condition, application of either main wheelbrake will only serve to increase the radius of turn. Because of the outboard location of the engines, the application of thrust in tight turns should be made on the outboard engine to efficiently complement the turning movement of the nosegear.

2.26.2 Nosewheel Centering. The nosewheel is automatically centered during gear retraction before the nosewheel enters the wheelwell. During gear retraction with weight off wheels, hydraulic pressure from the combined system bypasses the steering unit shutoff valve to center the nosewheel independent of rudder



NOMENCLATURE	FUNCTION
1 NWS ENGA caution light	Illumination when nosewheel steering engaged and will respond as a function of rudder pedal displacement. Nosewheel steering automatically centers with hook down. Nosewheel centering requires throttles at IDLE and weight-on-wheels with hook down.
2 Autopilot reference and nosewheel steering pushbutton	Press to engage and disengage nosewheel steering. Requires weight-on-wheels.
3 Rudder pedals	Controls nosewheel steering position with system engaged.

Figure 2-72. Nosewheel Steering Controls

pedal movement. If the nosewheel is cocked beyond 15° either side of center after takeoff, the nosewheel is automatically prevented from retracting and the LAUNCH BAR advisory light illuminates.

During carrier arrestment, the nosewheel is centered with weight on wheels and hook down when both throttles are retarded to IDLE to prevent castoring during rollback. After arrestment and rollback, the nosewheel will remain centered until nosewheel steering is engaged. Nosewheel centering is enabled by the same latching relay that enables nosewheel steering automatic disengagement with launch bar lowering. Therefore, if the nosewheel is automatically disengaged when the launch bar is lowered, the nosewheels will be hydraulically centered.

WARNING

Nosewheel centering can contribute to launch bar misalignment in the catapult shuttle, which could result in premature launch bar separation during launch. The nosewheel centering latching relay must be deactivated by depressing the nosewheel steering button after the hook check and before entering the catapult. It will also deactivate the nosewheel steering automatic disengagement function; the nosewheel steering must be manually disengaged when entering the catapult.

2.26.3 Shimmy Damping. Shimmy damping is provided in the steering actuator. Increased shimmy damping action is obtained with NWS disengaged.

CAUTION

If excessive nosewheel shimmy is encountered, disengage nosewheel steering.

2.27 NOSEGEAR CATAPULT SYSTEM

Catapult connection components on the nose landing gear shock-strut piston provide nosegear catapult capability. A launch bar attached to the forward face of the nosegear steering collar guides the aircraft onto the catapult track and serves as the tow link that engages the catapult shuttle. A holdback fitting secures the holdback restraint prior to launch. The two-piston nose strut uses the stored energy catapult principle to impart a positive pitch rotation movement to the aircraft at shuttle release, thus providing for a hands-off launch flyaway technique.

2.27.1 Nose Strut Kneel. Prior to catapult hookup, the nose strut is compressed 14 inches. Control of the nose strut kneel function is provided by the NOSE STRUT switch on the landing gear control panel (Figure 2-73). The three-position (EXTD, OFF, and KNEEL) toggle switch is spring loaded to return to the detented center OFF position.

The position of the strut remains in the last commanded position independent of electrical or hydraulic power interruptions. In both cases, the transfer control valve source of electrical power is the essential No. 2 bus, and combined hydraulic system fluid is used as the transfer medium. With external electrical power on the aircraft, the combined hydraulic system must be pressurized (>500 psi) before the control switch can command a position change of the transfer control valve. The control switch need only be held momentarily to effect a change in transfer control valve position.

Selection of KNEEL releases hydraulic fluid from the shock strut transfer cylinder to the combined hydraulic system return line, causing the weight of the aircraft to compress the shock strut 14 inches. Stroking of the nose strut causes the aircraft to rotate about the main wheels. The aircraft may be taxied or towed in the strut kneeled position except for the nuisance trip of the launch bar at greater than 10° steering angle; this is the position used for taxiing onto the catapult and enhances accessibility to the forward fuselage compartments during ground maintenance. Since the nose strut is bottomed during the catapult launch stroke, the energy stored in the last 4 inches of strut-piston stroke is released upon shuttle release at the end of the catapult stroke to impart a noseup pitching moment to rotate the aircraft to the fly-away attitude without any control required by the pilot. All the stored energy is expended before the nosewheels leave the deck edge.

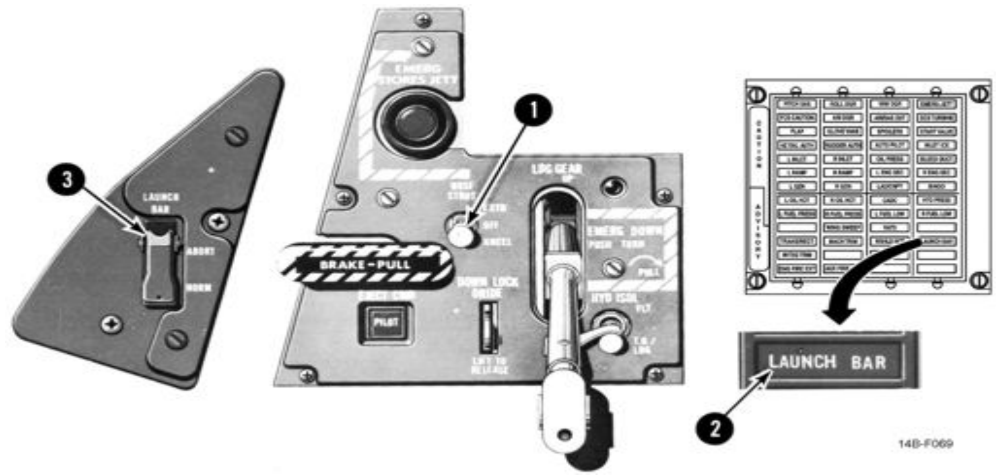
Note

Under certain launch conditions (high wind over deck and light aircraft gross weights), the nose strut will not be fully compressed during the catapult stroke. Subsequent nose rotation following shuttle release will be at a less than normal rate. Aircraft launch bulletins for the aircraft are written to ensure that catapult launch pressures are sufficient to provide safe launch pitch rates and fly-away capability.

Full extension of the nose strut after launch and weight off wheels provides a redundant and automatic transfer of the control valve to the extend position. With weight off wheels, the NOSE STRUT switch is inoperative.

2.27.2 Launch Bar. The launchbar is attached to the nosegear and serves as the tow link for catapulting the aircraft (see Figure 2-74). With the nose strut extended, the launch bar is held in the retracted position. The launch bar can be lowered by kneeling the aircraft and turning the nosewheel greater than ±10° from the centered position. The launch bar can also be lowered by the deck crew with no pilot action after the aircraft has been kneeled. A proximity sensing switch on the uplock detects the latch out of the locked position and illuminates the LAUNCH BAR advisory light (see Figure 2-73). Ears on the head of the launch bar engage under the lip of the catapult lead in track, and the head serves as a guide to steer the nosewheel on the catapult track and engage the shuttle. For an abort, the launch bar cannot be raised until the shuttle is disengaged.

2.27.2.1 LAUNCH BAR Light. The LAUNCH BAR advisory light is interlocked to go off when both throttles are at MIL even though the launch bar position and mechanism remain unchanged; this action is effected to establish a “lights out” criterion for launch. The light circuit is disabled with nosegear up and locked. A pilot-controlled LAUNCH BAR switch is installed that enables the pilot to disengage the launch bar from the catapult while remaining at MIL power and in the kneel position. This guarded switch is on the pilot left vertical console and is spring loaded at NORM.



NOMENCLATURE	FUNCTION
(1) NOSE STRUT switch	EXTD — Hydraulic pressure causes strut to extend. Combined hydraulic system must be pressurized before switch is activated on external power. Launch bar is lifted into the uplock position by torque arms as strut extends 14 inches. OFF — Spring-loaded return position. KNEEL — Nose strut transfer control valve releases pressure in the shock strut, which strokes 14 inches. Combined hydraulic system must be pressurized before switch is active on external power. Launch bar uplock can be released to allow bar to lower to deck by turning nosewheel ±10°.
(2) LAUNCH BAR advisory light	Illuminates under the following conditions: *Weight on wheels:* • Aircraft kneeled, throttles less than MIL (goes out when throttles are advanced to MIL to provide lights out criterion for catapult launch). • Launch bar not up and locked (normal operation) *Weight off wheels (inhibits nosegear retraction):* • Launch bar not up and locked • Nosewheel not within ±15° of center • Nose strut not fully extended.
(3) LAUNCH BAR switch	ABORT — Enables pilot to disengage the launch bar from the catapult while remaining at MIL power and in the kneel position. Must be held in ABORT. NORM — Spring loaded to this position.

Figure 2-73. Launch Bar Controls

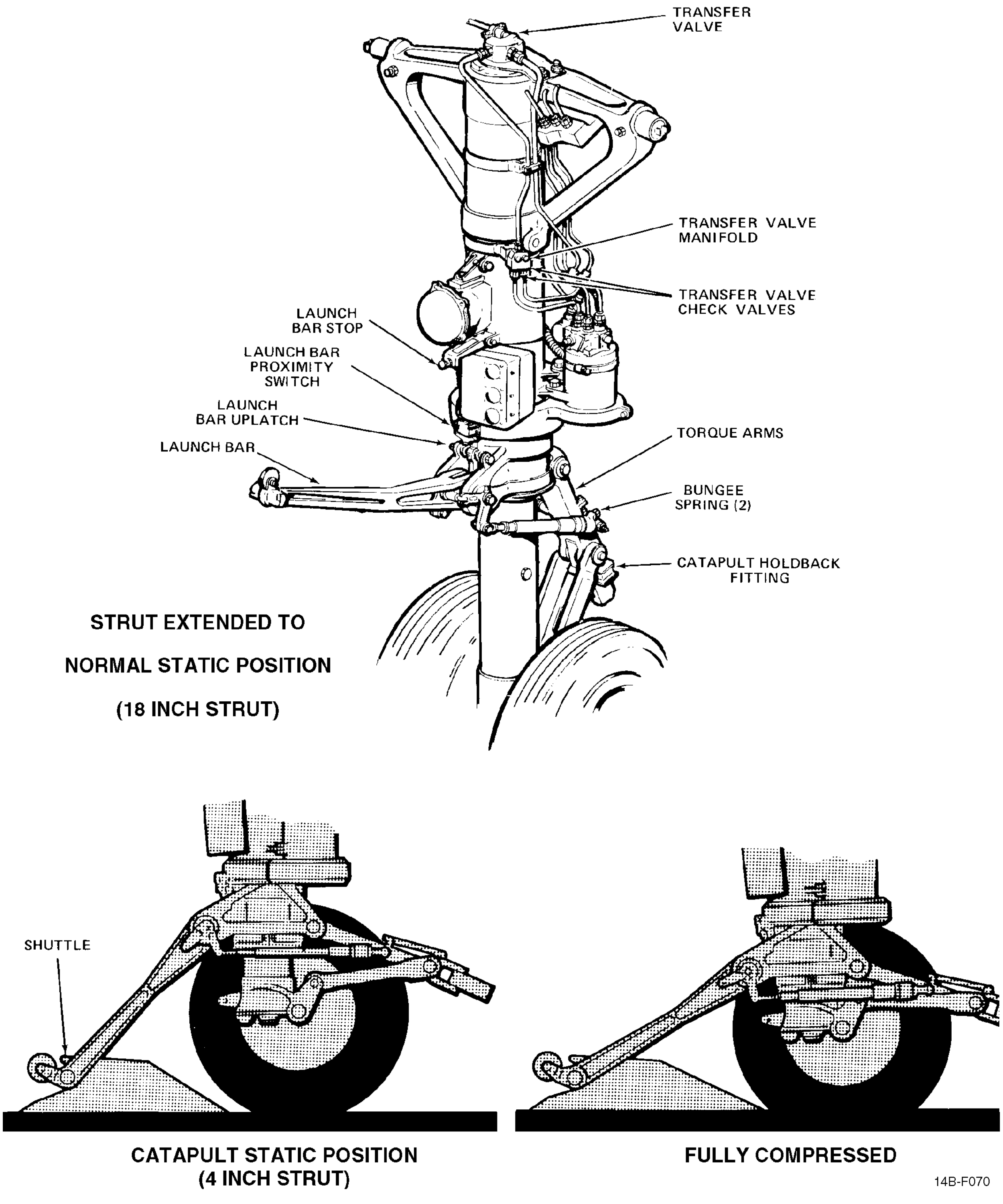


Figure 2-74. Launch Bar (Catapult)

CAUTION

To avoid damage to the launch bar retract mechanism, do not set the LAUNCH BAR switch to ABORT with the nosewheel deflected off center.

Note

The LAUNCH BAR switch is spring loaded and must be held in ABORT until the catapult officer signals to lower the launch bar.

After the catapult launch stroke, extension of the strut mechanically cams the launch bar up to the retracted and locked position. If the launch bar is not engaged in the uplock with weight off wheels, the LAUNCH BAR advisory light will illuminate and nosegear retraction will be electrically inhibited.

2.27.3 Holdback Fitting. The holdback fitting is provided on the nose strut for insertion of the holdback bar. A ground crewman must manually attach the bar before the aircraft is taxied into the catapult lead track. The holdback bar is reusable and provides for repeated releases at a tow force of 76,000 pounds. Force greater than this on launch causes the holdback bar to release the aircraft holdback fitting.

Single-engine, high-power turnup operations can use the holdback fitting to attach aircraft restraining hardware to deck-secured fittings. Prior to the application of single-engine high power, the nose strut should be kneeled and slack taken out of the holdback mechanism, otherwise dynamic loads may exceed mechanism design strength conditions.

2.28 ARRESTING HOOK SYSTEM

The arresting hook installation consists of a stinger tailhook and associated control mechanism mounted to the underside of the center fuselage. The hook shank is free to pivot up and down at its attachment point. A pneumatic dashpot preloads the hook down to minimize hook bounce on contact with the deck. The hook shank is free to pivot left or right within a ±26° sway angle with positive centering action provided by a pneumatic damper housed inside the tailhook shank. The trail angle of the arresting hook provides for hookpoint-deck contact even with the nose landing gear strut fully compressed.

2.28.1 Arresting Hook Operation. Normal operation of the arresting hook requires combined and flight hydraulic system pressure, dashpot charged, and dc essential No. 2 electrical power. Because of a redundant means of pilot control (electrical and mechanical), emergency extension of the arresting hook can be accomplished without these sources of power.

Note

Hook retraction requires electrical and combined hydraulic power.

2.28.1.1 Normal Operation. Normal operation (Figure 2-75) on the pilot hook control consists of a straight down-up movement of the HOOK handle. This action actuates switches that provide electrical command signals to the hook control valve. For lowering the hook, the uplock is released and the lift cylinder is vented. Combined hydraulic pressure is the medium that disengages the hook uplock actuator. When flight hydraulic pressure drops below 2,100 psi with weight off wheels, the hook/auxiliary flap-isolation relay circuit is energized. This disables the arresting hook control valve and therefore disallows normal hook extension. This condition remains until either the starboard engine-driven hydraulic pump (flight) produces greater than 2,400 psi or weight on wheels is restored.

Note

If emergency hook extension is inoperative in conjunction with a flight hydraulic failure, cycling the HYD VALVE CONT circuit breaker (7E5) with the hook handle down will permit hook extension.

Dashpot pressure of 800±10 psi assisted by gravity causes the arresting hook to lower. With the hook down, the pneumatically charged dashpot provides holddown contact force to minimize hook bounce and maintain the hook 37° down for arrestment. With the HOOK BYPASS switch in CARRIER, the approach and indexer lights will flash when airborne with gear down and hook up.

NOMENCLATURE	FUNCTION	
1 Arresting HOOK handle	UP —	Electrically energizes hydraulic retract actuator to raise hook into uplock.
	DN —	Electrically releases hydraulic uplock actuator and allows hook to extend by dashpot pressure and gravity.
	EMERG DOWN —	(Pull-twist) mechanically releases uplock actuator and allows hook to extend by gravity and dashpot pressure.
2 Hook transition light	Illuminates whenever arresting hook position does not correspond with handle position. Light will not go out in down position until hook is in full trail angle.	
3 HOOK BYPASS switch	FIELD —	Used for non-arrested landings. Bypasses the flashing feature of the approach lights and indexer when land ing gear is down and hook retracted.
	CARRIER —	Used for arrested landings. Approach lights and indexer flash when landing gear is down and the hook retracted.

Figure 2-75. Arresting Hook Controls

Note

- With the throttle at idle, weight on wheels, and hook down, a nosewheel steering centering command is automatically provided to prevent nosegear castoring on arrestment rollback. Pilot deflection of the rudder pedals while in the automatic nosewheel centering mode will not override the centering command until nosewheel steering is engaged by the pilot.

- With weight on wheels and hook down, the RATS advisory light should be illuminated indicating the RATS aircraft circuit has been enabled.

2.28.1.2 Hook Retraction. For hook retraction, the control valve pressurizes the retract side of the lift cylinder and the lock side of the actuator.

CAUTION

Do not attempt to raise the hook when the hook is engaged in the arresting gear.

When the arresting hook roller engages the uplock mechanism, the lift cylinder is depressurized. On deck, hook retraction time is approximately 3 seconds. The hook transition light is illuminated as long as a discrepancy exists between the hook and cockpit handle positions. The transition light remains illuminated during on-deck extension, which requires approximately 1 second.

Note

The hook transition light may remain illuminated when the hook handle is lowered at airspeeds greater than 300 knots because of hook blowback.

2.28.1.3 Emergency Hook Extension. The emergency control system lowers the hook by mechanically (cable) tripping the uplock and venting the hook lift actuator pressure. Emergency extension of the hook may be initiated when the handle is in either UP or DN. In either case, the hook handle is pulled aft (approximately 4 inches) and turned 90° counterclockwise. Rotation 90° counterclockwise will lock the handle in the extended position. With the handle locked, the hook will not retract regardless of the handle position (UP or DN).

Note

After emergency hook extension, the hook can be retracted airborne or on deck provided that the handle is rotated 90° clockwise, pushed full forward, and placed in UP. Combined and flight hydraulic system pressures are required to retract the hook while airborne. On deck, only combined hydraulic system pressure is required to retract the hook.

2.29 ENVIRONMENTAL CONTROL SYSTEM

The ECS regulates the environment of flight-crew and electronic equipment. The system provides temperature-controlled, pressure-regulated air for the following systems:

1. External drop tank pressurization
2. Cockpit pressurization
3. Canopy seals
4. Windshield and canopy defogging
5. Windshield anti-ice
6. Windshield air
7. Anti-g suit inflation
8. Pressure and exposure suit vent air
9. Wing airbag seals
10. Ammunition purging (aircraft prior to block 150)
11. Electronic equipment cooling and pressurization
12. Temperature control of liquid coolant supplied to AN/AWG-9 control system and AIM-54A Phoenix missile.

2.29.1 ECS Air Sources

2.29.1.1 Bleed Air. The normal source of ECS air is ninth-stage bleed air from both engines. Through a series of manifolds and valves, this air is cooled and mixed to reduce temperature and pressure to usable levels. The primary valves are the two engine bleed air shutoff valves, the dual pressure regulating and shutoff valve, and the turbine compressor modulating and shutoff valve, which are all controlled by the AIR SOURCE selector pushbuttons: L ENG, R ENG, and BOTH ENG (Figure 2-76).

2.29.1.2 Ram Air Source. If either the RAM or OFF pushbutton is selected by the pilot, the cooling turbine compressor is shut down and emergency ram air can be used to ventilate the cockpits and provide cooling air to the service and suit heat exchanger and those electronic subsystems requiring forced air cooling. However, if OFF is selected, pressurization to the service systems (canopy seal, anti-g-suit, pressure/ventilation suit, external fuel tank, wing airbag seal) and 400 °F air supply to the windshield air defog and heating systems is lost. Selecting AIR SOURCE RAM will provide air to the service systems and 400 °F manifold air to the defog and heating systems. This action, however, may result in damage to local structure, components, and wire should a duct failure exist. Interconnects inhibit gun firing with RAM or OFF selected. The emergency ram air door is on the lower right side of the fuselage, inboard of the right glove. To activate the ram air door, either the OFF or RAM AIR source pushbutton must be depressed and the RAM AIR switch on the air-conditioning control panel must be moved to INCR. To activate the emergency ram air door from full closed to full open requires approximately 50 seconds.

WARNING

Selection of the AIR SOURCE pushbutton to RAM with a failure of the ECS duct system will continue to circulate 400 °F air throughout the system surrounding aircraft components and may cause a fire.

CAUTION

- Before opening the ram air door, reduce airspeed to 350 KIAS or 1.5 Mach, whichever is lower, to prevent ram air temperatures above 110 °F from entering the system. After ram airflow is stabilized, airspeed may be varied as required for crew comfort or to increase flow to electronic equipment.
- The RAM AIR switch in aircraft incorporating AVC 4070 is no longer spring loaded to off. The switch must be manually placed to off before selecting AIR SOURCE RAM or OFF.
- With AIR SOURCE OFF selected, limit airspeed to less than 300 KIAS/0.8 IMN to prevent damage to the deflated wing airbag seals.

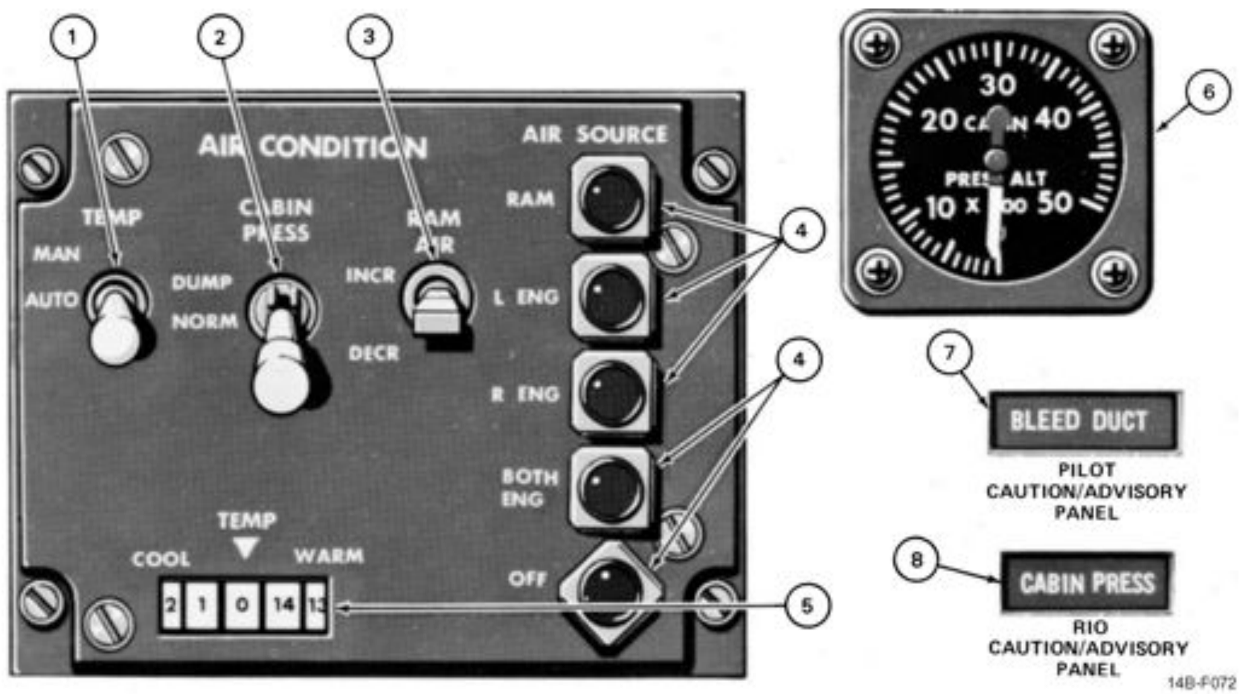
Note

Ram air door may take 50 seconds to fully open.

For maximum cockpit ram airflow, the cockpit pressurization must be dumped. Pressing either L ENG, R ENG, or both ENG pushbuttons automatically closes the ram air door if it is open.

2.29.1.3 External Air. The adapter for connecting a ground air-conditioning unit is under the fuselage, aft of the nose wheelwell. An additional provision for connecting an external source of servo air is in this same area.

Because the standard ground air-conditioning unit is not capable of cooling the cockpits, avionics, and AWG-9/AIM-54 simultaneously, a diverter valve is installed just downstream of the external air inlet. Cockpit control of the diverter valve is provided by the GND CLG switch on the RIO right console. Either OBC/CABIN or AWG-9/AIM-54 switch position may be selected.



NOMENCLATURE	FUNCTION	
(1) TEMP mode selector switch	AUTO —	Cockpit and pressure suit temperature is automatically maintained at that comfort level selected on the temperature control selector.
	MAN —	Cockpit temperature must be manually selected as airspeed and altitude change to maintain a desired temperature.
(2) CABIN PRESS switch Lever-lock switch which must be lifted to be moved to DUMP.	NORM —	Cockpit pressure will be maintained at an altitude of 8,000 feet up to 23,000 feet, above which the regulator maintains a 5-psi pressure differential.
	DUMP —	The cockpit safety valve is opened, depressurizing the cockpit.
(3) RAM AIR switch (Aircraft incorporating AVC 4070 the switch is no longer spring loaded to off. The switch must be manually placed to off before selecting AIR SOURCE - RAM/OFF)	INCR-DECR —	Manually modulates the ram air door and regulates the amount of ram air supplied to the cabin and electronics bay after the AIR SOURCE pushbutton is selected to RAM or OFF. (Approximately 50 seconds.)

Figure 2-76. Air-Conditioning and Pressurization Controls and Indicators (Sheet 1 of 2)

NOMENCLATURE	FUNCTION	
(4) AIR SOURCE selector pushbuttons	RAM —	Closes the bleed air flow modulator pressure regulator and shutoff valve, thereby securing the cooling bootstrap turbine compressor. Inhibits gun firing. The RAM AIR switch is enabled. Combined ram air and regulated 400 °F bleed air are available to the cockpits and air cooled electronic equipment for temperature control. When either BOTH ENG, L ENG or R ENG are selected, the ram air door automatically closes.
	L ENG —	The left engine is the source of bleed air for the environmental system and the right engine bleed air shutoff valve is closed.
	R ENG —	The right engine is the source of bleed air for the environmental system and the left engine bleed air shutoff valve is closed.
	BOTH ENG —	The right and left engine bleed air shutoff valves are pen and both supply bleed air to the environmental control system. This is the normal position. Automatically closes ram air door.
	OFF —	Both the left and right engine bleed air shutoff valves and the dual pressure regulator valve are closed. Inhibits gun firing. Pressurization and air conditioning are not available. Enables the RAM AIR switch.
(5) TEMP thumbwheel control	Selects cockpit and suit air temperature. It can be rotated through a 300° arc (0 to 14) with mechanical stops at each end placarded COOL and WARM. A midposition temperature (7) is approximately 70 °F in the automatic mode. With the TEMP mode selector switch in AUTO the temperature selected is automatically maintained by the modulating temperature control valves. In MAN, the TEMP control thumbwheel must be repositioned to maintain cockpit and suit air temperature with changes in airspeed and altitude.	
(6) CABIN PRESS ALT indicator	Displays cabin pressure altitude in 1,000-foot increments from 0 to 50,000 feet.	
(7) BLEED DUCT caution light	Indicates overheating (575 °F or greater) along the high-temperature bleed air duct routing forward of the engine fire wall up to the primary heat exchanger and the 400 °F modulating valve, overheating (255 °F or greater) from the 400 °F modulating valve forward to the bootstrap turbine.	
(8) CABIN PRESS caution light (RIO's cockpit)	Indicates cabin pressure is less than 5-psi absolute pressure or cockpit altitude is above 27,000 feet	

Figure 2-76. Air-Conditioning and Pressurization Controls and Indicators (Sheet 2)

If OBC/CABIN is selected, ground cooling air will go to the cockpit, all the forced-air-cooled avionics, and a controlled amount of air will be available to cool the AWG-9 liquid loop at a reduced heat load. If AWG-9/AIM-54 is selected, ground cooling air will go to the AWG-9/AIM-54 liquid cooling loop and all essential forced-air-cooled avionics.

External electrical power is automatically inhibited from VDIG, PMDIG, APX-76, CADC, and the CSDC if external air-conditioning is not connected to the aircraft.

Pressure switches on both sides of the ground air diverter valve (FO–13) interrupt electrical power to specific forced-air-cooled equipment, depending upon position selected by the GND CLG switch or shutoff electrical power if air pressure is insufficient.

Note

The equipment not cooled by ground cooling air when the GND CLG switch is in AWG-9/AIM-54 are AN/ALQ-126, PMDIG, CADC, VDIG, AN/APX-76.

2.29.2 Cockpit Air-Conditioning. ECS manifolding consists of:

1. The high-temperature (bleed air) manifold
2. The 400° manifold
3. The cold-air manifold.

High-temperature engine bleed air is routed through the primary heat exchanger. The cooled output of this heat exchanger is split, and a portion is mixed with hot, engine bleed air to a temperature of approximately 400 °F; the remainder is further cooled by the turbine compressor. Here the air is compressed, run through the secondary heat exchanger, and then expanded in the turbine section, resulting in cold air that is mixed with 400 °F air to obtain any temperature desired. The primary and secondary heat exchangers are between the left and right engine inlets and the fuselage. At speeds above 0.25 Mach, ram air across the heat exchangers is used for cooling. During ground operations and at airspeeds less than 0.25 Mach, airflow across the heat exchanger is augmented by air-powered turbine fans.

Note

Ground operation of the aircraft with either one or both engines in idle power reduces ECS cooling capacity. This can result in the illumination of the RIO COOLING AIR and/or AWG-9 COND advisory light. If the cooling capacity is inadequate at idle power, the throttle should be advanced to turn off the lights. It should not be necessary to advance the throttle beyond the point at which the engine exhaust nozzle closes (monitor exhaust-nozzle position indicator). To increase airflow to forced-air-cooled equipment, place CANOPY DEFOG-CABIN AIR control lever in CANOPY DEFOG.

The third heat exchanger is the service air-to-air heat exchanger. This normally uses cold air from the cold-air manifold as a heat sink but can use emergency ram air if the cold-air manifold is not operating. Air from the service heat exchanger is used by exposure suit, g-suit, canopy seal, and for pressurization of radar wave guide, antenna, transmitter, weapon control system and missile liquid-cooling loop tanks, and TV sight unit.

2.29.2.1 Temperature Management. The pilot can control cockpit temperature by selecting either a manual (MAN) mode or automatic (AUTO) mode with the TEMP mode selector switch (Figure 2-76). In the AUTO mode, temperature (60 to 80 °F) is selected by the pilot with the TEMP thumbwheel control. This desired temperature is maintained by a cabin temperature sensor in the forward left side of the cockpit. In the MAN mode, the TEMP thumbwheel control manually positions the cockpit hot-air-modulating valve to maintain cockpit and suit air temperatures. If cockpit inlet airflow temperature (in either AUTO or MAN) exceeds 250 °F, a cockpit overtemperature switch closes the hot air modulating valve.

The conditioned air entering the cockpit is divided forward and aft, with 50 percent of the air going to each cockpit. A CANOPY air diffuser lever on the right console in each cockpit individually controls the percentage of airflow through the cockpit diffusers and the canopy defog nozzles. When the lever is in CABIN AIR (full aft), 70 percent of the air is directed through the cockpit diffusers and 30 percent through the canopy defog nozzles. In DEFOG, 100 percent of the air is directed through the canopy defog nozzles.

2.29.2.2 Pressure Suit and Ventilation Air. The pressure suit and ventilation air system provides temperature controlled, pressure regulated engine bleed air to both pressure suits or to the ventilated seat cushions when pressure suits are not worn. The pilot can select either manual or automatic temperature control mode and regulate a desired suit or seat cushion temperature. Each crewman can individually control the volume of airflow through the pressure suit or seat cushion by the VENT AIRFLOW thumbwheel of his left inboard console.

2.29.2.3 Anti-G Suit. Each anti-g suit is connected to the aircraft pressurization system by an anti-g suit hose that delivers pressurized air to the suit control valve and then to the suit through a composite disconnect. Below 1.5g, the suit remains deflated. A spring balanced anti-g valve automatically opens when g forces exceed 1.5g. Operation of the anti-g suit valve may be checked by depressing the test button marked G VALVE on each crewman's left console.

2.29.3 Electronic Equipment Cooling. Ambient cooled equipment in the electronic bays is cooled by the air exhausted from the cockpits. Equipment incapable of being cooled by free convection is cooled from the cold-air manifold.

A schematic of the AWG-9 and AIM-54 and electronic equipment cooling is shown on FO–14. Controls and lights are shown in Figure 2-77.

2.29.3.1 Liquid Cooling. AWG-9 equipment is cooled by liquid coolant (FO–14). The heat is rejected in the ram air heat exchanger. This is accomplished by circulating coolant fluid through the electronics and ram air heat exchanger and/or the AWG-9 and AIM-54 heat exchanger. The cooling loop is also used for automatic warmup of the AWG-9 using bleed air.

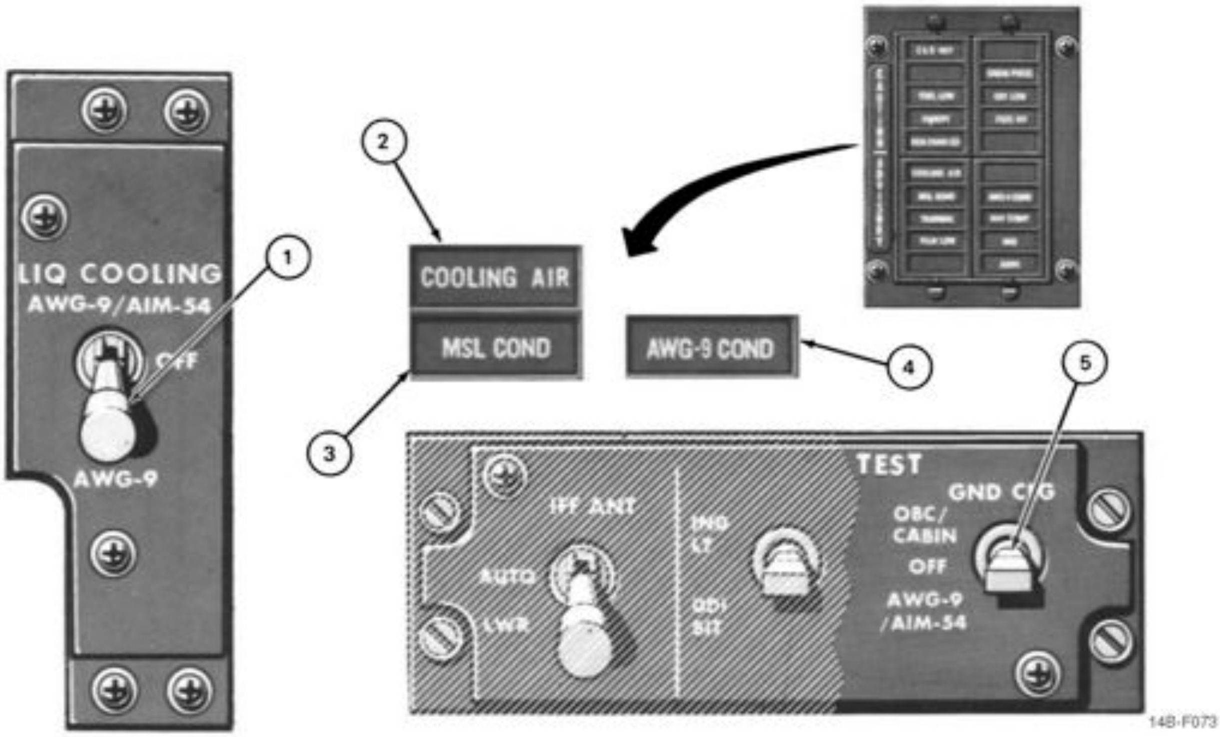
The AWG-9 liquid cooling loop incorporates a separate ram-air liquid-heat exchanger. A ram-air door is located under the right glove, forward of the primary heat exchanger inlet. There are no cockpit controls for this ram air door. It is controlled by the AWG-9/AIM-54 controller and is independent of the air-conditioning and pressurization system. The AWG-9 system ram-air heat exchanger automatically maintains the liquid temperature within operating limits.

WARNING

A potential fire hazard is present in the event of an AWG-9 coolant pump failure that can lead to the pump spraying flammable fluid into the ECS compartment. A PM acronym will appear on the PTID in the AWG-9 CM buffer when the AWG-9 coolant pressure, flow, or temperature sensors from flycatcher 7-00166 are activated. This PM acronym should alert the flightcrew to the need for immediate action to secure the AWG-9 coolant pump.

2.29.3.1.1 Controls and Lights. Figure 2-77 shows the controls and lights associated with the AWG-9 and AIM-54 cooling loop. The AWG-9 cooling loop is activated by the LIQ COOLING switch on the RIO left outboard console. In AWG-9/AIM-54, both the AWG-9 radar and AIM-54 missile cooling loops are activated for airborne operation. If AWG-9 is selected, only the radar cooling pump is activated. A temperature sensor in the AWG-9 and AIM-54 heat exchanger outlet illuminates the AWG-9 COND advisory light when the liquid temperature goes above 104 °F. In addition, a pressure switch in the AWG-9 pump illuminates the AWG-9 COND advisory light when pump output pressure is too low.

If the coolant pump temperature rises to 230±5 °F, the thermal switch opens shutting down the pump to prevent pump failure and illuminates the AWG-9 COND advisory light.



NOMENCLATURE	FUNCTION
1 LIQ COOLING switch	AWG-9/AIM-54 — Activates the AWG-9 and AIM-54 cooling pump motors. **Note** AIM 54C missiles do not need liquid cooling. OFF — Deactivates the AWG-9 and AIM-54 cooling pumps. AWG-9 — Activates the AWG-9 cooling pump for ground and airborne thermal conditioning.
2 COOLING AIR advisory light	Illuminates after a delay of 25 to 40 seconds when an overtemperature condition exists in the electronic forced air cooling system. With degraded cabin pressure or cabin flow, indicates possible bleed duct failure forward of the primary heat exchanger and 400° modulating valve.
3 MSL COND advisory light	Illuminates when temperature of the coolant flow to the missiles is above 115° ±3 °F; also indicates pump out pressure is below 60±5 psi. With WCS switch in STBY or XMIT and Phoenix fairing installed, light will illuminate when LIQ COOLING switch is in OFF or AWG-9. Illuminates when the overtemperature switch shuts down the AIM-54 coolant pump.
4 AWG-9 COND advisory light	Illuminates when coolant exiting the heat exchanger reaches 104 °F, pump output pressure is below 60 psi, or when the overtemperature switch shuts down the AWG-9 coolant pump.

Figure 2-77. AWG-9 and AIM-54 Liquid Cooling Controls and Lights (Sheet 1 of 2)

NOMENCLATURE	FUNCTION
5 GND CLG switch	OBC/CABIN — Positions ground cooling diverter to allow external cooling air for all forced-air-cooled electronic equipment. Reduced supply to AWG-9 liquid loop heat exchanger. Deactivates cockpit low-flow-override signal and removes primary power from AWG-9 transmitter. **CAUTION** • Servo air required to actuate servo operated valves. • Use OBC/CABIN or AWG-9/AIM-54 only when engines are shut down. **Note** With GND CLG switch in OBC/CABIN AWG-9 BIT failures will occur on the ground with weight on wheels. OFF — Deactivates the ground air diverter. Activates the cockpit low flow override signal and shall be selected when engines are operating. AWG-9/AIM-54 — The ground cooling diverter is positioned to allow external cooling air for the AWG-9 and AIM-54 liquid cooling system and all essential forced-air-cooled equipment. Deactivates the cockpit low-flow override signal.

Figure 2-77. AWG-9 and AIM-54 Liquid Cooling Controls and Lights (Sheet 2)

WARNING

Failure to turn off the AWG-9 or AIM-54 coolant pumps after illumination of an AWG-9 COND light or failure to respond properly to other indications of an overheating AWG-9 coolant pump could lead to a failure of the pump causing the flammable coolant fluid to spray into the compartment with subsequent potential for fire. Other indications of an overheating pump may be automatic shutdown of the AWG-9 with concurrent XM acronym, AWG-9 failure because of low-coolant pressure, coolant temperature, high or low-coolant flow with an associate PM acronym on the PTID, and/or popping of the AWG-9 coolant pump three phase circuit breakers.

2.29.3.1.2 Ground Operation. During ground operation, with electrical power, external air-conditioning and servo air available to the aircraft and the GND CLG switch in AWG-9 and AIM-54, the ground-cooling diverter valve directs the external conditioned air to the AWG-9/AIM-54 systems and to essential forced-air-cooled avionics. When OBC/CABIN is selected, external conditioned air is directed to the cockpit, and all forced-air-cooled avionics and a limited amount of air is available to cool the AWG-9 liquid loop. With the GND CLG switch in OBC/CABIN, the AWG-9 radar transmitter is inhibited from ground operation. With engines running on the ground, select OFF on the ground cooling switch.

2.29.3.2 Cockpit Air-Priority Function. The cockpit air-priority function is operational during all engine-on operations (FO–14). It provides the cockpit with priority over the AWG-9 liquid cooling loop in the event there is a shortage of conditioned air. On engine power, the GND CLG switch (Figure 2-77) should always be in OFF and the canopy locked to enable the cockpit air-priority function.

Up to 8,000 feet, a small positive differential pressure (inside to outside) is maintained within the cockpit to provide a controllable back pressure and, thereby, limit flow. If the flow limits cannot be met because of excessive leakage of air (causing excessive flow) from the cockpit, the cockpit priority system progressively closes the cold-air valve to the AWG-9 liquid heat exchanger to make more air available to the cockpit.

There is no indication to the flightcrew that the cockpit priority action is taking place unless it progresses to the point that an AWG-9 COND advisory light illuminates. Even then, it is only one of several problems that could have triggered the light.

2.29.3.3 AIM-54 Missile Cooling. The AIM-54 cooling (FO–14) is required to dissipate heat generated in the AIM-54 missile electronic systems. This is accomplished by circulating 18 gallons of coolant fluid per minute through one to six missiles (3 gpm per missile) at a controlled inlet-fluid temperature of 70 °F to the missiles. Heat picked up in the missile is rejected to ECS air in the missile AWG-9 and AIM-54 heat exchanger. The coolant fluid is also used for missile warmup.

If the temperature of the coolant delivered to the missiles goes above 115 °F, the MSL COND advisory light illuminates. A pressure switch in the AIM-54 cooling loop pump will illuminate the MSL COND advisory light when pump output pressure is low.

If the coolant temperature rises to 230±5 °F, an overtemperature switch on the coolant pump opens, shutting down the pump to prevent pump failure and illuminating the MSL COND advisory light.

2.29.4 Pressurization

2.29.4.1 Cockpit Pressurization. From sea level to 8,000-foot altitude, the cockpit is unpressurized. Between altitudes of 8,000 to 23,000 feet, the system maintains a constant cockpit pressure altitude of 8,000 feet. At altitudes above 23,000 feet, the cockpit pressure regulator maintains a constant 5-psi pressure differential greater than ambient pressures. An illustration of the cabin pressure schedule is shown in Figure 2-78.

2.29.4.1.1 Cockpit Pressure Indicators. A cockpit pressure altimeter (Figure 2-76) is provided for the pilot. In the rear cockpit, the RIO has a low-pressure caution light on the CAUTION ADVISORY light panel. This low-pressure caution light, placarded CABIN PRESS, illuminates when cockpit pressure drops below 5 psi absolute pressure or cockpit altitude is above 27,000 feet.

2.29.4.1.2 Cockpit Pressure Malfunctions. If the cockpit pressure regulator malfunctions, the cockpit

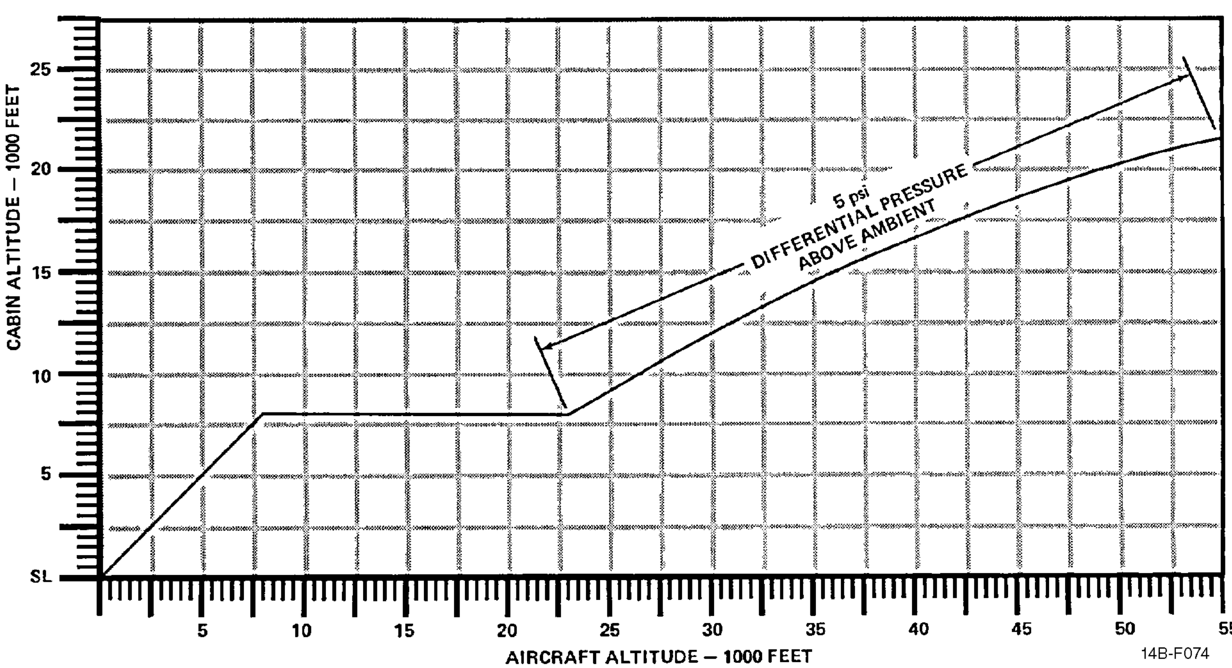


Figure 2-78. Cabin Pressure Schedule

safety valve will open to prevent a cockpit pressure differential from exceeding a positive 5.5 psi or a negative differential of 0.25 psi. The cockpit pressure regulator and the safety valve are pneumatically operated and function independently through separate pressure sensing lines.

2.29.4.1.3 Cockpit Pressure Dump. Cockpit pressurization can be dumped by the pilot by selecting DUMP with the CABIN PRESS switch. When DUMP is selected the safety valve is immediately opened and the cockpit is depressurized.

2.29.4.2 Canopy Seal Pressurization. Pressurized air from the air-conditioning system is ducted through the cockpit to the canopy seal. The seal is automatically inflated when the canopy actuator is moved to the closed position. A check valve in the canopy pressure regulating valve prevents the loss of canopy-seal pressurization if the conditioned air manifold is depressurized. Initial movement of the canopy actuator automatically deflates the seal.

2.29.5 Windshield Air and Anti-Ice. Compressor bleed air at approximately 390 °F and at high pressure is directed over the outside of the windshield through a fixed-area nozzle. This blast of hot air over the windshield will evaporate rain and ice and prevent its further accumulation. It is activated by selecting ON with the WSHLD AIR switch. A temperature overheat sensor at the base of the windshield protects the windshield from overheating. When the sensor detects overheating (300 °F), a signal closes the pressure regulating valve and illuminates the WSHLD HOT advisory light on the pilot CAUTION ADVISORY light panel (Figure 2-79).

CAUTION

- Selecting WSHLD AIR ON prior to entering rain or icing conditions may cause windshield cracking because of the rapid cooling effects of precipitation.

- Extended operation in clear air with the windshield air on may cause windshield cracking and discoloration.

2.29.6 Gun-Gas Purging. External airflow is used to ventilate the gun compartment for gun-gas purging. A flush air inlet on the fuselage gun bump and an aft louvered door containing a FOD screen provide a continual flow of air to purge gun gases. Gunfiring is permitted for 200 rounds burst limit.

2.29.7 Degraded ECS Operation. There are various temperature and pressure safeguard systems that cause the ECS system to shut down if an unsafe situation is detected. A complete failure of the dual valve will cause it to shut down the pressurization and air-conditioning system. Should that fail to close, a pressure sensor will close both individual engine bleed air shutoff valves if an overpressure situation exists in the downstream duct (155 psi). A shutdown of the bleed air supply duct, either automatically or pilot-selected AIR SOURCE OFF pushbutton, will cause total ECS air shutdown.

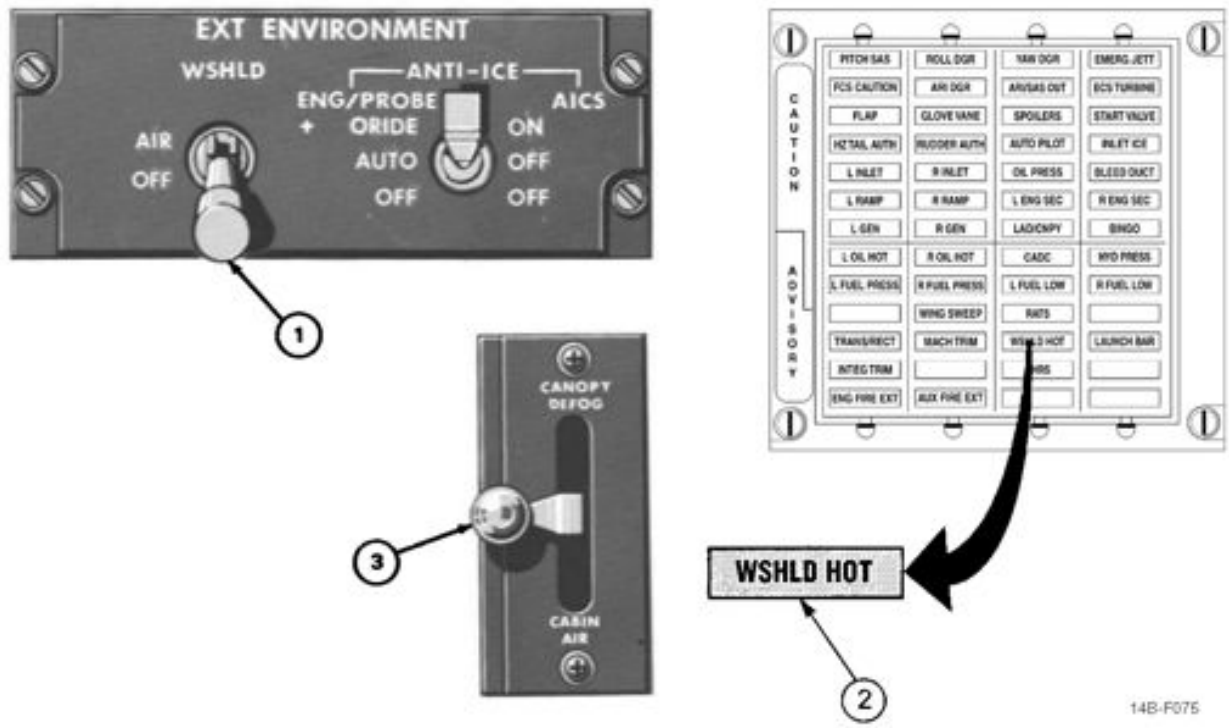
CAUTION

Failure of the left or right weight-on-wheels switches to the in-flight mode can cause loss of engine ejector air to the IDGs and hydraulic heat exchangers causing thermal disconnect and/or heat damage to the generators and aircraft hydraulic systems.

Note

- After an automatic shutdown of the system, the pilot should select either OFF or RAM AIR SOURCE to enable the emergency ram-air door and then place the RAM AIR switch to INCR for approximately 50 seconds to provide ram-air cooling to electronic equipment and to the cabin.

- Loss of electrical power with bleed air still operating will result in smoke entering the cockpit through the ECS system when the aircraft is on the deck. In flight, only cold air will be supplied to the cabin and suit. Icing of the water separator may occur, causing reduced flow to the cabin. Since the ECS panel is dependent on electrical power, selector pushbuttons will be inoperative.



NOMENCLATURE	FUNCTION	
(1) WSHLD switch	ON —	Provides a continuous blast of hot air (390 °F) over the exterior windshield. Used for windshield anti-ice.
	OFF —	Closes the shutoff valve after a 5-second delay. The system is deenergized.
(2) WSHLD HOT advisory light	Light Illuminates when center windshield overheats (300 °F).	
(3) CANOPY air diffuser lever (both cockpits)	CABIN AIR —	70% of the conditioned air directed through the cockpit air diffusers and 30% is through the canopy air diffusers. This is normal position.
	DEFOG —	Air flow is directed through the canopy air diffusers only.

Figure 2-79. Canopy Defog Controls and Windshield Air

Note

Retarding throttles to idle above 30,000 feet may result in a considerable reduction in ECS airflow, leading to a loss of cockpit pressurization, AWG-9 condition light, and/or cooling air light.

If the 400° manifold reaches 475 °F, a 400 °F shutoff valve closes, stopping the flow of unconditioned engine bleed air to the 400 °F manifold. If either compressor inlet or turbine inlet temperature becomes excessive, the refrigeration unit will shut down. Cockpit indications will be as follows:

1. No cockpit airflow.
2. RIO COOLING AIR advisory light illuminated.
3. RIO AWG-9 COND advisory light illuminated.
4. RIO MSL COND AIM-54 (aboard) advisory light illuminated.

5. Extended flight with AIR SOURCE OFF could cause an overheating condition of the CSDC and a subsequent loss of primary attitude and navigational indications (i.e., VDI, HUD, NAV aides).

The pilot should press the AIR SOURCE RAM pushbutton and set the RAM AIR switch to INCR to open the ram-air door to provide forced-air cooling to the electronic equipment and to the cabin.

ECS duct failures may be indicated by diminishing cabin cooling airflow and/or cabin pressurization with or without COOLING AIR advisory light illumination. Duct failures may additionally be indicated by pressurization loss to the service systems, and airflow loss to rain removal, defog, and heating systems. This cannot be verified if the system is not in use. Selection of AIR SOURCE OFF and ram air increase is appropriate when any indication of duct failure exists. ECS malfunctions that are not caused by duct failure are usually indicated by loss of temperature control without a cabin or system airflow/pressurization degradation. Failure of the 400 °F modulating valve or ducting should not cause illumination of the COOLING AIR light. Any duct failure in this area associated with the COOLING AIR light is strictly coincidental. However, the duct failure between the primary heat exchanger and the turbine compressor assembly, or between the secondary heat exchanger and the turbine compressor assembly, could cause degraded cooling airflow and a COOLING AIR light to illuminate.

Actuation of the overtemperature switch results in cycling of the 400 °F valve. During this period, the heating capacity of the 400 °F manifold would be degraded.

2.30 OXYGEN SYSTEM

Breathing oxygen is provided each crewman by converting liquid oxygen to gaseous oxygen within either one or two 10-liter liquid oxygen converters. Emergency oxygen is available to both crewmen through a high-pressure gaseous oxygen bottle in each ejection seat pan.

2.30.1 Normal Oxygen System. The normal oxygen system provides crewmen with 100-percent pressure-regulated, temperature-controlled oxygen. The system is designed for use with a pressure-demand type regulator that may be mask mounted or chest mounted. It is also compatible with the full-pressure suit oxygen regulator. Normally, one 10-liter liquid oxygen converter is installed. Provisions are made for installation of a second converter, if required. The liquid oxygen converters are in the right side of the fuselage adjacent to and beneath the forward cockpit. An access door in the side of the fuselage is provided for servicing the system. An oxygen quantity duration chart is shown in Figure 2-80.

An OXYGEN ON-OFF switch is located aft on the left console in each cockpit. In ON, oxygen is free to flow from the converter through the regulator to the mask. In OFF, a dual shutoff and relief valve at the control panel closes to shut off flow to the regulator.

2.30.1.1 Oxygen Quantity Indicator. An oxygen quantity indicator is on the right side of the pilot's right knee panel. The indicator is calibrated in liters and indicates quantity remaining in increments of 1 liter.

The indicator operates on 115 V power from essential bus No. 2. If electrical power is lost, the indicator will indicate less than zero and the OFF flag on the lower face of the indicator will appear. The liquid oxygen indicator is tested through the BIT system. When the MASTER TEST switch on the pilot MASTER TEST panel is set to INST and depressed, the indicator pointer should read 2 liters and the RIO OXY LOW caution lights illuminate.

2.30.1.2 Oxygen Caution Light. An OXY LOW caution light is on the RIO CAUTION and ADVISORY panel, forward on the right console. The amber light illuminates when oxygen remaining is less than 2 liters or pressure is low. When the light illuminates, a crosscheck with the oxygen quantity indicator will disclose whether the oxygen quantity is low or pressure is low.

CAUTION

If the OXY LOW caution light is extinguished by pulling the OXY/BINGO CAUTION circuit breaker (7F6), the BINGO and FUEL LOW caution light systems are inoperative.

Note

Repeated MASTER CAUTION and OXY LOW caution light illumination caused by erratic or cycling gauge indications may be eliminated by pulling the OXY QTY IND circuit breaker (3F3).

CABIN ALTITUDE	LITERS LIQUID OXYGEN									HOURS OF OXYGEN REMAINING — 100%
	20	15	10	5	4	3	2	1	LESS THAN 1	
35,000 Feet and Above	61.8	46.4	30.9	15.4	12.3	9.2	6.1	3.0	EMERGENCY DESCEND TO ALTITUDE NOT REQUIRING OXYGEN	**NOTE** • Hours of oxygen remaining are based on two-man consumption. • Duration data should be used as a guide only since oxygen consumption varies with the individual. • Conversion of liquid oxygen to gaseous oxygen is 860 liters of gaseous to 1 liter of liquid oxygen. • Consumption rates are based on MIL-D-19326D.
30,000 Feet	45.2	33.9	22.6	11.3	9.0	6.7	4.5	2.2		
25,000 Feet	34.8	26.2	17.4	8.7	6.9	5.2	3.4	1.7		
20,000 Feet	26.3	19.7	13.1	6.5	5.2	3.9	2.6	1.3		
15,000 Feet	21.2	15.9	10.6	5.3	4.2	3.1	2.1	1.0		
10,000 Feet	17.0	12.7	8.5	4.2	3.4	2.5	1.7	0.8		
8,000 Feet	15.5	11.6	7.7	3.8	3.1	2.3	1.5	0.7		
5,000 Feet	13.5	10.1	6.7	3.3	2.7	2.0	1.3	0.6		
Sea Level	10.9	8.1	5.4	2.7	2.1	1.6	1.0	0.5		

Figure 2-80. Oxygen Duration Chart

2.30.2 Emergency Oxygen System. The oxygen bottle in the survival kit of each ejection seat provides limited supply of gaseous oxygen for use in ejection and in the event of failure or depletion of the normal system. The bottle is charged to 1,800 to 2,100 psi and is opened automatically on ejection. Flow from the emergency bottle is routed through a pressure reducer. It then follows the path of the normal oxygen system, flowing through the oxygen regulator to the face mask. The supply of oxygen available from the emergency bottle is adequate for approximately 15 minutes. The emergency oxygen gauge is under the right rear or left front of the seat cushion in the survival kit of each ejection seat. The system is activated by pulling the green ring under the left side of the ejection seat cushion.

WARNING

If normal oxygen system is contaminated, set OXYGEN switch to OFF before pulling emergency oxygen handle.

2.31 PITOT-STATIC SYSTEM

The pitot-static pressure system supplies impact (pitot) and atmospheric (static) pressure to the pilot and RIO flight instruments, to the central air data computer (CADC), and to the engine air inlet control system (AICS) programmers. Some systems require static pressure only; others require static and pitot pressure (see Figure 2-81).

The pitot-static system is composed of two separate systems with individual pitot-static probes, one on each side of the forward fuselage.

The left pitot Pt probe supplies the pilot airspeed and Mach indicator, and the left AICS programmer. The right pitot Pt probe supplies the RIO airspeed and Mach indicator, the right AICS programmer, and the CADC with airspeed indications. An electrical Pt input from the left AICS programmer is supplied to the CADC backup channel as airspeed indications for wing sweep.

The left and right forward static ports (Ps_1) are manifolded to provide static pressure to the pilot airspeed and Mach indicator, servoed barometric altimeter, vertical velocity indicator, and the CADC. Static pressure from the right aft (Ps_2) static ports supply the

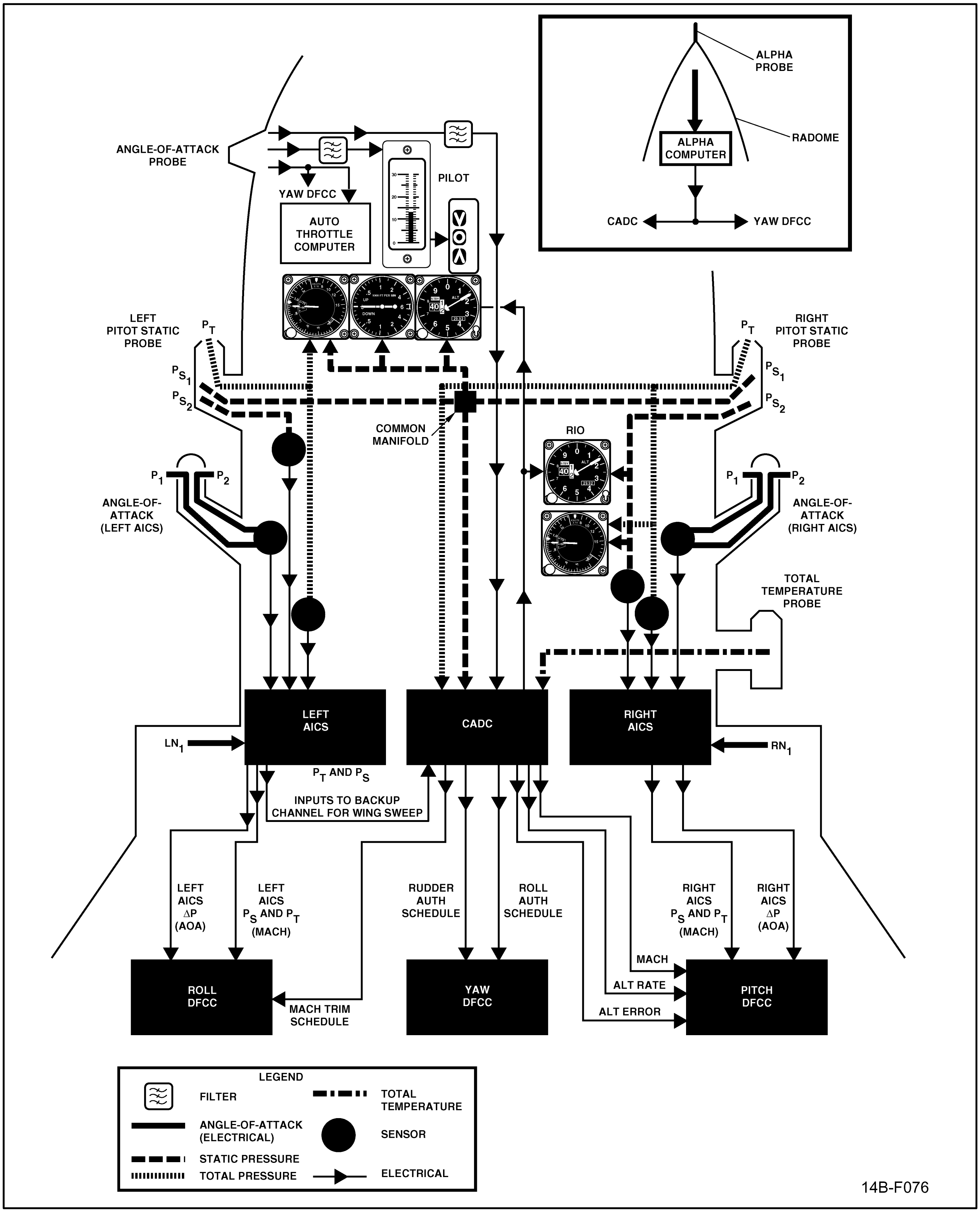


Figure 2-81. Airstream Sensors (DFCS)

RIO airspeed and Mach indicator, servoed barometric altimeter, and the right AICS programmer. Static pressure from the left aft (Ps_2) static ports supply the left AICS programmer.

With DFCS, the CADC and AICS programmers provide Mach number information to the digital flight control computers (DFCCs). The alpha computer, angle of attack probe (used for displaying angle of attack to the pilot), and the AICS programmers provide angle of attack information to the DFCCs. Electrical interfaces are shown on Figure 2-81.

Note

- With the in-flight refueling probe extended, the pilot and RIO altimeter and airspeed and Mach indicators show erroneous readings because of changes in airflow around the pitot-static probes.
- The RUDDER AUTH caution light may illuminate when the in-flight refueling probe is extended. Press the MASTER RESET pushbutton to reset the light.

2.31.1 Pitot-Static Heat. Each pitot-static probe is equipped with electrical heating elements to prevent icing. Pitot-static heat is controlled by the pilot through the ANTI-ICE switch on the pilot right console. In AUTO/OFF, pitot probe heat is available only with weight off wheels. ORIDE/ON activates the probe heat elements independently of the weight-on-wheels switch and illuminates the INLET ICE caution light on the CAUTION and ADVISORY panel.

WARNING

The ANTI-ICE switch should normally be in AUTO/OFF. Engine anti-icing has adverse effects on engine stall during takeoff and waveoff.

2.32 FLIGHT INSTRUMENTS

2.32.1 Vertical Display Indicator. The VDI provides an in-the-cockpit vertical display of aircraft attitude and navigation to the pilot. The VDI replaces the mechanical attitude director indicator of older aircraft systems as an aircraft attitude instrument (pitch, roll, and heading). TV video can also be presented on the VDI from the television camera set.

Note

Selecting TV on the pilot display control panel without a TCS installed will blank out the VDI presentation.

Attitude information is displayed on the VDI by an aircraft reticle, a horizon line, ground and sky texture, and a calligraphic pitch ladder. The aircraft reticle is fixed at the center of the display, and the horizon line and pitch ladder move about it in accordance with the aircraft pitch and roll attitudes.

The flight parameters displayed include magnetic heading, data link (D/L) commanded airspeed (Mach number) and altitude, and vertical velocity. Ground texture elements superimposed on the ground plane simulate both motion and simple perspective. Refer to Chapter 22 for additional information.

Note

If pitch or roll data are not updated within 240 milliseconds, the pitch ladder and roll marker will be blanked and the horizon, sky, and ground plane will darken.

2.32.2 Heads-Up Display. The HUD provides a combination of real-world cues and flight direction symbology that are projected directly on the windshield. The display is focused at infinity, thereby creating the illusion that the symbols are superimposed on the real world (and so that visual cues received from outside the aircraft are not obscured). The pilot usually steers based on his interpretation of the visually observed real world. Although symbology for the HUD is basically attack oriented, it also displays attitude, flight situation, and command information primarily for the landing mode. Refer to Chapter 22 for additional information.

2.32.3 Standby Attitude Indicator. A small standby gyro horizon indicator on the right side of the pilot instrument panel, and another on the left side of the RIO instrument panel are for emergency use should the vertical display indicator attitude information become unreliable. It is a self-contained, independent gyro that displays aircraft roll and pitch from the horizontal.

The presentation consists of a miniature airplane viewed against a rotating gray and black background that represent sky and ground conditions, respectively. Caging should be accomplished at least 2 minutes before takeoff to allow the spin axis to orient to true vertical. After the gyro has erected to vertical, the miniature airplane reference may be raised or lowered ±5° to compensate for pitch trim by turning the adjustment knob in the lower right corner of the instrument. The unit should be caged prior to engine start during cockpit interior inspection and also after flight prior to shutdown. In flight, recaging should be initiated only when error exceeds 10° and only when the aircraft is in a wings-level normal cruise attitude. Errors of less than 10° will automatically erect out at a rate of 2.5° per minute.

Electrical power is supplied by the essential ac buses. An OFF flag appears on the left side of the instrument face when power is removed or when the gyro is caged, but the gyro is capable of providing reliable attitude information (within 6°) for up to 9 minutes after a complete loss of power. The gyro can be manually caged by pulling the pitch trim knob on the lower right corner of the instrument.

2.32.4 Airspeed and Mach Indicator. The airspeed and Mach indicator on the instrument panel is a pitot-static system instrument that displays indicated airspeed from 80 to 850 knots on a fixed dial and Mach number from 0.4 to 2.5 on a rotating dial. Two independent index pointers can be manually set: one for an airspeed index and the other from a Mach index. The air data computer computes a maximum safe Mach number as a function of pitot-static pressure corrected for standard day temperature deviations. When a safe Mach is exceeded, the REDUCE SPEED warning light on the right side of the pilot VDI illuminates.

Note

- When power failure occurs, the safe Mach marker drives to the 12-o'clock position.
- The airspeed/Mach indicator is not compensated for static source position error. Therefore, depending upon atmospheric conditions, flight in excess of 0.95 IMN may generate destructive sonic booms.

The primary mode is selected by positioning the mode switch to RESET for approximately 3 seconds, provided that ac power is on. During standby operation, a red STBY flag appears on the dial face. The altimeter will automatically switch to standby operation if electrical power is interrupted for more than 3 seconds or if there is a system failure in the altimeter or altitude computer. Standby operation can also be selected by placing the mode switch to STBY. During standby operation, it is possible for the transponder to continue to transmit altitude information (corrected for position error) on mode C while the altimeter is displaying altitude uncorrected for position error.

WARNING

The primary (servoed) mode altimeter readings may be erroneous below 10,000 feet. In transonic flight, these errors could be as much as 1,200 feet above the actual aircraft altitude mean sea level (i.e., the aircraft is lower than the altimeter indicates). In supersonic flight, these errors could be as much as 4,000 feet below the actual aircraft altitude mean sea level (i.e., the aircraft is higher than the altimeter indicates). Refer to servoed altimeter residual error correction chart, NAVAIR 01-F14AAP-1.1.

Note

- When CADC/OBC is initiated, the altimeter is put into STBY and must be reset when the test is completed.
- When operating in either the primary (servoed) or STBY (barometric) modes of operation, altimeter position error corrections must be added to instrument readings.

An ac-powered internal vibrator is automatically energized in the standby mode to minimize friction in the display mechanism.

When the local barometric pressure is set, the altimeter should agree within 75 feet at field elevation in both modes, and the primary or standby readings should agree within 75 feet. In addition, the allowable difference between primary mode readings of altimeters is 75 feet at all altitudes.

CAUTION

- If momentary locking of the barocounters is experienced during normal use of the baroset knob, do not force the setting. Application of force may cause internal gear disengagement and result in excessive altitude errors in both primary and standby modes. If locking occurs, rotate the knob a full turn in the opposite direction and approach the setting again with caution.

- To prevent stripping barometric setting gear, do not force settings below 28.10 or above 31.00 in. Hg.

2.32.5 Radar Altimeter System (AN/APN-194). The radar altimeter is a low-altitude (0 to 5,000 feet), pulsed, range-tracking radar that measures the surface or terrain clearance below the aircraft. Altitude information is developed by radiating a short-duration rf pulse from the transmit antenna to the earth's surface and measuring elapsed time until rf energy returns through the receiver antenna. The altitude information is continuously presented to the pilot, in feet of altitude, on an indicator dial. The system also outputs a digital signal to the VDIG for display of radar altitude on the HUD from 0 to 1,400 feet during takeoff and landings.

The radar altimeter has two modes of operation. In the search mode, the system successively examines increments of range until the complete altitude range is searched for a return signal. When a return signal is detected, the system switches to the track mode and tracks the return signal to provide continuous altitude information.

When the radar altimeter drops out of the track mode, an OFF flag appears and the pointer is hidden by a mask. The altimeter remains inoperative until a return signal is received, at which time the altimeter will again indicate actual altitude above terrain.

Reliable system operation in the altitude range of 0 to 5,000 feet permits close altitude control at minimum altitudes. The system will operate normally in bank angles up to 45° and in climbs or dives except when the reflected signal is too weak.

The system includes a height indicator (altimeter), a test light on the indicator, a low altitude warning tone, a radar receiver-transmitter under the forward cockpit, and two antennas (transmit and receive), one on each side of the IR fairing, in the aircraft skin. During descent, the warning tone is heard when the aircraft passes through the altitude set on the limit index. When the aircraft is below this altitude, the low-altitude warning light stays on.

Note

- If radar altitude is unreliable, only the OFF flag is present.

- Radar altimeter can read as much as 100 feet higher than actual altitude when operating over water.

The radar altimeter receives power from the ac essential bus no. 1 through the RADAR ALTM circuit breaker (5D6) and from the dc essential breaker (6B6). The radar altimeter has a minimum warmup time of 3 minutes. During this time, failure indications and erroneous readouts should be disregarded.

2.32.5.1 Radar Altimeter. The radar altimeter (Figure 2-82) on the pilot's instrument panel has the only controls for the system. The indicator displays radar altitude above the earth's surface on a single-turn dial that is calibrated from 0 to 5,000 feet in decreasing scale to provide greater definition at lower altitudes. The control knob in the lower left corner of the indicator is a combination power switch, self-test switch, and positioning control for the low-altitude limit bug.

2.32.5.2 Altimeter BIT. Depressing and holding the control knob energizes the self-test circuitry; the green test light illuminates, the indicator reads 100±10 feet, and the HUD altitude scale reads approximately 100 feet. If the indicator passes below the altimeter limit bug setting, the aural and visual warnings are triggered. Normal operation is resumed by releasing the control knob.

2.32.5.3 Low-Altitude Aural Warning. A low altitude aural warning alarm provides a 1,000 Hz tone, modulated at 2 pulses per second. The tone is available to both crew members when the aircraft descends below the altitude set on the low-altitude limit bug. With gear up, tone is continuous when the aircraft descends below the altitude set on the low-altitude limit bug. With gear down, the tone lasts 3 seconds only.

NOMENCLATURE	FUNCTION
(1) Radar altimeter control knob (combination switch)	Initial clockwise rotation turns system power on; continued rotation increases altitude limit index setting. When depressed and held, it tests the system on the ground and in flight. Counterclockwise rotation decreases altitude limit index setting; fully counterclockwise turns system power off.
(2) OFF flag	OFF appears if altimeter is turned off, power is lost, or radar signal is unreliable.
(3) Low altitude warning light (red)	Disabled by AFC 863 (NVIS). In aircraft equipped for NVGs, a “cat’s eye” green light is installed on the panel below the radar altimeter, which illuminates as a warning whenever aircraft is below altitude set by the limit bug.
(4) Self-test light (green)	When control knob is depressed and held, light should illuminate and pointer should read 100±10 feet.
(5) Low-altitude limit index (limit bug)	Can be preset to low-altitude limit desired by turning control knob. **Note** Radio override has no effect on radar altimeter low-altitude warning tone.

Figure 2-82. Radar Altimeter

2.32.6 Vertical Velocity Indicator. The vertical velocity indicator on left side of pilot instrument panel is a sealed case connected to a static pressure line through a calibrated leak. It indicates rate of climb or descent. Sudden or abrupt changes in attitude may cause erroneous indications because of sudden change of airflow over static probe.

2.32.7 Turn-and-Slip Indicator. The turn-and-slip indicator on the pilot instrument panel gives information on rate of turn of aircraft around its vertical axis and turn coordination. The driving mechanism for the pointer is a dc meter movement that receives its input from a rate-of-turn transmitter. A needle-width deflection of pointer will initiate a 360° turn in 4 minutes. The inclinometer position of the instrument contains damping fluid and a ball that moves from center in an uncoordinated turn. Lighting for the pilot turn-and-slip indicator is controlled by the INSTRUMENT thumbwheel.

2.32.8 Accelerometer. The accelerometer on the pilot instrument panel is a direct-reading instrument that measures the accelerations of the aircraft along its vertical axis. The dial is graduated in g units from -5g to +10g. The normal reading of the instrument at rest is +1g. The instrument has three pointers of which one continuously indicates vertical acceleration of aircraft. One of the other pointers will stop and remain at maximum positive acceleration value attained, while the other will function in the same manner for negative acceleration values.

These two pointers remain at the highest values reached until reset by depressing a PUSH TO SET button on the lower left corner of instrument.

Note

Accelerometers may indicate over 1/2g low if the pullup rate is high.

2.32.9 Standby Compass. A conventional standby compass is above the pilot instrument panel. It is a semifloat-type compass suspended in compass fluid.

2.32.10 Clock. A mechanical 8-day clock is on the instrument panel in each cockpit. It incorporates a 1-hour elapsed time capability. A winding and setting selector is in the lower left corner of the instrument face. The knob is turned in a clockwise direction to wind the clock and pulled out to set the hour and minute hands. An elapsed time selector in the upper right corner controls the elapsed time mechanism. This mechanism starts, stops, and resets the sweep second and elapsed time hands.

2.33 ANGLE-OF-ATTACK SYSTEM

The angle-of-attack system measures the angle between the longitudinal axis of the aircraft and the relative wind in the vertical plane. This is used for approach monitoring and to warn of an approaching stall. Optimum approach angle of attack is not affected by gross weight, bank angle, density altitude, or load configuration. (See Figure 2-83 for angle-of-attack conversions.)

The system includes a probe-type transmitter, approach lights, an indicator, and an indexer. The indexer and approach lights are controlled by the indicator, which is electrically slaved to the sensor probe transmitter. In flight, the probe that is on left side of the fuselage aligns itself with the relative airflow like a weather vane.

Probe anti-icing is provided by means of a 115-Vac heating element along the probe and probe housing. The heating element is controlled by the ANTI-ICE switch on the pilot right console. During ground operation probe heat is on with the landing gear handle down and the switch in ORIDE/ON. With weight on wheels, the positions OFF/OFF and AUTO/OFF deactivate the probe-heating element.

2.33.1 Angle-of-Attack Test. A safety-of-flight check of the angle-of-attack indicator and other aircraft instruments can be performed while in flight or on the deck. When INST is selected on the pilot MASTER TEST switch, the reference bar on the angle-of-attack indicator should indicate 18.0±0.5 units. A check of the indexer can be made by selecting LTS on the MASTER TEST switch.

2.33.2 Angle-of-Attack Indicator. This indicator (Figure 2-84) displays the aircraft angle of attack, provides a stall warning reference marker, a climb bug, cruise bug, and an angle-of-attack approach reference bar for landing approach.

Angle of attack is displayed by a vertical tape on a calibrated scale from 0 to 30 units, equivalent to a range of –10° to +40° of rotation of the probe. The approach reference bar is provided for approach (on-speed) angle of attack at 15 units. The angle-of-attack indexer and approach lights will automatically follow the indicator.

Note

When the landing mode is selected, the AOA symbol on the HUD display is faulty. Use only the angle-of-attack indicator readings.

The climb reference marker is set at 5.0 units, the cruise marker at 8.5 units, and the stall warning marker at 29 units. These reference markers are preset to the optimum angle-of-attack values and cannot be changed by the pilot.

2.33.3 Angle-of-Attack Indexer. The angle-of-attack indexer on the pilot glareshield (Figure 2-84) has two arrows and a circle illuminated by colored lamps to provide approach information. The relay-operated contacts in the angle-of-attack indicator also control the angle of attack indexer. The upper arrow is for high angle of attack (green), the lower arrow is for low angle of attack (red), and the circle is for optimum angle of

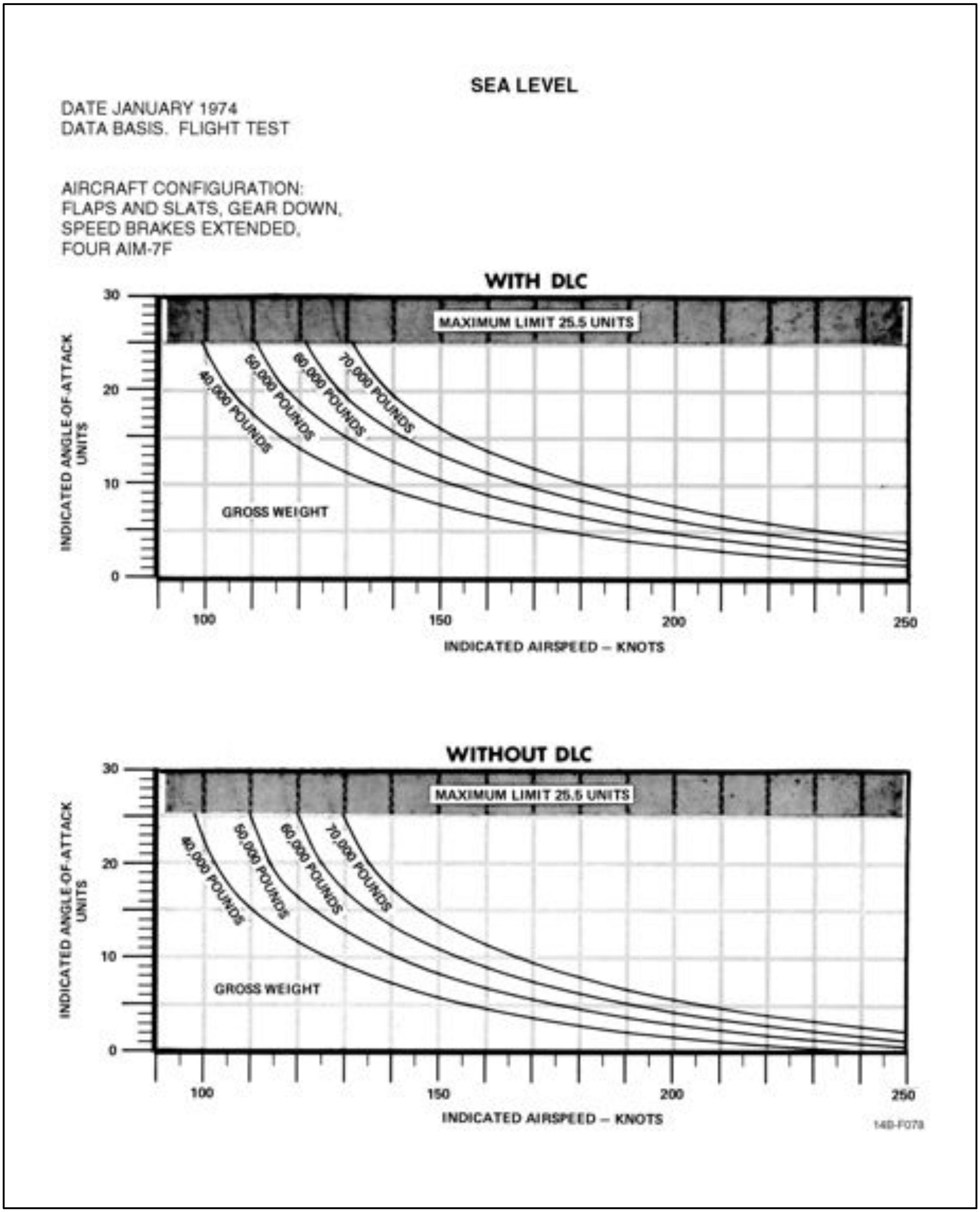


Figure 2-83. Angle-of-Attack Conversion (Sheet 1 of 2)

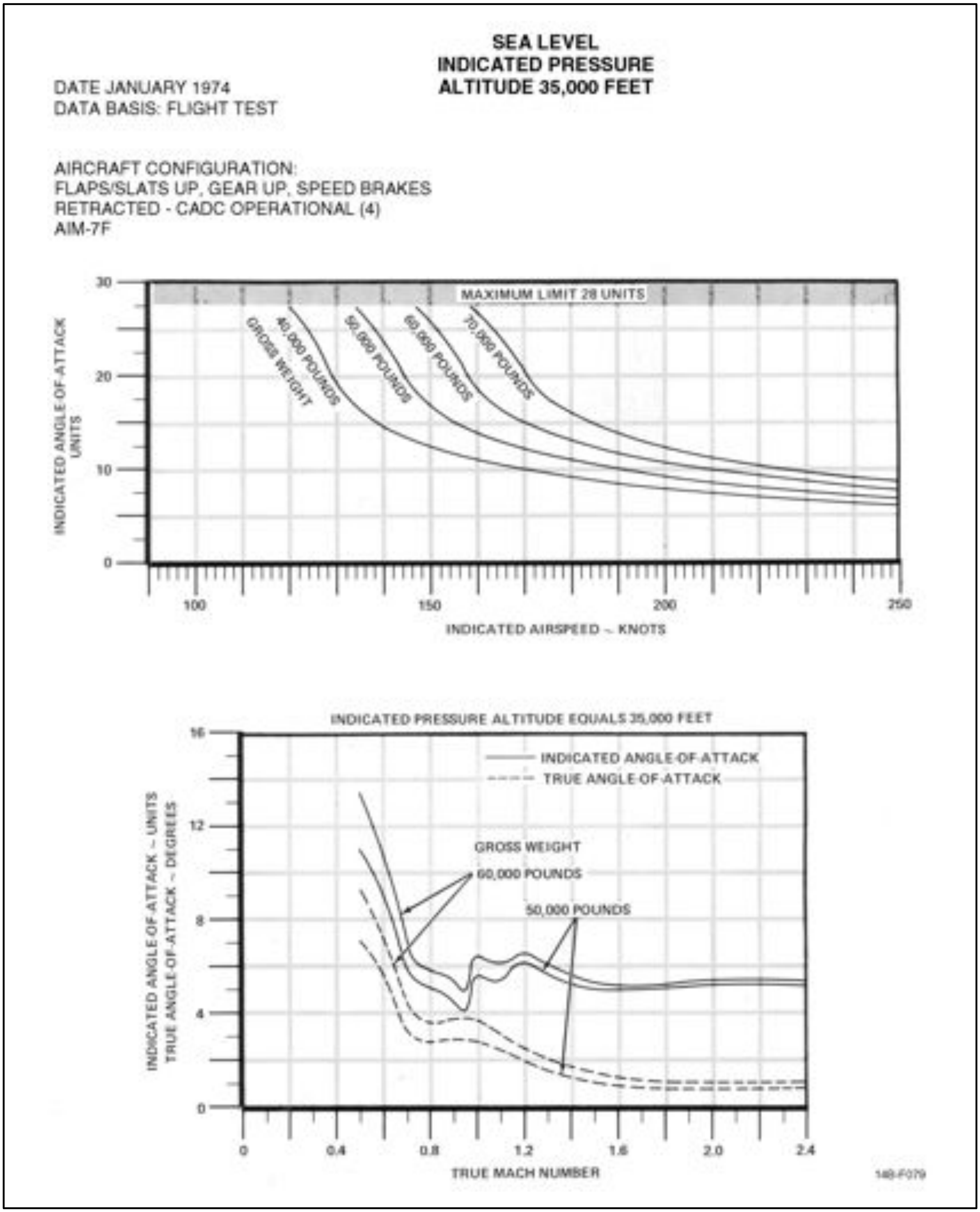


Figure 2-83. Angle-of-Attack Conversion (Sheet 2)

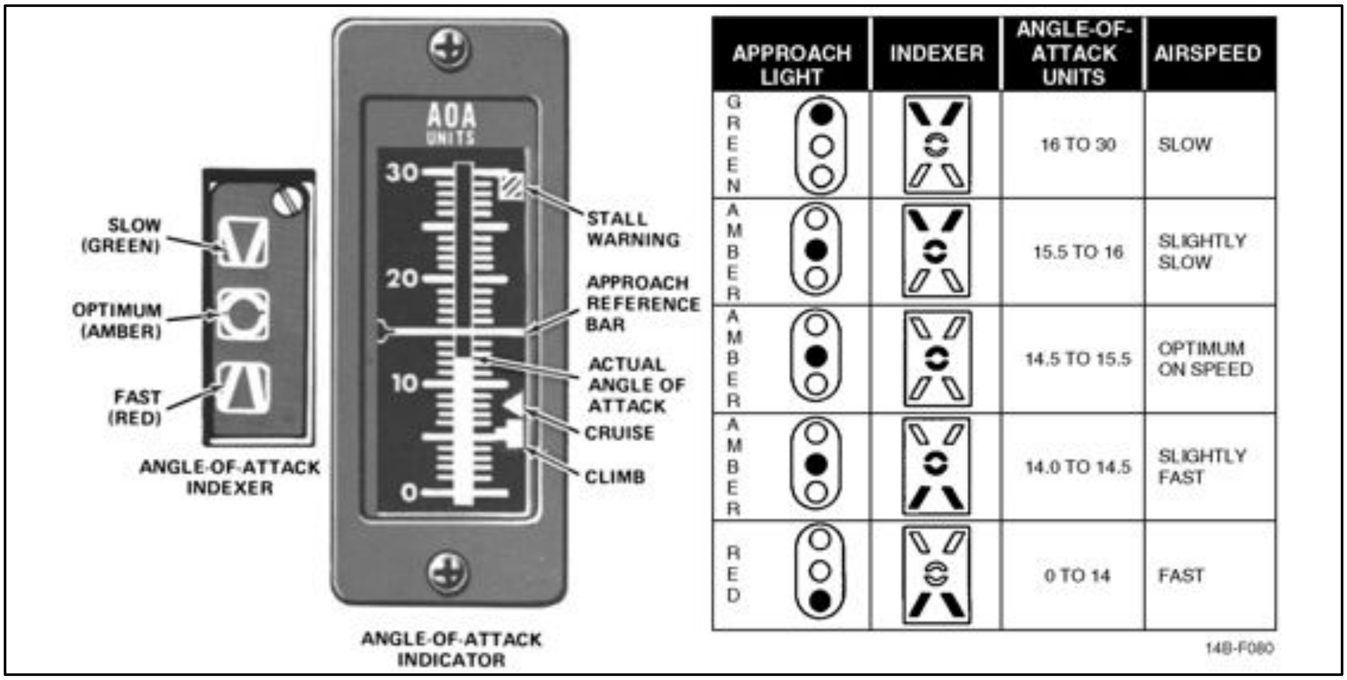


Figure 2-84. Angle-of-Attack Displays

attack (amber). When both an arrow and a circle appear, an intermediate position is indicated.

2.33.3.1 Indexer Lights. The indexer lights function only when the landing gear handle is down. A flasher unit causes the indexer lights to pulsate when the arresting hook is up with the HOOK BYPASS switch in CARRIER. The intensity of the indexer lights is controlled by the INDEXER thumbwheel control on the pilot MASTER LIGHT panel.

2.33.4 Approach Lights. The approach lights consist of red, amber, and green indicator lights above the nose-gear strut. The lights are actuated by the angle-of-attack indicator and provides qualitative angle-of-attack information to the landing signal officer during landing approaches. A flasher unit in the angle-of-attack system will cause the approach lights to pulsate when the arresting hook is up with the landing gear down and the HOOK BYPASS switch in the CARRIER position. When the FIELD position of the HOOK BYPASS switch is selected, the flasher unit is disabled.

A green approach light indicates a high angle of attack, slow airspeed; an amber light indicates optimum angle of attack; and a red approach light indicates a low angle of attack, fast airspeed.

2.34 CANOPY SYSTEM

The cockpit is enclosed by a one-piece, clamshell, rear-hinged canopy. Provisions are included to protect the pilot and RIO from lightning strikes by the installation of aluminum tape on the canopy above the heads of the crew. Normal opening and closing of the canopy is by a pneumatic and hydraulic actuator with a separate pneumatic actuator for locking and unlocking. The canopy can be opened to approximately 25° for ingress and egress in approximately 8 to 10 seconds. In emergencies, the canopy can be jettisoned from either crew position or externally from either side of the forward fuselage. For rescue procedures, see Chapter 12.

CAUTION

The maximum permitted taxi speed and headwind component with the canopy open is 60 knots.

Note

An occasional howl inside the canopy may occur in some aircraft when subjected to an approximate 4g maneuver. The howl has been attributed to the canopy rain seals;

when they are removed, the howl disappears. A canopy howl in aircraft with rain seals installed does not limit aircraft operation.

The canopy system is controlled with the canopy control handle under the right forward canopy sill at each crew position. An external canopy control handle is on the left side of the fuselage directly below the boarding ladder. A CANOPY caution light on the pilot and RIO CAUTION and ADVISORY panels illuminates when the canopy is not locked. Electrical power for the caution lights is supplied from the essential dc bus No. 2, through the CAN/LAD/CAUTION/EJECT CMD IND circuit breaker (7C5). A 1-inch by 2-inch white stripe is painted on the canopy frame and sill above the aft cockpit canopy control handle panel. Alignment of this stripe provides an additional visual guide that the canopy is in a closed and locked position.

Pneumatic pressure for normal canopy operation is stored in a high-pressure, dry-nitrogen reservoir. Servicing is accomplished externally through the nose wheelwell. Normal pressure should be serviced to 3,000 psi. A pressure gauge in the nose wheelwell should be checked during preflight. A fully charged nitrogen bottle provides approximately 10 complete cycles (open and close) of the canopy before the system is reduced to a minimum operating pressure of 225 psi. If pneumatic pressure drops below 225 psi, the canopy control module automatically prevents further depletion of the main reservoir and the canopy must be opened by the auxiliary mode.

2.34.1 Canopy Operation

2.34.1.1 External Canopy Controls. Access to the external canopy control is obtained through an access door on the left fuselage directly below the boarding ladder. Pulling the handle out and rotating it counterclockwise to NORM CL closes the canopy. Rotating further counterclockwise to the BOOST close position will allow the canopy to be closed under a high headwind or cold-weather conditions. If BOOST is used to close the canopy, the handle should be returned to NORM CL. Rotating it clockwise to NORM OPEN opens the canopy under normal operating conditions and rotating it further to AUX OPEN allows the canopy to be opened manually.

Note

NORM OPEN is not detented; therefore, do not rotate the handle further clockwise unless the AUX OPEN is desired. Using AUX OPEN unnecessarily will deplete the auxiliary uplock nitrogen bottle.

2.34.1.2 Cockpit Canopy Controls. The canopy pneumatic and hydraulic system is operated by actuation of either of the cockpit control handles (Figure 2-85), or the external control handle, which position valves within the pneumatic control module to open or close the canopy. The canopy pneumatic and pyrotechnic systems are shown on FO–15. Modes of operation available are OPEN, AUX OPEN, HOLD, CLOSE, and BOOST.

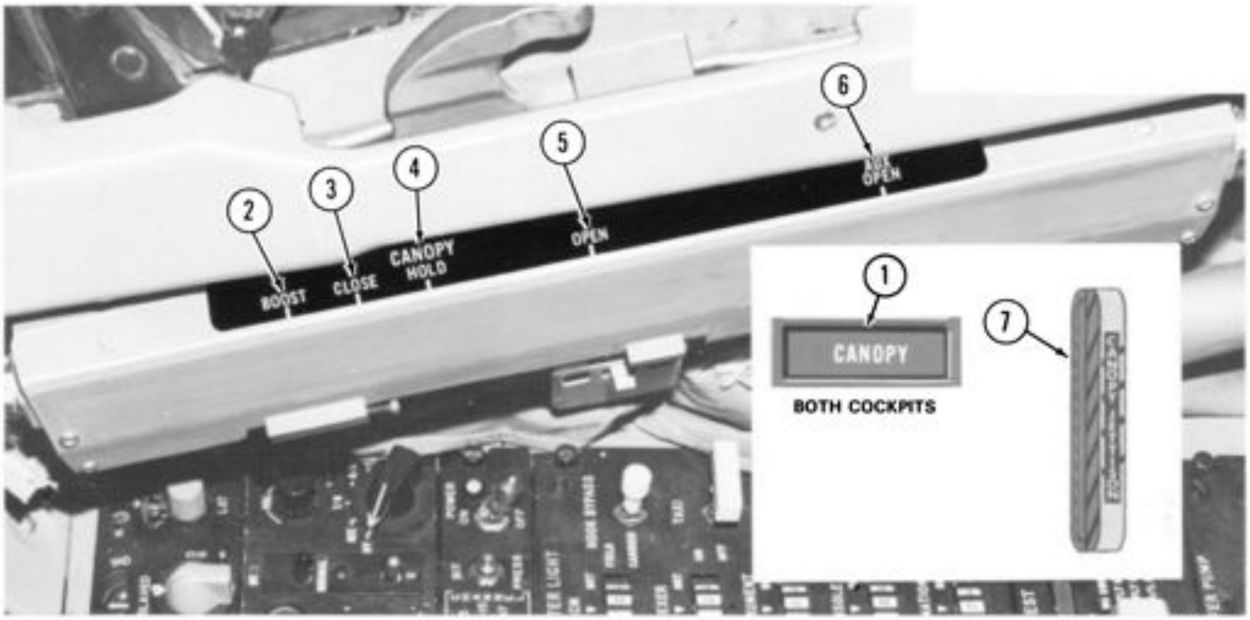
WARNING

Flightcrews shall ensure that hands and foreign objects are clear of front cockpit handholds, top and sides of ejection seat headboxes, and canopy sills to prevent personal injury and/or structural damage during canopy opening or closing sequence. Foreign objects can catch ejection system initiators on the right aft side of the ejection seat headboxes causing inadvertent ejection even with seat locking handles safed. Only minimum clearance is afforded when canopy is transiting fore or aft.

2.34.1.2.1 Open. When OPEN is selected, nitrogen is ported to the locking actuator through the control module and the canopy is moved aft disengaging the canopy hooks from the sill hooks. Pneumatic pressure is then ported to the canopy actuator to raise the canopy.

2.34.1.2.2 Hold. Selection of CANOPY HOLD during transition of the canopy stops the canopy in any intermediate position between closed and open by pressurizing the lock valves in the canopy actuator. These lock valves stop the transfer of hydraulic fluid.

With the canopy in any intermediate (CANOPY HOLD) position, moving the handle slowly toward OPEN will allow the canopy to begin to close until the handle is finally in OPEN. This occurs because the first motion of the handle moves the selector valve cam, which vents pressure from the lock valves and allows the canopy weight to transfer hydraulic fluid. Once the selector valve cam is completely moved to OPEN, pressure is then applied to the open side of the canopy actuator.



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NOMENCLATURE	FUNCTION
1 CANOPY caution light	Advises that the canopy is not in a down and locked position.
2 BOOST	Used to close the canopy in cold weather or when headwinds are greater than 30 to 60 knots.
3 CLOSE	Used under all flight conditions.
4 HOLD	Used to hold canopy in any position other than closed.
5 OPEN	Used to open the canopy under normal conditions.
6 AUX OPEN	Used to open canopy manually, which is required when nitrogen bottle pressure drops below 225 psi.
7 CANOPY JETTISON handle	Used to jettison canopy.

Figure 2-85. Cockpit Canopy Control Handle and Indicator Lights

CAUTION

If the canopy handle is left in an intermediate position for an extended period, the canopy will slowly close.

2.34.1.2.3 Close. In CLOSE it allows the canopy to close under normal conditions (30-knot headwind) using its own weight without an expenditure of stored nitrogen. When the control handle is set to CLOSE, both sides of the canopy actuator are vented to the atmosphere, allowing the canopy to lower itself. The final closing motion actuates a pneumatic timer, which directs pressure from the control module to the locking actuator and the canopy is moved forward to engage the canopy hooks in the sill hooks.

To close the canopy under high headwind conditions (30 to 60 knots) or cold-weather conditions, BOOST is used. The BOOST mode is activated by rotating the canopy control handle outboard past CLOSE stop and pushing the handle forward. With the control handle in this position, the control module ports additional regulated pneumatic pressure to the closed side of the canopy actuator. If BOOST is used to close the canopy, the handle should be returned to CLOSE.

2.34.1.3 Auxiliary Canopy Opening. When the main pneumatic reservoir pressure is reduced to 225 psi, the canopy control module automatically prevents further depletion of reservoir pressure and the canopy must be opened manually. Actuation of the auxiliary mode can be affected from either the pilot or RIO canopy control handle or from the ground external canopy control. To open the canopy from the cockpit in this mode, the canopy control handle in the cockpit must be rotated outboard to move the handle past OPEN stop and then pulled aft to AUX OPEN. This activates a pneumatic valve that admits regulated pneumatic pressure from an auxiliary nitrogen bottle to the locking actuator and moves the canopy aft out of the sill locks. When the canopy is unlocked, pneumatic pressure from the main reservoir is ported to the open side of the canopy actuator to counterbalance the weight of the canopy allowing the canopy to be manually opened or closed by the flight crew.

Before leaving the cockpit, the control handle should be returned to HOLD. If left in AUX OPEN, the canopy's own weight or a tailwind could force the canopy down with low pressure in the main reservoir. Once the auxiliary canopy unlock bottle is used, the canopy will not return to the normal mode of operation and cannot be locked closed until the auxiliary pneumatic selector valve on the aft canopy deck is manually reset (lever in vertical position).

WARNING

The backup initiator and auxiliary pneumatic selector valve linkages are in close proximity and are similar in appearance. Reset of the auxiliary pneumatic selector valve should be performed by trained personnel and only after the backup initiator is pinned. If the backup initiator is inadvertently activated, the escape system safe and arm mechanism will be partially armed. Subsequent ejection will cause RIO to impact canopy.

The auxiliary canopy unlock nitrogen bottle is on the turtleback behind the canopy hinge line (refer to FO–15). Servicing of the auxiliary bottle is through the small access panel immediately behind the canopy on this turtleback. A fully charged bottle will provide approximately 20 canopy cycling operations in the auxiliary open mode.

2.34.1.4 Canopy Jettison. The canopy can be jettisoned from either cockpit or from external controls on each side of the fuselage. An internal control handle in each cockpit (Figure 2-85) is on the forward right side of each flightcrew's instrument panel and is painted yellow and black for ease of identification. To activate the jettison control handle, push handle in, squeezing the outer face of the handle, and then pull out.

The length of pull is approximately 1/2 to 3/4 inch and the handle comes free of the aircraft when actuated. Pulling either canopy jettison handle actuates an initiator that ignites the canopy separation charge and actuates the canopy gas generator. The canopy separation charge ignites the expanding, shielded, mild detonating cord lines, routed through the canopy sill hooks, breaking the sill hook frangible bolt. This allows the hooks to rotate upward, releasing the canopy. The canopy gas generator produces high-pressure gas that forces the canopy hydraulic actuator shaft upward, ballistically removing the canopy.

Ejection cannot be performed through the canopy: therefore, the canopy is jettisoned as part of the normal ejection sequence. A downward pull on the face curtain or an upward pull on the lower ejection handle jettisons the canopy prior to ejection.

2.34.1.4.1 External Canopy Jettison Handles. There are two external emergency jettison handles located on the lower left and right fuselage below the pilot cockpit, appropriately marked for rescue. Opening either access door and pulling the T handle fires an initiator that detonates the canopy separation charge and actuates the canopy gas generator. The sequence is the same as when the cockpit handles are pulled. The jettison control handles require squeezing the inner face of the handle and then pulling for actuation. The length of pull is approximately one-half to three-quarters of an inch and the T handle comes free on the aircraft when actuated. See Chapter 12 for canopy external jettisoning procedures.

2.35 EJECTION SYSTEM

The aircraft is equipped with an automatically sequenced command escape system incorporating two Martin-Baker Mk GRU-7A rocket-assisted ejection seats. Both seats are identical in operation and differ only in rocket nozzle diameter to provide a divergent ejection trajectory. When either crewmember initiates the command escape system, the canopy is ballistically jettisoned and each crewmember is ejected in a preset time sequence. Ejection trajectories are canted laterally to provide additional separation of the seats. The RIO is ejected to the right and the pilot to the left.

The ejection system is capable of safe ejection on the deck at zero airspeed. Preflight procedures and location of safety pins are shown in Chapter 7 of this manual; ejection procedures are discussed in Chapter 16. Ejection sequence is illustrated on FO–16.

WARNING

Loose gear in the cockpit is an FOD and missile hazard, especially during carrier operations, maneuvering flight, or ejection sequences. Gear that is stowed in or that migrates to the turtledeck area can move forward and interfere with ejection initiators, preventing proper ejection sequencing or causing inadvertent ejection when the canopy is opened. Carriage of gear that cannot be contained in the cockpit storage compartment shall be kept to a minimum consistent with mission requirements and the mission environment.

2.35.1 Command Ejection Lever. A command ejection lever (Figure 2-86) above the RIO left outboard console allows the RIO to select either pilot or RIO control of the command ejection system. Each position has an internal locking detent. The handle is unlocked by lifting upward and moved by a forward or aft motion. If the handle is released before reaching the aft position it is spring loaded to return forward. It will automatically lock in the forward position; however, a downward motion is required to positively lock it into the aft position. To select MCO command ejection position, raise the handle and pull aft. An EJECT CMD flip-flop-type indicator on the landing gear panel indicates the command mode selected. The RIO may eject individually when the command ejection lever is in the pilot control position. When the command ejection lever is in the MCO command position, the RIO can initiate ejection of both seats. Regardless of the position of the command ejection lever, an ejection initiated by the pilot will always eject both crewmen. Command ejection by either crewmember will eject the RIO first and the pilot 0.4 second later. Total time for ejection is 0.9 second.

2.35.2 Ejection Seat Operation

2.35.2.1 Face Curtain. The automatic ejection sequence is initiated by pulling the face curtain immediately aft and above the occupant's head. When the face curtain is pulled, the curtain is removed from its retainer and the system initiator is mechanically actuated, starting the ejection sequence. The face curtain protects the occupant's head and face from windblast as the seat leaves the aircraft. As the pilot seat rises, the drogue gun and time-release mechanism sears are extracted by trip rods, and the emergency identification friend or foe transponder and electronic countermeasures destruct switch are activated.

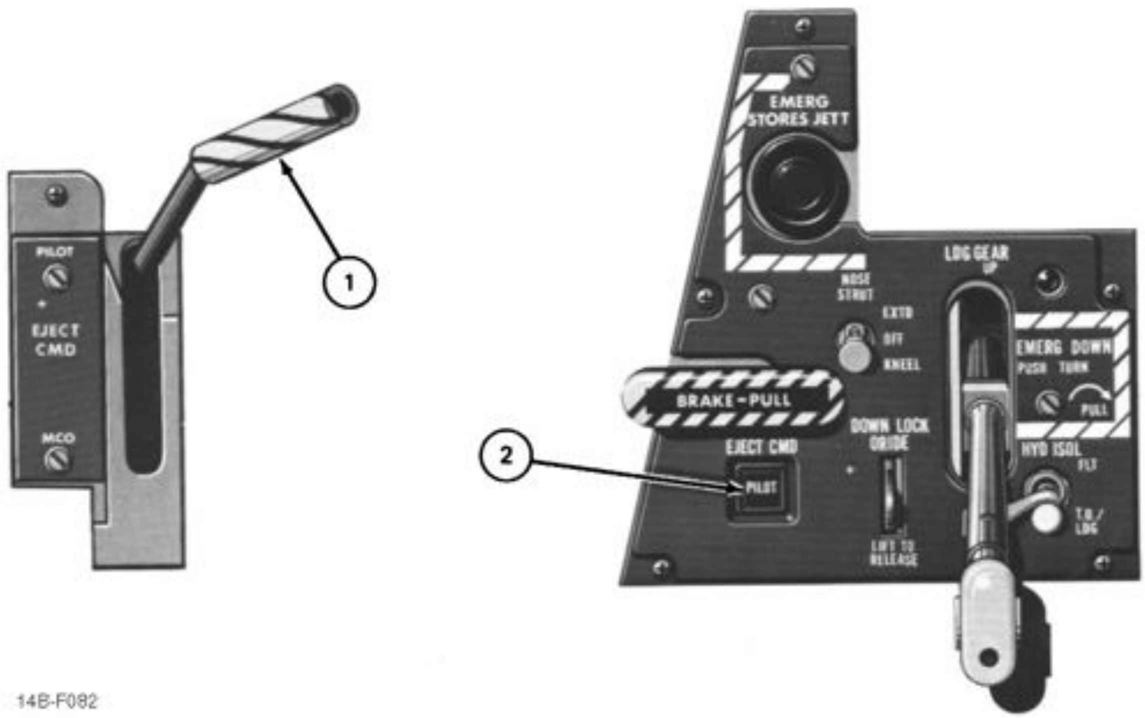
Note

The seat is fired after approximately 7 inches of face-curtain travel.

2.35.2.2 Lower Ejection Handle. The lower ejection handle is on the front of the seat bucket between the occupant's legs. The sequence for ejection remains the same, since both the face curtain and the lower ejection handle initiate seat firing by mechanically actuating the escape system initiator. The seat initiator is fired after 2 inches of lower firing handle travel.

WARNING

- Actuation of the lower ejection handle requires approximately 20 to 25 pounds of pull.
- The lower firing handle lock may be overridden in the locked position by a pull force of approximately 50 pounds. Continued pulling of the handle after the lock has been overridden will initiate the ejection sequence provided the ground locks have been removed.



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NOMENCLATURE	FUNCTION	
(1) EJECT CMD lever RIO cockpit)	PILOT —	Ejection initiated by the pilot will eject himself and RIO — the RIO first. Ejection initiated by the RIO will eject only the RIO. Pilot eject command indicator — PILOT.
	MCO —	Ejection initiated by the pilot will eject himself and RIO — the RIO first. Ejection initiated by the RIO will eject himself and pilot — the RIO first. Pilot eject command indicator — MCO.
(2) EJECT CMD (flip-flop) indicator	PILOT —	Indicates command ejection lever is in PILOT. Only the pilot can eject himself and RIO — RIO-initiated ejection will eject only himself.
	MCO —	Indicates command ejection lever is in MCO. Both pilot and RIO can eject both flightcrew members — RIO will eject first.

Figure 2-86. Command Ejection Lever

Note

If the face curtain does not actuate the ejection seat, the face curtain should be held while the lower ejection handle is actuated to prevent the possibility of entanglement with the drogue chute when the drogue gun fires.

2.35.3 Ejection Initiation. When either ejection handle is pulled, the ejection pyrotechnic system is actuated and the following sequence of events occurs:

1. The seat shoulder harness power retraction reel is fired.
2. The sill locks are released and the canopy is ballistically jettisoned.
3. The seat safe-and-arm device is armed.

When canopy jettison is completed, the safe-and-arm device is fired by an 8-foot lanyard attached to the canopy. During a command sequence ejection the pyrotechnic train instantaneously triggers the RIO seat and the pilot seat is delayed 0.4 second. A 10-inch backup lanyard attached to the canopy activates an initiator with a 1.1-second time delay as a backup to fire the safe-and-arm device.

The powered inertia reel pulls the occupant back in the seat within 0.25 second. When the catapult gun fires, the expanding gases drive the catapult tubes upward and eject the seat from the aircraft. As the seat rises, the legs are pulled back into the leg pads and the restraint cords are pulled tight. As the seat continues to rise, tension built up in the leg restraint cords shears the rivets securing the cords to the deck. The legs remain secured to the seat by snubbers wedging against the restraint cord, preventing any flailing of the occupant's legs. The legs remain secured to the seat until the time-release mechanism actuates a plunger, freeing the legs prior to separation from the seat. While the seat is going up the rail, the following events occur:

1. Oxygen hose, vent air, and anti-g lines are disconnected.
2. The drogue gun trip rod is pulled.
3. The time-release mechanism trip rod is pulled.
4. The emergency oxygen bottle is activated.
5. The rocket motor gas generator lanyard is pulled.

As the pilot seat rises, the drogue gun and time-release mechanism sears are extracted by trip rods, and the emergency IFF transponder and ECM destruct switches are activated.

When fully extended, the rocket motor lanyard fires the gas generator, which fires the rocket motor under the seat.

2.35.3.1 Seat Catapult and Rocket Firing. One-half second after the drogue gun trip rod is extracted, a small controller drogue chute is drawn from the pack by a metal piston fired from the drogue gun. The controller drogue chute then tows the stabilizer chute out of its container. The stabilizer chute is secured to the seat by a scissor shackle until released by the time-release mechanism.

When the seat is below an altitude of 11,500 to 14,500 feet (barostat setting), the time-release mechanism starts a 2.0-second time delay, after which the time-release mechanism releases the drogue parachute from the scissors shackle, allowing the drogue chute to pull the personnel parachute withdrawal line out of the guillotine and deploy the personnel parachute. At the same time the harness restraints, lapbelt, leg restraints, survival kit, upper block of the personnel services disconnect, and face curtain are unlocked. The occupant is then free to be pulled from the seat sticker clips by the line stretch of the main parachute as the seat rotates away. When the occupant is free from the seat, he makes a normal parachute descent with the survival kit connected to him by the integrated torso harness.

2.35.3.2 Manual Seat Separation. If the time-release mechanism fails, the crewmember can manually separate from the seat by pulling up and aft on the emergency restraint release handle (front right side of seat bucket). Rotating the emergency harness release handles fires the guillotine severing the personnel parachute withdrawal line and releasing the lap belt, shoulder harness, leg-line straps, parachute container, survival kit, and personnel services disconnect. The occupant must kick free of the seat and manually deploy the personnel parachute by pulling the parachute rip cord.

WARNING

If the emergency restraint release has been pulled, the personnel parachute must be deployed manually.

2.35.4 Ejection Seat Components

2.35.4.1 Personnel Parachutes. The personnel parachute is in a rectangular backpack aft of the occupant on a seat-mounted support shelf. It consists of a 28-foot canopy, suspension lines, and personnel harness connections. The parachute pack is attached to the seat by two lockpin fittings. On ejection, the locks are automatically released by the time-released mechanism at both points. The parachute pack is attached to the occupant by canopy release fittings attached to the integrated torso harness.

2.35.4.2 Parachute Harness Sensing-Release Units. This is a seawater-activated system that automatically releases the parachute from the crewmember. When the sensing-release units are immersed in seawater, cartridges are fired that allow the parachute risers to separate from the canopy releases (see Figure 2-87, sheet 2).

On parachute assemblies equipped with ACSE 383 (four-line release) capabilities, the following procedures apply during descent.

WARNING

The four-line release should not be activated if damage to the canopy or broken suspension lines are observed after deployment of a full canopy.

1. After visual inspection of parachute and deciding to activate the four-line release, the flight crewman should grasp the release lanyard loops on the inside of rear risers and break the release ties by a sharp pull (approximately 20 pounds force). This action will free the rear four suspension lines from the connector links, allowing the canopy to form a lobe in the rear center and permit a steady escape of air. This will eliminate oscillation and give minimal directional control of the canopy to the right or left by pulling on the respective release lanyard.
2. In preparation for landing, the flightcrew should attempt to determine the surface wind direction by any means possible (i.e., smoke, dust, etc.) and turn the canopy into the wind if possible before landing. Over land, this will minimize speed over the ground and the associated chance of landing injuries. Over water this will minimize the chance of line entanglement because of forward travel of canopy away from the flightcrew.

2.35.4.3 Integrated Torso Harness. The integrated torso harness is a vest-like garment worn by the crewmember. It eliminates the need for the crewmember to wear the parachute to and from the aircraft and takes the place of a separate lapbelt and shoulder harness. The upper torso harness is connected to the parachute by canopy release fittings that are attached to the locking reel assembly. Two buckles on the lower part of the torso harness connect to the seat lapbelt fittings. The lapbelt girth can be adjusted to accommodate each individual flight crewmember by adjusting each belt strap (see Figure 2-87).

2.35.4.4 Emergency Restraint Release. This control is the black-and-yellow-striped handle forward on the right side of the seat bucket. In the forward (locked) position, the occupant and his personal equipment are secured to the seat. When the emergency restraint release is lifted and rotated to the full aft (unlocked) position, the occupant and his personal equipment are disconnected from the seat except for the sticker clips. The initial travel of this handle fires the parachute withdrawal-line guillotine, severing the personnel parachute from the drogue parachute. Further travel simultaneously releases the lapbelt harness locks, personnel parachute container retention straps, survival kit attachment lugs, inertia reel straps, both leg restraint cords, and unlocks the sticker clip retainers. Minimal force will pull the sticker clips free, allowing the occupant to separate from the seat shell with the seat pan and personnel parachute.

WARNING

Actuating the emergency restraint release will not lock the face curtain.

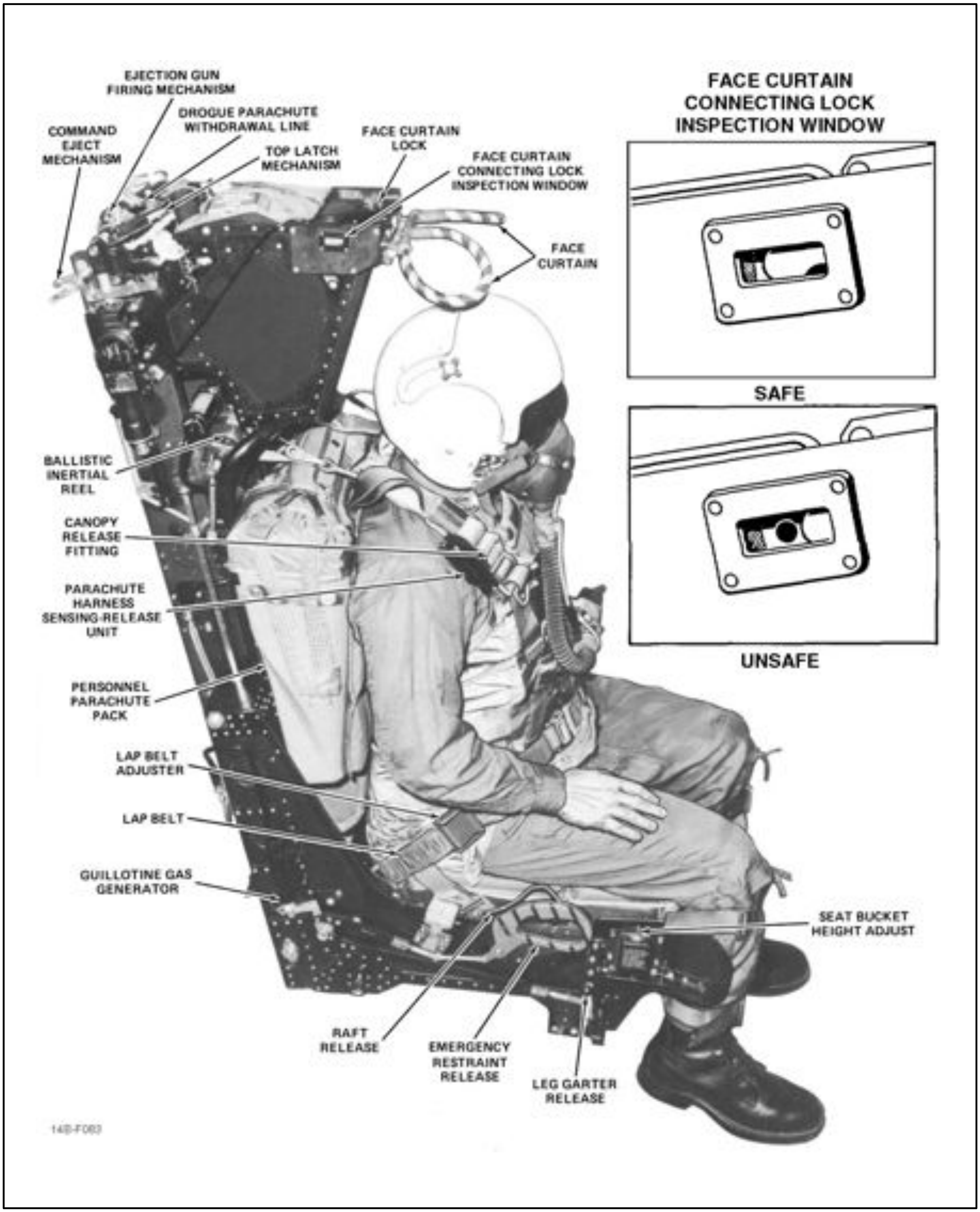


Figure 2-87. Mk GRU-7A Ejection Seat (Sheet 1 of 2)

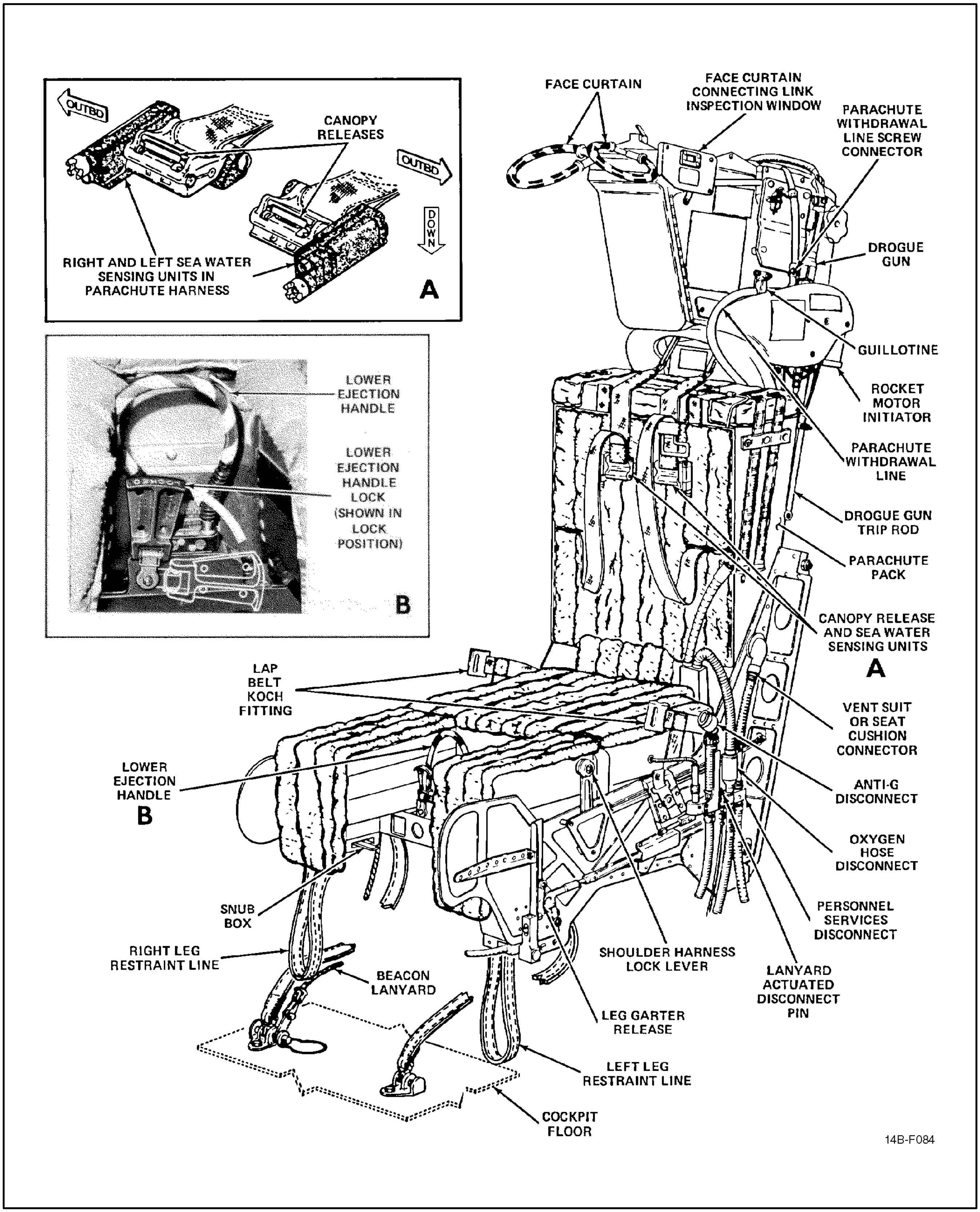


Figure 2-87. Mk GRU-7A Ejection Seat (Sheet 2)

WARNING

When the emergency restraint release is actuated, the lower firing handle is automatically locked and ejection cannot be initiated from the seat using the lower handle. Ejection may still be initiated with the face curtain but will be extremely hazardous and will require manual parachute deployment.

This lever is normally in the locked position. Emergencies such as over-the-side bailout or failure of the time-release mechanism will require operation of this control.

2.35.4.5 Shoulder Harness Lock Lever. This control is on the left side of the seat. In the forward (locked) position, forward movement of the occupant is restricted and any slack created by rearward movement is taken up by the inertial reel. The control is locked in this position by a detent. In the spring-loaded center position, the occupant can move forward freely unless the reel locks owing to excessive forward velocity. When the forward velocity decreases sufficiently, the inertia straps are released without the necessity of repositioning the manual control. Both straps feed from the same shaft and it is impossible for one to lock without the other. If the reel is locked manually the control must be positioned full aft to the unlocked position to release the straps.

2.35.4.6 Leg Restraints. The leg garters and restraint cords keep the occupant's leg firmly against the leg rests during ejection. The garters are placed around the leg above the calf and above the ankle. They should be tight enough so they do not slip down over the calf.

The leg-restraint cords are attached to the aircraft deck and routed through the snubber box seat structure. They are then passed through garter rings and snapped into the leg-line locks. The garter rings are snapped into the bayonet fitting when strapping in. Leg-line snubber release is accomplished by pulling the release lever located on the outer side of the leg-line snubber boxes. Leg restraints may be adjusted by pulling the lever located on the inner side of the leg-line snubber box.

2.35.4.7 Ventilated Cushions. Each seat is equipped with a ventilated back and seat cushion to provide comfort for the seat occupant. Air from the pressure ventilation suit system flows through the internal ducting in the seat cushion and is discharged through the perforated surface.

2.35.4.8 Seat Adjustment. Seat adjustment is controlled by a three-position, momentary-contact switch on the right side of the right thigh support. Moving the switch forward (FWD) lowers the seat and AFT raises the seat. Seat adjustment is limited to 5 inches of vertical movement. Electrical power is supplied from the right main ac bus, through the ACM LT/SEAT ADJ/STEADY POS LT circuit breaker (2I4).

Note

The seat height-adjustment actuator is an intermittent-duty motor with duty cycle of 1 minute on and 10 minutes off.

2.35.4.9 Survival Kit. An SKU-2/A survival kit packed within a two-piece fiberglass container and attached to the occupant by strap-harnessing is in the seat bucket of each crewman ejection seat (see Figure 2-88). The upper half of the kit is a contoured lid assembly covered by a ventilated seat pad and contains an emergency oxygen bottle that can be activated automatically by seat ejection, or manually by pulling the emergency oxygen actuator. The lower half of the kit contains the following:

1. Liferaft
2. Dye markers
3. Signal flares
4. Space blanket
5. Desalter kit or canned water
6. Fifty feet of nylon cord
7. AN/URT-33 beacon
8. Morse code and signal card
9. Bailing sponge
10. SRU 31/P flightcrew survival kit.

Note

Emergency provisions included in the SKU-2/A survival kit are subject to local operation and may be altered at the discretion of the area commander.

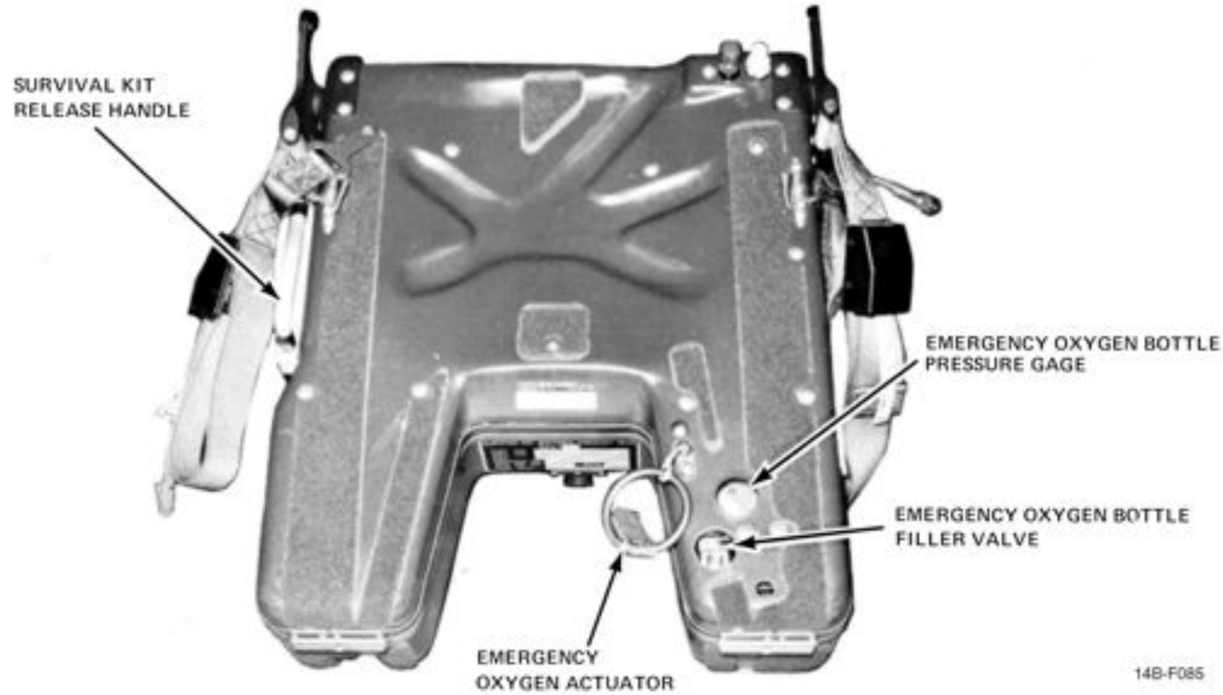


Figure 2-88. Survival Kit

After the seat clears the aircraft during the ejection sequence, a time-release mechanism releases the flight crewmember harness and survival kit from the seat. The opening shock of the personnel parachute deployment snaps the flight crewmember and the survival kit clear of the seat. During descent, when the flight crewmember pulls the raft release (one on each side of the kit), the lower half of the kit falls away but remains connected to the upper half by a lanyard approximately 23 feet long. As the lower half reaches the end of its free fall, the liferaft inflation mechanism is actuated and the raft inflates.

When ejecting over water, the liferaft should be inflated before entering the water. If the crewman enters the water before the raft release is pulled, the liferaft can be inflated only by first pulling the raft release and then pulling the liferaft lanyard until the raft is inflated.

2.36 LIGHTING SYSTEM

2.36.1 Exterior Lights. The exterior lights include position lights, formation lights, anticollision lights, a taxi light, approach lights, and an air refueling probe light. All exterior lighting controls except for the air refueling probe light and approach lights, are located on the MASTER LIGHT panel on the pilot right console. The exterior lights master switch on the outboard throttle must be on for any exterior light to function (except for approach lights). The pilot light control panel is shown in Figure 2-89. A two-channel flasher unit is used for flashing lights. One channel flashes the anticollision and position lights and has circuit protection from the ANTICOLL/SUPP POS/POS LTS circuit breaker (2I1). The second flasher channel flashes the angle-of-attack indexer and approach lights and has circuit protection from the ANGLE OF ATTK IND AC circuit breaker (3C3).

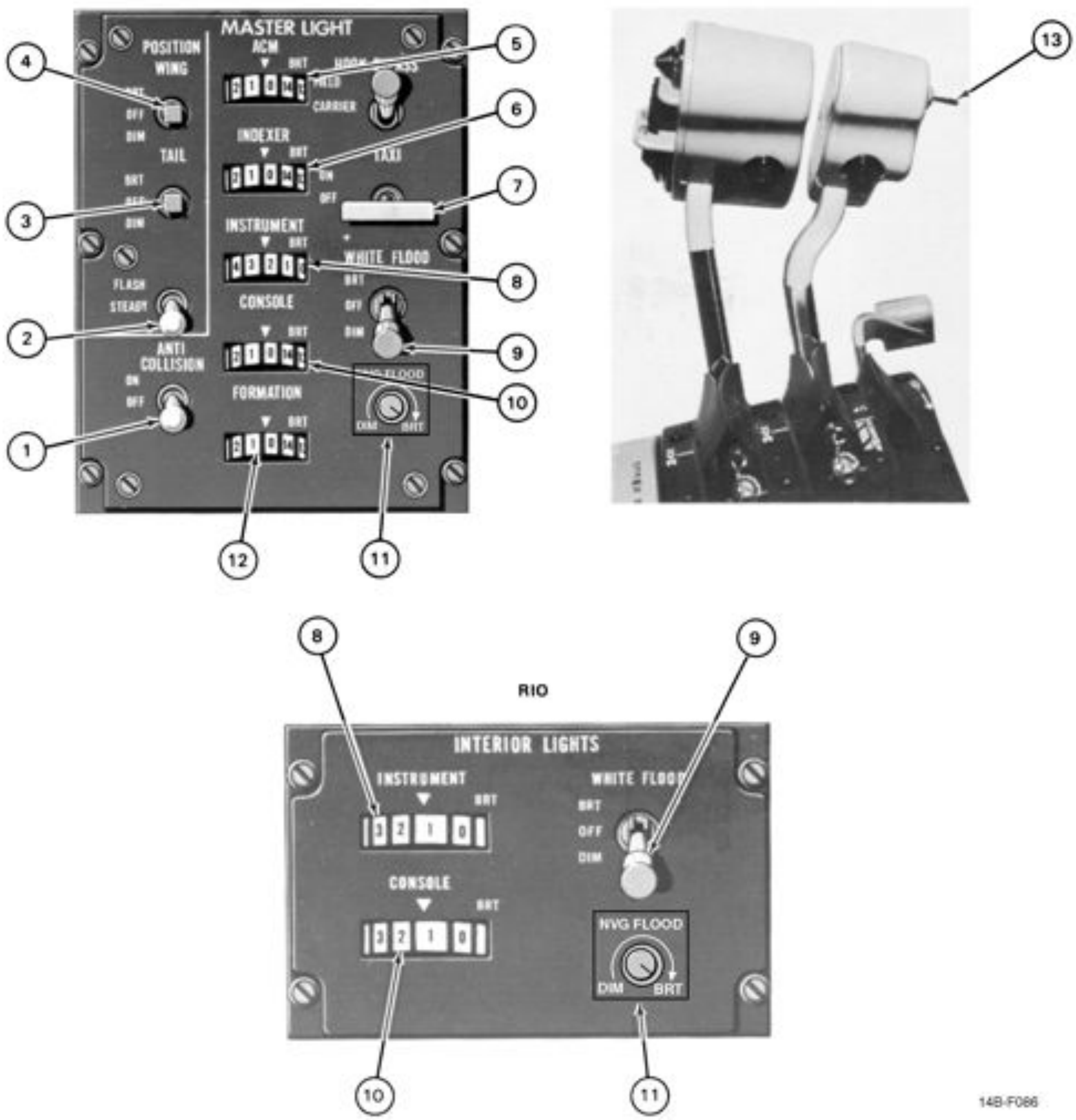


Figure 2-89. Cockpit Light Controls (Sheet 1 of 2)

NOMENCLATURE	FUNCTION	
1 ANTI COLLISION light switch	ON and OFF —	Energizes or deenergizes the anticollision lights. When anticollision lights are on, the flasher unit for the position lights is disabled.
2 POSITION lights flasher switch	FLASH —	Causes the wing or supplementary tail and position lights to operate in a flashing mode with landing gear up. With gear down supplementary lights operate steady only.
	STEADY —	With the wing and tall (or either) position lights on, lights are on steady.
3 TAIL POSITION light switch	BRT —	Bright tail lights
	OFF —	Deenergizes tail position lights
	DIM —	Dim tall lights
4 WING POSITION light switch	BRT —	Bright wing lights
	OFF —	Deenergizes wing lights
	DIM —	Dim wing lights
5 ACM panel light	0 to 14 —	Tums lights on thumbwheel
	1 to 14 —	Night variable intensity
6 INDEXER thumbwheel	0 to 14 —	Variable increase in intensity of indexer lights.
7 TAXI light switch	ON —	Nose gear must be down and locked and the master exterior light switch must be on.
	OFF —	Turns light off.
8 INSTRUMENT lights thumbwheel	0 to 1 —	Turns instrument panel lights on.
	1 to 14 —	Variable increase of intensity to a maximum brightness at 14.
9 WHITE FLOOD lights switch	BRT—	Bright light.
Note	DIM —	Dim light.
Switch must be pulled out to be moved to BRT or DIM	OFF —	Tums light off.
10 CONSOLE lights thumbwheel	0 to 14 —	Turns internal faceplate console lights on.
	1 to 14 —	Variable increase of console lights intensity to maximum brightness at 14.
11 NVIS FLOOD lights control	BRT —	Bright green NVIS console and glareshield floodlights only.
	DIM —	Dim green console and glareshield floodlights only, full dim turns floodlights off.
12 FORMATION lights thumbwheel	0 to 14 —	Turns formation lights on.
	1 to 14 —	Variable increase of light intensity to maximum of 14.
13 Exterior lights master switch	ON —	Enables all exterior lights. Dims approach lights.
	OFF —	Permits pilot to turn off all exterior lights. Increases intensity of approach lights.

Figure 2-89. Cockpit Light Controls (Sheet 2)

Note

The anticollision, position and supplementary position, formation, and taxi lights are inoperative when operating on emergency generator.

2.36.1.1 Position Lights. The position lights consist of a red light on the left wing tip, a green light on the right wing tip, and a white position light in the fin cap assembly. Supplemental position lights include upper and lower red lights on the left wing glove, and upper and lower green lights on the right wing glove. When the wing-sweep angle is forward of 25°, the wingtip position lights are operational; when the wings are swept aft of 25°, the wingtip position lights are disabled and the glove position lights are operational. When operating in steady mode with the nosegear down and locked and the wings forward of 25°, both the wingtip position lights and the glove position lights are operational. The position lights are powered from the right main ac bus through the exterior lights master relay.

Note

When the anticollision lights are on, the flasher for the position lights is disabled and the lights revert to steady.

2.36.1.2 Anticollision Lights. There are three red, flashing anticollision lights. One anticollision light is installed in the bottom of the TCS pod on the lower forward fuselage. Another anticollision light is installed in the top forward part of the left vertical stabilizer. The third anticollision light is on the top aft part of the right vertical stabilizer and directs its anticollision beacon up and down.

The lower fuselage forward anticollision light remains off during takeoff and landing with the nosewheel door open. With the nosewheel door closed, the lower fuselage forward anticollision light will operate with the ANTI COLLISION light switch set to ON. The anticollision lights are powered through the right main bus with circuit protection on the RIO ac right main circuit breaker panel TAXI/FORM LT (2H2).

2.36.1.3 Formation Lights. The formation lights consist of wingtip lights on each wing, fuselage lights, and vertical fin tip lights on both sides of the aircraft.

All formation lights are green. Intensity of the lights are controlled by the FORMATION thumbwheel on the MASTER LIGHT panel. Electrical power is supplied through the right main bus with circuit protection on the RIO ac right main circuit breaker panel TAXI/FORM LT (2H2).

2.36.1.4 Taxi Light. The taxi light installed on the nosewheel is a fixed position light. A limit switch on the nosegear door will turn the light off when the gear is retracted. A two-position ON/OFF switch is on the MASTER LIGHT panel. Electrical power is supplied through the right main bus with circuit protection on the RIO circuit breaker panel TAXI/FORM LT (2H2).

2.36.2 Interior Lights. The interior lighting of the cockpit consists of red instrument panel and console panel lights, green and white floodlights for additional console and instrument panel lighting, and a utility and map light for each flightcrew station. At the pilot station, the interior lights are controlled from the MASTER LIGHT panel on the right outboard console. The RIO can control his interior lighting from the interior light panel on his right outboard console.

2.36.2.1 Instrument and Console Panel Lights. All flight instruments in the pilot and RIO instrument panel and console panel lights are lighted by aviation red lighting. Individual thumbwheel controls are provided for the pilot and RIO instrument and console lighting. The thumbwheels have 14 variable selections from 0 to 14. Initial rotation from 0 to 1 activates the circuitry and provides a low-intensity light. Further rotation up to a maximum intensity (14) increases the brightness. The INSTRUMENT thumbwheel also controls the intensity of the CAUTION ADVISORY panels and the digital data indicator lights, which consist of high and low-intensity lighting. The console lights thumbwheel turns power on for the internal faceplate console lights. The pilot instrument lighting power source is the ac essential bus No. 1 and will operate in the 1-kVA mode of the emergency generator. Lighting for the pilot turn-and-slip indicator is controlled by the INSTRUMENT lighting thumbwheel. The engine indicator group uses integral white lighting for daylight operations.

2.36.2.2 Floodlights. The floodlights consist of 4.2-watt green and 20-watt white lights that illuminate the instrument and console panels. When navigating around thunderstorms, the white floodlights should be turned on bright to assist in preventing temporary blindness from lightning. The WHITE FLOOD toggle switch on the pilot master light panel and another on the RIO light panel are safety interlock switches that must be pulled up to be positioned to BRT or DIM. In DIM, low-intensity floodlighting is provided.

Note

When the white floodlights are on (BRT or DIM), the intensity of the CAUTION and ADVISORY panel lights is increased to day (bright) illumination mode.

Console and instrument panel glareshield floodlights are available from DIM to BRT via the NVIS floodlight rheostat. The floodlights are protected by a circuit breaker on the RIO ac essential No. 1 circuit breaker panel. The white floodlights are protected by the WHITE FLOOD LT circuit breaker (2H6) on the RIO ac right main circuit breaker panel.

2.36.2.3 Utility and Map Lights. The pilot utility and map light is on a bracket above the right outboard console. The RIO utility and map light is in a bracket above and midway along the right console. Each light has a rheostat control including ON and OFF settings on the rear of the lamp. A red filter may be selected by rotating the face of the lamp. Pressing the locking button on top of the lamp permits rotating the face of the lamp to reselect a white light with a flood or spot illumination option. An alligator clip and swivel mounting allow the light to be positioned on a clipboard or other convenient location. A flasher button on the heel of the lamp allows either crewmember to use the light as a signal lamp. The utility and map lights are supplied electrical power from the ac essential No. 2 bus and are protected by the UTILITY LT circuit breaker (4D5).

2.36.3 Warning and Indicator Lights. Warning, caution, and advisory lights (Figure 2-90 and Figure 2-91) are provided in both cockpits to alert the pilot and RIO of aircraft equipment malfunctions, unsafe operating conditions, or that a particular system is in operation.

Warning lights illuminate to warn of hazardous conditions that require immediate corrective action. Caution lights show yellow letters on an opaque background to indicate an impending dangerous condition. The lower half of the CAUTION ADVISORY panel consists of advisory lights that show green letters on opaque background. Advisory lights indicate degraded operations that may require corrective action.

WARNING

Radiation hazard exists on deck when the RDR ENABLED caution light is illuminated. The light indicates that the RADAR TEST ENABLE switch (maintenance switch) is in the “A” (radiate and scan) position. This condition permits the weight-on-wheels interlock to be bypassed, allowing the transmitter to radiate out the antenna when XMT is selected on the hand control unit. Illumination of the light does not indicate a weight-on-wheels failure.

In addition, the digital data indicator on the RIO right console contains 40 advisory lights associated with datalink communication. Repeater datalink advisory lights are on the left side of the pilot VDI. A functional description of each light is included in the applicable system description.

2.36.3.1 MASTER CAUTION Light. The pilot MASTER CAUTION light is centrally located on the air combat maneuver panel, and, in the aft cockpit, the RIO MASTER CAUTION light is on the right instrument panel. When the lights are illuminated, yellow letters show on an opaque background. Individual MASTER CAUTION lights flash whenever a caution light on the respective CAUTION and ADVISORY panel illuminates. A MASTER CAUTION light may be turned off by depressing its lens. This will activate a reset switch that rearms the master circuit for a subsequent caution light. A caution light lit on the CAUTION and ADVISORY panel will not be turned off by resetting the MASTER CAUTION light.

2.36.3.2 Indicator Lights Test. A check of all indicator lights can be performed while airborne or during on-deck operations. The pilot caution and advisory lights, the MASTER CAUTION light, and all associated circuitry are tested through the MASTER TEST panel. The test is initiated by selecting LTS and pressing the master test knob. Electrical power is routed through the circuitry to provide simulated failure signals to the caution and advisory lights. Illumination of each warning, caution, and advisory light verifies proper continuity of the indicator lights. A malfunction is indicated by failure of a light to illuminate.

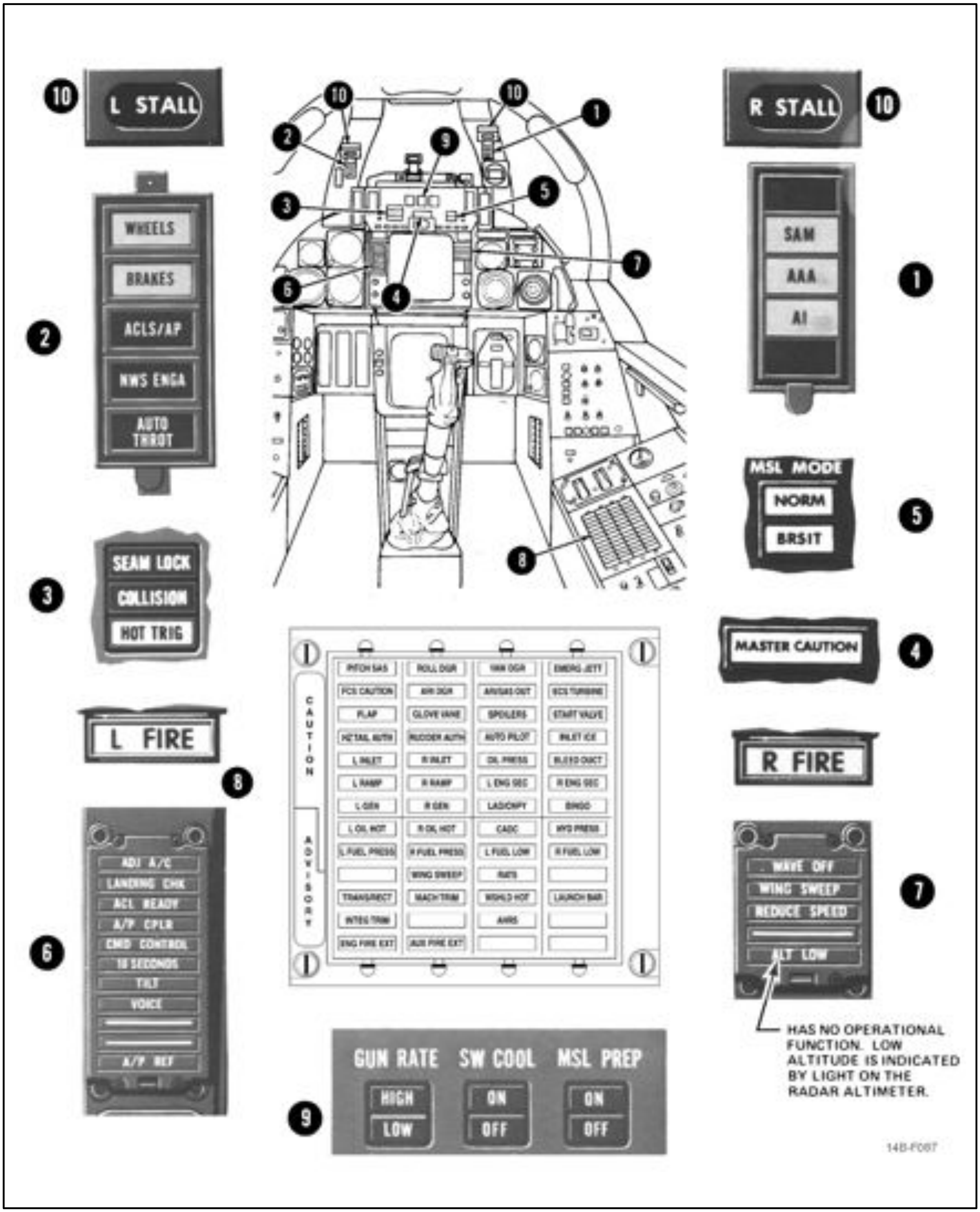


Figure 2-90. Pilot Indicator Lights (Sheet 1 of 5)

NOMENCLATURE	FUNCTION
1 SAM (warning)	Steady illumination when a surface-to-air missile tracking radar is detected. Flashing when a missile has been launched.
AAA (warning)	Steady illumination when an antiaircraft tracking radar is detected. Flashing when an AAA radar-firing signal is detected.
AI (warning)	Steady illumination indicates an airborne interceptor tracking is detected.
2 WHEELS (warning)	Flashes with flaps down more than 10°, either throttle below approximately 85 percent, and any landing gear not down and locked. Will not illuminate with a gear transition light and landing gear indicating safe gear down.
BRAKES (warning)	Indicates antiskid failure or failure of priority valve in the brake power module to switch to combined hydraulic system. Illuminates when parking brake is pulled.
ACLS/AP (caution)	Indicates ACLS or autopilot mode is disengaged.
NWS ENGA (caution)	Indicates nosewheel steering is engaged. Nosewheel steering is controlled by rudder pedal displacement with weight on wheels. Automatically centers with hook down.
AUTO THROT (caution)	Indicates APC has been disengaged by means other than the throttle mode switch.
3 SEAM LOCK (advisory)	Indicates Sidewinder missile acquisition (lockon).
COLLISION (advisory)	Indicates that collision steering has been selected by RIO.
HOT TRIG (warning)	Indicates that firing logic conditions are available. Pilot trigger or bomb button and RIO launch button will fire or release ordnance when actuated.
4 MASTER CAUTION (caution)	Flashes when any CAUTION light on the pilot CAUTION ADVISORY panel illuminates.
5 MODE STP switch	Indicates missile mode selected. Refer to NAVAIR 01-F14AAA-1A.
6 ADJ A/C (advisory)	Indicates that an aircraft is in (or close to) own aircraft traffic pattern.
LANDING CHK (advisory)	Indicates carrier air traffic control center has a channel available for ACL and aircraft should prepare for carrier landing.
ACL READY (advisory)	Indicates aircraft has been acquired by CATCC and that glidepath information is being transmitted to aircraft for zero pitch and zero bank.
A/P CPLR (warning)	Indicates CATCC is ready to control aircraft.
CMD CONTROL (warning)	Indicates aircraft is under data link control for landing.
10 SECONDS (warning)	Indicates carrier motion is added to glidepath information and data-link commands during ACL. For other modes, it indicates time before arrival at specific point in approach path.
TILT (warning)	Indicates that no data link update received for last 2 seconds during ACL. For other modes it indicates no message received during last 10 seconds.
VOICE (warning)	Indicates CATCC is not available for ACL. Standard voice commands are required.

Figure 2-90. Pilot Indicator Lights (Sheet 2)

NOMENCLATURE	FUNCTION
A/P REF (warning)	Indicates autopilot is selected but not engaged (except attitude and heading hold).
7 WAVEOFF (warning)	Indicates unsafe condition for landing.
WING SWEEP (warning)	Indicates failure of both wing sweep channels and/or disengagement of spider detent.
REDUCE SPEED (warning)	Indicates main flap comparator failure with flaps not retracted and airspeed greater than 225 KIAS. Maximum safe Mach number exceeded (2.4 M) or total temperature above 388 °F.
8 PITCH SAS (caution)	Indicates inoperative pitch channel or pitch SAS.
FCS CAUTION (caution)	Indicates DFCS failure has occurred. If no other lights are illuminated, indicates loss of redundancy only (subsequent failure may result in loss of significant DFCS functionality.
ROLL DGR (caution)	Indicates inoperative roll channel and degraded roll authority.
ARI DGR (caution)	Indicates degraded ARI performance. If caused by loss of a Mach number signal, LSXC and wing rock suppression functions will be inoperative.
YAW DGR (caution)	Indicates inoperative yaw channel and degraded yaw authority.
ARI/SAS OUT (caution)	Indicates loss of either roll or yaw SAS and all ARI functions. Will be illuminated if either the ROLL STAB Aug or YAW STAB AUG switches are selected OFF.
EMERG JETT (caution)	Indicates EMERG STORES JETT pushbutton is activated. either the ROLL STAB AUG or YAW STAB AUG switches are selected OFF.
LADDER (caution)	Indicates ladder is not stowed.
INLET ICE (caution)	Indicates ice accumulated on ice detector in left inlet with ENG/PROBE/AICS ANTI-ICE switch in AUTO/OFF or ORIDE/ON selected.
FLAP (caution)	Indicates disagreement between main and/or auxiliary flap position, or asymmetry lockout. CADC failure. WG SWP DR NO. 2/MANUV FLAP (LE2) circuit breaker pulled. Landing flaps down and airspeed greater than 225 KIAS.
HZ TAIL AUTH (caution)	Indicates failure of lateral tail authority actuator to follow schedule or CADC failure.
RUDDER AUTH (caution)	Indicates disagreement between position and command failure of rudder authority actuators to follow schedule, or CADC.
SPOILERS (caution)	Indicates spoiler failure causing a set of spoilers to be locked down.
AUTO PILOT (caution)	Indicates failure of one or more pilot relief modes.
R INLET L INLET (caution)	Indicates AICS programmer and/or system failure.
OIL PRESS (caution)	Indicates left or right engine oil pressure is 11 psi or less.

Figure 2-90. Pilot Indicator Lights (Sheet 3)

NOMENCLATURE	FUNCTION
BLEED DUCT (caution)	Indicates bleed air leak sensing elements detect temperatures greater than 575 °F between engine and primary heat exchanger. Also indicates hot air leak detection (excess of 255 °F) between primary heat exchanger and ECS turbine compressor.
L RAMPS R RAMPS (caution)	Indicates ramps are neither positioned in stow nor trail locks during critical flight conditions. (See Figure 2-5.)
START VALVE (caution)	Starter solenoid air valve open after start.
L ENG SEC R ENG SEC (caution)	Indicates augmenter fan temperature controller (AFTC) is in secondary mode. Afterburner is inoperative and MIL thrust levels can vary from as little as 65% to as much as 116% of primary mode MIL thrust.
L GEN R GEN (caution)	Indicates that corresponding generator is inoperative because of fault in generator, control unit, or electrical distribution system.
CANOPY (caution)	Indicates that canopy is not in down-and-locked position.
BINGO (caution)	Indicates fuel totalized is less than preset value.
L OIL HOT R OIL HOT (caution)	Indicates oil temperature too high. May be an indication of the high-scavenge oil temperature; continued engine operation will result in reduced gearbox life and lubrication degradation.
CADC (caution)	Indicates failure associated with air data computer.
HYD PRESS (caution)	Indicates hydraulic pressure from either engine-driven pump is less than 2,100 psi.
L FUEL PRESS R FUEL PRESS (caution)	Indicates insufficient discharge pressure (less than 9 psi) from respective turbine-driven boost pump.
L FUEL LOW R FUEL LOW (caution)	Indicates fuel thermistors uncovered in aft and left or forward and right fuel feed group (approximately 1,000 pounds remaining in individual fuel feed group.
WING SWEEP (advisory)	Indicates failure of a single channel in the system.
RATS (advisory)	RATS aircraft circuit enabled.
TRANS/RECT (advisory)	Indicates one operable transformer-rectifier is powering the total dc load, or dual transformer-rectifier failure.
MACH TRIM (advisory)	Indicated failure of Mach trim actuator to follow schedule.
WSHLD HOT (advisory)	Indicates center windshield is overheated.
LAUNCH BAR (advisory)	Weight-on-Wheels: ● Aircraft kneeled, either throttle less than MIL, launch bar not up and locked (normal indication until MRT checks). Weight-off-Wheels: ● Launch bar not up and locked. ● Launch bar not within ±15° of center, cocked nosegear. ● Nose strut not fully extended.
INTEG TRIM (advisory)	Indicates a discrepancy between input command signal and actuator position, or an electrical power loss within the computer.

Figure 2-90. Pilot Indicator Lights (Sheet 4)

NOMENCLATURE	FUNCTION
L OIL HOT R OIL HOT (caution)	Indicates oil temperature too high. May be an indication of the high-scavenge oil temperature; continued engine operation will result in reduced gearbox life and lubrication degradation.
CADC (caution)	Indicates failure associated with air data computer.
HYD PRESS (caution)	Indicates hydraulic pressure from either engine-driven pump is less than 2,100 psi.
L FUEL PRESS R FUEL PRESS (caution)	Indicates insufficient discharge pressure (less than 9 psi) from respective turbine-driven boost pump.
L FUEL LOW R FUEL LOW (caution)	Indicates fuel thermistors uncovered in aft and left or forward and right fuel feed group (approximately 1,000 pounds remaining in individual fuel feed group.
WING SWEEP (advisory)	Indicates failure of a single channel in the system.
RATS (advisory)	RATS aircraft circuit enabled.
TRANS/RECT (advisory)	Indicates one operable transformer-rectifier is powering the total dc load, or dual transformer-rectifier failure.
MACH TRIM (advisory)	Indicated failure of Mach trim actuator to follow schedule.
WSHLD HOT (advisory)	Indicates center windshield is overheated.
LAUNCH BAR (advisory)	Weight-on-Wheels: • Aircraft kneeled, either throttle less than MIL, launch bar not up and locked (normal indication until MRT checks). Weight-off-Wheels: • Launch bar not up and locked. • Launch bar not within ±15° of center, cocked nosegear. • Nose strut not fully extended.
INTEG TRIM (advisory)	Indicates a discrepancy between input command signal and actuator position, or an electrical power loss within the computer.
AHRS (advisory)	Indicates attitude or heading information from AHRS is unreliable.
ENG FIRE EXT (advisory)	Indicates low pressure (approximately 90 psi below the nominal 600 psi) in the fire extinguishing agent container.
AUX FIRE EXT (advisory)	Indicates low pressure (approximately 90 psi below the nominal 600 psi) in the auxiliary fire extinguishing agent container.
9 GUN RATE switch SW COOL switch MSL PREP switch	Indicates gun firing rate selected. Indicates Sidewinder seekerhead cooling has been enabled. Indicates AIM-7/AIM-54 missile preparation selection.
10 L STALL R STALL (warning)	Indicates an engine stall condition.

Figure 2-90. Pilot Indicator Lights (Sheet 5)

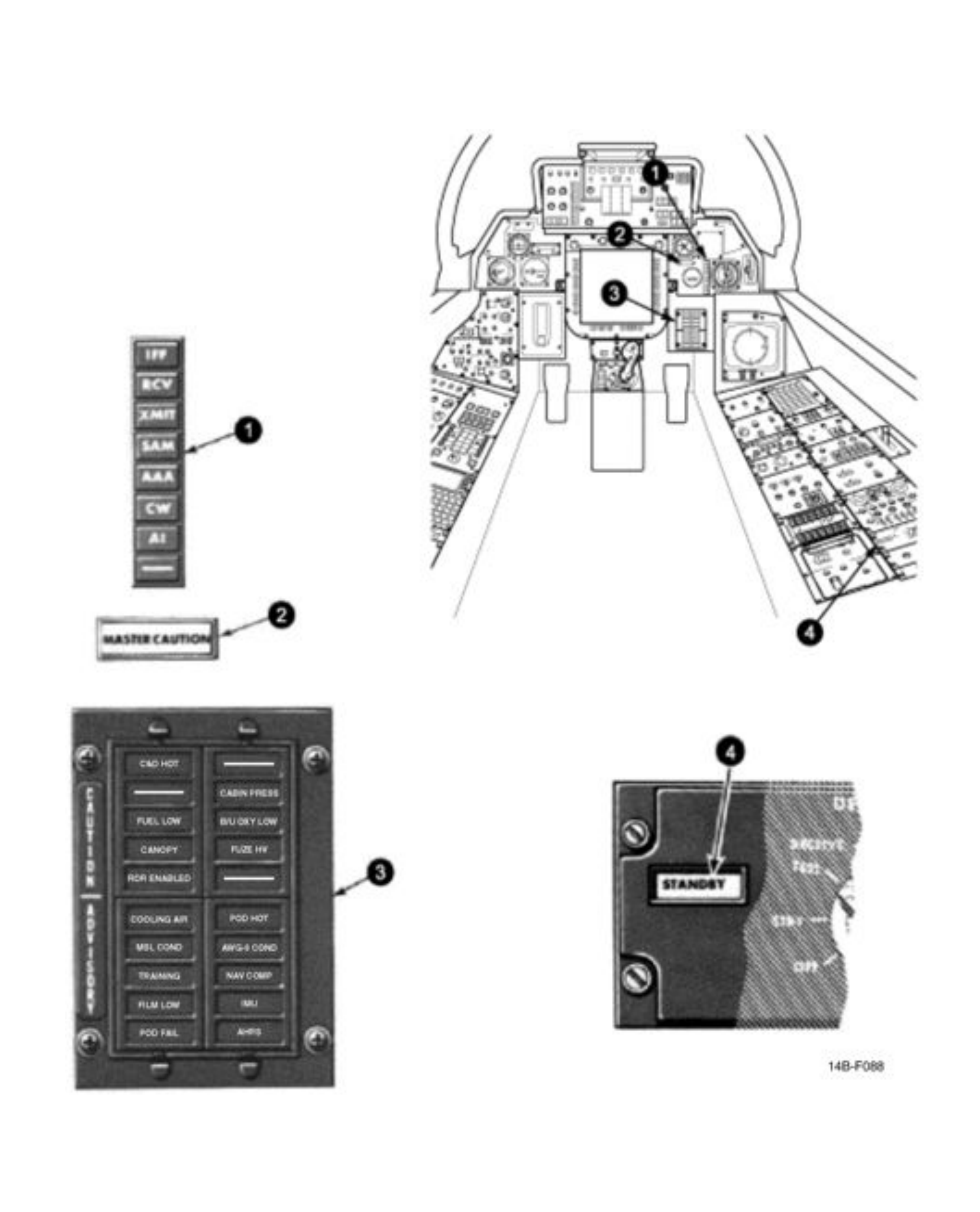


Figure 2-91. RIO Indicator Lights (Sheet 1 of 3)

NOMENCLATURE	FUNCTION
1 IFF (advisory)	Indicates mode 4 interrogation was received, but system has not generated reply.
REC (advisory)	Indicates ALQ-126 is receiving a threat identification signal.
XMIT (advisory)	Indicates ALQ-126 is transmitting.
SAM (warning)	Steady illumination when a surface-to-air missile tracking radar is detected. Flashing when a missile has been launched.
AAA (warning)	Steady illumination when an anti-aircraft tracking radar is detected. Flashing when an AAA radar firing signal is detected.
CW (warning)	Indicated a continuous wave emitter is detected.
AI (warning)	Steady illumination indicates an airborne interceptor tracking is detected.
2 MASTER CAUTION (caution)	Flashes when any CAUTION light on the RIO's CAUTION ADVISORY panel illuminates.
3 C&D HOT (caution)	Indicates RIO's controls and displays are overheating.
CABIN PRESS (caution)	Indicates aircraft cabin pressure has dropped below 5-psi pressure differential r cockpit altitude is above 27,000 feet.
FUEL LOW (caution)	Indicates fuel thermistors uncovered in aft and left or forward and right fuel feed group (approximately 1,000 pounds) remaining in individual fuel feed group.
OXY LOW (caution)	Indicates oxygen quantity is 2 liters or less or pressure is low.
CANOPY (caution)	Indicates that canopy is not in down and locked position.
FUZE HV (caution)	Indicates that the AWW-4 electric fuse is inoperative.
RDR ENABLED (caution)	Indicate that radar operation on the ground is possible.
COOLING AIR (advisory)	Indicates an overtemperature condition exists in the electronic forced air cooling system. With degraded cabin pressure or flow, indicates possible bleed duct failure forward of primary heat exchanger and 400° modulating valve.
MSL COND (advisory)	Indicates temperature of coolant flow to missiles is above 115° ±3 °F; coolant pump outflow pressure is below 60±5 psi. Indicates overtemperature switch has shutdown the coolant pump. With Phoenix fairing installed and WCS switch in STBY or XMIT, indicates LIQ COOLING switch is in OFF or AWG-9.
AWG-9 COND (advisory)	Indicates coolant temperature exiting heat exchanger is greater than 104 °F, coolant pump output pressure is below 60 psi, or the overtemperature switch has shut down the coolant pump.
NAV COMP (advisory)	Indicates that a condition requiring the RIO's attention has occurred in the navigation system. Check the CDNU for more information.
FILM LOW (advisory)	Indicates mission recorder film is low.

Figure 2-91. RIO Indicator Lights (Sheet 2)

NOMENCLATURE	FUNCTION
IMU (advisory)	Indicates failure in the inertial measuring unit. If not accompanied by the NAV COMP light, the failure is in the analog circuitry between the EGI and CSDC(R). Check CDNU for more information.
AHRS (advisory)	Indicates attitude or heading information from AHRS is unreliable.
POD HOT (advisory)	Indicates overheating of LANTIRN pod.
POD FAIL (advisory)	Indicates failure of LANTIRN pod.
4 STANDBY (advisory)	Indicates DECM system is in warmup with power switch is STBY. With switch in REC or RPT, indicates a malfunction. With switch in TEST, indicates failure at end of test.

Figure 2-91. RIO Indicator Lights (Sheet 3)

Illumination of any caution light causes the MASTER CAUTION light to flash. If the MASTER CAUTION light illuminates steadily during the LTS test, it indicates a failure of the MASTER CAUTION light, primary power failure, failure of the flasher module, or that failure has been detected by the BIT circuits.

The following indicator lights are also illuminated by the LTS test through the MASTER TEST panel:

1. ACLS/AP
2. ALT LOW
3. Approach indexer
4. A/P REF
5. AUTO THROT
6. BRAKES
7. EMERG STORES JETT button
8. L FIRE
9. R FIRE
10. GO/NO GO
11. GUN RATE, HIGH and LOW
12. HOOK light
13. HOT TRIG
14. LDG GEAR transition light
15. NWS ENGA
16. REDUCE SPEED
17. Refueling probe light
18. SAM
19. L STALL
20. R STALL
21. WHEELS
22. WING SWEEP

All indicator lights located on the sides of the VDI (including the DDI repeater lights) are tested with the caution and advisory lights.

WARNING

Failure of the EMERG STORES JETT button to illuminate during the LTS check could indicate that the jettison button bulb is burned out or that the test circuit is defective. In this event, status of the emergency stores jettison circuit cannot be determined. If the switch is activated, stores will jettison when weight is off wheels. Under some lighting conditions it may be difficult to determine when the light is illuminated. Ensure that the light goes out when LTS MASTER TEST is deselected. Failure of the light to go out indicates emergency jettison is selected and stores will jettison with weight off wheels.

Note

The DATA LINK power switch must be on to check the DDI lights.

The RIO caution and advisory lights are tested in the same manner through IND LT on the TEST panel on the right console.

2.37 JETTISON SYSTEM

2.37.1 Jettison Modes. Four jettison modes are provided in the aircraft:

1. Emergency
2. ACM
3. Selective
4. Auxiliary

Weapon arming and fuzing and missile motor ignition are safed during all jettison release modes.

WARNING

Stores shall be jettisoned above the minimum fragmentation clearance altitude, when possible, even though weapon arming and fuzing is safed in all jettison modes.

WARNING

If jettisoned during a takeoff emergency, external fuel tanks may collide with the aircraft because of their unstable characteristics.

External fuel tanks, Phoenix, and Sparrow missiles can be released through all jettison modes except auxiliary jettison. Figure 2-92 shows the aircraft loading station locations.

Note

Sidewinder missiles cannot be jettisoned.

2.37.1.1 Emergency Jettison. Emergency jettison is used to separate from the aircraft as fast as possible all external stores except Sidewinder. The emergency jettison circuit is interlocked only through weight off wheels and overrides any previous logic in the armament system. This mode is actuated by the pilot through the EMERG STORES JETT switch on the landing gear control panel (Figure 2-93) and does not require MASTER ARM switch is set to ON. This applies an emergency jettison command to the station select sequencer in the armament control panel. The station select sequencer logic automatically generates the selected station jettison commands for all stations (except those that carry Sidewinders) independent of the STA SEL switches.

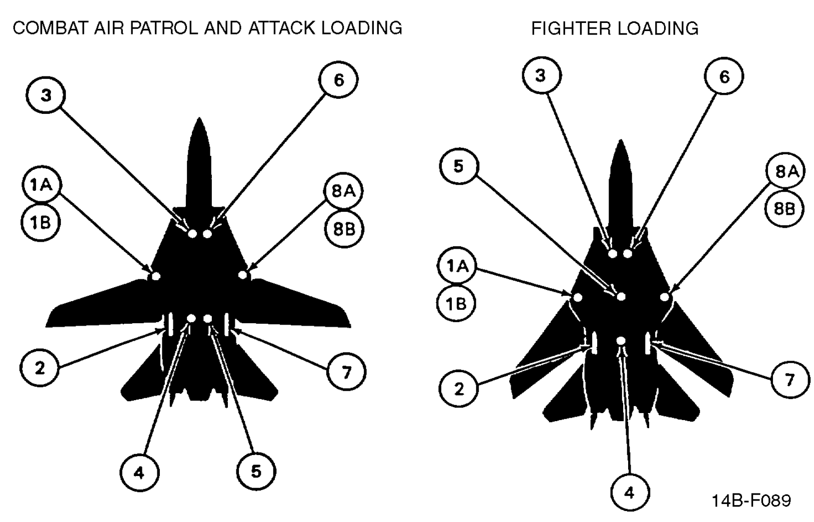


Figure 2-92. Aircraft Store Locations

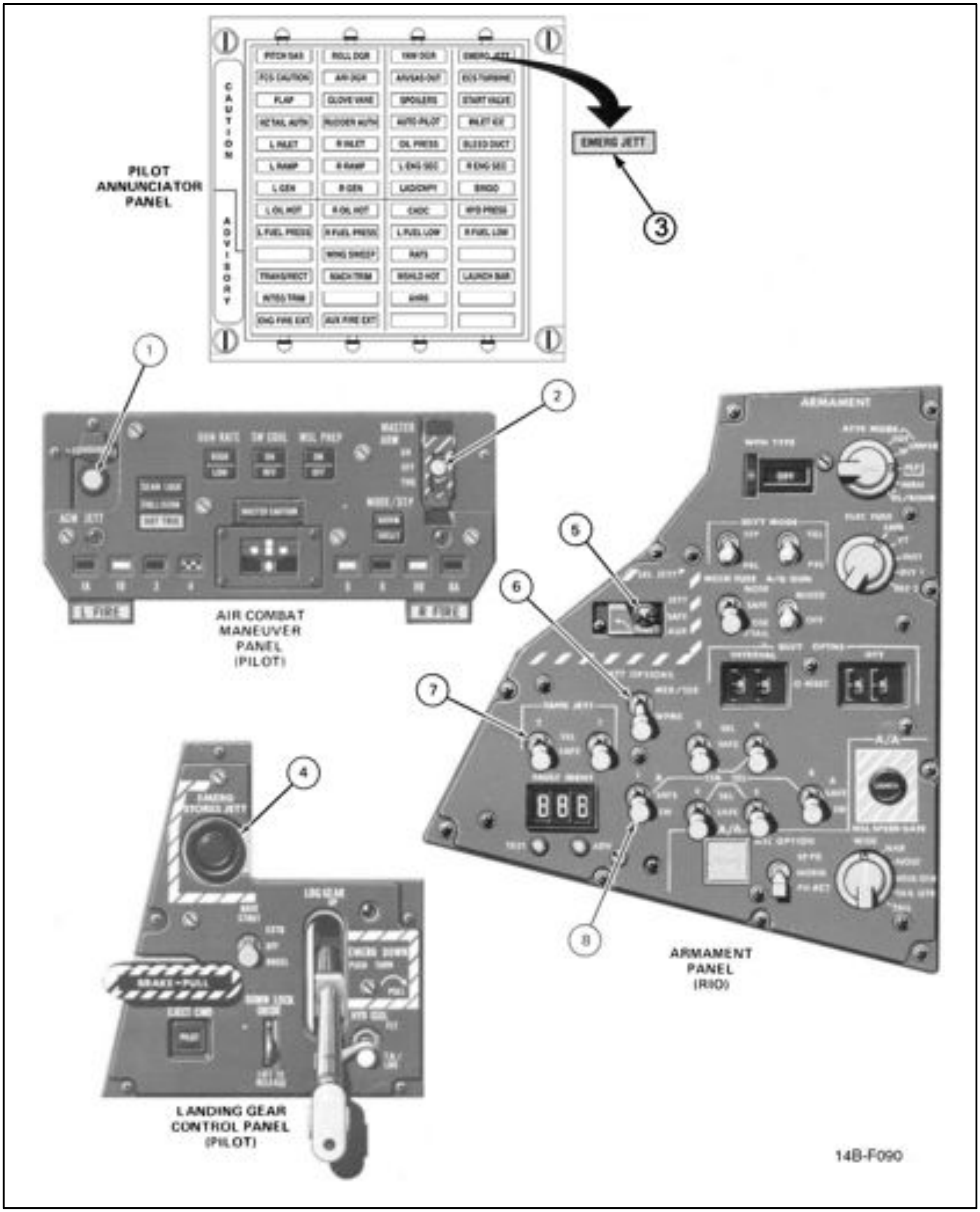


Figure 2-93. Jettison Controls and Indicators (Sheet 1 of 3)

NOMENCLATURE	FUNCTION
1 ACM JETT pushbutton	Enables ACM jettison. Pushbutton is under ACM switch cover. In order to activate this jettison mode, cover must be up which places the WCS in the ACM mode. When pressed only those stores selected on then armament control panel are jettisoned. To ensure release of all selected the ACM JETT pushbutton must be depressed and held for at least 2 seconds. ACM jettison will not release any Sidewinder missiles even if their stations are selected.
2 MASTER ARM Switch **CAUTION** During airborne AWG-9 power up, HOT TRIG light may illuminate for approximately 15 seconds during auto BIT sequence 2 if MASTER ARM is ON. Therefore, MASTER ARM should always be OFF before turning on or recycling power to AWG-9.	Controls power for operational release, selective, and auxiliary jettison. Switch is covered by safety guard which must be raised to be activated. Master arm is interlocked with landing gear handle and nose gear door. With landing gear handle down, no arming or release power is available to release stores except by emergency jettison. Arming power is available only with landing gear handle up and nose gear door closed. **Note** Emergency and ACM jettison have no master arm interlock. OFF — No electrical power to release circuitry. TNG — Initiates in-flight training system. ON — Prerequisite for jettison except ACM or emergency Jettison. Energizes pilot's trigger and bomb button for weapon delivery. Prerequisite for HOT TRIG indication.
3 EMERG JETT caution light	Indicates EMERG STORES JETT pushbutton is activated.
4 EMERG STORES JETT pushbutton	Enables emergency jettison. When pressed, the switch is illuminated. This function is checked by MASTER TEST switch in LTS. The MASTER CAUTION light and the EMERG JETT caution light illuminate when the EMERG STORES JETT pushbutton is activated.
5 SEL JETT switch	Allows RIO to jettison from selective stations. it is a three-position, lever-locked switch with guarded positions. JETT — Releases weapons from all stations selected according to established outboard to inboard, aft to forward sequence, with a 100-ms interval automatically set between releases. SAFE — Inhibits jettison in selective mode. This is normal switch position. AUX — Backup nonejection mode used when selective jettison has failed. Guarded position, which provides for freefall release from parent racks of stores from selected stations.

Figure 2-93. Jettison Controls and Indicators (Sheet 2)

NOMENCLATURE	FUNCTION
	CAUTION To prevent store-to-store collisions, only one station should be selected at a time for AUX jettison. **Note** Only stores loaded on BRU-32 parent racks can be AUX jettisoned.
6 JETT OPTIONS	MER/TER — Enables rack and weapon jettison with appropriate configuration. WPNS — Selects weapon jettison only with appropriate configuration.
7 TANK JETT switch	Selects station 2 and/or 7 for selective or ACM jettison. SEL — External fuel tanks selected for selective or ACM jettison. SAFE — Inhibits tank jettison.
8 STA SEL switches	Allows selective, auxiliary, or ACM jettison of Phoenix or Sparrow missiles. Selects lower station for selective or ACM jettison.
1 B, 8B	SAFE — Inhibits all release and jettison except emergency. SW — Not used.
4, 5 3, 6	SEL — Bombs or flares selected for normal release, selective, auxiliary, or ACM jettison. Selective or ACM jettison for Sparrow or Phoenix missiles.

Figure 2-93. Jettison Controls and Indicators (Sheet 3)

The station jettison release sequence is: 1B/2/7/8B-4-5-3-6.

Note

- The time interval between stations indicated by (-) is 100 ms.
- Stations lB, 8B, 2, 7 are jettisoned simultaneously.

2.37.1.2 ACM Jettison. The ACM jettison mode selectively jettisons all external stores except Sidewinders. ACM jettison is similar to emergency jettison except instead of weight off wheels; it requires landing gear handle UP and RIO selection of those stations to be separated. As in emergency jettison, MASTER ARM need not be ON. This mode is used to separate from the aircraft as fast as possible all those selected external stores not needed for the air combat situation.

After station selection by the RIO, this mode is actuated by the pilot placing the ACM switch on the ACM panel to ON and depressing the ACM JETT pushbutton under the ACM cover.

Note

- Sidewinder is inhibited from ACM JETT even if selected by the RIO.
- To ensure release of all selected stores, the ACM JETT pushbutton must be depressed and held at least 2 seconds.

The station release sequence is:

1. 2, 7 in pairs — Salvo
2. 1B, 8B ripple singles — Sequential

3. 4, 5 ripple singles — Sequential
4. 3, 6 ripple singles — Sequential.

Air-to-ground stores on stations 3, 4, 5, and 6 are jettisoned from the BRU-32 parent rack in the ACM jettison mode. The JETT OPTIONS switch is not functional. ITERS and ITER-loaded stores cannot be jettisoned.

2.37.1.3 Selective Jettison. Selective jettison is used to separate selected external stores from one or more stations. This mode provides options and capabilities not provided by the other jettison modes. It may be used to clean the aircraft of fuel tanks or other stores selected to be jettisoned. Unlike emergency and ACM jettison, in addition to landing gear handle UP, this mode requires the pilot to set MASTER ARM switch to ON. Selective jettison is actuated by the RIO by setting the SEL JETT switch to JETT after having first selected those stations to be jettisoned. The fixed interval between releases until completion of the separation program is 100 ms.

CAUTION

Do not attempt jettison of external fuel tanks until wing fuel tanks are depleted. Wing fuel may be lost if the external tank quick disconnect valve sticks in the open position.

Note

- Current ITER cable limitations prevent the jettison of either the stores loaded on an ITER or the ITER itself. ITER-loaded stores may only be separated in flight via normal release.
- The JETT OPTIONS switch is not functional. (AWG-15F)

The station release sequence is:

1. 2, 7 in pairs — Salvo
2. 1B, 8B ripple singles — Sequential
3. 4, 5 ripple singles — Sequential
4. 3, 6 ripple singles — Sequential.

2.37.1.4 Auxiliary Jettison. Auxiliary jettison is a nonejection backup mode to be used when other release or jettison modes have failed.

The fuel tanks and the missiles cannot be separated in auxiliary jettison. All air-to-ground stores with the exception of those carried on ITERs can be jettisoned through this mode. Like selective jettison, this mode requires MASTER ARM switch set to ON in addition to landing gear handle up, but is actuated by the RIO placing the SEL JETT switch to AUX rather than JETT after having first selected the station to be jettisoned.

All stations selected are released simultaneously. If the stores are not ejected, the parent rack hooks merely open.

WARNING

Since auxiliary jettison is a gravity drop rather than ejected separation, the aircraft will be restricted in its flight envelope when jettisoning through this mode. Since this mode is also a true salvo rather than fast ripple, no more than one station should be selected by the RIO for each release.

2.38 MISCELLANEOUS EQUIPMENT

2.38.1 Boarding Ladder. A boarding ladder consisting of three folding sections is housed in the left fuselage between the two cockpits. It is held in the closed position by two mechanical locking pins actuated by the ladder control handle in the face of the boarding ladder. The ladder must be manually released or stowed from the ground level. Unfolding the remaining two sections places the ladder in a fully extended position. The bottom rung of the ladder is approximately 26 inches above the deck when in a fully extended position, with the nosegear unkneeled, and 12 inches above the deck if the nosegear is kneeled. A LADDER caution light on the pilot's CAUTION ADVISORY panel advises the pilot that the boarding ladder is not in a full up-and-locked position.

2.38.1.1 Boarding Steps and Handhold. There are two positive locking board steps: one on either side of the boarding ladder directly below each cockpit. They may be opened or closed from either cockpit or standing on the boarding ladder. A single handhold is directly above the boarding ladder. It is a spring-loaded door that fairs with the fuselage when released.

2.38.2 Nose Radome. The nose radome is attached to the aircraft by a top hinge and bottom-mounted latches, permitting it to be rotated up for access and maintenance. A jury strut attached to lower part of the dome can be fastened to the aircraft bulkhead to hold the dome open. A minimum overhead clearance of 16 feet is required when opening the radome. The radar antenna must be stowed before opening the radome. Antenna stow position is 0° azimuth and 60° tilted down.

Note

After the nose radome is raised and the jury strut fastened in position, release hydraulic pressure to take load off hydraulic system.

2.38.3 Systems Test and System Power Ground Panel. The SYS TEST and SYS PWR ground check panel (Figure 2-94) is on the RIO left console panel (accessible from the boarding ladder with the canopy open) for controlling the activation of electrical circuits using ground external power. The panel cover is designed so that, when it is closed, the switches inside are in the proper position for flight. In addition, when the landing gear handle is in UP, all switches are deactivated. The panel serves a maintenance and preflight purpose and is not intended for use by the flightcrew.

Figure 2-94. Systems Test and System Power Ground Panel

2.39 BANNER-TOWED TARGET EQUIPMENT

The aerial banner-towed target equipment consists of a tow adapter, a standard Navy or Air Force 7 1/2 × 40 foot or 6 × 30 foot aerial banner target and approximately 1,500 feet of 11/64-inch armored cable tow line fitted at both ends with a Mk 8 tow ring.

The tow adapter is installed on the hinge point assembly of the tailhook by ground crew personnel. Pilot action is not required for banner hookup. The banner is released in flight or on deck by lowering the tailhook.

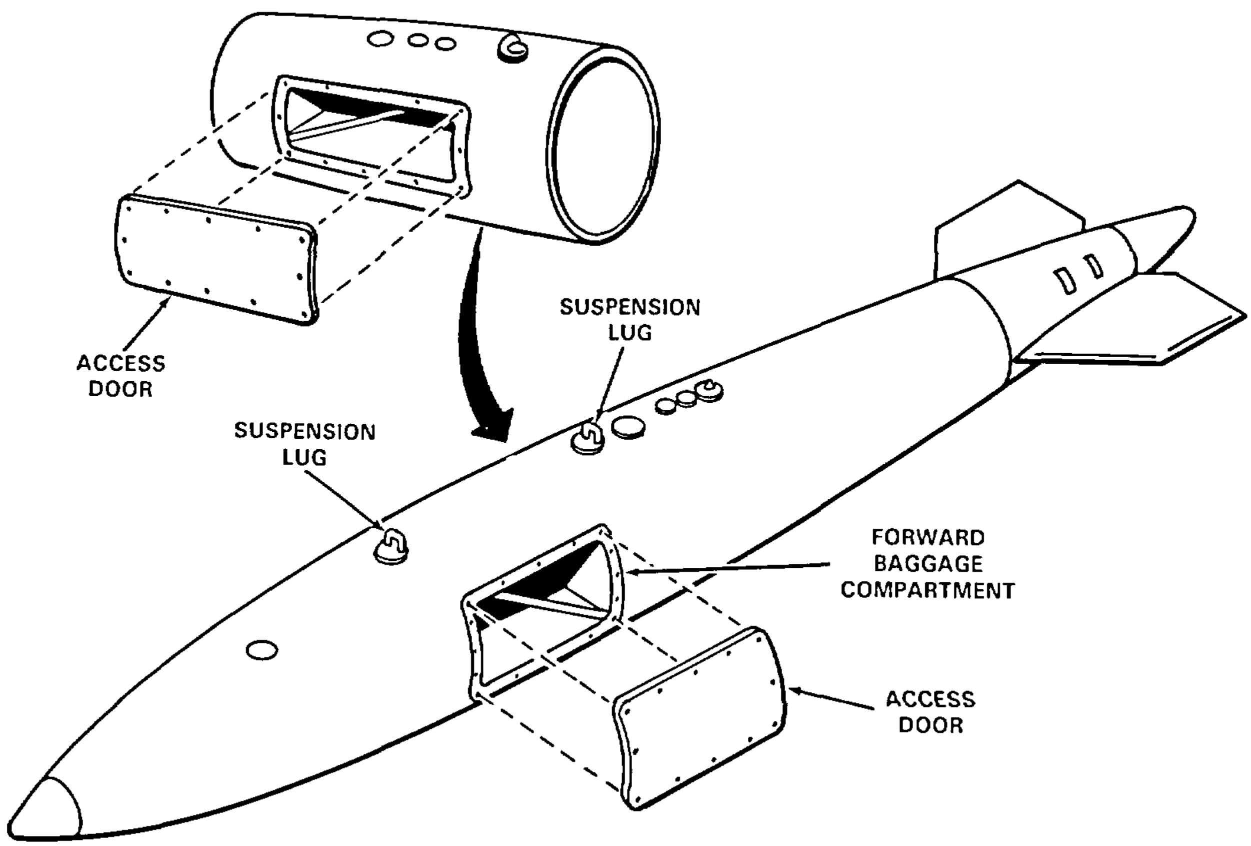
Refer to Chapter 9 for banner-towed target procedures and Chapter 4 for banner towing restrictions.

2.39.1 Shipboard Banner-Towed Target Equipment. The aerial banner-towed target equipment for shipboard use consists of a tow adapter, a standard 8 × 40 foot aerial banner tow target, 1,200 feet of half inch diameter nylon tow line fitted at both ends with thimbles, packed into a bundle 8 feet long and 30 inches wide, and 75 feet of 3/16-inch diameter steel cable leader fitted at the aircraft towing end with a Mk 8 Mod 0 target release ring.

2.40 EXTERNAL BAGGAGE CONTAINER (CNU-188/A)

The external baggage container (Figure 2-95) is a modified Aero 1D 300-gallon fuel tank that incorporates forward and aft baggage compartments. Each compartment has an access door (forward, left side; aft, right side), a shelf, and a baggage tiedown harness. The tiedown harness consists of two sets of seatbelt straps that form a crossover pattern to secure baggage to the shelf. The external baggage container may be loaded with any equipment that fits within the confines of the shelf, does not exceed the shelf weight, and maintains the cg limits. Locate baggage as near the center of the shelf as possible. Care should be taken to ensure that straps are tight to preclude any significant shift of cargo.

WEIGHT:	218 LB.
LENGTH:	227 IN.
DIAMETER:	26.5 IN.
CAPACITY:	350 LB.
SUSPENSION:	30 IN.



CNU-188/A EXTERNAL BAGGAGE CONTAINER

14B-F092

Figure 2-95. External Baggage Container (CNU-188/A)

CHAPTER 3

Servicing and Handling

3.1 SERVICING DATA

The following servicing data is for use of the flightcrew and maintenance crews who are unfamiliar with servicing the aircraft (Figure 3-1.) When operating in and out of military airfields, consult the current DOD IFR supplement for compatible servicing units, fuel, etc. Figure 3-2 contains a tabulation of servicing data and power units required to support the aircraft

3.1.1 Ground Refueling. Single-point refueling is provided for pressure filling of all aircraft fuel tanks through a standard refueling receptacle on the lower right side of the forward fuselage. Ground refueling is controlled by two precheck selector valves and the vent pressure gauge adjacent to the refuel receptacle on the ground refuel and defuel panel. Positioning of these valves can be used for selective ground refueling of either the fuselage or wing and drop tanks. The direct-reading vent pressure gauge indicates pressure in the system vent lines. When aircraft fuel tanks are full, fueling stops automatically. For hot refueling procedures, refer to Chapter 7. For defueling procedures, refer to NAVAIR 01-F14AAA-2-1.

The maximum refueling rate is approximately 500 gallons per minute at a pressure of 50 psi. Nominal and minimum pressure is approximately 15 psi; maximum pressure is 50 psi.

WARNING

Ensure that both the fueling unit and the aircraft are properly grounded, bonding cable is connected between aircraft and refueling source, and that fire extinguishing equipment is readily available.

CAUTION

During ground refueling operations, the direct-reading vent pressure indicator shall be observed and refueling stopped if pressure indication is in the red band (above 4 psi).

Note

- If the aircraft is being regularly serviced with JP-4 type fuel, the main fuel-control fuel-grade (specific gravity adjustment) selector on each engine should be reset to the JP-4 position. If the aircraft is being regularly serviced with JP-8 or JP-5 fuel, the fuel-control fuel-grade (specific gravity adjustment) selector on each engine should be reset to the JP-5 position. Satisfactory engine performance depends upon trimming of the engine fuel controls to ensure rated thrust, to prevent exceeding engine temperature limits, and to ensure airflow compatibi–lity with the air inlet duct opening.

- Removal of JP-8 type fuel from the aircraft is not required before refueling with JP-5. If removal of JP-8 from the aircraft aboard ship is necessary, it shall not be defueled into the storage tanks containing JP-5.

3.1.2 Engine Oil. For normal servicing, the sight gauge on the oil storage tank is the primary indicator as to whether servicing is required. During servicing, overflow oil exits the overflow discharge port when the tank is properly serviced (Figure 3-3, sheet 2). Servicing is accomplished using the PON-6 servicing cart. Normal oil consumption is 0.03 gallon per hour with the maximum being 0.1 gallon per hour. For oil servicing

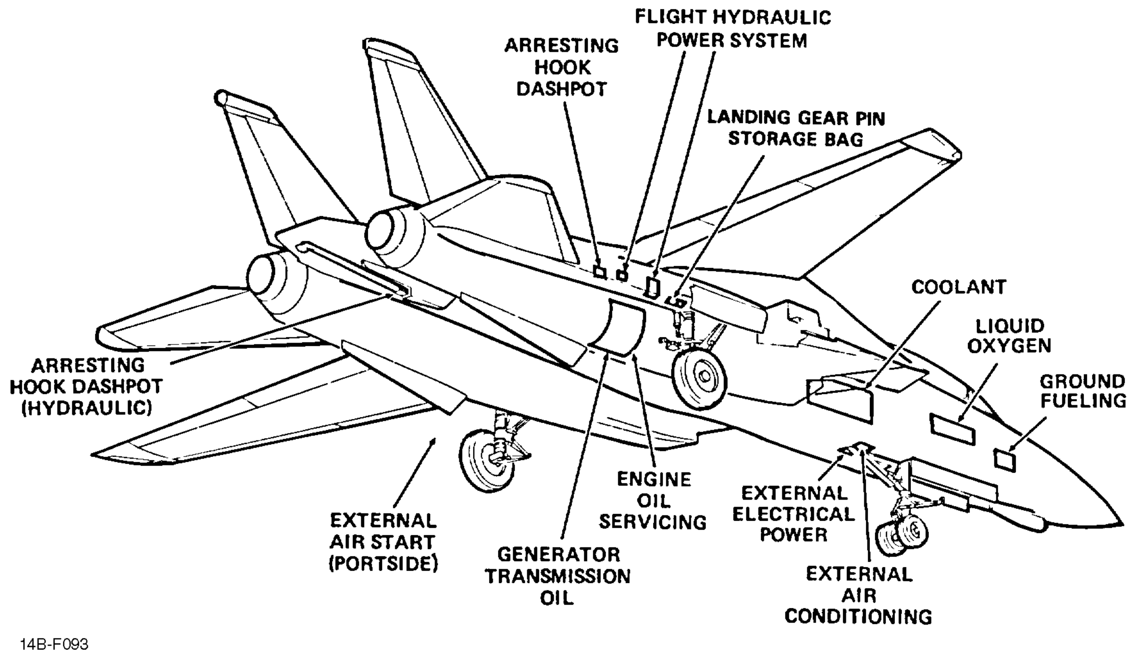


Figure 3-1. Aircraft Servicing Locations

procedures, refer to NAVAIR 01-F14AAA-2-1. The protrusion of a bypass indicator underneath the oil scavenge pump indicates a clogged filter element and requires replacement.

WARNING

- Lubricating oil, MIL-L-23699, is toxic and flammable. Protection: chemical splash-proof goggles, gloves, and good ventilation; keep sparks, flames, and heat away. Keep lubricating oil off skin, eyes, and clothes; do not breathe vapors. Wash hands thoroughly after handling.

- Do not overservice oil storage tank. Overservicing can cause scavenge pump failure and subsequent engine failure.

Note

Engine oil level should be checked within 30 minutes of engine shutdown, otherwise run engine at 80-percent rpm or greater for 10 minutes to ensure proper servicing.

3.1.3 Integrated Drive Generator Oil. The IDG has a filter bypass indicator at the bottom of the filter bowl (Figure 3-3, sheet 2). Extension of the indicator indicates contamination of the filter and the need for filter element replacement. Refer to NAVAIR 01-F14AAA-2-1 for IDG oil filter replacement and servicing.

IDG oil level is checked at the IDG mounted on the forward right side of the forward accessory gearbox of each engine. It is serviced at the pressure fill port on the right side.

To obtain a valid fluid level check, the sight gauge must be checked no sooner than 5 minutes and no later than 60 minutes after engine shutdown.

ITEM	DESIGNATION SPECIFICATION	NATO CODE	COMMERCIAL EQUIVALENT	DOD IFR SUPPLEMENT CODE	REMARKS
Fuel	MIL-T-5624 (JP-5)	F-44	Jet A	JP-5	Selector (main engine control) on both engines should be set for type fuel in use. (JP-8 is equivalent to JP-5)
	MIL-T-5624 (JP-4)	F-40	Jet B	JP-4	
	MIL-T-83133 (JP-8)	F-34	Jet A-1	JP-8	
Engine oil	MIL-L-23699	0-156	None	0-156	Use MIL-L-7808 when ground temperature is –40 °F (–40 °C).
	MIL-L-7808	0-148	None	0-148	
Integrated Drive Generator (IDG) Transmission oil	MIL-L-23699 MIL-L-7808	0-156 0-148	None None	0-156 0-148	Use MIL-L-7808 when ground temperature is –40 °F (–40 °C).
Hydraulic fluid	MIL-H-83282	None	None	None	
Oxygen (Liquid)	MIL-0-27210 type II	None	None	LOX	
Oxygen (Gaseous)	MIL-0-27210 Type I	None	None	HPOX LHOX	Survival kit shall be removed from aircraft for servicing emergency oxygen bottle.
Nitrogen	BB-N-411 (Type I, Grade A)	None	None	None	Use clean, oil-free filtered dry air, if nitrogen is not available.
Liquid Coolant	Coolant 25, 25R (Monsanto Chemical Co)	None	NA	None	Either coolant may be mixed without adverse reaction.
	Chevron Flo-Cool 180 (Chevron Chemical Co)	None	NA	None	
Wipe On Rain Repellant Fluid	MIL-W-6882	None	None	None	Clean and dry windshield. Apply with cloth using overlapping wipes. After 1-minute drying, wipe clean with soft cloth.

Figure 3-2. Aircraft Servicing Data (Sheet 1 of 2)

	POWER			
	PNEUMATIC STARTING	ELECTRICAL POWER	AIR CONDITIONING	HYDRAULIC
Acceptable USN Units	ASHORE: NCPP-1O5 RCPT-1O5 A/M47A-4 AFLOAT: A/S47A-1	NC8A MD-3 MD-3A MD-3M MA-3MPSU A/M32A-60 A/M32A-60A	NR 5C (electrical) NR 8 (diesel) MA-1 MA-1A A/M32C-5 A/M32C-6	AHT-63/64 TTU-228/E (AHT-73) MJ-3
Ground Support Equipment Requirements	200 lb/min at 75±3 psi (STD. DAY)	115±20 V AC, 400±25 Hz, 60 kVA, 3 phase rotation	70 lb/min At 3 psi and 60 °F	50 gal/min maximum at 3,000 psi

PNEUMATIC PRESSURE	
SYSTEM	PRESSURE
Emergency Landing Gear	3,000 psi at 70 °F
Combined Hydraulic	1,800 psi at 70 °F
Flight Hydraulic	1,800 psi at 70 °F
Canopy Normal (1,200 psi Minimum)	3,000 psi at 70 °F
Canopy Auxiliary (800 psi Minimum)	3,000 psi at 70 °F
Wheel brake accumulators (2)	1,900 psi at 70 °F
Arresting Hook Dashpot	800±10 psi
Main Gear Shock Struts (2)	980 psi
Nose Gear Shock Strut	1,300 psi

TIRES		
TYPE	OPERATION	PRESSURE
Nose (2) 22 X 6.6-10 20 Ply	Ashore Afloat	105 psi 350 psi
Main (2) 37 X 11.50-16 28 Ply	Ashore Afloat	245 psi 350 psi

N5/95

Note

Dry nitrogen, specification BB-N-411, Type 1, Grade A, is preferred for tire inflation and charging pneumatic systems since it is inert, and therefore will not support combustion.

Figure 3-2. Aircraft Servicing Data (Sheet 2)

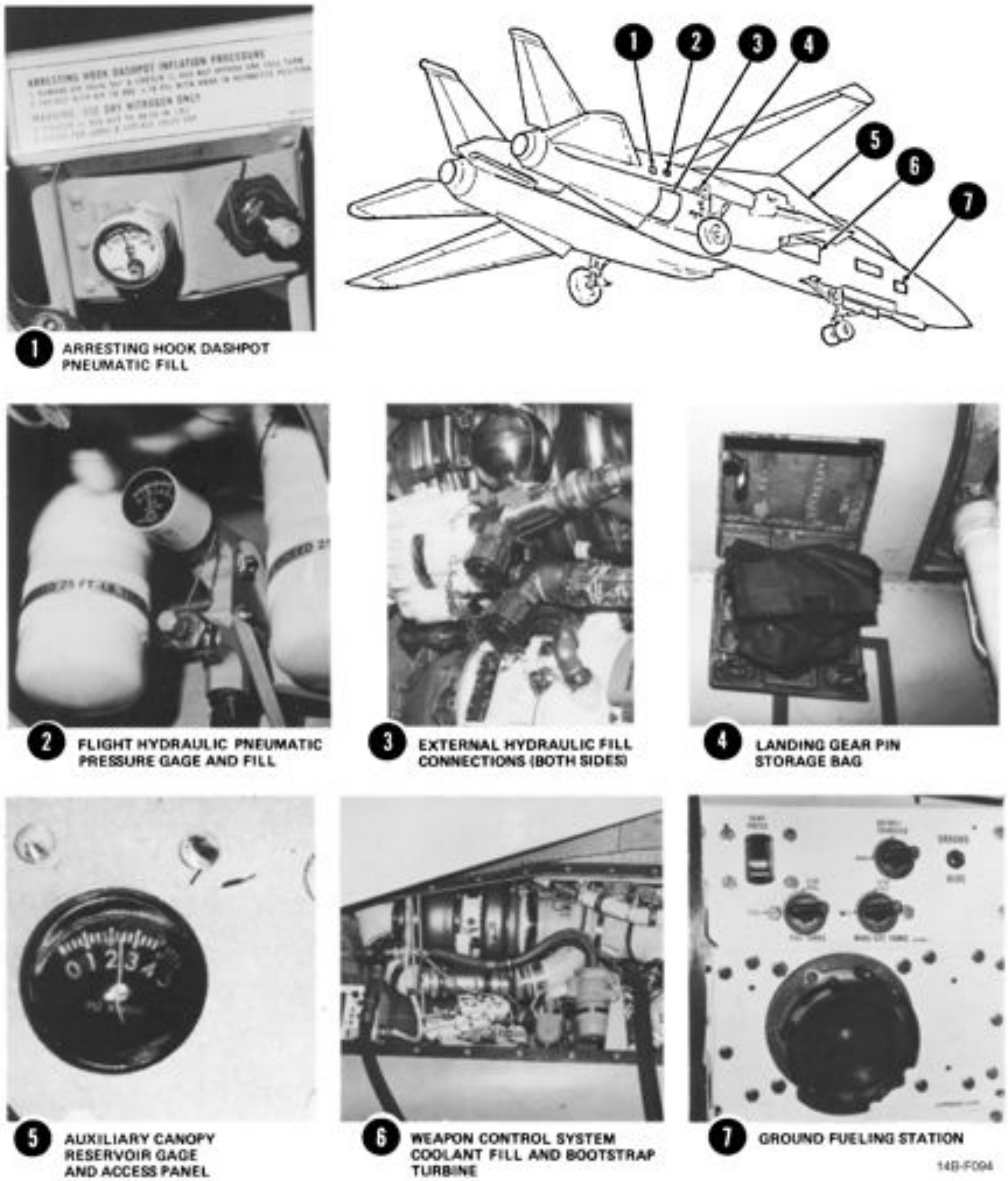


Figure 3-3. Aircraft Servicing (Sheet 1 of 3)

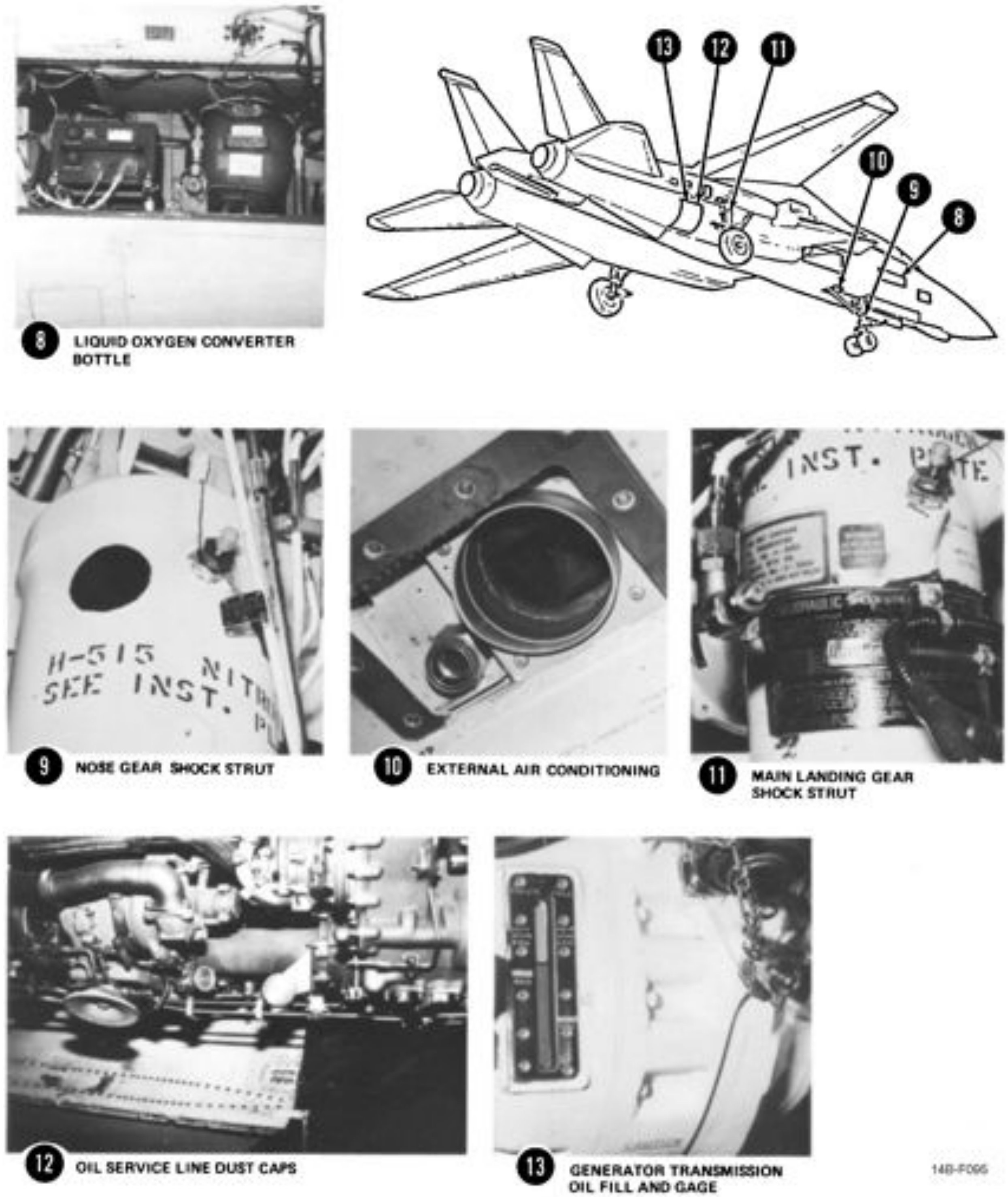


Figure 3-3. Aircraft Servicing (Sheet 2)

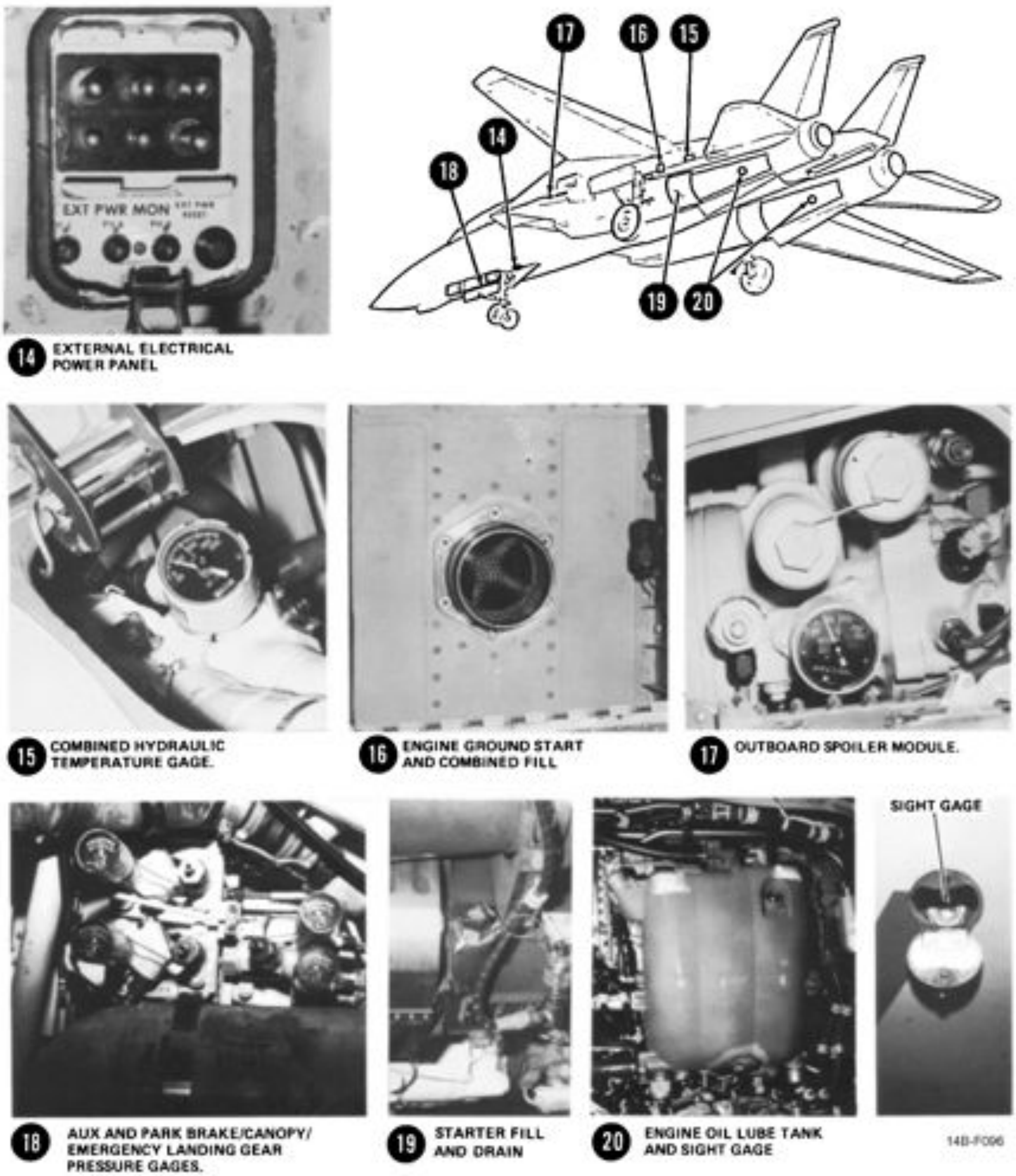


Figure 3-3. Aircraft Servicing (Sheet 3)

3.1.4 Hydraulic Systems. The main hydraulic systems are serviced at the flight and combined hydraulic system ground servicing panels. A hydraulic pressure filling cart is required to service the systems with fluid, and an air-nitrogen cart is required to preload the reservoirs. The outboard spoiler backup module is serviced at the servicing panel on the outboard nacelle of the port engine. Additional hydraulic servicing is required at the main landing gear shock strut (Figure 3-3, sheet 2), the nosewheel shock strut (Figure 3-3, sheet 2), and the arresting hook dashpot (see Figure 3-3, sheet 1).

The flight reservoir fill and ground power access panel and the flight system filter module (Figure 3-3, sheet 1) are on the starboard side. Indication of hydraulic system fluid contamination can be detected by the position of the buttons on the delta-P type filter units.

The combined hydraulic system reservoir fill and filter module (Figure 3-3, sheet 3) are on the port side of the aircraft. A temperature recording gauge in the same area indicates the maximum temperature attained by the hydraulic fluid during the last turnup or flight. After a reading has been taken, the temperature gauge must be reset prior to the next turnup.

3.1.5 Pneumatic Systems. The pneumatic power supply systems, which provide for normal operation of the canopy and for emergency extension of the landing gear, are ground charged through a common filler in the nose wheelwell (see Figure 3-3, sheet 3). The auxiliary canopy open pneumatic bottle is in the turtleback behind the cockpit (see Figure 3-3, sheet 1). Additional pneumatic servicing points are at both hydraulic systems, servicing panels, brake systems, and at the arresting hook.

Individual pneumatic servicing points and pressure gauges are provided for the auxiliary and parking brake systems.

Note

Dry nitrogen, specification BB-N-411B, Type 1, Grade A, is preferred for tire inflation and for charging pneumatic systems since it is inert and, therefore, will not support combustion.

3.2 GROUND HANDLING

3.2.1 Danger Areas. Engine exhaust and intake danger areas are shown in Figure 3-4. Noise danger areas are shown in Figure 3-5. Figure 3-4 shows temperature distribution with afterburners at maximum nozzle opening for idle, military, and maximum power. Figure 3-4 shows exhaust jet wake velocity distribution with afterburner at maximum nozzle opening for idle, military, and maximum power.

WARNING

- The high temperature and velocity of the engine exhaust is extremely dangerous. Stay outside the engine exhaust area included within a 90° cone extending 900 feet behind the aircraft.
- Suction at the air intake is strong enough to kill or seriously injure personnel by drawing them into or against the inlet.
- All personnel in the immediate area shall wear ear protection whenever an engine is operating.

Note

- If engines are run up in front of a blast deflector, exhaust jet wake is deflected up and to the sides resulting in distortion of the patterns shown.
- At maximum afterburner power, nozzles are nearly fully open; at military power the nozzles are nearly fully closed.

3.2.2 Radiation Hazard Areas. Radiation hazards from high-power radio and radar radiation are included in NAVAIR 01-F14AAA-1A.

3.2.3 Fuel Ignition Hazard. When performing fueling or defueling operations, use minimum safe distances outside of radiation hazard areas. Fuel ignition hazard occurs within 90 feet of the aircraft where radio frequency radiation-induced sparks could ignite flammable vapors of fuels. Fuel ignition hazard is based on $5W/cm^2$ peak power density.

WARNING

- AT HIGH TRUST SETTINGS, THE SUCTION DANGER AREA AROUND ENGINE INLETS MAY EXTEND AS FAR AS 4 FEET AFT OF THE INLET DUCT LOWER LIP.
- EAR PROTECTION SHALL BE WORN AT ALL TIMES.

NOTE

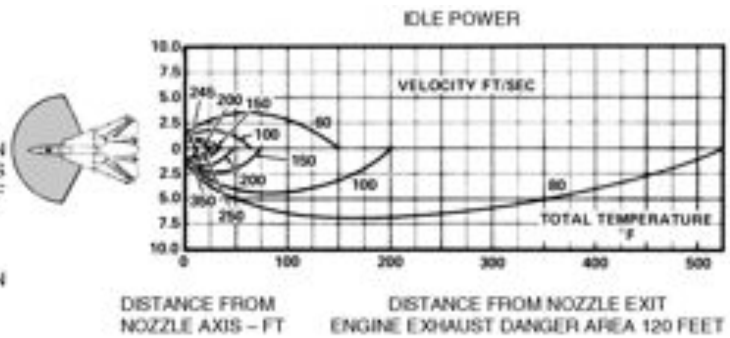
- THIS ILLUSTRATION CONTAINS ESTIMATED EXHAUST JET WAKE VELOCITY AND TOTAL TEMPERATURE DISTRIBUTION OF F110-GE-400 (F-14B AIRCRAFT) MIXED FLOW AUGMENTED (AFTERBURNING) TURBOFAN ENGINE. THIS IS IN ACCORDANCE WITH GENERAL ELECTRIC GEK 92500 OPERATION AND SERVICING MANUAL WITH MAXIMUM OPENING FOR IDLE POWER AND FULLY CLOSED (MINIMUM OPENING) FOR MILITARY POWER.

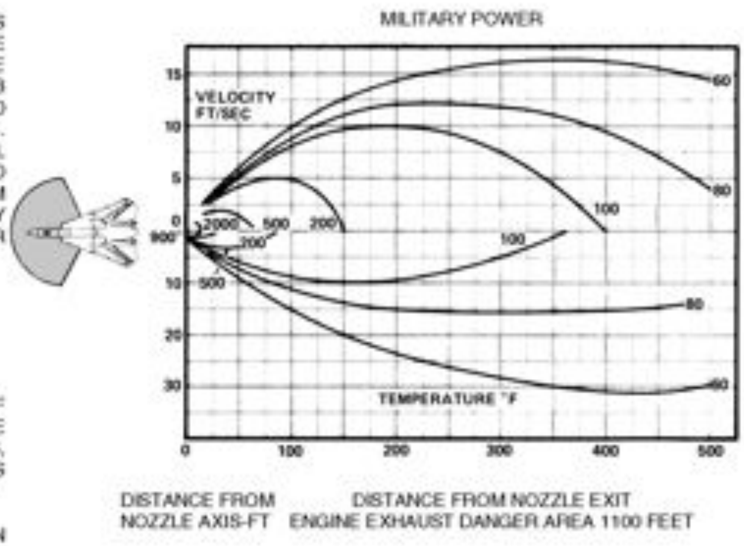
WARNING

- IF ENGINES ARE RUN UP IN FRONT OF BLAST DEFLECTOR, EXHAUST JET WAKE IS DEFLECTED UP AND TO SIDES, RESULTING IN DISTORTION OF PATTERNS SHOWN.
- AT HIGH TRUST SETTINGS, THE SUCTION DANGER AREA AROUND ENGINE INLETS MAY EXTEND AS FAR AS 4 FEET AFT OF THE INLET DUCT LOWER LIP.
- EAR PROTECTION SHALL BE WORN AT ALL TIMES.

NOTE

- THIS ILLUSTRATION CONTAINS ESTIMATED EXHAUST JET WAKE VELOCITY AND TOTAL TEMPERATURE DISTRIBUTION OF F110 GE 400 (F-14A (PLUS) AIRCRAFT) MIXED FLOW AUGMENTED (AFTERBURNING) TURBOFAN ENGINE. THIS IS IN ACCORDANCE WITH GENERAL ELECTRIC GEK 92500 OPERATION AND SERVICING MANUAL WITH MAXIMUM NOZZLE OPENING FOR MAXIMUM AUGMENTED (MAX AB POWER.
- IF ENGINES ARE RUN UP IN FRONT OF BLAST DEFLECTOR, EXHAUST JET WAKE IS DEFLECTED UP AND TO SIDES, RESULTING IN DISTORTION OF PATTERNS SHOWN.





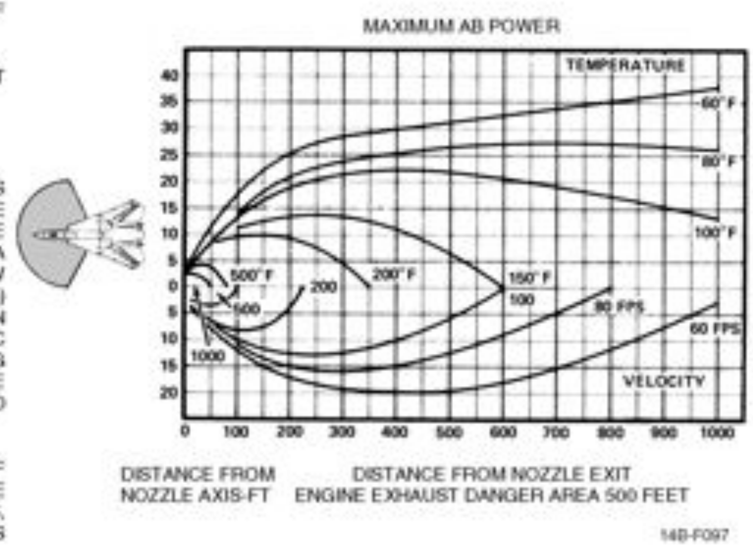


Figure 3-4. Runup Danger Areas — Exhaust Jet Wake Velocity and Temperature

SOUND LEVELS IN dBA		
THIS TABLE CONTAINS ESTIMATED SOUND LEVELS FOR F110-GE-400 (MIXED FLOW) AUGMENTED) AFTERBURNING TURBOFAN ENGINE. SOUND LEVEL CONTOUR LETTERS A, B, C, AND D (SHOWN IN THIS ILLUSTRATION) REPRESENT A SPECIFIC dBA VALUE. WHEN dBA VALUE IS IN THIS TABLE, IT SHALL BE SUBSTITUTED IN PLACE OF CONTOUR LETTER.		
CONTOUR	MAXIMUM AFTERBURNER POWER	MILITARY POWER
A	145	140
B	140	135
C	135	132
D	130	130

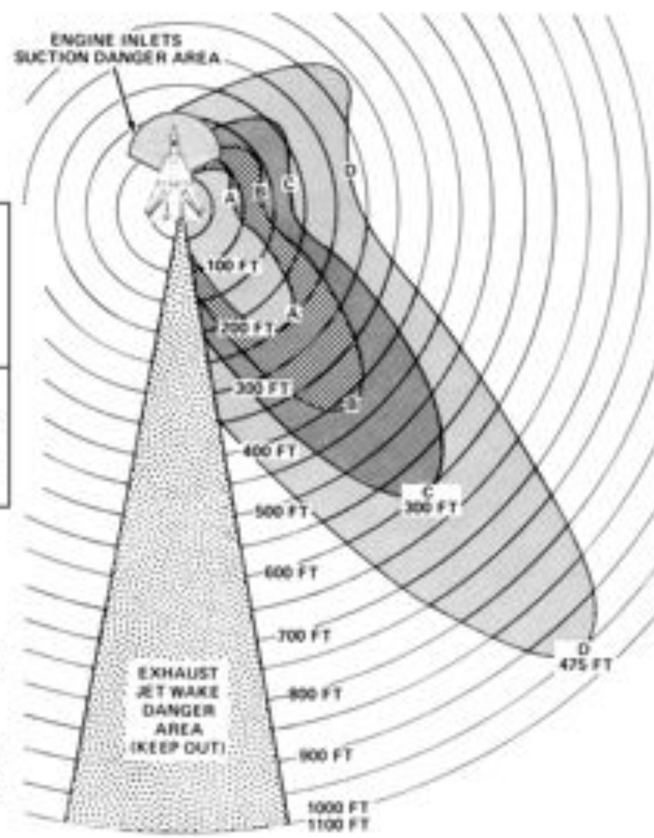
ALLOWABLE NOISE EXPOSURE SOUND LEVEL IN dBA (SLOW RESPONSE)							
TYPE EAR PROTECTIVE DEVICES	EXPOSURE TIME (HRS*)						
	1/4	1/2	1	2	4	6	8
NO PROTECTION	109	104	99	94	89	86	84
EARPLUGS WITH AVERAGE SEAL	123	118	113	108	103	100	98
EARPLUGS AND EAR MUFFS	129	124	119	114	109	106	104

* DURATION OF EXPOSURE PER DAY
REF. BUMED INST 6260.5B, 5 MARCH 1970

NOTE

SOUND LEVEL CONTOURS SHOWN ARE FOR SINGLE-ENGINE OPERATION. CONTOURS ARE SYMMETRICAL ABOUT ENGINE CENTERLINES DURING DUAL-ENGINE OPERATION.

EAR PROTECTIVE DEVICES



WARNING

- EARPLUGS AND EAR MUFFS SHALL BE WORN TOGETHER WHEN PERFORMING ENGINE RUNUP.
- IF ENGINES ARE RUN UP IN FRONT OF BLAST DEFLECTOR, EXHAUST JET WAKE AND SHOULD SHALL BE DEFLECTED UP AND TO SIDES, RESULTING IN DISTORTION OF CONTOUR PATTERNS SHOWN.
- AT MAXIMUM POWER, F110-GE-400 ENGINE AFTERBURNERS ARE AT MAXIMUM NOZZLE OPENING (ZONE 5). AT MILITARY POWER THE NOZZLES ARE FULLY CLOSED (MINIMUM OPENINGS).

14B-F098

Figure 3-5. Noise Danger Areas

Good housekeeping operations are of utmost importance in areas where radar transmission is anticipated. Rf radiation may cause steel wool to be set afire or metallic chips to produce sparks, which in turn may ignite spilled fuels or oils around aircraft and buildings. Keep all areas clean and refuse in approved containers.

3.2.4 Transmission Aboard Carrier. Radar transmission aboard a carrier shall be limited to over-the-side operation at the discretion of the commander. The aircraft shall be spotted so the nose radome overhangs the side of the carrier. All necessary safety precautions shall be enforced to prevent injury to personnel and damage to equipment aboard the carrier and on adjacent ships that may accidentally stray into the main beam of the radar.

3.2.5 Towing Turn Radii and Ground Clearances. Forward and rearward towing (Figure 3-6 and Figure 3-7) can be accomplished with a standard tow bar (NT-4 aircraft universal tow bar) and the tow tractor. The pilot cockpit shall be manned with qualified personnel during towing operations.

CAUTION

Before and during towing, ensure that the needle(s) in the AUX/PARK brake pressure gauge(s) remain in the green band to ensure sufficient pressure to lock the wheels.

3.2.6 Tiedown Points. Aircraft tiedown points are illustrated in Figure 3-8. When mooring a parked aircraft, do not depend upon chocks alone to hold the aircraft in position. Tiedowns shall be installed in a symmetrical pattern being careful not to chafe against the aircraft structure.

The normal six-point tiedown (Figure 3-8, sheet 1) locations permit all maintenance servicing including engine removal, jacking, and weapons loading. Standard chain-type tiedowns are used for an 18-point symmetrical tiedown during heavy weather (Figure 3-8, sheet 2).

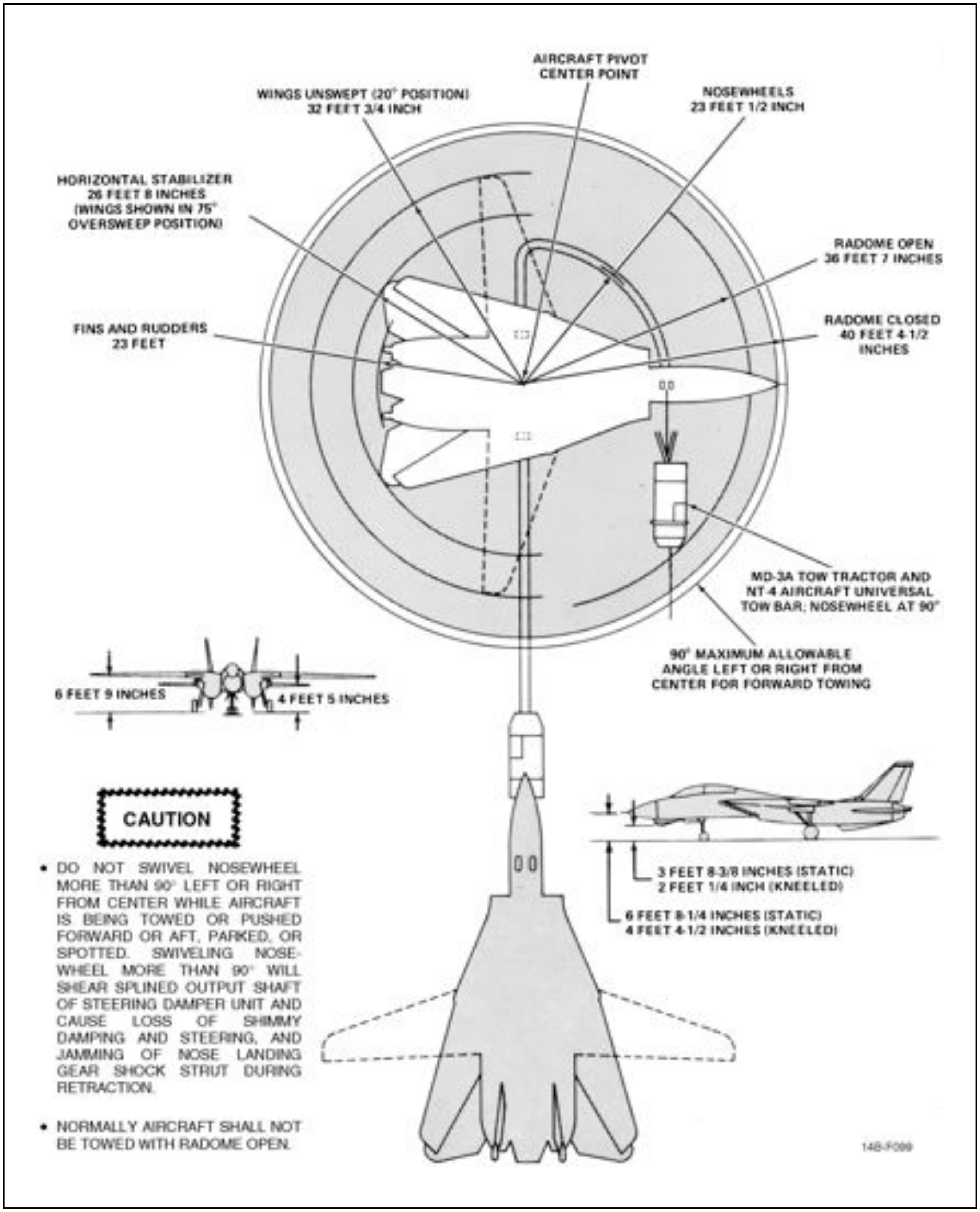


Figure 3-6. Towing Turn Radii

CAUTION

DO NOT EXCEED 120° MAXIMUM AVAILABLE NOSEWHEEL SWIVEL ANGLE DURING PARKING OR SPOTTING IN TIGHT SPACES; STEERING DAMPER UNIT WILL BE DAMAGED.

CAUTION

- AUTHORIZED BRAKE RIDER SHALL MAN PILOT STATION AT ALL TIMES DURING TOWING, EXCEPT WHEN TOWING AIRCRAFT WITH INOPERATIVE BRAKES.
- WING AND TAIL WALKERS, AND MAIN LANDING GEAR CHOCK MEN SHALL BE AVAILABLE AT ALL TIMES DURING TOWING.
- IN NOSEWHEEL WELL, BRAKE ACCUMULATORS PRESSURE GAGE SHALL INDICATE 3,000 psi ON PILOT CENTER CONSOLE, BRAKE PRESSURE INDICATOR NEEDLE SHALL BE AT RIGHT END OF AUX GREEN BAND.

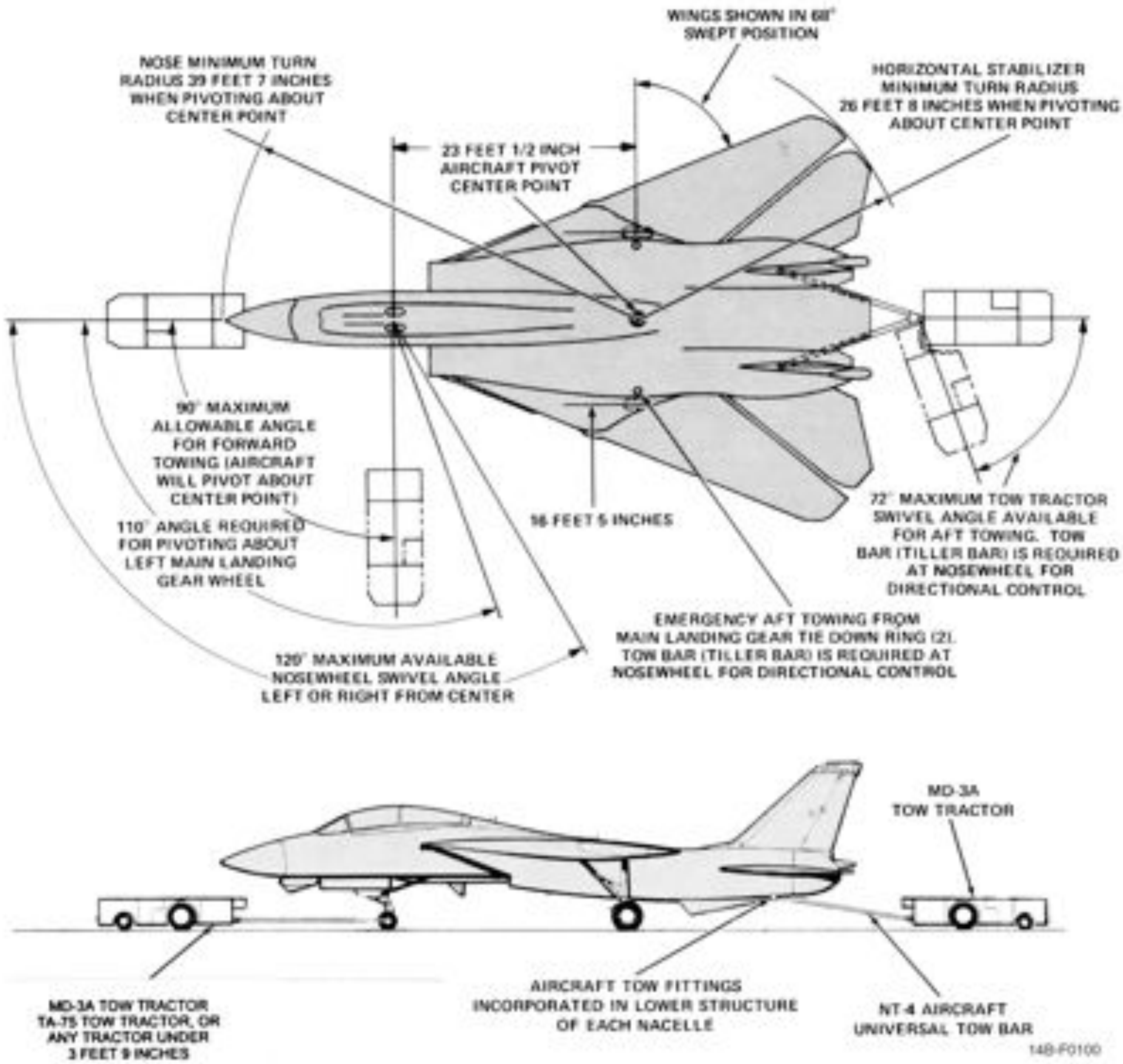
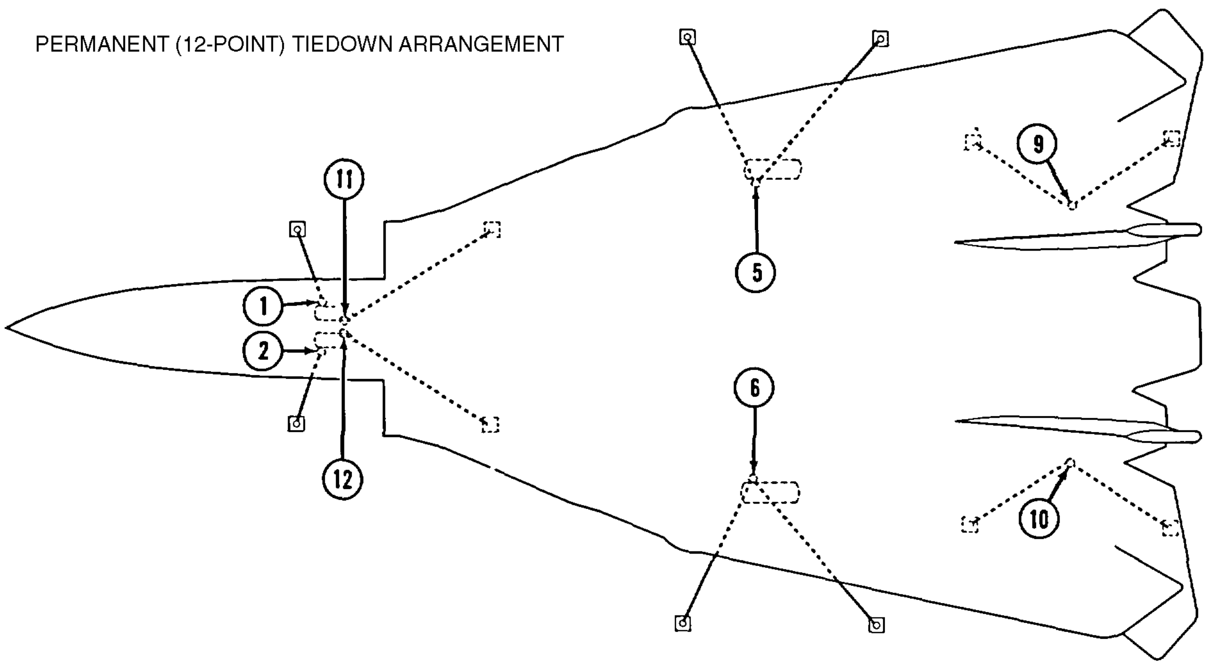


Figure 3-7. Towing

PERMANENT (12-POINT) TIEDOWN ARRANGEMENT



AIRCRAFT TIEDOWN FITTINGS

LOCATION	FITTING NO.	ACCESS NO.	HEIGHT ABOVE GROUND	FUSELAGE STATION
FUSELAGE	1	2221-4	62 INCHES	296.0
	2	1221-6		
MAIN GEAR SHOCK STRUT (OUTBOARD SIDE)	5	—	43 INCHES	567.0
	6			
MAIN GEAR SHOCK STRUT (LOWER INBOARD SIDE)	7	—	10.5 INCHES	569.0
	8			
SPONSON (BELOW HORIZONTAL STABILIZER)	9	6232-3	60 INCHES	747.0
	10	5232-3		
NOSE GEAR DRAG BRACE	11	—	44 INCHES	297.9
	12			

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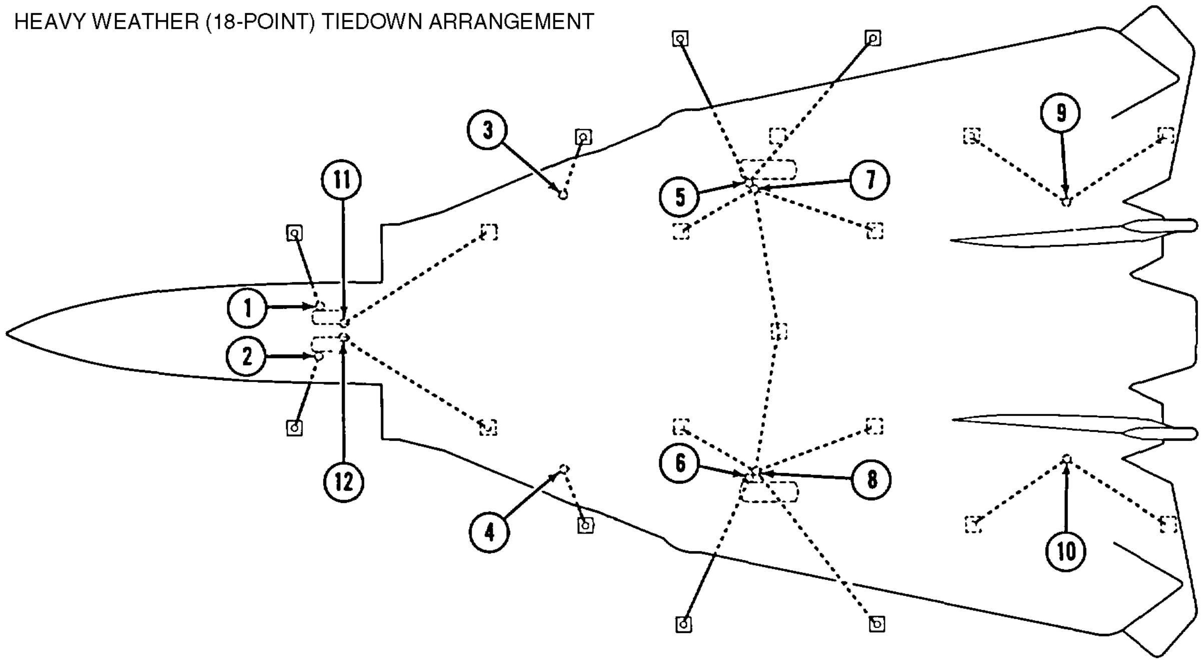
Figure 3-8. Tiedown Arrangement (Sheet 1 of 2)

HEAVY WEATHER (18-POINT) TIEDOWN ARRANGEMENT



AIRCRAFT TIEDOWN FITTINGS

LOCATION	FITTING NO.	ACCESS NO.	HEIGHT ABOVE GROUND	FUSELAGE STATION
FUSELAGE	1	2221-4	62 INCHES	296.0
	2	1221-6		
WING GLOVE	3	2233-5	85.3 INCHES	451.75
	4	1233-5		
MAIN GEAR SHOCK STRUT (OUTBOARD SIDE)	5	—	43 INCHES	567.0
	6			
MAIN-GEAR SHOCK STRUT (LOWER INBOARD SIDE)	7	—	10.5 INCHES	569.0
	8			
SPONSON (BELOW HORIZONTAL STABILIZER)	9	6232-3	60 INCHES	747.0
	10	5232-3		
NOSE GEAR DRAG BRACE	11	—	44 INCHES	297.9
	12			

14B-F0102

Figure 3-8. Tiedown Arrangement (Sheet 2)

CHAPTER 4

Operating Limitations

4.1 LIMITATIONS

This section includes the aircraft and engine limitations that must be observed during normal operations. The aerodynamic and structural limitations in this section apply only to F-14B aircraft for the store station configurations shown in Figure 4-1. Engine limitations apply to all aircraft with the F110-GE-400 engine.

4.1.1 Engine Limits. Engine instrument markings for various operation limitations are shown in Figure 4-2. Engine operating limitations are shown in Figure 4-3.

The engine secondary (SEC) mode may be intentionally selected in flight only under the following conditions:

1. Engine operating between 85-percent rpm and military power

2. Airspeed less than 1.0 IMN.

4.1.2 Starter Limits. Starter cranking limits are as follows:

1. Crossbleed — 2 minutes.

2. Start cart — 5 minutes.

When the time limit is reached, 10 minutes cooling is required before cranking engine.

4.1.3 Airstart Envelope. The engine spooldown and windmill airstart envelopes are shown in Figure 4-3.

4.1.4 Crosswind Limits. Crosswind takeoffs and landings are permitted with a crosswind component not to exceed 20 knots at 90°.

4.1.5 Ground Operation Limits.

1. Maximum tire speed — 190 knots.

2. Maximum canopy-open speed — 60 knots.

WARNING

Use of antiskid must be in accordance with the following procedures:

- Select antiskid while stopped on the runway in the takeoff position. After landing, turn antiskid off once slowed below 15 knots prior to clearing the runway.

- Use only during landing or aborted takeoff.

- Do not use antiskid while taxiing.

4.1.6 Ejection Seat Operation Limits. See ejection envelope curves in Figure 16-1.

1. Maximum speed (seat) 450 KIAS/0.9 IMN (whichever is greater).

4.1.7 Limits. Autopilot should not be used under the following conditions:

1. Airspeeds greater than 400 KIAS/0.9 IMN

2. Altitude above 42,500 feet.

4.2 AIRSPEED LIMITATIONS

The limits and restrictions in this chapter represent the maximum capability of the aircraft commensurate with safe operations. Aerodynamic and structural excesses of these limits shall be entered on the Maintenance Action Form for appropriate maintenance action.

STORE CONFIGURATION	AIRCRAFT STORE STATION						
	1A	1B	2	3, 4, 5, & 6	7	8B	8A
1A(*)	—	—	—	—	—	—	—
1B1	AIM-9	AIM-9	—	—	—	AIM-9	AIM-9
1B2	AIM-9	—	—	—	—	—	AIM-9
1C	—	—	TANK	—	TANK	—	—
2A(*)	—	—	—	4 AIM-7	—	—	—
2B1	AIM-9	AIM-9	—	4 AIM-7	—	AIM-9	AIM-9
2B2	AIM-9	—	—	4 AIM-7	—	—	AIM-9
2B3	AIM-9	AIM-7	—	4 AIM-7	—	AIM-7	AIM-9
2B4	—	AIM-7	—	4 AIM-7	—	AIM-7	—
2C(*)	—	—	TANK	4 AIM-7	TANK	—	—
2C1	AIM-9	AIM-9	TANK	4 AIM-7	TANK	AIM-9	AIM-9
2C2	AIM-9	—	TANK	4 AIM-7	TANK	—	AIM-9
2C3	AIM-9	AIM-7	TANK	4 AIM-7	TANK	AIM-7	AIM-9
2C4	—	AIM-7	TANK	4 AIM-7	TANK	AIM-7	—
3A(*)	—	—	—	4 AIM-54	—	—	—
3B1	AIM-9	AIM-9	—	4 AIM-54	—	AIM-9	AIM-9
3B2	AIM-9	—	—	4 AIM-54	—	—	AIM-9
3B3	AIM-9	AIM-7	—	4 AIM-54	—	AIM-7	AIM-9
3B4	—	AIM-7	—	4 AIM-54	—	AIM-7	—
3B5	AIM-9	AIM-54	—	4 AIM-54	—	AIM-54	AIM-9
3B6	—	AIM-54	—	4 AIM-54	—	AIM-54	—
3C(*)	—	—	TANK	4 AIM-54	TANK	—	—
3C1	AIM-9	AIM-9	TANK	4 AIM-54	TANK	AIM-9	AIM-9
3C2	AIM-9	—	TANK	4 AIM-54	TANK	—	AIM-9
3C3	AIM-9	AIM-7	TANK	4 AIM-54	TANK	AIM-7	AIM-9
3C4	—	AIM-7	TANK	4 AIM-54	TANK	AIM-7	—
3C5	AIM-9	AIM-54	TANK	4 AIM-54	TANK	AIM-54	AIM-9
3C6	—	AIM-54	TANK	4 AIM-54	TANK	AIM-54	—

WARNING

- In all cases the center of gravity position must remain within limits. The aft limit can be easily exceeded if stations 3 and 6 are not loaded.
- With MASTER ARM ON and all conditions satisfied for AIM-54 launch, an ATM-54 (training round) will be ejected if the trigger or launch button is depressed.
- With MASTER ARM ON and all other conditions satisfied for AIM-7 launch, a CATM-7F-1 (Sparrow training round) will be ejected when the trigger or launch button is pressed unless a modified shear wafer is installed. Emergency/selective jettison of a CATM-7F-1 is still possible with a modified shear wafer installed.

(*) These store configuration limits also apply when multipurpose stub pylons are carried at stations 1 and 8.

- Flight operating limitations applicable to the above configurations are also applicable to down loading there from except down load of external tank to MXU-611 shall be considered as a clean store station for limitation purposes.
- For captive carriage of inert or live AIM-54, installation of ejector cartridges in LAU-93 is mandatory in order to provide jettison capability.
- For captive carriage of inert or live AIM-7, installation of ejector cartridges in LAU-92 is mandatory in order to provide jettison capability. This does not apply to CATM-7F-2 missiles used for ballast (refer to NAVAIR 01-14AAA-75 Weapon Stores Loading Manual).
- For shorebased operations all CATM-7F-1 (Sparrow training rounds) shall be configured with a modified shear wafer to preclude inadvertent activation of the guidance and control unit, and subsequent ejection of the missile.
- Simultaneous loading of AIM-7 on store station 4 and AIM-54 on store stations 3 and 6 is an authorized configuration. Limitations of fuselage AIM-54 apply for carriage, individual missile limitations apply for launch/jettison.

Figure 4-1. Store Station Configuration

F110-GE-400
OIL: MIL-L-23699 OR MIL-L-7808
FUEL: MIL-J-5624 JP5 (JP-4, JP-8 ALTERNATES)

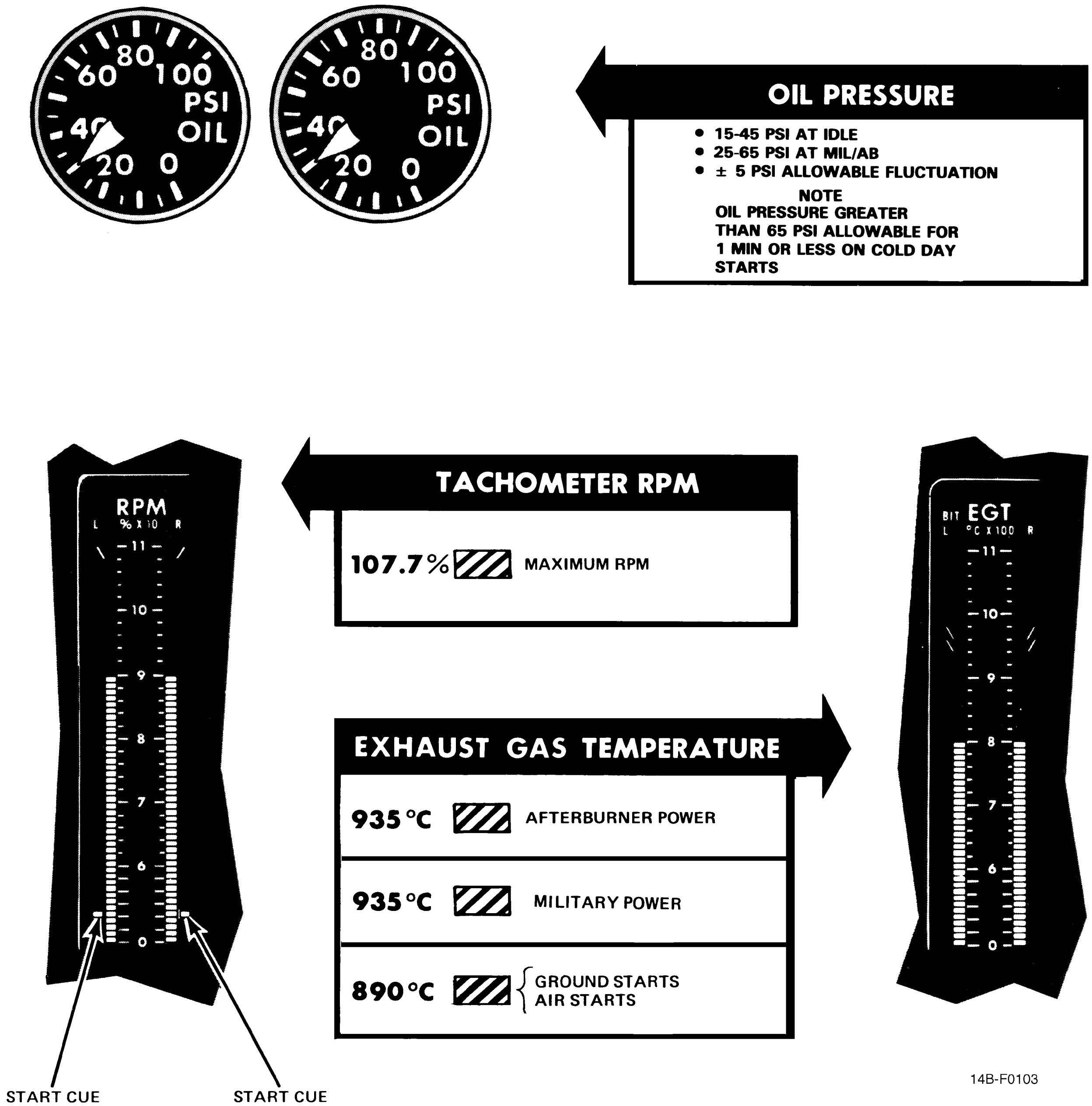


Figure 4-2. Instrument Markings

F110-GE-400

OIL: MIL-L-23699 OR MIL-L-7808

FUEL: MIL-J-5624 (JP-5) (JP-4, JP-8 ALTERNATES)

OPERATING CONDITIONS	OPERATING LIMITS	
THRUST SETTING	MAXIMUM MEASURED EXHAUST GAS TEMP (°C)	NORMAL OIL PRESSURE (PSIG)
MAXIMUM (AFTERBURNING)	935	25 TO 65
MILITARY	935	25 TO 65
IDLE STABILIZED	935	15 TO 45
STARTING		
(GROUND)	890	—
(AIRSTART)	890	—

NOTE

- OIL PRESSURE WILL INCREASE PROPORTIONATELY WITH RPM.
- UNDER COLD CONDITIONS, OIL PRESSURE MAY EXCEED 65 PSI FOR 1 MINUTE

RPM LIMITS

ANY EXCEEDED LIMIT SHOULD BE REPORTED AS A DISCREPANCY
AND MAXIMUM RPM, EGT, AND TIME NOTED.

OPERATING CONDITIONS	OPERATING LIMITS
STEADY STATE OR TRANSIENT	107.7% RPM

Figure 4-3. Engine Operating Limits

4.2.1 Maximum Airspeed. Maximum speeds are presented in indicated knots and Mach number. These values are derived from the position-error-correction curves of the production pitot-static-operated airspeed and altitude system. Angle-of-attack is presented utilizing the conventional indicated units AOA while sideslip angle limits are presented in terms of degrees rudder deflection.

Note

Unless otherwise specified, the limits presented herein pertain to flight with the stability augmentation system on.

4.2.1.1 Cruise Configuration. With wing sweep in the MANUAL or AUTO mode, the maximum allowable airspeeds are shown in Figure 4-4.

In emergency wing-sweep mode the following combination of Mach and wing-sweep schedule must be used:

<0.4 IMN — 20°

<0.7 IMN — 25°

<0.8 IMN — 50°

<0.9 IMN — 60°

>0.9 IMN — 68°

4.2.1.2 Approach Configuration

1. Landing gear — 280 KIAS.
2. Landing flaps and slats — 225 KIAS.

CAUTION

- With the landing gear extended or in transit, abrupt rolls or uncoordinated turns above 225 KIAS can cause structural failure of the landing gear doors.
- After takeoff, move the FLAP handle to the UP position passing 180 KIAS to ensure flap and slat airspeed limits are not exceeded.

4.2.1.3 In-Flight Refueling

1. Refueling probe — 400 KIAS/0.8 IMN.
2. In-flight refueling
   a. Cruise configuration — 200 to 300 KIAS/0.8 IMN.
   b. Approach configuration — 170 to 200 KIAS.

4.3 ACCELERATION LIMITS

Note

- Limits are based on a gross weight of 49,548 pounds. See Figure 4-5 for the variation of maximum load factor with gross weights greater than 49,548 pounds.
- Coordinated turns with small rudder and lateral stick inputs are defined as symmetrical flight.

4.3.1 Cruise Configuration. See Figure 4-5 and Figure 4-6.

4.3.2 Approach Configuration

1. Landing gear and/or landing flaps and slats extended — 0 to 2.0g, symmetrical or rolling.

4.4 ANGLE-OF-ATTACK LIMITS

4.4.1 Cruise Configuration. AOA is limited by the maximum allowable normal load factor of Figure 4-5 with wingsweep in AUTO. For wing sweep not in AUTO, AOA limits of Figure 4-7 still apply. Since roll SAS now increases departure resistance at higher AOA, it should be left on for all flight conditions. With operating ARI, subsonic pilot control inputs with landing gear retracted are not limited by AOA or sideslip and therefore Figure 4-6 does not apply to fully functional DFCS aircraft.

WARNING

With ROLL SAS ON, departure resistance is increased because of DFCS ARI functionality and therefore should remain on at all times.

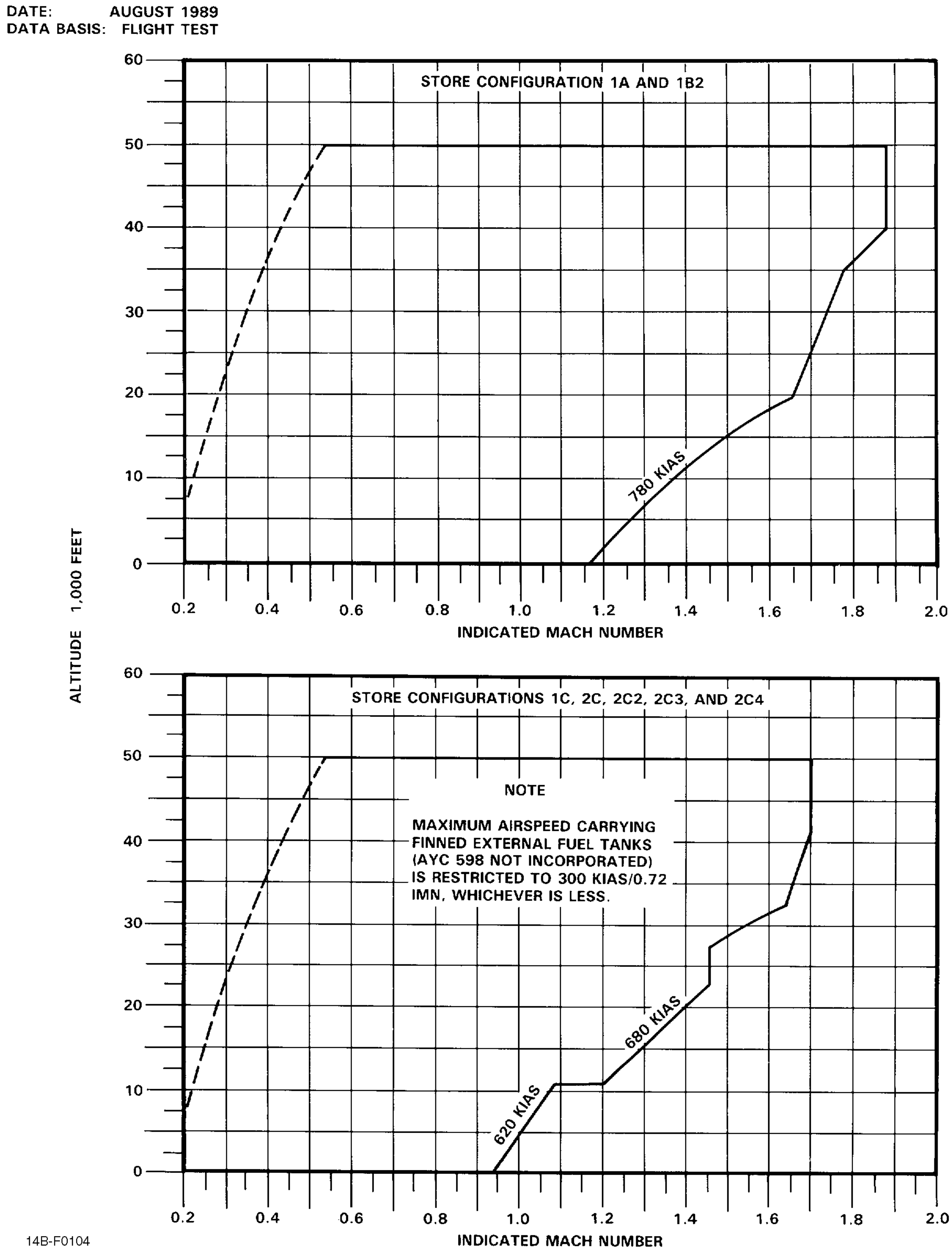


Figure 4-4. Maximum Allowable Airspeeds (Sheet 1 of 3)

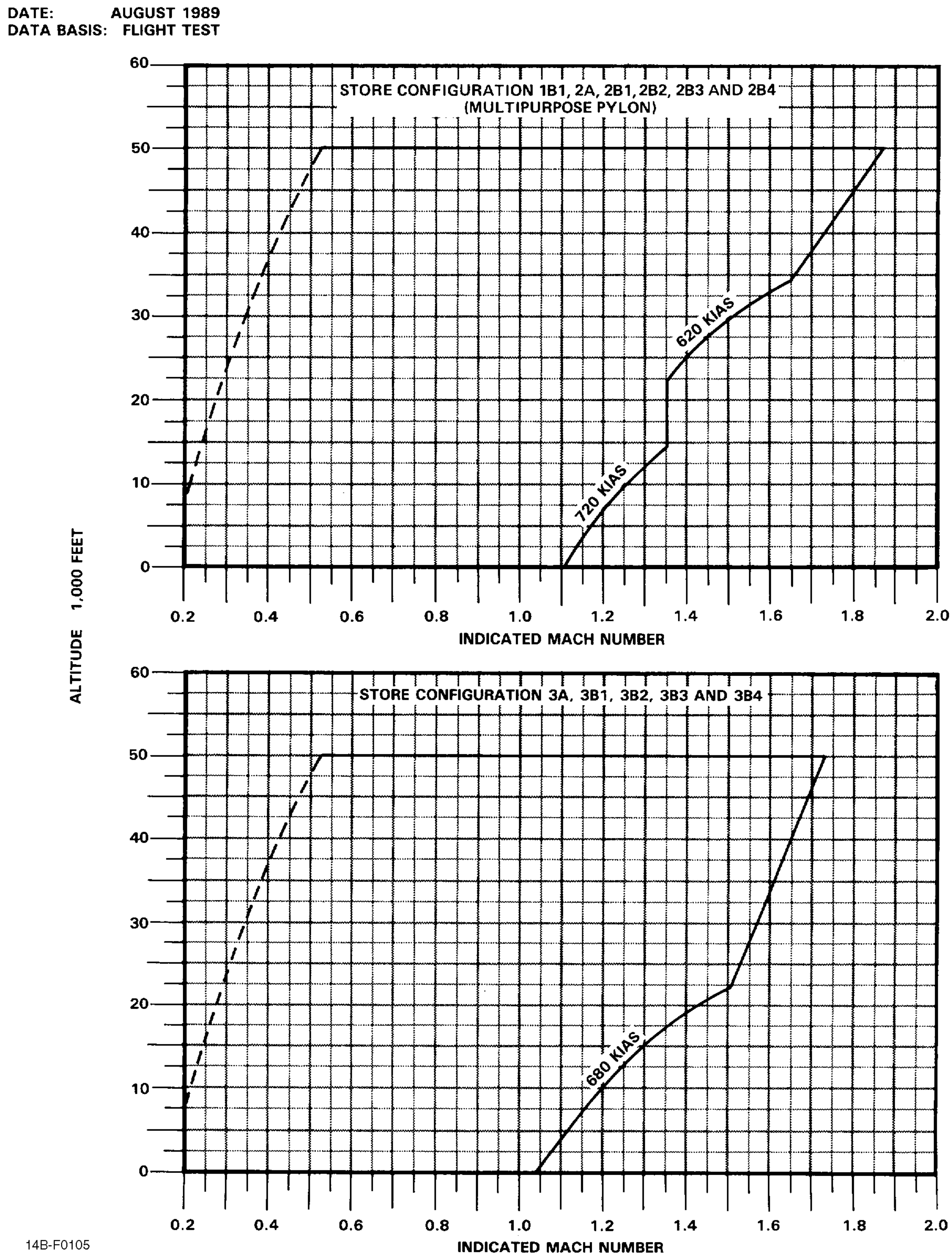


Figure 4-4. Maximum Allowable Airspeeds (Sheet 2)

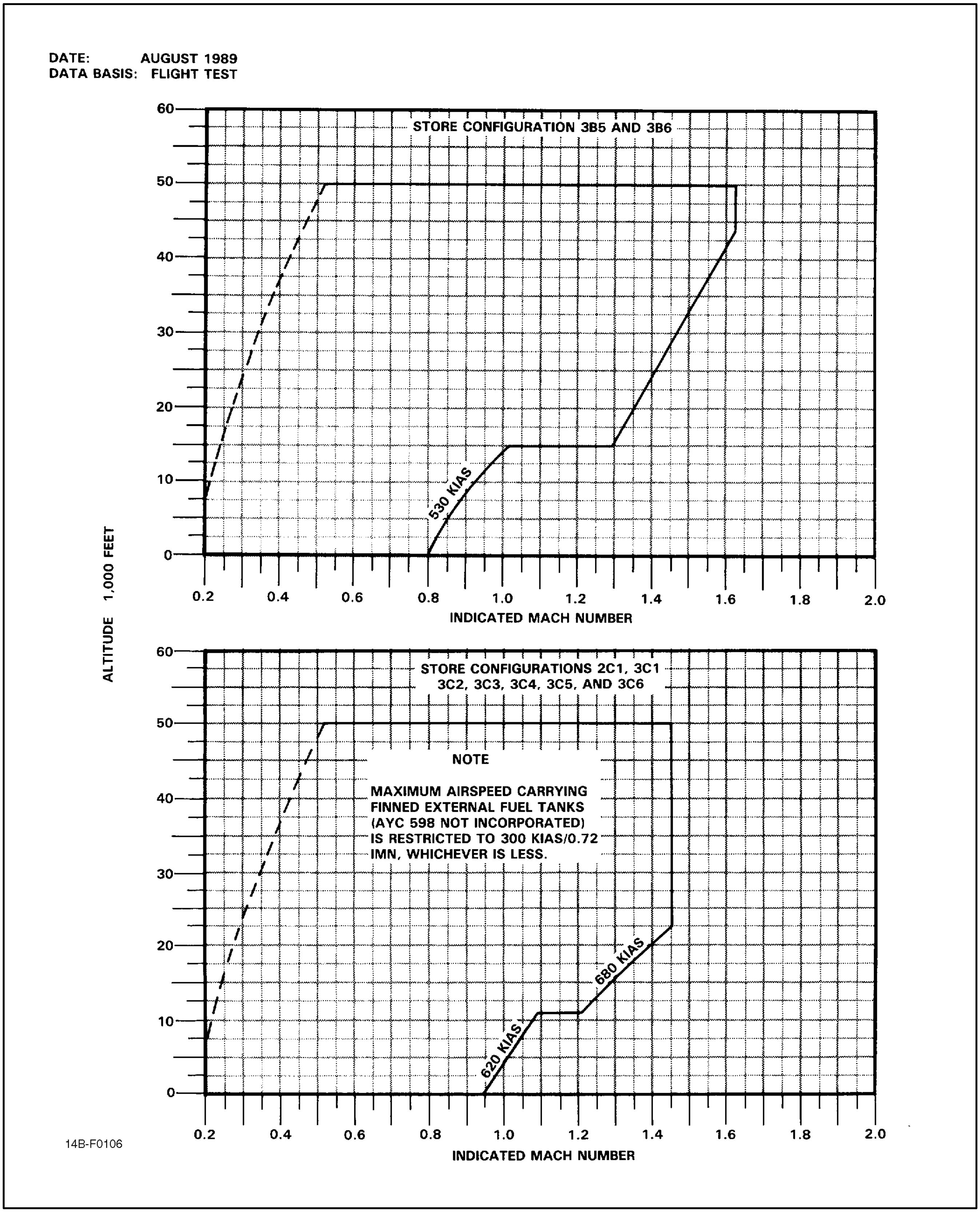


Figure 4-4. Maximum Allowable Airspeeds (Sheet 3)

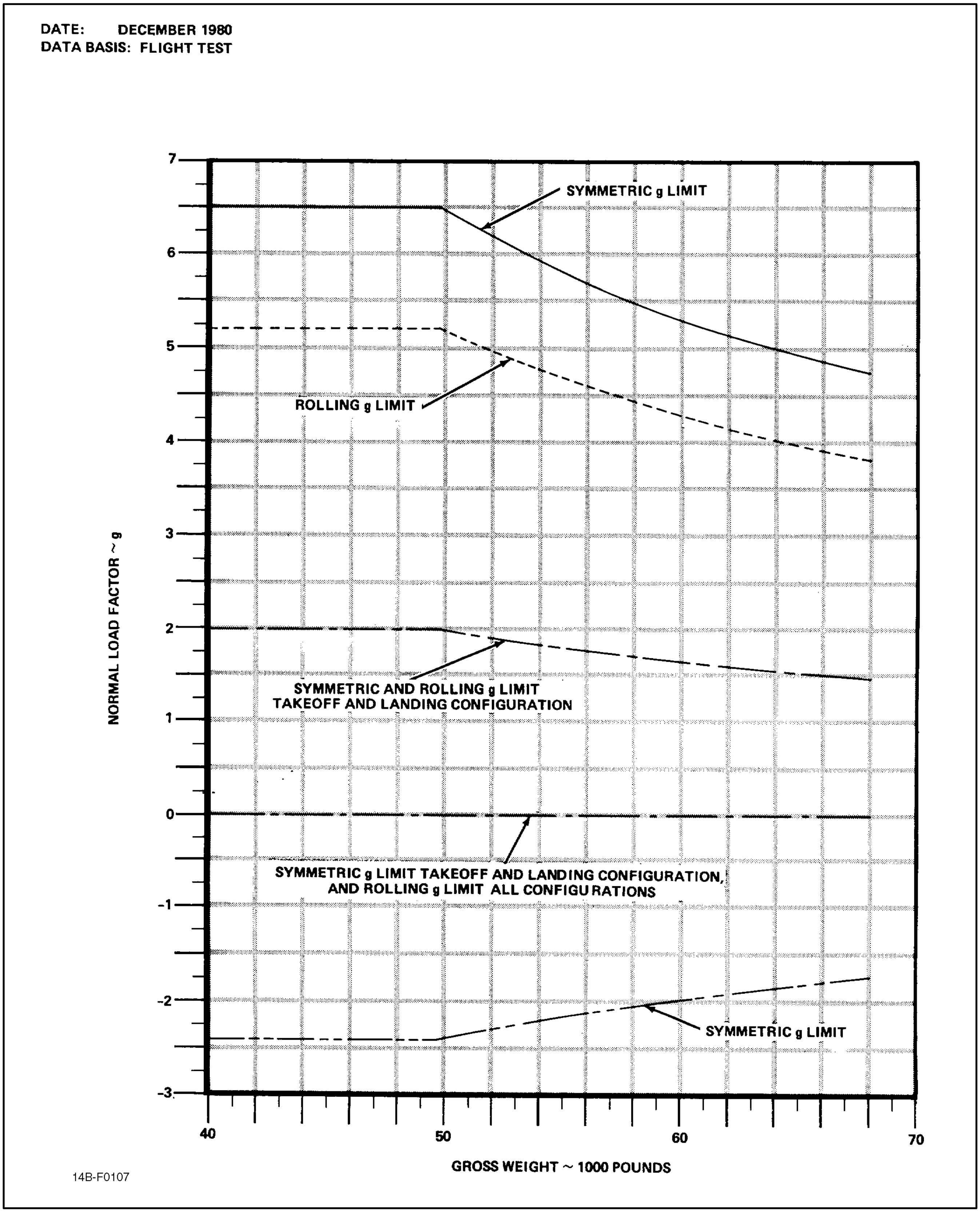


Figure 4-5. Variation of Maximum Allowable Normal Load Factor with Gross Weight

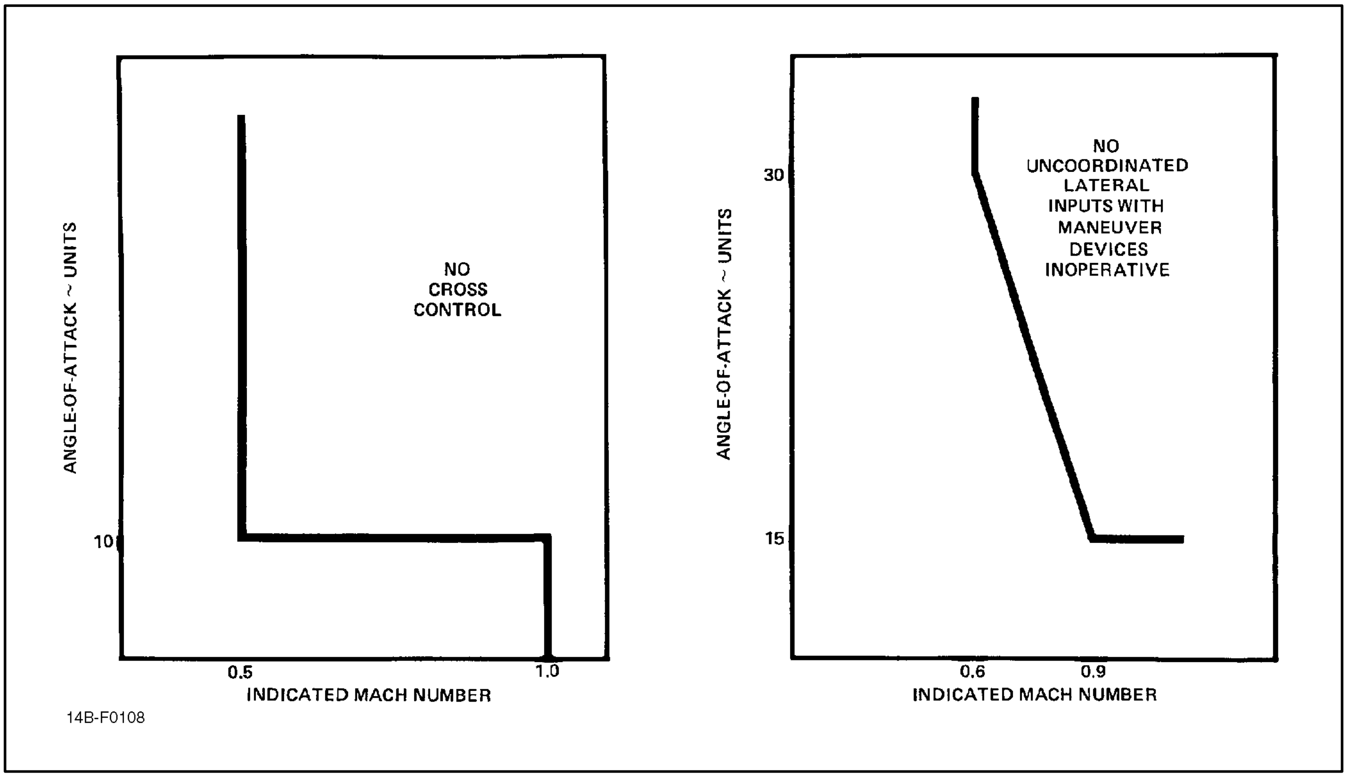


Figure 4-6. Maneuvering Limits — Cruise Configuration

WARNING

Aircraft has significantly improved roll rate capability with ROLL SAS ON, which increases susceptibility to inertia coupled departures due to overly aggressive multi-axis control inputs.

4.4.2 Approach Configuration. Maximum allowable AOA and rudder deflection with landing gear and/or flaps extended is shown in Figure 4-8.

4.5 MANEUVERING LIMITS

4.5.1 Approach Configuration. With landing gear and/or landing flaps and slats extended, abrupt yaws are prohibited. Refer to Figure 4-6. Maneuvering Limits — Cruise Configuration for approach configuration sideslip limits.

With landing gear extended or in transit, abrupt rolls and uncoordinated turns shall not be performed above 225 KIAS.

4.5.2 Cruise Configuration. With maneuver flaps/slats extended, maximum allowable load factor is 6.5 g or the limits of Figure 4-5, whichever is less. No additional g and/or AOA limits are placed on ROLL SAS ON maneuvering, or cross control inputs.

WARNING

Maneuvering with YAW SAS OFF or inoperative shall not be conducted above 15 units AOA with landing gear retracted.

Since inoperative auto-maneuvering devices may signal improper operation of DFCS primary AOA input, uncoordinated lateral control inputs shall not be used in the area of the flight envelope indicated in Figure 4-6 when auto-maneuvering flaps/slats are not operating.

4.5.3 Rolling Limits. With maneuver slats and flaps/slats extended, maximum allowable load factor is 5.2g or the limits of Figure 4-9, whichever is less.

CRUISE CONFIGURATION

AIRCRAFT CONFIGURATION:
- ALL WING MOUNTED AIM-54 LOADINGS
- WING SWEEP NOT IN AUTO

DATE: MAY 1977
DATA BASIS: FLIGHT TEST

NOTE
ABOVE 0.93 IMN, AOA IS LIMITED BY MAXIMUM ALLOWABLE LOAD FACTOR

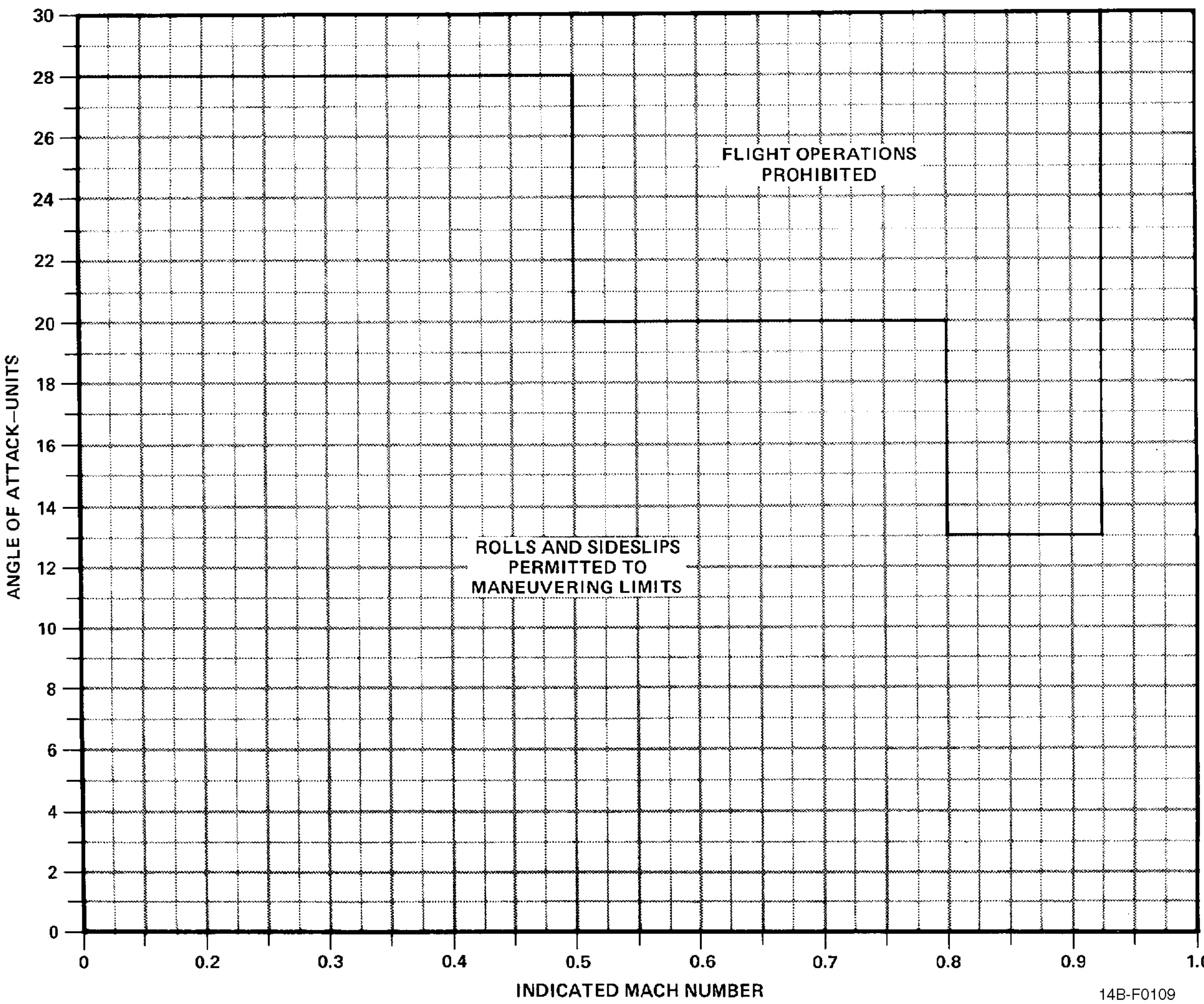


Figure 4-7. AOA Limits

LANDING GEAR AND/OR FLAPS EXTENDED

DATE: MAY 1977
DATA BASIS: FLIGHT TEST

NOTE

- NORMAL STALL APPROACH IN 1.0 g FLIGHT AT NO GREATER THAN 1.0 KNOT PER SECOND DECELERATION RATE.
- LATERAL CONTROL INPUTS ABOVE 18 UNITS AOA WILL PRODUCE NOSE-UP PITCHING MOMENTS AND APPARENT STICK FORCE LIGHTENING.
- NO INTENTIONAL SIDESLIPS OTHER THAN 1.0 g WINGS LEVEL.
- ABRUPT CONTROL REVERSALS PROHIBITED.
- ABRUPT YAWS (FULL ALLOWABLE CONTROL DISPLACEMENT IN LESS THAN 1.0 SECOND) PROHIBITED.
- NORMAL ±30° RUDDER DEFLECTION IS AVAILABLE AND PERMISSIBLE IN ORDER TO MAINTAIN AIRCRAFT CONTROL IN THE EVENT OF AN ENGINE FAILURE.
- DIVERGENT WING ROCK OCCURS ABOVE 25 UNITS AOA.

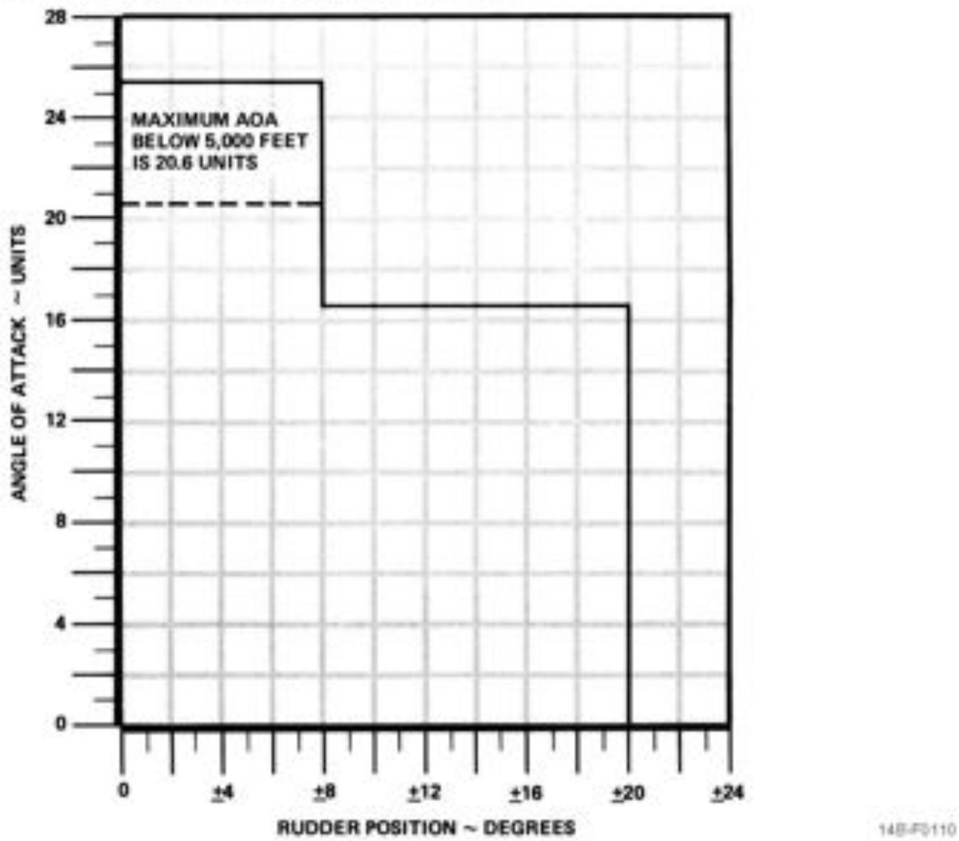
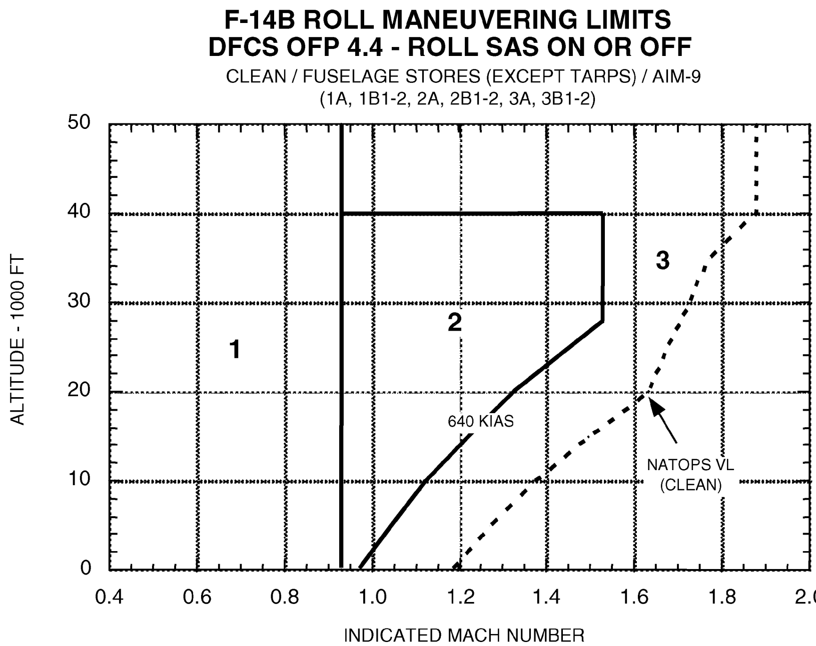


Figure 4-8. Maximum Allowable AOA Rudder Deflections



ROLLING MANEUVERS LIMITED TO:

REGION 1: 0.0 TO 5.2 G.
360° MAXIMUM BANK ANGLE CHANGE AT 1 G.
180° MAXIMUM BANK ANGLE CHANGE AT OTHER THAN 1 G.

REGION 2: 0.0 TO 4.0 G.
360° MAXIMUM BANK ANGLE CHANGE AT 1 G.
180° MAXIMUM BANK ANGLE CHANGE AT OTHER THAN 1 G.

REGION 3: NO ABRUPT STICK INPUTS.
360° MAXIMUM BANK ANGLE CHANGE AT 1.0 G ONLY.
ABOVE 1 G, ROLLING MANEUVERS LIMITED TO COORDINATED TURNS USING MAXIMUM 0.5 INCH LATERAL STICK INPUTS.

NOTE: 1. DO NOT EXCEED MAXIMUM ALLOWABLE AIRSPEED FOR STORE LOADING PER NATOPS Figure 4-4.

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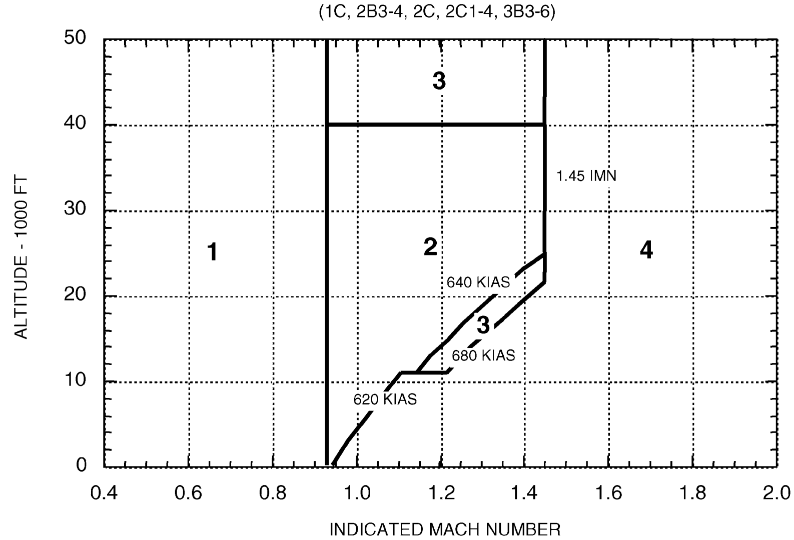
Figure 4-9. DFCS Maneuvering Limits — Rolling (Sheet 1 of 3)

F-14B ROLL MANEUVERING LIMITS
DFCS OFP 4.4 - ROLL SAS ON OR OFF

TANKS / PYLON STORES (EXCEPT AIM-9) / TARPS + TANKS / TARPS + PYL AIM-7/9
(1C, 2B3-4, 2C, 2C1-4, 3B3-6)



ROLLING MANEUVERS LIMITED TO:

REGION 1: 0.0 TO 5.2 G.
360° MAXIMUM BANK ANGLE CHANGE AT 1 G.
180° MAXIMUM BANK ANGLE CHANGE AT OTHER THAN 1 G.

REGION 2: 0.0 TO 4.0 G.
360° MAXIMUM BANK ANGLE CHANGE AT 1 G.
180° MAXIMUM BANK ANGLE CHANGE AT OTHER THAN 1 G.

REGION 3: NO ABRUPT STICK INPUTS.
360° MAXIMUM BANK ANGLE CHANGE AT 1.0 G ONLY.
ABOVE 1 G, ROLLING MANEUVERS LIMITED TO COORDINATED TURNS USING MAXIMUM 0.5 INCH LATERAL STICK INPUTS.

REGION 4: NO ABRUPT STICK INPUTS.
ROLLING MANEUVERS LIMITED TO COORDINATED TURNS AT 1 G USING MAXIMUM 0.5 INCH LATERAL STICK INPUTS.

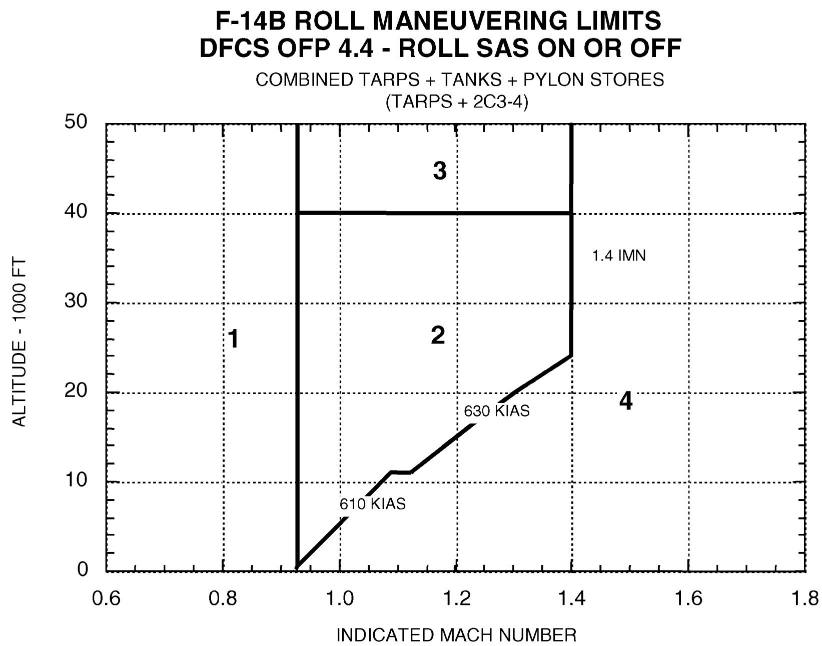
WARNING

USE OF AGGRESSIVE LATERAL STICK INPUTS IN REGION 4 MAY RESULT IN STRUCTURAL DAMAGE TO THE AIRCRAFT.

NOTES:
1. DO NOT EXCEED MAXIMUM ALLOWABLE AIRSPEED FOR STORE LOADING PER NATOPS Figure 4-4 AND Figure 4-11.
2. ROLL LIMITS APPLY TO TARPS PLUS ANY OF THE FOLLOWING LOADINGS: 2A, 2B1-4, 2C, 2C1-2, 3A, 3B1-6.

14B-F0112

Figure 4-9. DFCS Maneuvering Limits — Rolling (Sheet 2)



ROLLING MANEUVERS LIMITED TO:

REGION 1: 0.0 TO 4.5 G.
360° MAXIMUM BANK ANGLE CHANGE AT 1 G.
180° MAXIMUM BANK ANGLE CHANGE AT OTHER THAN 1 G.

REGION 2: 0.0 TO 3.5 G.
360° MAXIMUM BANK ANGLE CHANGE AT 1 G.
180° MAXIMUM BANK ANGLE CHANGE AT OTHER THAN 1 G.

REGION 3: NO ABRUPT STICK INPUTS.
360° MAXIMUM BANK ANGLE CHANGE AT 1.0 G ONLY.
ABOVE 1 G, ROLLING MANEUVERS LIMITED TO COORDINATED TURNS USING MAXIMUM 0.5 INCH LATERAL STICK INPUTS.

REGION 4: NO ABRUPT STICK INPUTS.
ROLLING MANEUVERS LIMITED TO COORDINATED TURNS AT 1G USING
MAXIMUM 0.5 INCH LATERAL STICK INPUTS.

WARNING

USE OF AGGRESSIVE LATERAL STICK INPUTS IN REGION 4 MAY RESULT IN STRUCTURAL DAMAGE TO THE AIRCRAFT.

NOTE: 1. DO NOT EXCEED MAXIMUM ALLOWABLE AIRSPEED FOR STORE LOADING PER NATOPS Figure 4-11.

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Figure 4-9. DFCS Maneuvering Limits — Rolling (Sheet 3)

CAUTION

- Lateral trim will increase roll rates in the direction opposite trim. In order to minimize lateral trim and prevent excessive roll rates in the transonic and supersonic regimes, the aircraft must be trimmed directionally first to center the ball/yaw string, and then laterally as required.
- Do not initiate full lateral stick inputs above 4.5g if a 5.2g limit applies or above 3.5g if a 4.0g limit applies. Control system dynamics may cause the load factor to increase beyond limits.
- If the outboard spoilers fail with airspeed greater than 400 KIAS and wing sweep less than 62°, limit lateral stick deflection to one-half pilot authority.

Note

Angle-of-attack limitations shown in Figure 4-7 apply to wingsweep not in AUTO.

4.5.4 Sideslip Limits

4.5.4.1 All External Store Configurations

1. Below 0.7 IMN — Rudder inputs as required to maneuver aircraft at high AOA.
2. Above 1.7 IMN — Intentional sideslips prohibited.

WARNING

If a supersonic engine stall and/or failure occurs, arrest roll rate with lateral stick only. Yaw SAS will maintain sideslip angle within acceptable limits.

Note

Use of full available rudder is permitted at all airspeeds if required to counteract adverse yaw encountered in maneuvering flight.

4.5.5 Prohibited Maneuvers. The following additional maneuvers are prohibited:

1. Intentional spins.
2. During afterburner operations:
   a. Sustained 0 to – 0.5g flight.
   b. Flight from – 0.5g to – 2.4g's for more than 10 seconds.
3. At MIL power or less, zero or negative-g flight for more than 20 seconds.
4. AIM-9 launch with landing flaps and slats extended.
5. Fuel dumping with AB operating or with speedbrakes extended.
6. Dual-engine afterburner takeoffs, waveoffs, bolters or catapult launches.
7. Single-engine maximum afterburner takeoffs, waveoffs, bolters, or catapult launches.
8. Rolling maneuvers with blank angle changes in excess of 360°.

4.6 SAS LIMITS

4.6.1 Cruise Configuration

1. Pitch SAS off — LBA.
2. Yaw SAS off — 0.93 IMN.
3. Roll SAS off — 0.93 IMN for external store configuration 3B5, 3B6, 3C5, and 3C6; 700 KIAS/1.33 IMN for all other configurations.

4.6.2 Approach Configuration

1. Pitch SAS off — LBA.
2. Yaw SAS off — LBA.
3. Roll SAS off — Not permitted during takeoff and landing flap and slat transition.

Roll SAS must be left on for carrier landings with store asymmetry greater than 170,000 inch-pounds (e.g., weapon rail at station 6 and AIM-54 missile at station 8 equals 170,000 inch-pounds).

4.7 TAKEOFF AND LANDING FLAP AND SLAT TRANSITION LIMITS

4.7.1 Clean and Symmetric Stores Loading. See Figure 4-10.

1. All transitions will be made in less than 45° bank angle, roll SAS on.

2. All normal (flaps and slats fully down) takeoff transitions will be initiated at a minimum altitude of 200 feet AGL.

3. All other transitions will be made at standard field operating altitudes but no less than 800 feet AGL.

4. All flap and slat extensions and retractions will be made at a maximum of 12 units AOA.

4.7.2 External Stores Loading With Up to 66,000 Inch-Pounds (5,500 Foot-Pounds) Asymmetry (AIM-7 on Stations 1B or 8B Equals 64,000 Inch-Pounds)

1. All transitions will be made in wings-level flight with roll SAS on.

2. All normal (flaps and slats fully down) takeoff transitions will be initiated at a minimum altitude of 200 feet AGL.

3. All flaps and slat extensions and retractions will be made at a maximum of 12 units AOA.

4.7.3 External Stores Loading With Greater Than 66,000 Inch-Pounds (5,500 Foot Pounds) Asymmetry

1. All transitions will be made in wings-level flight with roll SAS on at a minimum altitude of 1,200 feet and at a maximum of 12 units AOA.

4.8 GROSS WEIGHT LIMITS — TAKEOFF, LAUNCH, AND LANDING

1. Catapult launch — 76,000 pounds.

WARNING

Single-engine rate of climb at 76,000-pound gross weight using optimum flight control technique is predicted to be between 300 and 600 feet per minute. Emergency jettison of stores may be required to establish adequate rate of climb.

2. Field takeoff and emergency landings (minimum rate of descent landings only) — 72,000 pounds.

3. Field landings — 60,000 pounds.

   a. Aircraft with AYC-679 or AYC-805:

      (1) FCLP or carrier landings — 54,000 pounds.

   b. Aircraft without AYC-679 or AYC-805:

      (1) FCLP or carrier landing — 51,800 pounds.

      (2) Carrier landings when operational necessity dictates — 54,000 pounds.

Note

Landing approaches to touchdown should not exceed 17 units AOA to avoid nozzle/ventral fin damage.

Only normal minimum rate-of-descent landings (minimum sink speed) are permitted while carrying AIM-7E/F and/or AIM-9 on the multipurpose pylon or AIM-7E/F missiles on fuselage stations until the following AACs are incorporated:

   c. AAC 618 — Modifies multipurpose pylon.

   d. AAC 673 — Modifies fuselage backup structure.

   e. AAC 688 — Modifies pylon-mounted swaybraces.

STORE ORDNANCE/STATION	FLAP LIMITATIONS (INCH-POUNDS) 1A	1B	3	6	8B	8A	2	7
SIDEWINDER	27,220	24,820	—	—	24,820	27,220	—	—
SPARROW	—	63,000	10,500	10,500	63,000	—	—	—
PHOENIX	—	126,000	15,000	15,000	126,000	—	—	—
TANKS (EMPTY)	—	—	—	—	—	—	14,260	14,260
TANKS (FULL)	—	—	—	—	—	—	126,852	126,852
WING FUEL	WINGS 20° ONE WING FULL, OTHER EMPTY							431,405

Note

Do not attempt shipboard landing with inoperative roll SAS and greater than 170,000 in-lbs asymmetry unless divert field unavailable.

FLAP TRANSITIONS:

CLEAN OR SYMMETRICAL	UP TO 66,000 IN-LBS ASYMMETRY	GREATER THAN 66,000 IN-LBS ASYMMETRY
1. Less than 45° angle of bank	1. Wings level	1. Wings level
2. Roll SAS on	2. Roll SAS on	2. Roll SAS on
3. Minimum 200 feet AGL on takeoff	3. Minimum 200 feet AGL	3. Minimum altitude of 1,200 feet AGL for takeoff and landing
4. Dirty-up altitude minimum 800 feet AGL	4. Dirty-up at minimum 800 feet AGL	4. Minimum 180 knots.
5. Minimum 180 knots	5. Minimum 180 knots	**WARNING** Available roll control will be marginal to inadequate in event of asymmetric flap/slats without lockout. **Note** Incompatibility of flap transition limit with existing Case I procedures recognized. Although improvement of flap/slat system reliability has been accomplished, not enough data are available concerning failure mode/rate of improved asymmetry sensor. Minimum flap transition altitude may be waived in cases of operational necessity.

Figure 4-10. Flap Limitations

4.9 BARRICADE ENGAGEMENT LIMITS

1. Wings at full-forward sweep angle (20°) — 51,800 pounds (maximum).

   a. Flaps and slats extended or retracted.

   b. No external stores except AIM-7 or AIM-54 on fuselage stations only.

   c. Empty external fuel tanks permitted only for engagements due to landing gear malfunction.

2. Wing-sweep angle greater than 20° up to 35° — 46,000 pounds (maximum).

   a. Flaps and slats extended or retracted.

   b. No external stores except empty external fuel tanks for landing gear malfunction.

3. Wing-sweep angle greater than 35° — Not permitted.

4.10 CENTER OF GRAVITY POSITION LIMITS

Unless otherwise stated, the following cg limits apply:

STORE CONFIGURATIONS	MAXIMUM FORWARD	MAXIMUM AFT
1A, 2A	6.3% MAC	18.5% MAC
1B1, 1B2, 1C, TARPS, 2B1–4, 2C, 2C1–4	6.3% MAC	17.5% MAC
All other configurations	6.3% MAC	17.0% MAC

Throughout this section on flight operating limitations, all cg positions are quoted assuming the following reference conditions:

1. Zero fuel gross weight (includes weight of stores carried on flight).

2. Wing-sweep angle equals 20°.

3. Landing gear and flaps are extended.

WARNING

The aft cg limit will be exceeded if all stations are configured for AIM-54 missiles or Mk 83/84 bombs and only stations 4 and 5 are loaded or remain as a result of firing, dropping, or jettison of stations 1, 3, 6, and 8. If the aft cg limit is exceeded, airspeed/ AOA control may be difficult. Fuel states of 5,000 to 6,000 pounds result in the most favorable cg position. Slightly aft wing-sweep positions of 25° to 30° will move the neutral point aft and should restore normal longitudinal stability.

4.11 EXTERNAL STORES AND GUN LIMITS

4.11.1 280-Gallon External Fuel Tank Limits

1. Catapult launch with a partially filled external tank is not authorized because of surge load considerations.

2. Carriage of external tanks not incorporating AYC 598 is limited to 300 KIAS/0.72 IMN.

WARNING

CV arrestment, CV touch-and-go, or normal field landings with full or partial fuel in the external tanks is not authorized because of overload of the nacelle backup structure. Only minimum rate-of-descent landings (minimum sink rate) are authorized.

CAUTION

Dive angles in excess of 10° nose down with 900 pounds or more fuel in an external tank will result in fuel venting (dumping).

4.11.2 External Baggage Container (CNU-188/A). The external baggage container (blivet) may be carried on station 4 or 5 with all loadings authorized for the TARPS pod (Figure 4-11). Simultaneous carriage of a blivet and a TARPS pod or two blivets is not authorized. The blivet must be configured with a long tail cone and no fins.

AUTHORIZED STORES LOADING	ROLL SAS	MAXIMUM AIRSPEED
Stations 1 and 8: (2) AIM-7 and (2) AIM-9 or (4) AIM-9 Stations 2 and 7: (2) finless external fuel tanks Station 5: TARPS pod Stations 3 and 6: (2) AIM-54 Rail and fairings or (2) AIM-7/CATM-7	ON or OFF	Sea level to 11,000 feet mean sea level (MSL) — 610 KIAS. Above 11,000 feet MSL — 680 KIAS or 1.40 IMN whichever is less.
Stations 1 and 8: (2) AIM-7 and (2) AIM-9 or (4) AIM-9 Station 5: TARPS pod Stations 3 and 6: (2) AIM-54 Rails and fairings or (2) AIM-7/CATM-7	ON or OFF	Sea level to 32,000 feet MSL — 700 KIAS or 1.40 IMN whichever is less. Above 32,000 feet MSL — 1.52 IMN.

Figure 4-11. TARPS Limitations

1. Maximum airspeed — 520 KIAS/0.90 IMN.
2. Acceleration limit — LBA.
3. AOA limit — Figure 4-7.
4. Jettison — Not authorized.
5. Carrier operations — Authorized.
6. Maximum load: 200-lb max (fwd shelf) + 150-lb max (aft shelf) = 350-lb total.

4.11.3 Tactical Contingency Pod (AN/ALQ-167). The ALQ-167 may be carried on station 3 or 6 with other NATOPS authorized stores. Simultaneous carriage of a TARPS pod and ALQ-167 is authorized provided the opposing forward fuselage station is loaded with AIM-7, CATM-7, or LAU-93.

1. Maximum airspeed — 720 KIAS/1.3 IMN (whichever is less).
2. Acceleration limit — –2.0g to +6.5g.
3. Jettison — Not authorized.
4. Carrier operations — Authorized.

4.11.4 Gun Burst Limits

1. Burst limit — 200 rounds.

If two consecutive 200-round bursts are fired, a 30-second cool down period is required.

4.11.5 Launch Limits

Maximum flight conditions for launch of external stores are listed in the following paragraphs.

4.11.5.1 AIM-7

1. Stations 3,5, and 6 — Vmin to Vmax, all altitudes, +1.0g to limits of basic aircraft.
2. Stations 1 and 8 — Vmin to Vmax except 1.4 IMN maximum 25,000 feet and below, 1.5 IMN maximum above 25,000 feet, all altitudes, +1.0g to limits of basic aircraft.
3. Station 4 (AIM-7E) — Not authorized.
4. Station 4 (AIM-7F without K-9 autopilot) — Not authorized.

5. Station 4 (AIM-7F with K-9 autopilot) — Vmin to Vmax, all altitudes, +1.0g to limits of basic aircraft (other than zero bank angle). (Missiles with K-9 autopilot are identified by segmented black line under missile serial number or letters “POP” after serial number).

Note

For zero bank angle, limit is Vmin to Vmax, all altitudes, 0g to limits of basic aircraft.

6. Station 4 (AIM-7M) — Same as AIM-7F with K-9 autopilot.

4.11.5.2 AIM-9

1. All stations — Vmin to Vmax, all altitudes, 1.0g to limits of basic aircraft.

WARNING

AIM-9 launch is prohibited, with landing flaps and slats extended.

Note

Engine stall may result from firing of AIM-9 missiles. Engine exhaust gas temperature should be monitored after each firing.

4.11.5.3 AIM-54

1. All stations — Vmin to Vmax, all altitudes, +1.0g to limits of basic aircraft (other than zero bank angle.)

CAUTION

AIM-54 ECU failures may result if electrical power transients occur with MSL PREP switch ON. Ensure that MSL PREP switch is OFF prior to WCS power up or down or cycling generator power including engine start, shutdown, and emergency generator checks.

Note

For zero bank angle, limit is Vmin to Vmax, all altitudes, 0g to limits of basic aircraft.

4.11.6 Jettison Limits. Flight conditions for jettison (emergency only) of external stores are listed in the following paragraph.

4.11.6.1 AIM-7

1. Stations 1 and 8 — Vmin to Vmax, all altitudes, +1.0g to limits of basic aircraft (other than zero bank angle).

Note

For zero bank angle, limit is Vmin to Vmax, all altitudes, 0g to limits of basic aircraft.

2. Stations 3 and 6 — Vmin to 400 KIAS/0.7 IMN, all altitudes, +1.0g.

3. Stations 4 and 5 — Vmin to 400 KIAS, all altitudes, +1.0g

WARNING

AIM-7 on stations 3 and 6 exhibit pronounced outboard movement when jettisoned.

4.11.6.2 AIM-54

1. All stations — Vmin to Vmax, all altitudes, + 1.0g to limits of basic aircraft (other than zero bank angle).

Note

For zero bank angle, limit is Vmin to Vmax, all altitudes, 0g to limits of basic aircraft.

4.11.6.3 Capped 280-Gallon External Fuel Tank (With AYC 822 Incorporated) (Landing Gear and Flaps Retracted)

1. Full or empty tanks — Less than 0.88 IMN, all altitudes, 1.0g to +3.0g.

2. Partially full tanks — Less than 250 KIAS/0.72 IMN, all altitudes, wings level +1.0g.

3. Landing gear and/or flaps and slats extended (emergency only) — Less than 225 KIAS, all altitudes, +1.0g.

4.11.6.4 Finless 280-Gallon External Fuel Tank (With AYC 598 Incorporated) (Landing Gear and Flaps Retracted)

1. Full or empty tanks — Less than 350 KIAS/0.88 IMN, all altitudes, wings level +1.0g flight.

2. Partially full tanks — Less than 250 KIAS/0.72 IMN, all altitudes, wings level +1.0g flight.

3. Landing gear and/or flaps and slats extended (emergency only) — Less than 225 KIAS, all altitudes, +1.0g.

WARNING

If jettisoned during takeoff emergency, external fuel tanks may collide with aircraft because of their unstable characteristics.

4.12 BANNER TOWING RESTRICTIONS

1. Airspeed — 220 KIAS maximum recommended.
2. Maximum angle of bank — 30°; 20° throttles at idle below 5,000 feet.
3. Use of speedbrakes — Prohibited in flight.

Note

- During takeoff, adequate clearance exists to use speedbrakes for takeoff abort without contacting tow cable.

- The maximum aircraft gross weight for a shipboard banner launch is 67,000 pounds.

4.13 TACTICAL AIR RECONNAISSANCE POD SYSTEM LIMITATIONS

See Figure 4-11 for airspeed limits and stores loadings authorized with TARPS pod.

4.13.1 Authorized Stores Loading

1. Downloading authorized store stations 1, 2, 7, and 8 only. Stations 3 and 6 must remain loaded for cg control.

2. Carrier and field arrestment operations authorized.

3. Aft cg limit is 17.5-percent MAC, nonjettisonable (captive carry) AIM-7 missiles, specially configured interim AIM-7 missile or AIM-54 rails and fairings shall be carried on stations 3 and 6 for cg control (see Interim AIM-7 as Ballast, paragraph Interim AIM-7 as Ballast). Full ammunition pod, ALQ-100/126, or other authorized equipment substitution may be required along with AIM-7 missiles or AIM-54 fairings and rails to maintain cg within aft limit. Individual weight and balance calculations shall be performed to ensure cg limits are not exceeded.

4. Pulling MACH TRIM circuit breaker will eliminate stick force requirement during low-altitude, high-speed flight.

CAUTION

MACH TRIM circuit breaker should be reset prior to landing. Attempt reset below 0.6 IMN above 5,000 feet, if possible, to minimize trim change transients. Failure to reset circuit breaker may result in reduced nose-down longitudinal control authority. Reduced authority may degrade the pilot's ability to counter pitchup during waveoffs with aft cg.

5. AIM-54 carriage/launch not authorized any station.

6. Special weight and balance information for TARPS pod configuration is available. Refer to handbook of Weight and Balance (NAVAIR 01IB-40).

4.13.2 Interim AIM-7 as Ballast. TARPS-equipped aircraft are authorized to use a specially configured interim AIM-7 missile as ballast. AIM-7 missiles specially configured for TARPS use will be designated as CATM-7E-2 or CATM-7F-2. Until then, R40293, R40268, R40302, R40264, R40144, R40298, R40674, R40297, R40274, R40267, and R40235 are authorized as TARPS ballast, and weight and balance information provided for the AIM-7F missile shall be used to determine weight and balance of aircraft.

1. CATM-7E-2 — 360 lb/per missile located at aircraft station 381.7.

2. CATM-7F-2 — 440 lb/per missile located at aircraft station 381.7.

PART II

Indoctrination

CHAPTER 5

Indoctrination

5.1 GROUND-TRAINING SYLLABUS

5.1.1 Minimum Ground-Training Syllabus. The ground-training syllabus sets forth the minimum ground training that must be satisfactorily completed prior to operating the F-14B. If the air crewmember has a current F-14A NATOPS qualification, the ground syllabus will consist of the F-14B unique systems. The ground-training syllabus for each activity will vary according to local conditions, field facilities, requirements from higher authority, and the immediate unit commander's estimate of the squadron's readiness. The minimum ground-training syllabus for the pilot and the RIO is set forth in the following paragraphs.

5.1.1.1 Familiarization

1. Flight physiological training as appropriate
2. F-14B flightcrew academic course
3. F-14B OFT/COT/WST (within 5 days).

5.1.1.2 Flight-Support Lectures

1. F-14B flightcrew academic course.

5.1.1.3 Intercept Flight Support

1. F-14B flightcrew academic course.

5.1.1.4 Weapons Firing Flight-Support Lectures

1. Weapons preflight procedures
2. Arming/dearming procedures
3. Firing procedures
4. Safety procedures
5. Jettison/dump areas.

5.1.1.5 FCLP/CARQUAL Flight-Support Lectures

1. Mirror and Fresnel lens optical landing system
2. Day landing pattern and procedures
3. Night landing pattern and procedures
4. Shipboard procedures and landing patterns
5. CCA/ACLS procedures
6. In-flight refueling (day/night).

5.1.2 Waiving of Minimum Ground-Training Requirements. All F-14B flight crewmembers shall be instructed on the differences from model in which qualified and comply with those items listed below, as directed by the unit commanding officer.

Where recent crewmember experience in similar aircraft models warrants, unit commanding officers may waive the minimum ground-training requirements provided the flight crewmember meets the following mandatory qualifications:

1. Has obtained a current medical clearance
2. Is currently qualified in flight physiology
3. Has satisfactorily completed the NATOPS flight manual open- and closed-book examinations
4. Has completed at least one emergency procedure period in the OFT/COT/WST (within 10 days)
5. Has received adequate briefing on normal and emergency operating procedures
6. Has received adequate instructions on the use and operation of the ejection seat and survival kit.

5.2 FLIGHT-TRAINING SYLLABUS

5.2.1 Flightcrew Flight-Training Syllabus. Before flight, all flight crewmembers will have completed the familiarization and flight-supportlectures previously prescribed. A qualified FRS instructor pilot will occupy the rear seat for the first familiarization flight. A qualified FRS instructor RIO can occupy the rear seat if the pilot in command has been previously NATOPS qualified in the F-14B. The geographic location, local command requirements, squadron mission, and other factors will influence the actual flight-training syllabus and the sequence in which it is completed. The specific phases of training are listed in the following paragraphs.

5.2.2 Flightcrew Flight-Training Phases

5.2.2.1 Familiarization

1. Military power takeoffs
2. Buffet boundary investigation
3. Approach to stalls
4. Slow flight
5. Acceleration run to Mach 1.3
6. Subsonic and supersonic maneuvering
7. Investigate all features of the DFCS/stab aug
8. Formation flight
9. Aerobatics
10. Single-engine flight at altitude and airstarts
11. Simulated single-engine landings
12. Landing with full and no flaps
13. Acceleration runs at various altitudes.

5.2.2.2 Instruments

1. Basic instrument work
2. Penetration and approaches
3. Local area round-robin (day and night) flights.

An F-14B pilot is considered instrument qualified if currently instrument qualified in the F-14A.

5.2.2.3 Weapon Systems Employment. Qualification is in accordance with existing training and readiness directives.

5.2.2.4 Field Carrier Landing Practice and Carrier Qualifications. Qualification is in accordance with existing training and readiness directives.

5.3 OPERATING CRITERIA

5.3.1 Ceiling/Visibility Requirements. For all flights by a pilot who is not instrument qualified in the F-14B, the ceiling, visibility, and operating area weather must be adequate for VFR operations. For flights with a pilot who is instrument qualified in the aircraft, the following table delineates appropriate weather conditions depending on pilot experience.

COMBINED TIME F-14B (HOURS)	CEILING AND VISIBILITY (FEET) (MILES)
Less than 10	VFR
10 to 20	800 and 2; 900 and 1-1/2;1,000 and 1
20 to 45	700 and 1; 600 and 2; 500 and 3
45 and above	Field minimums or 200 and1/2, whichever is higher.

Where adherence to these minimums unduly hampers pilot training, commanding officers may waive time-in-model requirements for actual instrument flight, provided pilots meet the following criteria:

1. Have a minimum of 10 hours combined time in the F-14B
2. Completed two simulated instrument sorties
3. Completed two satisfactory tacan penetrations
4. Completed five satisfactory GCA approaches.

5.3.2 NATOPS Qualification and Currency Requirements. F-14 NATOPS qualifications are for a specific aircraft series. The following terms are defined for use in interpreting the F-14 qualification and currency requirements.

Aircraft Type:	The broadest classification of aircraft as to its physical characteristics (e.g., fixed wing or rotary wing).
Aircraft Model:	The basic mission symbol and design number or an aircraft (e.g., P-3, F-14, H-3).
Aircraft Series:	The specific version of an aircraft model (e.g., F-14A, F-14B, F-14D).

5.3.2.1 Initial NATOPS Qualification in Aircraft Series. Initial F-14 NATOPS qualification in series shall include satisfactory completion of the following requirements:

1. Formal ground syllabus training;

2. The NATOPS open book, closed book, and boldface exams;

3. A flight syllabus at a fleet replacement squadron. The syllabus shall include ten (10) flight hours under instruction, four (4) of which may be flown in a CNO approved flight simulator for the same aircraft series; and

4. A separate NATOPS evaluation flight check to be conducted in a CNO-approved simulator. If a CNO-approved simulator is not available, check may be conducted in the aircraft.

FRS commanding officers may waive the flight hour requirement for radar intercept officers (RIO). If the air crewmember has a current F-14A NATOPS qualification, the flight hour requirement may be waived and the flight syllabus may consist of one familiarization flight.

5.3.2.2 Continued NATOPS Qualification. To maintain a continued NATOPS qualification after initial qualification in aircraft series until currency is established, pilots and RIOs shall:

1. Comply with minimum flight hour requirements in each specific phase as determined by the unit commanding officer.

5.3.2.3 NATOPS Currency. Flight crewmembers who have more than 45 hours in F-14A/B/D aircraft model are considered current in aircraft series, provided they continue to satisfy the following requirements:

1. Have satisfactorily completed the ground phase of the NATOPS evaluation check, including OFT/ COT/WST/MFT emergency procedures check (if available), and have completed a NATOPS evaluation check with grade of conditionally qualified or better within the past 12 months;

2. Have flown ten (10) hours in aircraft model [five (5) hours of which shall be in aircraft series]. And made five (5) takeoffs and landings in aircraft model within the last 90 days; and

3. Are considered qualified by the commanding officer of the unit having custody of the aircraft.

Flight crewmembers who are current in the F-14A and F-14D may be considered current in the F-14B. NATOPS requalification for the F-14A, F-14B, and F-14D can be accomplished during the same evaluation check, provided the NATOPS open, closed, boldface exams and currency requirements are met for each series.

5.3.2.4 Currency Renewal. Flight crewmembers who have not remained current shall complete the following requirements in order to re-establish currency:

1. Flight crew members who have not maintained 10 hours in model, 5 hours in series, and 5 takeoffs and landings in model in the last 90 days shall:

   a. Complete a safe for flight simulator check with a squadron NATIOS instructor, and

   b. Be considered qualified by the commanding officer of the unit having custody of the aircraft.

2. Flight crewmembers who are current in the series except for a NATOPS evaluation check within the last 12 months shall:

   a. Complete NATOPS evaluation check (including emergency procedures simulator check, NATOPS open book, closed book and boldface examinations) with squadron NATOPS instructor, and

b. Be considered qualified by the commanding officer having custody of the aircraft.

3. Flight crewmembers without a current NATOPS evaluation check and who have not maintained 10 hours in model, 5 hours in series, and 5 takeoffs and landings in model in the last 90 days shall:

If 6 months or less since last flight:

a. Perform an emergency procedure and safe for flight check in a CNO approved simulator.

b. Fly one night with a squadron NATOPS instructor, and then

c. Complete a NATOPS evaluation check (including NATOPS open book, closed book and boldface examinations), and

d. Be considered qualified by the commanding officer of the unit having custody of the aircraft.

If greater than 6 months since last flight, a repeat of the initial NATOPS qualification requirements is required at the FRS.

5.3.3 Requirements for Various Flight Phases

5.3.3.1 Night — Pilot

1. Combined time in the F-14B not less than 10 hours.

5.3.3.2 Night — RIO

1. Not less than 3 hours in the F-14B as crewmember.

5.3.3.3 Cross Country — Pilot

1. Have a minimum of 15 hours total in the F-14B as first pilot or fly with a qualified instructor RIO

2. Have a valid instrument card

3. Have completed at least one night familiarization flight in the F-14A/B or fly with a qualified instructor RIO

4. Have completed maintenance checkout for servicing aircraft.

5.3.3.4 Cross Country — RIO

1. Have completed at least one night familiarization flight in the F-14A/B or fly with a qualified instructor pilot.

5.3.3.5 Air-to-Air Missile Firing — Pilot

1. Have a minimum of 15 hours combined time in the F-14A/B

2. Be considered qualified by the commanding officer.

5.3.3.6 Air-to-Air Missile Firing — RIO

1. Have a minimum of 25 hours combined time in the F-14A/B as crewmember

2. Have satisfactorily completed a minimum of two intercept flights during which simulated firing runs were conducted utilizing the voice procedures and clear-to-fire criteria to be utilized in live firing

3. Be considered qualified by the commanding officer.

5.3.3.7 Carrier Qualifications. Each crewmember will have a minimum of 50 hours combined time in the F-14A/B, of which 15 hours is nighttime and meet the requirements set forth in the CV NATOPS manual.

1. Minimum-hour requirement for radar intercept officers may be waived by the commanding officer based upon individual experience level and crew composition.

5.3.4 Mission Commander. The mission commander shall be a NATOPS-qualified pilot or RIO, qualified in all phases of the assigned mission, and designated by the unit commanding officer.

5.3.5 Minimum Flightcrew Requirements. The pilot and the RIO (or two pilots) constitute the normal flightcrew for performing the assigned mission for all flights. Unit commanders may authorize rear-seat flights for personnel other than qualified pilots and RIOs, provided such personnel have received thorough indoctrination in the use of the ejection seat and oxygen equipment and in the execution of rear-seat functions and emergency procedures. Where operational necessity dictates, unit commanders may authorize flights with rear seat unoccupied, provided the requirement for such flight clearly overrides the risk involved and justifies the additional burden placed on the pilot. In no case is solo flight authorized for shipboard operations, combat, or combat-training missions.

5.4 FLIGHT CREWMEMBER FLIGHT EQUIPMENT REQUIREMENTS

In accordance with OPNAVINST 3710.7, the flying equipment listed below will be worn or carried, as applicable, by flight crewmembers on every flight. All survival equipment shall be secured in such a manner that it will be easily accessible and will not be lost during ejection or landing. All equipment shall be the latest available as authorized by the Aircrew Personal Protective Manual, NAVAIR 13-1-6.

1. Protective helmet
2. Oxygen mask
3. Anti-g suit
4. Fire-retardant flightsuit
5. Steel-toed flight safety boots
6. Life preserver
7. Harness assembly
8. Shroud cutter
9. Sheath knife
10. Flashlight (for all night flights)
11. Strobe light
12. Pistol with tracer ammunition or approved flare gun
13. Fire-retardant flight gloves
14. Identification tags
15. Antiexposure suit in accordance with OPNAVINST 3710.7
16. Personal survival kit
17. Other survival equipment appropriate to climate of the area
18. Full pressure suit and Mk 4 life preserver on all flights above 50,000 feet MSL
19. Pocket checklist
20. Navigation packet.

PART III

Normal Procedures

CHAPTER 6

Flight Preparation

6.1 PREFLIGHT BRIEFING

Preflight briefings shall be conducted immediately before the launching of scheduled flights and must be carried out in an expeditious but thorough manner. Ample time should be given for briefing with external assets as well as for conducting internal-element briefs. When scheduling a brief, consideration should be made to ensure that enough time is given for the aircrew to finish briefing, don all flight gear, check out any special items required for the mission (authenticators, cameras, guns), read the aircraft discrepancy book, and man the aircraft in order to make the scheduled launch time. For this reason, it is imperative that all pilots and RIOs be in flightsuits ready for the brief at the designated time.

The brief should optimally be conducted in a designated briefing room, free of distractions, with a white dry-erase board and 1:72 scale aircraft models. A briefing board should be put up prior to the brief, depicting applicable admin items, mission objectives, flight conduct, special instructions, and necessary diagrams. Aircrew should utilize appropriate tactical manuals and current Weapon School manuals and journals for mission planning. The briefing shall include, but not be limited to, the following.

6.1.1 Administration. The following items should be covered for each flight, regardless of the mission.

1. Event number
2. Launch/recovery times/recovery order
3. Lineup/call signs/avionics plan
4. Mission assigned/alternate missions
5. External assets/call signs
6. Weather
7. Base, en route, target area, divert
8. Water/air temperature, sea state
9. Ordnance and stores carried/preflight/restrictions on use
10. Communication plan
11. Area/NOTAMs
12. Clearance/NAVAIDs
13. Ground/deck procedures
14. Takeoff/departure/rendezvous
15. En route/formation
16. Tanking plan
17. Combat checks/OBC/alpha check
18. Recovery procedures (VFR/IFR)
19. Joker/bingo fuel
20. NORDO procedures
21. Emergencies/diverts/SAR/birdstrike
22. Training rules
23. Contingencies.

6.1.2 Mission. Aircrew should brief each section that applies to their expected mission. Missions not specifically discussed in this chapter should be covered using the appropriate tactical manual.

6.1.2.1 Low-Level/Strike Ingress

1. Time hack
2. Controlling agency route brief
   a. Restrictions/hot areas
3. Current charts/CHUM

4. Entry/exit times
5. Formation/altitude/airspeed
6. Navigation mode/plan
7. Waypoint LAT/LONG
8. Communications
9. Checkpoints/timing
10. Turnpoints/corrections
11. Radar plan/search contracts
12. Threat awareness (SAM, AAA, A/A)
13. DECM/RWR/expendables
14. Target area ingress — Initial point/target
15. Abort criteria/procedures
16. Safety.

6.1.2.2 Air-to-Ground Strike

1. Time hack
2. A/G checklist complete
3. Range/area
4. Time on target
5. Communications
6. Swing fighter consideration
7. Target area tactics
    a. SEAD window
    b. Target ID/acquisition
    c. Tactic/backup tactic
    d. Aircraft interval/sequence
    e. Aim points/backup aim points
    f. Threat awareness (SAM, AAA, A/A)
    g. DECM/RWR/expendables
8. Weaponeering/switchology
    a. Target type
    b. Weapon
    c. Attack/delivery mode
    d. Fuze/delay
    e. Functioning Delay
    f. Interval
    g. Stick length
    h. Frag pattern
    i. Manual mil setting
    j. Stations selected
    k. Laser Codes
9. Release conditions
    a. Dive angle
    b. Airspeed/Mach
    c. Release/recovery altitude
    d. Heading
    e. Slant range
    f. Time of fall
10. Off-target rendezvous/egress/RTF
11. Hung ordnance/jettison
12. Abort criteria/procedures
13. Safety.

6.1.2.3 Air-to-Air

1. Mission type/objectives/strike integration/ friendly assets
2. Threat awareness (A/A, SAM, AAA)

3. ROE/PID criteria
4. GCI/control/bullseye
5. Precommit
   a. Position/time/CAP management
   b. Formation/visual lookout
   c. Radar gameplan
   d. Defense in depth
6. Commit
   a. Authority/criteria
   b. Abort/resetIntercept
   c. Geometry/flow
   d. Formation/altitude/airspeed
   e. Communications (cadence/priority)
   f. Radar search responsibilities
   g. Meld/targeting
   h. Sort/lock range/no sort
   i. Drop criteria/factor bandit range
   j. Degrades
   k. Float/strip
   l. Preplanned coordinated maneuvers
   m. RWR
   n. Abort/reset
7. Approaching the merge/merge
   a. Missile employment
   b. Fuel package
   c. Crank/expendables
   d. IRCM
   e. Section/division maneuvering
   f. Engage/blowthrough
8. Postmerge/egress
   a. Target area considerations/frag
   b. Flow/new ROE
   c. Radar gameplan
   d. Visual lookout doctrine/commit
   e. Rendezvous
9. Defensive considerations
   a. Communications
   b. Threat/nose position/RWR
   c. Missile/gun defense
   d. E-pole.

6.1.2.4 TARPS

1. Mission type
   a. SSC/mapping/standoff/point target
2. Pod checks — On deck/airborne
3. Operating area/route/TOT
4. Navigation mode/plan — Primary/secondary
   a. INS/GPS/visual/DR
   b. Checkpoints
   c. Post-target IPs
   d. Topography/terrain
5. Target/acquisition/ID/placement
6. Sensors
   a. Primary/secondary/tertiary
   b. Vg/H settings
   c. Troubleshooting

7. Formation/altitude/airspeed
8. Communications
9. Radar plan
10. Threat/awareness (SAM, AAA, A/A)
11. DECM/RWR/expendables
12. Egress
    a. Target area considerations/frag
    b. Rendezvous/RTF
13. Abort criteria/procedures
14. Safety.

CHAPTER 7

Shore-Based Procedures

7.1 CHECKLISTS

Aircraft checklists are available in two forms, based on the degree of flightcrew familiarization; since the sequence remains the same, the only difference in the forms is the degree of amplification. As the flightcrew becomes more proficient in type, a more abbreviated form is available to promote operational efficiency, and safety is not compromised since in all instances the thoroughness of checks remains the same. The placarded takeoff and landing checklists on the cockpit instrument panels are a fundamental element in all instances. In the interest of procedural standardization, the shore-based and carrier-based procedures are maintained the same except for the response relative to the checks. The expanded procedures presented in this flight manual describe in detail those items that should be checked on each flight. Adherence to these procedures will provide the flightcrew with a detailed status of weapons system performance incident to flight. However, it is incumbent on the flightcrew to expand the checks as necessary to verify the corrective status of previously reported discrepancies. Reference should be made to the functional checkflight procedures (paragraph 10.2) for more detailed tests that can be performed on the aircraft and weapon systems if deemed necessary. The flightcrew should be thoroughly familiar with the details of the procedures outlined herein so that the abbreviated checklist forms of the procedures may be safely employed. As the first level of simplification, the NATOPS PCL contains a reprint of the normal procedures, with less amplifying information.

7.1.1 TARPS. A bracketed T **[T]** in a procedural step identifies items pertaining only to TARPS aircraft.

7.2 EXTERIOR INSPECTION

A proper preflight inspection begins with a thorough review of aircraft status and past maintenance history. An understanding of previous discrepancies, corrective action and their impact on the flight can best be gained at this time. The flightcrew should ensure that any and all discrepancies have been properly corrected or deferred prior to accepting the aircraft as ready for flight.

7.2.1 Around Aircraft. En route to the aircraft, attention should be directed to the maintenance effort going on in the line area. The flightcrew should ensure that no hazardous situations exist. The entire area should also be generally examined for FOD hazards.

The area around the aircraft that may not be visible from the cockpit should be examined. Particular attention should be paid to support equipment adjacent to the aircraft. It should be determined that the wings and flight controls can be safely moved and that the effect of jet blast during start and taxi will not create a dangerous situation.

7.2.2 FOD Inspection. Engine intakes and adjacent deck areas are of prime concern since the F110-GE-400 is highly susceptible to FOD damage and the engines are capable of picking up objects from the deck. Air inlet control system ramps, bleed doors, environmental control system cooling intakes, exhausts, and afterburner ducts are catchalls for loose objects. They should be closely inspected for security and foreign objects. Inspect all panels for security and loose fasteners.

7.2.3 Ground Safety Devices and Covers. The following items should be installed:

1. Main landing gear ground safety locks (2)
2. Nose landing gear ground safety pin
3. Launch abort mechanism lock (if applicable)
4. Wheel chocks
5. AN/ALE-39 ground safety pins
6. LAU-7/LAU-92 ground safety pins
7. Sidewinder seeker-head covers (if applicable)

The following items should be removed:

1. Intake, probe, bleed door, and ECS duct covers

2. Water-intrusion tape.

7.2.4 Surface Condition. All surfaces should be checked for cracks, distortion, or loose or missing fasteners. All lights and lenses should be checked for cracks and cleanliness.

7.2.5 Security of Panels. All fasteners should be flush and secure on all panels.

7.2.6 Leaks. All surfaces, lines, and actuators should be checked for oil, fuel, and hydraulic leaks. Particular attention should be paid to the underside of the fuselage, engine nacelles, and outer wing panels.

7.2.7 Movable Surfaces. All movable surfaces (flight controls and high-lift devices) should be inspected for position, clearance, and obvious damage.

7.2.8 Inspection Areas. The exterior inspection is divided into the following 10 areas labeled 'A' through 'J' in Figure 7-1. Checks peculiar to only one side are designated (L) or (R) for the left or right side. Both the pilot and RIO should preflight the entire aircraft individually.

7.2.8.1 Ⓐ Forward Fuselage

1. Access panel fasteners forward of engine inlets — No Loose or Missing Fasteners.

2. Gun (L) — Safety Pin Installed in Clearing Sector Holdback Assembly, Louvers Clear.

3. Probes — Secure, Openings Clear; AOA PROBE (Rotates freely).

4. Nosewheel well

   a. Electrical leads — Connected, No Evidence of Overheating.

   b. Hydraulic lines — No Chafing or Leaks.

   c. Doors and linkages — Cotter Pins Installed, No Distortion.

   d. Brake accumulator — 1,900 psi Minimum.

   e. Canopy air bottle gauge — 1,200 psi Minimum.

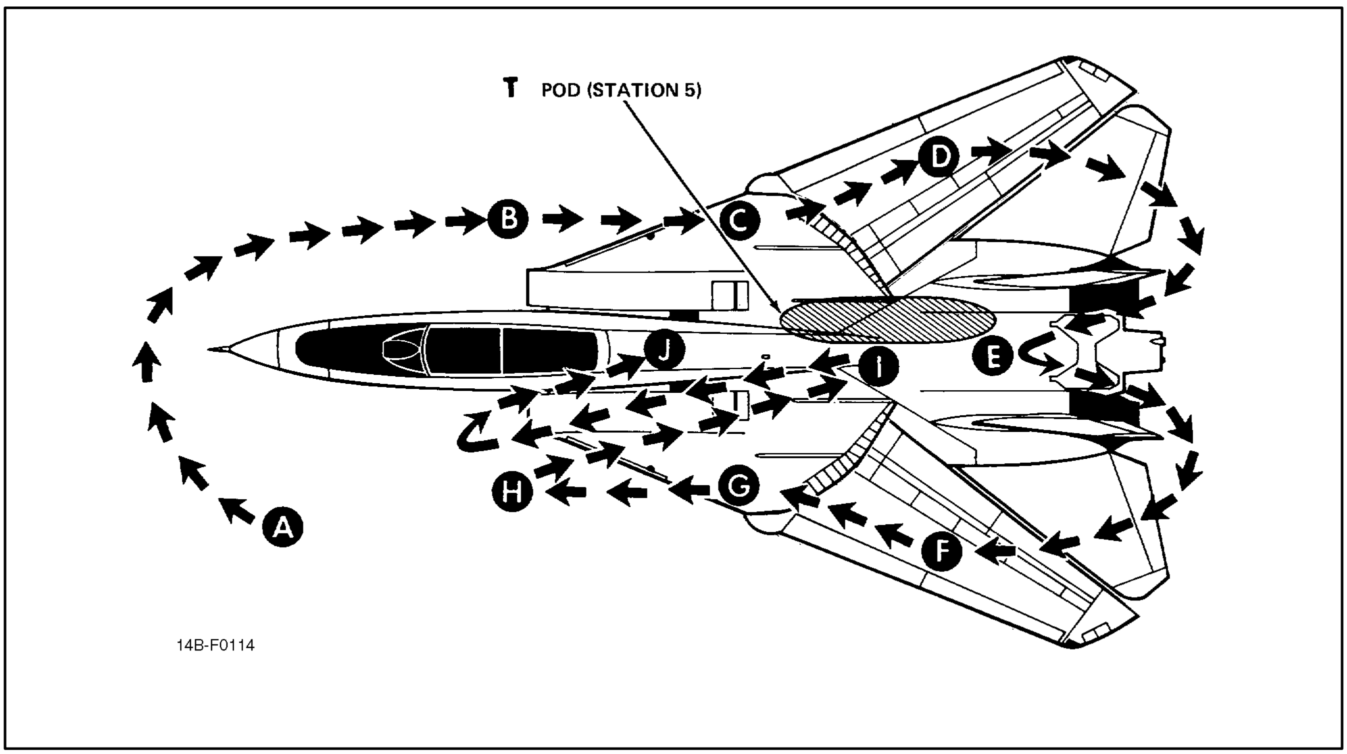

Figure 7-1. Exterior Inspection

f. Emergency landing gear nitrogen bottle gauge — 3,000 psi Minimum.

g. Emergency landing gear air release valve — Ensure That Valve is in Closed Position.

h. Retract actuator — Piston Clean, No Leaks.

i. Flight maintenance indicator — Secure.

j. Antiskid control box — BIT flags — Not Tripped.

k. Cabin pressure port screens — Clean.

l. Master arm override — Cover Closed.

5. Nose strut — Piston Clean, Free of Cracks and Scoring, and Uplock Roller Free.

6. Steering actuator — Secure, No Leaks.

7. Launch bar and holdback fitting

a. Abort — Full Up (Safety Lock Installed, if Applicable).

b. Roller — Free Rotation.

c. Uplatch and holdback — Free Movement.

8. Nosewheels and tires — Proper Inflation. No Cuts, Bulges, Uneven Wear, or Embedded Objects.

9. Drag brace — No Leaks, Door Secure.

10. Approach lights — Lenses Clean, No Cracks, Secure.

11. TV camera — Check, Blue Desiccant.

12. IR/TV pod — APN-154 Antenna and Anticollision Light Secure.

13. Radome — Lock Handle Fastened, Rosemont Probe Straight.

14. LOX vent outlet (R) — No Obstructions.

7.2.8.2 Ⓑ Right Inlet

1. Ramps, metal seals, and rubber seals — Intact, Free of Dirt, Grit, and Cracks.

2. IGVs — Blades and Stators Free of Nicks and Cracks.

   Plane captain to verify that all visible damage has been blended.

3. ECS heat exchanger inlet and fan

   a. Fan — Free Rotation.

   b. Overspeed pin — Recessed.

   c. ECS inlet — Free of FOD, Cables Connected (2).

4. Inlet — Free of Standing Water, Drains Clear.

7.2.8.3 Ⓒ Right Nacelle and Sponson

1. Station 7 and 8 Stores

   a. Stores — Aligned.

   b. Access panels — Secure.

   c. Sidewinder coolant doors — Latched.

   d. Stores safety pins — Installed.

If external fuel tank/MXU-611 aboard:

   e. Ground safety handle — Pulled.

   f. Fuel quantity sight gauge — Ball Float Vertical.

   g. Sway braces — Tightened Down.

   h. Hook latch indicator — White Vertical Line Visible.

   i. Inboard and outboard Fuel caps — Fastened With Butterfly Latch Secured Facing Aft.

2. Main wheelwell:

   a. Doors and linkages — Secure.

   b. Uplock microrollers — Free.

c. Uplock hooks — Secure.

d. Hydraulic lines — No Chafing or Leaks.

3. Drag brace — Secure, Down Lock Safety Pin Forward.

4. Side brace — Seated in Latch.

5. Main struts — Pistons Clean, Free of Cracks or Scoring.

6. Brakes — Pucks, Safety-Wired, Wear Indicators Visible (Pins at Least Flush). Lower Torque Arm Swivel, Key and Key Retainer Properly Installed and Safety-Wired.

7. Hubcap — Secure, Safety-Wired.

8. Main wheels and tires:

   a. Wheels and tires — Proper Inflation. Cuts, Bulges, Uneven Wear, or Embedded Objects (look behind chocks).

9. Gear down microrollers — Contact Made.

10. Engine compartment (if applicable):

    a. Integrated drive generator-transmission fluid — Fluid Visible, Filter (2) Pins Flush.

    b. Engine oil servicing caps — Check.

    c. Bilges — No FOD, Evidence of Overheating, or Leakage.

    d. Fuel, oil, and hydraulic lines — Free of Chafing or Leaks.

    e. Bleed air lines — No Heat Discoloration or Damage.

    f. AB fuel pump filter — Pin Flush.

    g. Lube and scavenge bypass filter — Pin Flush.

    h. Oil nozzle filter — Pin Flush.

11. Flight hydraulic reservoir — 1,800 psi Minimum, Filter Pins Flush.

12. Flight hydraulic system tape gauge — Minimum of 7 on Tape.

13. Hook dashpot pressure gauge — 800±10 psi.

14. Ventral — No Damage, IDG Oil Cooler Intake Clear.

7.2.8.4 (D) Right Glove and Wing

1. Slats, flaps, and cove doors — Surfaces and Hinges Secure.

2. Wing cavity seal — Free of Cuts and Chafing.

3. Formation and position lights — Intact, Lenses Clean.

7.2.8.5 (E) Aft and Under Fuselage

1. Horizontal tails — Leading Edges Free of Damage.

2. Exhaust nozzles and fairings

   a. Nozzles and fairings — No Cracked or Missing Leaves or Seals.

   b. Bottom surface — No Scrapes or Cracks.

   c. Spray rings — Intact.

   d. Turbine blades — No Evidence of Overheating.

3. Fuel vent — No Leakage or FOD.

4. Tailhook

   a. Hook point — Smooth.

   b. Nut and cotter pin — Installed.

   c. Safety pin — Remove if Hook is Securely Latched Up.

5. Backup flight control module — No Leaks (feel aft of inspection doors), Filter Pins Flush, Close Both Access Doors.

6. Fuel dump — No Leakage from Mast, Free of FOD.

7. Stations 3 through 6 stores

   a. Stores — Aligned.

   b. Access panels — Secure.

   c. Stores safety pins — Installed.

8. Fuel cavity drains — No Leakage.

9. **[T]** Pod — Check For Security.

10. **[T]** Protective window covers — Removed.

11. **[T]** Camera windows — Clean.

12. **[T]** Camera S/C — As Briefed.

13. **[T]** Light meter — Facing Outboard.

14. **[T]** Lens filter — As Briefed.

7.2.8.6 Ⓕ Left Glove and Wing

1. Slats, flaps, and cove doors — Surfaces and Hinges Secure.

2. Wing cavity seal — Free of Cuts and Chafing.

3. Formation and position lights — Intact, Lenses Clean.

7.2.8.7 Ⓖ Left Nacelle and Sponson

1. Station 1 and 2 racks and stores

   a. Racks and stores — Aligned.

   b. Access panels — Secure.

   c. Sidewinder coolant doors — Latched.

   d. Stores safety pins — Installed.

   If external fuel tank/MXU-611 aboard:

   e. Ground safety handle — Pulled.

   f. Fuel quantity sight gauge — Ball Float Vertical.

   g. Sway braces — Tightened Down.

   h. Hook latch indicator — White Vertical Line Visible.

   i. Inboard and outboard fuel caps — Fastened With Butterfly Latch Secured Facing Aft.

2. Main wheelwell

   a. Doors and linkages — Secure.

   b. Uplock microrollers — Free.

   c. Uplock hooks — Secure.

   d. Hydraulic lines — No Chafing.

3. Drag brace — Secure, Down Lock Safety Pin Removed.

4. Side brace — Seated in Latch.

5. Main struts — Pistons Clean, Free of Cracks or Scoring.

6. Brakes — Pucks, Safety-Wired, Wear Indicators Visible (pins at least flush). Lower Torque Arm Swivel, Key and Key Retainer Properly Installed and Safety-Wired.

7. Hubcap — Secure, Safety-Wired.

8. Main wheels and tires

   a. Wheels and tires — Proper Inflation. No Cuts, Bulges, Uneven Wear, Embedded Objects (look behind chocks).

   b. Uplock hooks — Secure.

9. Gear up microrollers — Contact Not Made.

10. Engine compartment (if applicable)

    a. Integrated drive generator — Fluid Visible (2) Pins Flush.

    b. Engine oil servicing caps — Check.

    c. Bilges — No FOD, Evidence of Overheating, or Leakage.

    d. Fuel, oil, and hydraulic lines — Free of Chafing or Leaks.

    e. Bleed air lines — No Heat Discoloration or Damage.

f. AB fuel filter — Pin Flush.

g. Lube and scavenge bypass filter — Pin Flush.

h. Oil nozzle filter — Pin Flush.

11. Combined hydraulic reservoir — 1,800 psi Minimum, Filter Pins Flush.

12. Combined hydraulic system tape gauge — Minimum of 7 on Tape.

13. Airstart door — Ground Hydraulic and Electric Covers Tight.

14. Ventral — No Damage, IDG Oil Cooler Intake Clear.

7.2.8.8 (H) Left Inlet

1. Ramps, metal seals, and rubber seals — Intact, Free of Dirt, Grit, and Cracks.

2. IGVs — Blades and Stators Free of Nicks and Cracks.

   Plane captain to verify that all visible damage has been blended.

3. Ice detector (L) — Secure.

4. ECS heat exchanger inlet and fan

   a. Fan — Free Rotation.

   b. Overspeed pin — Recessed.

   c. Inlet — Free of FOD, Cables Connected (2).

5. Outboard spoiler module temperature indicator and servicing — No Leaks, Fluid Indicator Rod Protruding.

6. Inlet — Free of Standing Water, Drains Clear.

7.2.8.9 (I) Fuselage Top Deck and Wings

1. Bleed exit doors — Free of FOD, Hardware Intact.

2. ECS heat exchanger exhausts — Free of FOD and Cracks.

3. Overwing fairings — No Cracked or Bent Fingers.

4. Eyebrow doors — Intact.

5. Speedbrake — No Distortion or Leaks.

6. Vertical tails and rudders — No Distortion, Lights Intact.

7.2.8.10 (J) Canopy

1. Canopy lanyard — Connected, Yellow Flag Attached at Both Ends.

WARNING

The backup initiator and auxiliary pneumatic selector valve linkages are in close proximity and are similar in appearance. Reset of the auxiliary pneumatic selector valve should be performed by trained personnel and only after the backup initiator is pinned. If the backup initiator is inadvertently activated, the escape system safe-and-arm mechanism will be partially armed. Subsequent ejection will cause the RIO to impact the canopy.

2. Auxiliary canopy bottle — Cable Taut.

3. Canopy hooks and seal — Secure, Seal Intact.

4. Ejection seat safe-and-arm device safety pins (see Figure 7-2 and Figure 7-3) — Pulled.

5. Auxiliary canopy bottle gauge — 800 psi Minimum.

6. Blade antennas — Intact.

7. Canopy — Clean, Free of Cracks and Deep Scratches.

7.3 EJECTION SEAT INSPECTION

The pilot and RIO shall perform the following checks on their respective ejection seats prior to flight. Ground safety pin removal should be confirmed on all actuation devices where a pin can be inserted to safety the mechanism for ground maintenance (see Figure 7-3).

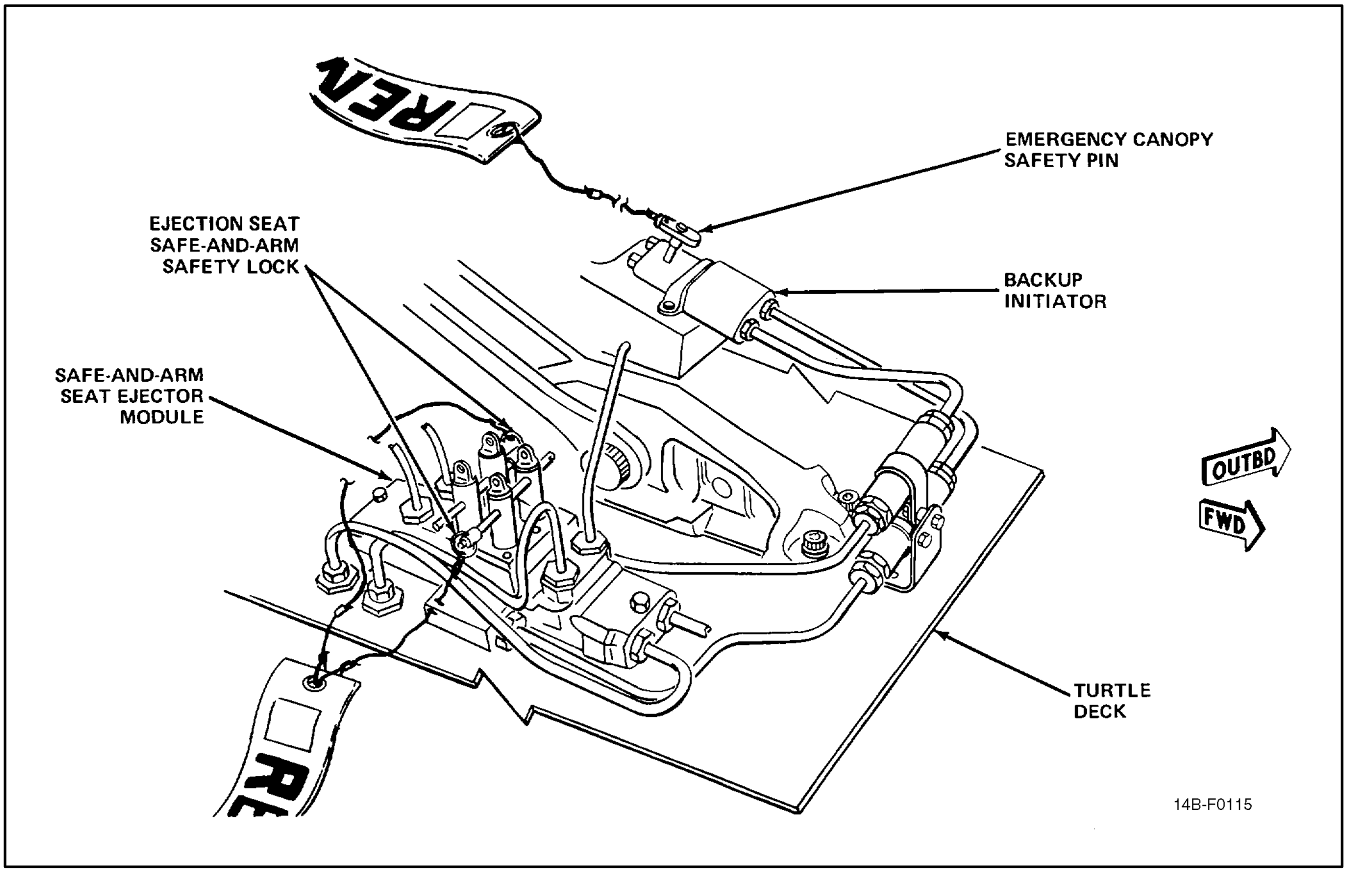

Figure 7-2. Ejection Seat Safe and Arm Module

Abbreviated preflight checklists for the ejection seat are provided in the pocket checklist and on the ejection seat headbox.

1. Face curtain locking tab — Up (locked).

2. Lower ejection handle — Guard Up (locked).

3. Face curtain connecting link (R) — Safe Indication.

Tabs adjacent as viewed through inspection window.

4. Time-release mechanism trip rod — Connected. No red indication showing on inner rod and rod attached to ejection gun crossbeam. Seat fully inserted into timing release mechanism with no gap between seat and body.

WARNING

If seat is not fully inserted into timing release mechanism, inadvertent operation of the timing release mechanism may occur. This will safe the lower firing handle and release the occupant from the seat mechanism.

5. Face curtain automatic release linkage — Disconnected.

6. System initiator — Connected and Pin Removed.

   Check that initiator is connected to withdrawal arms and inner and outer torque shaft.

7. Time-release mechanism rod — Scissor Release Pin Protruding.

   Check that pin is protruding above housing so as to inhibit plunger movement and scissor release.

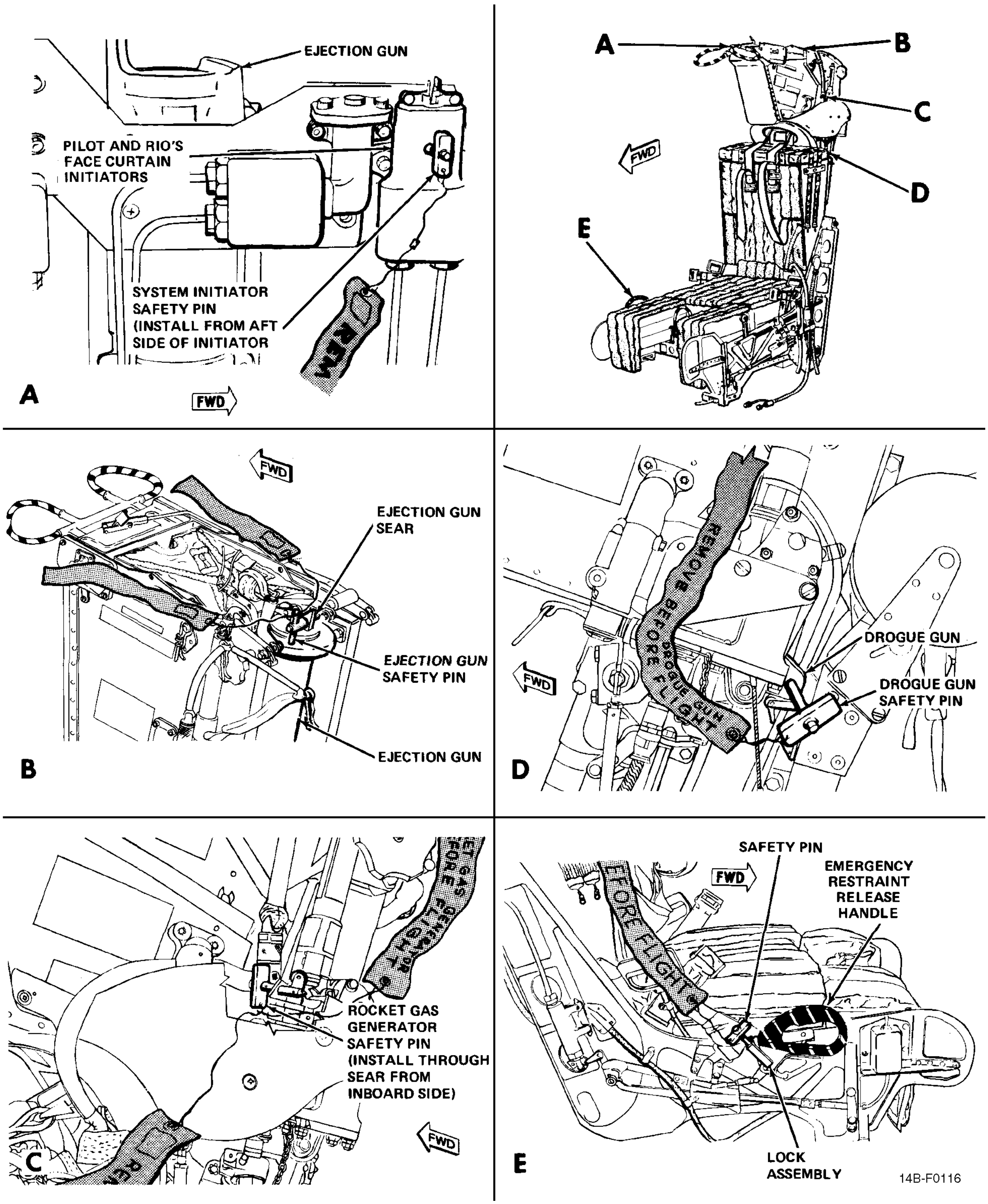

Figure 7-3. Mk GRU-7A Ejection Seat Safety Pins

8. Drogue chute link lines — Clips Engaged.

9. Scissor shackle — Stowed, Drogue Lanyard Connected.

10. Ejection gun sear — Connected and Pin Removed.

11. Ejection gun sear withdrawal links — Connected.

    Check that withdrawal links are connected to sear.

12. Drogue chute housing flaps — Tacked Down.

13. Face curtain — Secure.

    Check that face curtain crossbar is securely restrained in the headbox.

14. Face curtain connecting link (L) — Safe Indication.

    Tabs adjacent as viewed through inspection window.

15. Drogue chute lines (L) — Clips Engaged.

16. Drogue withdrawal line — Connected to Drogue Slug.

    Check that shielded withdrawal line is free for the slug to deploy the stabilizing drogue chute.

17. Drogue slug shear pin — Head Impressed.

18. Top latch mechanism — Flush.

    Check that top latch dowel is flush with or slightly recessed from the end of the housing.

19. Parachute withdrawal line screw connector — Fingertight.

    Check that the screw connector is torqued with essentially no gap.

WARNING

If the personnel parachute withdrawal line is not securely connected, automatic deployment of the parachute will not occur after ejection.

20. Guillotine cutter — Withdrawal Line Routed Through Guillotine.

    Check that the sheathed parachute withdrawal line is routed through the guillotine cutter under the yellow protective guard.

21. Power inertia reel sear — Connected.

    Check that actuating link is connected to the power inertia reel gas generator sear.

22. Fork ends of harness sear rods — Connected.

23. Rocket motor initiator sear — Connected and Pin Removed.

24. Drogue gun trip rod — Connected and Pin Removed.

    No red indication showing on inner rod and rod attached to ejection gun crossbeam.

25. Rocket motor initiator sear extraction lanyard — Attached.

    Check that the lanyard is attached to the sear actuating link and the drogue gun trip rod.

26. Parachute premature deployment lanyard — Secured.

    Check that the lanyard is anchored to the inertia reel housing.

27. Shoulder harness — Secured.

    Check that inertia reel straps are anchored to inertia reel housing.

28. Canopy releases — Proper Installation.

    Check that EPAs are outboard of canopy release fittings.

29. Ripcord — Routed Through Parachute Pack Ring.

30. Manual ripcord eyelet — Connected to Leap Ripcord Pin.

31. Ripcord pins — Straight/No Corrosion.

32. Ventilation hose — Connected to Seat or Disconnected.

    Connect as appropriate depending on flight suit configuration.

33. Personnel services block — Verify Connection to Seat Bucket Disconnect Lanyard(s) (2) Secured to Deck.

34. Raft release handles — Note Type.

35. Lap belt restraint — Secured.

    Tug lap restraint fittings to assure that end fittings are secured to seat bucket.

36. Emergency oxygen trip cable — Secured.

    Check that the seat kit cable is attached to the personnel services disconnect in order to enable automatic oxygen actuation upon ejection.

37. Survival kit sticker clips and lugs — Secured and Engaged.

    Check clips secured to seat bucket fitting and release linkage attached.

38. Survival kit front lock release lever — Full Forward.

    Check that survival kit front lock release lever peg is full forward against leg line release linkage.

WARNING

Failure of survival kit front lock release lever to return to its full-forward position will prevent ejection by means of the lower ejection handle.

Note

It may be necessary to raise seat to see lever.

39. Emergency oxygen supply bottle — Full Indication, 1,800 psi (in black).

40. Emergency oxygen actuator — Connected/ Stowed.

41. Leg restraint cords — Secured to Deck, Routed Through Snubber, Anchored to Seat Release Fitting.

42. Survival kit forward restraint pin — Engaged.

    Pull upward on forward edge of survival kit to ensure that restraint pin is engaged.

43. URT-33 lanyard — Connected.

44. Emergency restraint release handle — Down and Secured, Pin Removed.

    Check that handle is full down and trigger protrudes from grip.

45. Guillotine initiator sear — Connected.

    Check that emergency release handle actuating linkage is connected to sear and leg restraint release linkage.

46. Ejection and canopy pins — Stowed.

7.4 PILOT PROCEDURES

The interior inspection provides a systematic coverage of all cockpit controls to ensure proper setup prior to the application of external power, assuming no external air conditioning source will be used prior to engine start. These checks correspond to the condition that the plane captain should set up in the cockpit as part of the preflight. Each cockpit setup consists of a sequential sweep of controls on the left console, instrument panel, and right console.

7.4.1 Interior Inspection — Pilot

WARNING

NATOPS prohibits the attaching or stowing of unauthorized equipment on or above the canopy rails during CV launch and arrestment, due to the potential for missile hazard.

1. Harnessing — Fasten.

   a. Leg restraint lines and garters — Connect.

      Connect leg line bayonet fitting to leg garter quick-release buckle on the respective side. Ensure that leg lines are not twisted.

   b. Personal services (vent and anti-g hoses) — Connect.

      Insert personal vent and anti-g hoses into seat block fittings. In the absence of a suit vent requirement, the seat block vent hose should be inserted into the seat back fitting to provide ventilation air through the seat and back cushions.

   c. Lap belt — Attach.

      Attach lap belt fittings and pull bucket straps snug so as to provide secure lap restraint for flight and seat kit suspension in the event of emergency egress or ejection.

   d. Shoulder harness — Attach.

   e. Inertia reel — Check.

      Position the shoulder harness lock lever forward to the lock position and check that both shoulder straps lock evenly and securely when leaning back. Position lock lever full aft to unlock harness; release lever to the neutral position.

   f. Oxygen-audio connection — Attach.

      Attach composite fitting without causing unnecessary twisting of hard hose.

2. Oxygen — Check.

   Turn OXYGEN switch ON, purge with mask held away from face. Place mask to face and check for normal breathing and regulator and mask operation. Turn OXYGEN switch OFF, check no breathing.

3. VENT AIRFLOW thumbwheel — Set.

   Set thumbwheel as desired to control vent airflow anywhere between no flow (O) and full flow (15).

4. Tone VOLUME controls — Set.

5. Tacan function selector — OFF.

   a. Channel — Set.

   b. Mode switch — Set.

   c. VOL knob — Counterclockwise.

6. ICS panel — Set.

   a. VOL knob — As Desired.

   b. Amplifier — NORM.

   c. Function selector — COLD MIC.

7. STAB AUG switches — OFF.

8. UHF function selector — OFF.

WARNING

The emergency wingsweep handle can be moved independent of the wings and wingsweep indicators when no hydraulic power and/or electrical power are on the aircraft. Care must be taken to accurately determine the position of the emergency wingsweep handle prior to application of hydraulic power. Inadvertent wingsweep to the position selected by the emergency wingsweep handle may occur, resulting in potential damage to the aircraft. When positioning the wings during ground operation other than pilot poststart or postlanding checklist procedures, use the emergency wingsweep handle to minimize the possibility of moving the wings inadvertently.

9. Wing-sweep switch — MAN.

10. Emergency wingsweep handle — Corresponding.

11. Left and right throttles — OFF.

12. Speedbrake switch — RET.
13. Exterior lights master switch — Set.

    Position switch in accordance with standard procedures for day or night and field or carrier operations.

14. FLAP handle — Corresponding.
15. Throttle friction lever — OFF (aft).
16. ASYM LIMITER switch — ON (guard down).
17. L and R ENG MODE SELECT switches — PRI.
18. BACK UP IGNITION switch — OFF.
19. THROTTLE TEMP switch — NORM.

Note

The F110-GE-400 engine automatically compensates for temperature variations.

20. THROTTLE MODE switch — BOOST.
21. L and R INLET RAMPS switches — AUTO.
22. ANTI SKID SPOILER BK switch — OFF.
23. FUEL panel — Set.
    a. WING/EXT TRANS switch — AUTO.
    b. REFUEL PROBE switch — RET.
    c. DUMP switch — OFF.
    d. FEED switch — NORM (guard down).
24. LDG GEAR handle — DN.

    Check HYD ISOL switch in TO/LDG

25. NOSE STRUT switch — OFF.
26. Parking brake — Pull.
27. Radar altimeter — OFF.
28. Altimeter — Set.

    Set field or carrier elevation as applicable.

29. Left and right FUEL SHUT OFF handles — In.
30. ACM panel — Set.
    a. ACM switch — OFF (guard down).
    b. MASTER ARM switch — OFF (guard down).
31. Weapon select — OFF.
32. VDIG and HSD retaining locks — Engaged.

Note

Visually check for security of cockpit equipment, particularly the vertical display indicator, instrument panel gauges, and the heads-up display camera.

33. HUD and VDI filters — As Required.

    Filter control handle on right side of VDI should be pushed in for day flights and pulled out (filter in place) for night operations.

34. Standby attitude gyro — Caged.
35. G-meter — Reset.
36. Clock — Wind and Set.
37. Fuel Bingo — Set.

    Set total fuel remaining value for initial activation of fuel BINGO caution reminder consistent with mission profile to be flown.

38. Circuit breakers — Checked.
39. Brake accumulator pressure — Check in Green.
40. HYD HAND PUMP — Check.

    Extend handpump handle and stroke to check firmness of pumping action and an indication of pressure buildup on the brake pressure gauge. Stow handpump handle in a convenient position for ready access.

41. HOOK handle — Corresponding.
42. DISPLAYS panel — Set.
    a. MODE pushbutton — T.O.
    b. HUD DECLUTTER switch — OFF.
    c. HUD AWL switch — ACL.
    d. VDI MODE switch — NORM.
    e. VDI AWL switch — ACL.

f. HSD MODE switch — NAV.

g. STEER CMD pushbutton — DEST.

h. DISPLAYS POWER switches — OFF.

43. ELEV LEAD knob — SET.

44. L and R generator switches — NORM.

WARNING

Ground engine operation without electrical power supplied by either the generators or external power may cause 20-mm ammunition detonation because of excessive heat in the gun ammunition drum.

45. EMERG generator switch — NORM (guard down).

46. Air-condition controls — Set.

a. TEMP mode selector switch — AUTO.

b. TEMP thumbwheel control — As Desired (5 to 7 midrange).

c. CABIN PRESS switch — NORM.

d. AIR SOURCE pushbutton — OFF.

During operations in freezing temperatures, selection of AIR SOURCE to OFF will preclude ingestion of ice particles into the ECS from a groundstart unit. After engine start, reselect AIR SOURCE to BOTH.

47. WSHLD AIR switch — OFF.

48. ANTI-ICE switch — AUTO/OFF.

49. COMPASS panel — Set.

a. Mode selector knob — SLAVED.

b. Hemisphere N-S switch — Set.

c. LAT knob — Set.

50. ARA-63 panel — OFF.

a. CHANNEL selector — Set.

b. POWER switch — OFF.

51. MASTER LIGHT panel controls — As Required.

Set external and interior lighting controls consistent with day or night and field or carrier operating conditions.

52. MASTER TEST switch — OFF.

53. EMERG FLT HYD switch — AUTO (guard down).

54. HYD TRANSFER PUMP switch — SHUT OFF (guard up).

55. CANOPY air diffuser lever — CABIN AIR.

56. VIDEO CONTROL switch — OFF.

57. Storage case — Inspect.

Check adequacy of flight planning documents and storage of loose gear.

7.4.2 Prestart — Pilot

1. External electrical power — ON.

2. If wings are not in OV SWP:

a. WING SWEEP DRIVE NO. 1 and WG SWP DRIVE NO 2/MANUV FLAP cbs (LE1, LE2) — Pull.

b. Emergency WINGSWEEP handle — Extend and Match Captain Bars With Wing Position Tape.

CAUTION

Wings will move to emergency handle position regardless of wing-sweep cb position.

Note

If wings are in OV SW, do not extend handle.

3. ICS — Check.

4. Landing gear indicator and transition light — Check.

   Check gear position indication down and transition light off.

5. MASTER TEST switch — Check.

   Coordinate with RIO.

   a. LTS

      Check that all warning, caution, and advisory lights illuminate. The brightness of the ACM panel and the indexer lights should be set during the test. The DATA LINK switch must be ON to check the DDI lights.

WARNING

- Initial failure with subsequent illumination after slight adjustment of either fire warning light during lights test is indicative of a weakened fire light retaining clip and/or current flow impediments at the bulb contact points. Either condition seriously degrades fire warning indication reliability. The fire warning lights must be seated securely with the operable bulb contact points free of impediments to current flow at all times to ensure proper operation of the fire warning light.

- Failure of the EMERG STORES JETT push-button to illuminate during LTS check could indicate that the pushbutton light is burned out or that the test circuit is defective. If the switch is actuated, stores will jettison when weight is off wheels. If this occurs, status of the emergency stores jettison circuit cannot be determined. Under some lighting conditions it may be difficult to determine when the light is illuminated. Ensure that the light goes off when LTS on MASTER TEST switch is deselected. Failure of the light to go off indicates that emergency jettison is selected; stores will jettison when weight is off wheels.

   b. FIRE DET/EXT

      L and R FIRE lights illuminate to verify continuity of respective system. The GO light will illuminate verifying continuity through the four squib lines, that 28 Vdc is available at the left and right fire switches, and that the fire extinguisher containers are pressurized.

   c. INST

      Check for the following responses after 5 seconds:

      (1) RPM — 96 percent.

      (2) EGT — 960 °C.

      Initiates engine overtemperature alarm L STALL and R STALL warning lights flash.

      (3) FF — 10,500 Pph.

      (4) AOA (units) — 18±5.

      Reference and indication

      (5) Wing sweep — 45°±2.5°.

      Program, command, and position.

      (6) FUEL QTY — 2,000±200 Pounds (both cockpits).

      (7) Oxygen quantity — 2 Liters.

      (8) L and R FUEL LOW lights — Illuminated (both cockpits).

   d. MASTER TEST switch — OFF.

6. Ejection seats — Armed.

   Verify seat armed with RIO.

7. CANOPY handle — Close (RIO command close).

WARNING

Flightcrews shall ensure that hands and foreign objects are clear of front cockpit hand-holds and top of ejection seats and canopy sills to prevent personal injury and/or structural damage during canopy opening or closing sequence. Only minimum clearance is afforded when canopy is transitioning fore and aft.

Note

If CLOSE does not close the canopy, depress the grip latch and release and push handle outboard and forward into BOOST. If it is necessary to use BOOST, the handle shall be returned to CLOSE to avoid bleed-off of pneumatic pressure.

8. ACM panel — Set.

   a. Gunrate — Set and Check Rounds Remaining.

   b. SW COOL — OFF.

   c. MSL PREP — OFF.

   d. MSL MODE — NORM.

   e. Station loading status windows — Check.

      Verify proper indication consistent with external store loading condition.

9. EMERG STORES JETT pushbutton light — Out.

Note

The MASTER CAUTION light and the EMERG JETT caution light illuminate when the EMERG STORES JETT pushbutton is activated.

10. LADDER light — Out.

    Plane captain shall stow boarding ladder and steps.

11. Inform RIO — Ready To Start.

12. Starter air — ON.

CAUTION

The ECS air source shall remain off during engine start until external air is disconnected in order to reduce the possibility of bleed air duct contamination.

7.4.3 Engine Start — Pilot. Prior to engine start, the pilot and plane captain should ascertain that the turnup area is clear of FOD hazards, adequate fire-suppression equipment is readily available, and engine intakes and exhausts are clear. Although the engines cannot be started simultaneously, either engine can be started first. The following procedure establishes starting the right engine first. Whenever possible the aircraft should be positioned so as to avoid tailwinds, which can increase the probability of hot starts.

WARNING

Coordinate movement of any external surfaces and equipment with the plane captain or director.

CAUTION

- If engine chugs and/or rpm hangup is encountered with one engine turning during normal ground start, monitor exhaust gas temperature for possible hot start. AIR SOURCE pushbutton should be set for the operating engine until rpm stabilizes at idle; then set to BOTH ENG.

- To prevent possible engine overtemperature during crossbleed start attempts, select the operating engine for air source and return to BOTH ENG after rpm stabilizes at idle or above.

1. ENG CRANK switch — L (left engine).

2. ENG CRANK switch — OFF.

3. ENG CRANK switch — R (right engine).

4. ENG CRANK switch — OFF.

   Plane captain will bleed FLT and COMB hydraulic systems during steps 1 and 3.

5. EMERG FLT HYD switch — Cycle.

   a. EMERG FLT HYD switch — LOW.

      Check that ON flag is displayed in EMER FLT LOW hydraulic pressure window. Verify control over horizontal tail and rudder control surfaces as viewed on surface position indicator.

   b. EMERG FLT HYD switch — HIGH.

      Check that ON flag is displayed in EMER FLT HI hydraulic pressure window. Verify control over empennage flight control surfaces and higher surface deflection rate.

   c. EMERG FLT HYD switch — AUTO (LOW).

      Check that OFF flags are displayed in both EMER FLT HI and LOW hydraulic pressure windows.

CAUTION

Combined and brake accumulators should be charged prior to backup module checks. Checks should be made slowly enough to ensure continuous ON indication in the hydraulic pressure indicator to prevent damage to the pump or motor.

Note

Ensure combined and flight hydraulic pressures are zero prior to testing emergency flight hydraulic system to allow proper check of 300 psi priority valve.

6. ENG CRANK switch — R (right engine).

   Place the crank switch to the R position where the switch is solenoid held until automatically released to the neutral (OFF) position at the starter cutout speed of approximately 49- to 51-percent rpm. Manual deselect of the switch to OFF will interrupt the crank mode at any point in the start cycle. Oil pressure and flight hydraulic pressure rise will become evident at 20-percent rpm.

CAUTION

- If no oil pressure or hydraulic pressure is indicated, start shall be aborted by setting ENG CRANK switch to OFF.
- If the ENG CRANK switch does not automatically return to the OFF position by 50-percent rpm during start, ensure the ENG CRANK switch is OFF prior to 60-percent rpm to prevent starter overspeed.
- If the START/VALVE caution light is illuminated after the ENG CRANK switch is OFF, select AIR SOURCE to OFF to prevent starter overspeed.
- When attempting a crossbleed or normal ground start, do not attempt to reengage the ENG CRANK switch if the engine is spooling down and rpm is greater than 46 percent. Between 30- and 46-percent rpm, the ENG CRANK switch may not stay engaged because of normal variation in starter cut-out speed.

Note

During cold starts, oil pressure may exceed 65 psi. This pressure limit should not be exceeded for more than 1 minute.

7. Right throttle — Idle at 20-percent rpm.

CAUTION

If an idle crossbleed start is attempted with high-residual engine EGT and/or throttles are advanced from OFF to IDLE prior to 20-percent rpm, higher than normal EGT readings may occur. If the EGT appears to be rising abnormally, increasing the supply engine to 80-percent rpm may yield a normal start temperature.

Note

- Advancing the R throttle from OFF to IDLE automatically actuates the ignition system. An immediate indication of fuel flow (≈300 to 350 pph) will be exhibited and light-off (EGT rise) should be achieved within 5 to 15 seconds. Peak starting temperatures will be achieved in the 40- to 50-percent rpm range. After a slight hesitation, the EGT will return to normal. Exceeding 890 °C constitutes a hot start. During the initial starting phase, the nozzle should expand to a full-open (100-percent) position.

- If the START VALVE caution light is illuminated after the ENG CRANK switch is OFF, or if the ENG CRANK switch does not automatically return to OFF, ensure that the ENG CRANK switch is off by 60-percent rpm and select AIR SOURCE to OFF to preclude starter overspeed.
- Loss of electrical power may result in smoke entering the cockpit via the ECS.

8. R GEN light — Out.

The right generator should automatically pick up the load on the left and right main AC buses as indicated by the R GEN light going out at approximately 59-percent rpm.

9. R FUEL PRESS light — Out.

The fuel-pressure lights should go off by the time the engine achieves idle rpm.

10. Idle engine instrument readings — Check.

a. RPM — 62 to 78 percent.

b. EGT — 500 °C (nominal).

c. FF — 950 to 1,400 Pph (nominal).

d. NOZ position — 100 Percent.

e. OIL — 25 to 35 psi (nominal) (15 psi minimum).

f. FLT HYD PRESS — 3,000 psi.

11. External power — Disconnect.

WARNING

Ground engine operation without electrical power supplied by either the generators or external power may cause 20-mm ammunition detonation because of excessive heat in the gun ammunition drum.

12. ENG CRANK switch L — (left engine).

When combined hydraulic pressure reaches 3,000 psi, return switch to neutral (center) position.

13. HYD TRANSFER PUMP switch — Normal.

Hydraulic transfer pump will operate from flight side to maintain the combined side between 2,400 to 2,600 psi.

CAUTION

If the transfer pump does not pressurize the combined system within 10 seconds, immediately set HYD TRANSFER PUMP switch to SHUTOFF.

14. HYD TRANSFER PUMP switch — SHUTOFF.

15. Repeat steps 6 through 10 for left engine.

16. Starter air — Disconnect.

17. AIR SOURCE switch — L ENG, R ENG, then BOTH ENG.

Verify cockpit airflow in three positions.

18. HYD TRANSFER PUMP switch — NORMAL.

19. Ground safety pins — Remove and Stow.

Plane captain should remove landing gear pins and stow them.

7.4.4 Poststart — Pilot

1. STAB AUG switches — All ON.

2. MASTER TEST — EMERG GEN.

   The resultant power interruption should cause the DFCS flight control computers to self-isolate, activating the lights listed below. With a good emergency generator check, (green “GO” light) ensure that all lights clear with a MASTER RESET prior to deselecting the emergency generator. DFCS voltage monitoring should result in illumination of all lights when emergency generator is deselected. Lights will remain on when normal voltage is regained, requiring a MASTER RESET to re-engage DFCS flight control computers. STAB AUG switches should remain engaged.

   DFCS caution/advisory lights:

   PITCH SAS, ROLL DGR, YAW DGR, FCS CAUTION, ARI DGR, ARI/SAS OUT, HZ TAIL AUTH, RUDDER AUTH SPOILERS, AUTO PILOT, & MACH TRIM.

3. MASTER RESET pushbutton — Depress.

   Verify DFCS caution lights extinguished.

   Note

   An FCS CAUTION at this point probably indicates a PQVM fault due to a lack of pitch and roll attitude inputs from the IMU (DCP FAIL group will indicate IMU4).

4. MASTER TEST switch — OFF.

5. MASTER RESET pushbutton — Depress.

   Verify DFCS caution lights extinguished. STAB AUG switches should not disengage.

6. Advise RIO that test and checks are completed.

7. Controls and displays — ON.

8. AFTC — Check.

   a. L ENG MODE SELECT switch — SEC.

      L ENG SEC light illuminates; RPM drops, left NOZ indicator pointer below zero.

   b. Advance L throttle to ensure engine response.

   c. L ENG MODE SELECT switch — PRI.

      L ENG SEC light goes out, left NOZ indicator to 100 percent.

   d. Repeat for R ENG.

   CAUTION

   Selecting secondary (SEC) mode closes exhaust nozzles increasing exhaust nozzle jet wake hazard.

   Note

   - Performing AFTC check during OBC inhibits the engine monitoring system portion of FEMS until primary mode is reselected.

   - Operating engines in secondary mode inhibits the engine monitoring system portion of FEMS until primary mode is reselected.

9. EMERGENCY WING SWEEP handle — OV SW.

   CAUTION

   - If the “OVER” flag is not displayed in the wing sweep indicator with the wings in oversweep the stick should remain centered.

   - If wings are not in oversweep, move the wings to 68° using wing sweep emergency handle in raised position. Then raise handle to full extension and hold until HZ TAIL AUTH caution light goes out and OVER flag appears on wing sweep indicator. Move handle to full aft OV SW and stow.

10. WING SWEEP MODE switch — AUTO.

11. WING SWEEP DRIVE NO. 1 and WG SW DR NO. 2/MANUVFLAP cb — IN (LE1, LE2).

12. WING/EXT TRANS switch — OFF.

13. COMM/NAV/GEAR/DISPLAYS — ON.

    a. UHF function selector — T/R + G or BOTH.

    b. TACAN function selector — T/R.

    c. ARA-63 power switch — ON.

    d. Display control switches — ON.

    e. Radar altitude — ON.

14. Trim — Set 000.

15. Standby gyro — Erect.

16. MASTER RESET pushbutton — Depress.

17. DCP — Verify codes (FAIL, FLT, IBIT).

WARNING

Aircraft shall be considered down with PFCC, RFCC, or YFCC codes in the DCP FAIL group or with an inoperative DCP display. Initiation of OBC/IBIT with this condition will result in invalid IBIT indications.

Note

An FCS CAUTION at this point probably indicates a PQVM fault due to a lack of pitch and roll attitude inputs from the IMU (DCP FAIL group will indicate IMU4). This fault will not affect DFCS IBIT results and can be cleared with a MASTER RESET before or after, but not during OBC.

18. MASTER TEST switch — OBC.

19. AUTOPILOT switch — ENGAGE.

CAUTION

OBC commencement with autopilot engaged and nose down trim may result in a force link disconnect when the stick hits forward stick stop during the pitch parallel actuator checks.

20. OBC — Initiate.
    (coordinate with RIO and plane captain).

WARNING

- If CIA acronym is displayed in CM after completion of OBC, aircrew must select maintenance display to determine type of failure in the AWG-15. The possibility of inadvertent stores release exists when this acronym is present.

- Increased suction around intakes during inlet ramp programming and the automatic movement of the horizontal stabilizers presents a FOD hazard and a potential for injury to ground personnel not clear of these areas.

The following systems are automatically exercised during the 1-1/2 minutes required to complete the OBC tests. Failures are displayed on the PTID display.

a. The AICS self-test turns on hydraulic power and exercises the ramps through full cycle STOW — EXTND — STOW. During the test, the respective RAMP light illuminates until the ramp return to the fully stowed position and the hydraulics are shut off. A failure is indicated by an INLET light and/or OBC readout.

b. AUTO THROTTLE.

   This test is a computer self-test with output commands inhibited to prevent throttle movement.

c. Verify DFCS IBIT operation by flashing A/P ref and ACLS lights. During the course of the test, the DFCS caution lights remain illuminated until the test is satisfactorily completed. All lights should be off at termination of test. Observe following:

(1) DFCS caution and advisory lights

(2) Pitch trim check (slow longitudinal stick motion)

(3) Pitch parallel actuator (rapid longitudinal stick motion)

(4) Individual spoiler operation (only if wings 20° and flaps down) Stab actuator tests (horizontal tail and rudder movement)

(5) Autopilot disengage

(6) Rudder pedal shaker

(7) DCP display LED check

d. Check for “PASS” in DCP. If faults are displayed, record FCS fault codes using INC/DEC pushbuttons. Ensure FAIL and FLT codes are cleared prior to takeoff.

21. Speedbrake switch — EXT, then RET.

Cycle speedbrake switch to EXT, release, and check for partial extension. Select EXT again, checking indicator for transition for full extension. Select RET and check indicator for an indication of full retraction. Check for stabilizer position fluctuation during speedbrake extension and retraction to verify integrated trim operation.

22. REFUEL PROBE switch — ALL EXT, then RET.

Cycle the probe to the extend position, noting illumination of the probe light with switch-probe position disparity. Check probe nozzle head for condition. Retract probe and again check that transition light goes out when fully retracted and doors closed.

23. WSHLD AIR switch — Cycle.

24. MASTER TEST switch/OBC — OFF.

If engaged, verify that autopilot disengages automatically.

CAUTION

Sweep times from 68° to 20° in excess of 9 seconds may be indicative of an impending wing sweep motor failure and should be further investigated.

25. WING/EXT TRANS switch — OFF.

26. Trim — Checked and set 000.

CAUTION

Ensure adequate clearance before moving wings.

Note

For CV operations, omit steps 27 through 50.

27. EMERGENCY WING SWEEP handle — 20°.

Move the emergency WING SWEEP handle to 20° (full forward) and engage the spider detent. Stow handle and guard. HZ TAIL AUTH light illuminates coming out of OVSW. Light goes out when OVSW stops removed.

28. MASTER RESET pushbutton — Depress.

The WING SWEEP warning and advisory lights go out and the AUTO and MAN modes are enabled.

29. External lights — Check (prior to night/IMC flight).

WARNING

During night operations, aircraft with inoperable tail and aft anticollision lights will not be visible from the rear quadrant even under optimum meteorological conditions, thus increasing midair potential.

30. Flaps and slats — DN.

Check for full deflection of the flaps and slats to the down position and automatic activation of the outboard spoiler module. Check for 3° TEU stabilizer position.

31. Flight controls — Cycle.

Complete full cycle sweep of longitudinal, lateral, directional, and combined longitudinal-lateral controls while checking for full authority on surface position indicator. Check that all spoilers extend at the same rate with slow lateral stick deflections and extend to full up position.

Observe the following:

a. Pitch control — 36° TEU to 9° TED horizontal tail (33° to 12° without ITS).

b. Lateral control — 24° total differential tail.

c. Directional control — ±30° rudder.

d. Longitudinal/Lateral combined — 35° TEU to 15° TED horizontal tail.

e. Spoilers — 55°.

CAUTION

A stabilizer vibration may occur when the control system linkage is held in contact with a total tail stop during stick cycling checks. This vibration is acceptable, provided it damps when the control stick is moved to clear the stop in contact. Clearance from the stop can best be verified by movement of the matching stabilizer indicator needle away from its maximum travel position

32. DLC — Check.

Verify horizontal tail shift with DLC input.

33. ANTI SKID SPOILER BK switch — SPOILER BK.

34. Spoilers and throttles — Check.

35. ANTI SKID SPOILER BK switch — OFF.

36. DCP — Verify codes (FAIL, FLT, IBIT)

WARNING

Aircraft shall be considered down with PFCC, RFCC, or YFCC codes in the DCP FAIL group or with an inoperative DCP display. Initiation of OBC/IBIT with this condition will result in invalid IBIT indications.

37. MASTER TEST switch — DFCS BIT (IBIT ARM). (coordinate with RIO and plane captain).

38. AUTOPILOT switch — ENGAGE.

39. MASTER TEST switch — DFCS BIT (IBIT RUN). (coordinate with RIO and plane captain)

40. DCP — Verify & record codes (FAIL, FLT, IBIT)

Check for “PASS” in DCP. If faults are displayed, record FCS fault codes using INC/DEC pushbuttons.

41. DCP — Clear codes (FAIL & FLT).

Ensure FAIL and FLT codes are cleared prior to takeoff.

42. Flaps and slats — UP.

43. Maneuver flaps — Down.

44. WING SWEEP MODE switch — MAN 50°.

CAUTION

If wing sweep commanded position indicator (captain bars) does not stop at 50°, immediately select AUTO with WING SWEEP switch.

45. Maneuver flaps — Crack up.

46. WING SWEEP MODE switch — BOMB.

Check maneuver flap retraction.

47. EMERGENCY WING SWEEP handle — 68°.

48. EMERGENCY WING SWEEP handle — OV SW.

49. WING SWEEP MODE switch — AUTO.

50. MASTER RESET pushbutton — Depress.

Note

CV checklist resumes.

51. ANTI SKID SPOILER BK switch — BOTH.

52. ANTI SKID — BIT.

    Ensure coarse alignment is completed before releasing parking brake.

53. ANTI SKID SPOILER BK switch — OFF.

54. Radar altimeter — BIT.

    Depress SET knob; check that radar altitude displays 100 feet and indicator green light is illuminated. Release knob and pointer should display 0 feet; warning tone signal (both cockpits) and ALT LOW light illuminated momentarily.

55. Displays — Check.

56. Tacan — BIT.

57. ARA-63 — BIT.

58. HUD—VIDEO — BIT.

59. Altimeter — SET/RESET mode.

    Barometric setting and error determined. Check in RESET mode.

60. Compass — Check.

    Validate IMU heading on alignment on VDI, HSD, and BDHI. Cross-check with known references and standby compass.

61. Flight instruments — Check.

7.4.4.1 Final Checker (Ashore)

1. NOSE STRUT switch — Kneel, Check Launch Bar DN.

CAUTION

Ensure all tiedowns have been removed before selecting kneel.

2. Hook — DN, Check RATS Advisory Light On, Then Up.

3. LAUNCH BAR switch — Cycle.

4. NOSE STRUT switch — EXTD.

7.4.4.2 Final Checker Aboard CV

1. Hook — Down On Director's Signal; Check RATS Advisory Light On, Then Up

CAUTION

Carrier operations with an inoperative RATS will increase CV wind-over-deck requirements. Failure to notify CV OPS may result in damage to the ship's arresting gear and aircraft tailhook assembly structure.

2. Nosewheel steering — Cycle OFF, Then ON

WARNING

Failure to cycle nosewheel steering following hook check will permit nosewheel steering centering to remain engaged and can cause mispositioning of the launch bar during catapult hookup. This can result in launch bar disengaging from shuttle during catapult stroke.

7.4.5 Taxiing. Prior to releasing the parking brake, the IMU should be aligned to at least a diamond symbol; otherwise, the alignment process will automatically be interrupted until the parking brake is reapplied.

To set the aircraft in motion starting from a static position, advance the throttles slightly. While departing the line area, both flightcrews should clear the extremities of the aircraft and the wings should remain at 68° or in OVSW to minimize the span clearance. Once in motion, IDLE thrust is normally sufficient to sustain taxi speeds and full nosewheel steering authority may be realized.

7.4.5.1 Taxi Speed. Taxi speed should be maintained at a reasonable rate consistent with traffic, lighting, and surface conditions.

CAUTION

- Before taxiing aircraft with wings in over-sweep and full wing fuel tanks, trim stabilizer to zero to prevent wingtip and stabilizer interference.
- When taxiing across obstacles, ensure nosewheel is centered to preclude launch bar from impacting nose wheelwell doors.
- To prevent overheating, do not ride the wheelbrakes.

7.4.5.2 Taxi Interval. The taxi interval should be sufficient to avoid taxiing in another aircraft's jetwash, which presents additional FOD potential. Although the antiskid system is armed at speeds less than 15 knots, the antiskid system is not operative. The nosewheel steering can remain engaged throughout the taxi phase. Application of wheelbrakes in conjunction with nosewheel steering should be performed symmetrically to minimize nose-tire sideloads. In minimum radius turns (Figure 7-4) using nosewheel steering, the inboard wheel rolls backwards as the axis of rotation is between the main gear. Because of the distance from the cockpit to the main landing gear, the pilot should make allowance for such in-turns to prevent turning too soon and cutting corners short.

7.4.5.3 Crew Comfort. Crew comfort during taxi operations is affected by the nosestrut air curve characteristics that maintain the strut in the fully extended (stiff strut) position except during deceleration. Because of the wide stance of the main gear, differential application of wheelbrakes is effective for turning the aircraft without the use of nosewheel steering. Subsequent to flight, while returning to the line at light gross weights, one engine may be shut down to prevent excessive taxi speeds at IDLE thrust.

CAUTION

On-deck engine operations for extended periods can result in an unacceptable buildup in fluid (hydraulic, engine oil, and IDG oil) temperatures by taxing heat exchanger capacities. Since the left IDG supplies the majority of the electrical power, it is more susceptible to overheat-ing than the right. Tailwinds or large power demand, or both, at high ambient air temperatures increase the chances of fluid overtemperature.

Since the outboard spoiler module is automatically energized with the flap handle down and weight on wheels, it is necessary to restrict the amount of flaps-down operation on the deck to prevent module fluid overheating.

7.4.6 Taxi — Pilot

CAUTION

Taxiing with the left engine secured is not authorized. Normal braking and nosewheel steering control will be lost if the hydraulic transfer pump (BIDI) fails while taxiing with the left engine secured.

1. Parking brake — Release.
2. Nosewheel steering — Check.

   NWS ENGA light illuminates upon engagement. Check control and polarity in static position before commencing to taxi.

   Note

   If nosewheel steering is inoperative, the emergency gear extension air release valve may be tripped, which will prevent gear retraction.

3. Brakes — Check.

   Check for proper operation by applying left or right brake individually and observing brake pressure recovery to the fully charged condition.

4. Turn-and-slip indicator — Check.

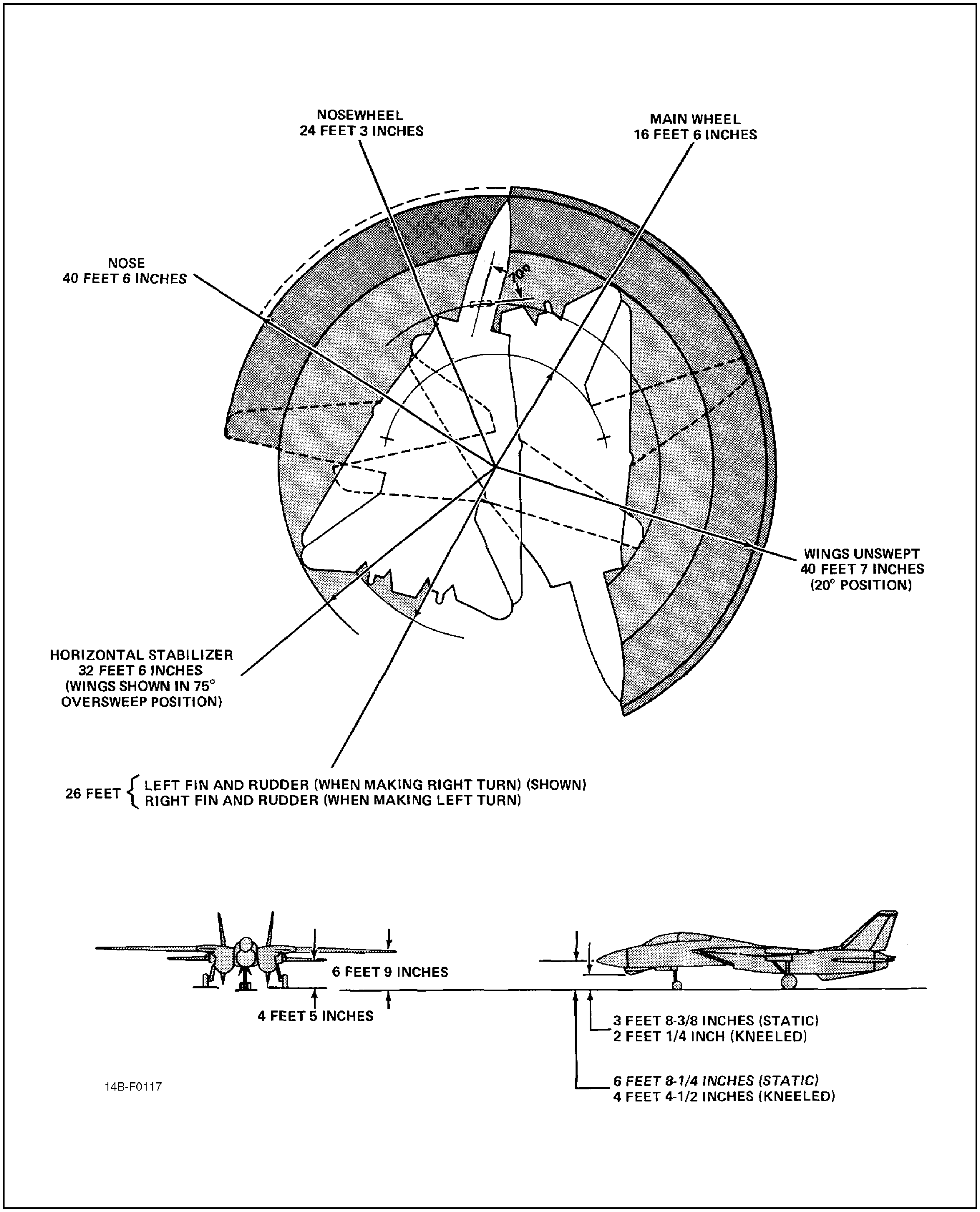

Figure 7-4. Taxi Turn Radii (Maximum Nosewheel Steering 70°)

5. Ordnance — Safe.

   Perform the following functions at prescribed location prior to takeoff in accordance with base operating procedures:

   a. Missile seeker and tuning — Check.

   b. Gun and external stores — Ground Safety Pins Removed and Armed.

7.4.7 Takeoff

7.4.7.1 Normal Takeoff. The aircraft take off checklist should be completed prior to calling for takeoff clearance, and all annunciator lights should be off except NWS ENGA. Full flaps and slats are optional for all takeoffs regardless of thrust or gross weight conditions.

Both flight crewmen should be operating in HOT MIC during this phase of flight to enhance communications in event of emergency. Upon tower clearance and after visually clearing the approach zone, the pilot should taxi onto the runway (take downwind side if another aircraft to follow) and roll straight ahead to align the nosewheel and to check compass alignment.

Hold in position for takeoff using the toe pedal brakes with nosewheel steering engaged. Perform engine checks at 90-percent rpm. Select MIL on the roll and monitor engine performance.

Note

- Do not use the parking brake to restrain the aircraft under high-power conditions since tire skid might result.

- If static engine runup greater than 90-percent rpm is required, runup should be performed one engine at a time.

7.4.7.2 Afterburner Takeoff. Afterburner takeoffs are limited to single-engine minimum afterburner takeoffs, waveoffs, bolters, or catapult launches. Dual engine afterburner and single-engine maximum afterburner takeoffs, waveoffs, bolters, or catapult launches are prohibited. Refer to Chapters 4 and 11.

7.4.7.3 Brake Release. After takeoff power checks are completed and at a safe interval behind the preceding aircraft, release the toe pedal brakes. Nosewheel steering should be used for directional control during the initial takeoff roll. Although the rudder becomes effective at 40 to 60 knots, to ensure adequate directional control in the event of an engine failure, nosewheel steering should remain engaged until 100 KIAS. Refer to Chapter 11 for nosewheel steering on and off abort data.

Note

- Takeoffs performed with standing water on the runway may result in unstable engine operation because of water ingestion.

- The nose strut should return to the fully extended position (+1.5° pitch attitude) upon brake release; failure to do so will increase the takeoff ground roll. Use of differential braking to control directional alignment should be avoided because of its attendant effect on ground-roll distance.

7.4.7.4 Takeoff Roll/Lift-Off. Minimum ground roll takeoff procedures do not differ from the normal procedures. Maintain the control stick at the trimmed condition during the prerotation ground-roll phase to minimize aircraft drag. After the precomputed rotation speed (refer to NAVAIR 01-F14AAP-1.1), pull the control stick straight aft so that 25° symmetrical deflection of the horizontal tails is achieved at the predicted rotation speed. Hold the control stick aft so that 25° horizontal tail deflection is achieved until lift-off, which will occur at approxi-mately a 6° noseup pitch attitude. With the wings swept forward, the aircraft seems to balloon from the runway in a near-level nose attitude with a more docile transition to flight than characteristic of swept-wing aircraft.

Note

- The use of excessive back stick on takeoff may cause the tail surfaces to stall, delaying aircraft rotation and extending takeoff distance.

- Although on-deck pitch attitude rotation in excess of 10° provides marginal tail-ground clearance, the aircraft is airborne well before such a phenomenon becomes a limiting factor.

7.4.7.5 After Lift-Off. After lift-off, relax the aft stick force as the aircraft accelerates towards an in-trim condition. Raise the landing gear control handle after ensuring that the aircraft is definitely airborne. Pitching moments associated with gear retraction are negligible and a gear UP indication should be achieved about 15 seconds after initiation.

CAUTION

Illumination of indexer lights is not a positive indication that the main landing gear is clear of the runway. Raising the gear before a positive rate of climb is established will result in blown main tires.

At approximately 180 KIAS (depending on longitudinal acceleration) the FLAP handle can be placed in the UP position. A moderate noseup pitching moment occurs during the flap and slat retraction phase, which takes approximately 8 seconds. Do not attempt to correct immediately after lift-off to counter a lateral drift caused by a crosswind condition. The use of large lateral control deflection should be avoided to keep from breaking out the wing spoilers, which have a negative effect on lift and drag. Differential tail authority within the spoiler deadband (half inch lateral stick deflection) is adequate for maintaining wings-level flight or effecting gradual turns with symmetric thrust. Before reaching the flap (225 KIAS for 10° flaps) and gear (280 KIAS) limit speeds, the pilot should ascertain that all devices are properly configured for higher speed flight. The combined hydraulic system non-flight essential components (landing gear, brakes, and nosewheel steering) may be isolated by selecting FLT on the hydraulic isolate switch. A gradual climbout pitch attitude should be maintained until intercepting the optimum climb speed. A recheck of engine instruments and configuration status should be performed after cleanup during the climbout phase.

7.4.8 Flaps-Up Takeoff. Before the takeoff roll, the procedures for flaps-up takeoff are identical to flaps down except that the flaps remain retracted and only inboard spoiler brakes are available. During the prerotation ground-roll phase, maintain the control stick at the trimmed condition to minimize aircraft drag. At the precomputed rotation speed, smoothly position the stick aft (about 2 inches) to maintain a 5° to 10° pitch attitude until airborne.

Do not exceed 10° of pitch attitude until well clear of the runway, as excessive noseup attitudes will cause the vertical fins and tailpipes to contact the runway surface.

CAUTION

Because of increased longitudinal control effectiveness with the flaps retracted, overcontrol of pitch attitude during takeoff is possible. Large or abrupt longitudinal control inputs should be avoided until well clear of the runway.

Transition to flight will occur smoothly as compared to the ballooning effect in flaps-down takeoffs. After main gear lift-off, relax the aft stick force as the aircraft accelerates.

Because of the smooth, flat transition to flight, care should be taken to avoid premature landing gear retraction and resulting blown tires. Raise the landing gear control handle only after ensuring that the aircraft is airborne.

Note

- During flaps-up takeoffs, all flap/wing electromechanical interlocks are removed from the CADC and wing-sweep control box, allowing possible inadvertent wing sweep in the event of a CADC failure.

- Outboard spoilers are inoperative with weight on wheels.

7.4.8.1 Maneuvering Flaps Takeoff. Maneuvering flaps provide improved takeoff performance when compared to the flaps-up configuration and eliminate the pitching moment associated with main flap and slat retraction after takeoff. Slow-speed handling characteristics are superior to the flaps-up configuration. Additionally, possible automatic maneuvering flap/slat extension during rotation/transition to flight can be avoided by extending maneuvering flaps before takeoff.

7.4.9 Formation Takeoff. Formation takeoffs are permitted in the flaps-up/maneuvering flaps-down configurations for section only. However, they shall not be permitted at night, with crosswind component in excess of 10 knots, with standing water on the runway, on runways less than 8,000 feet long and 200 feet wide, or with dissimilar aircraft All aspects of the takeoff must be briefed by the flight leader. Briefing should include flap setting, power settings, use of nosewheel steering, abort procedures, and signals for power and configuration changes.

7.4.9.1 Takeoff Roll/Lift Off. With the completion of the takeoff checks, the lead aircraft will take position on the down-wind side of the runway with the wingman on a normal parade bearing with no wing overlap. Upon signal from the leader, the engines will be advanced to 90-percent power. When ready for flight, the pilots shall exchange a thumbs-up signal. On signal from the leader, brakes are released, MIL is selected, and the leader reduces power by 2 percent. Directional control is then maintained with nosewheel steering until rudder becomes effective. During takeoff roll, the leader should make only one power correction to enhance the wingman position. If optimum position cannot be obtained, relative position should be maintained until the flight is safely airborne. At the precomputed rotation speed, the leader should rotate the aircraft 5° to 10° nose up on the HUD or VDI, and maintain this attitude until the flight is airborne. Turns into the wingman should not be made at altitudes less than 500 feet above ground level.

Note

- No auxiliary flap electromechanical interlocks exist to prevent inadvertent wing sweep in the event of a CADC malfunction.
- Outboard spoilers are inoperative with weight on wheels.

7.4.9.2 Wingman. The wingman should strive to match the leader's attitude as well as maintain parade bearing with wingtip separation. When both aircraft are safely airborne, the gear is retracted on signal from the leader.

CAUTION

- In the event of an aborted takeoff, the aborting aircraft must immediately notify the other aircraft and the tower. The aircraft not aborting should ensure positive wingtip separation is maintained and select full military power to accelerate ahead of the aborting aircraft. This will allow the aborting aircraft to move to the center of the runway and engage the available arresting gear, if required.
- It is imperative that the wingman be alert for the overrunning situation and take timely action to preclude this occurrence. Should an overrunning situation develop after becoming airborne, the wingman should immediately increase lateral separation from the leader to maintain wing position. Safe flight of both aircraft must not be jeopardized in an attempt to maintain position.

7.4.10 Takeoff Aborted. See paragraph 13.1.

7.4.11 Takeoff Checklist. Prior to takeoff, the checklist will be completed by the challenge (RIO) and reply (pilot) method with ICS on HOT MIC as a double-check of the aircraft configuration status (see Figure 7-5). For CV operations, steps 1 through 9 may be completed while tied down. For field operations, steps 1 through 14 should be completed in the warm-up area.

7.4.12 Ascent Checklist. At level-off or 15,000 feet (whichever occurs first):

1. Cabin pressurization — Check.
2. Fuel transfer — Check.
3. In-flight OBC — Run.

7.4.13 In-Flight OBC. The RIO should perform an OBC check as follows:

WARNING

Inadvertent jettison of external stores may result during Class I OBC.

RIO CHALLENGE	PILOT REPLY
1. “BRAKES.”	“CHECK OK, ACCUMULATOR PRESSURE UP.”
2. “FUEL TOTAL _________LB.”	“NORMAL FEED, AUTOTRANSFER DUMP OFF, TRANSFER CHECKED, TOTAL________, WINGS_______, AFT AND LEFT ______, FWD & RIGHT________________, FEED TANKS FULL _____ BINGO SET________________.”
3. “CANOPY CLOSED, LOCKS ENGAGED, LIGHT OUT, STRIPES ALIGNED, HANDLE IN CLOSED POSITION”	“CLOSED, LOCKS ENGAGED, LIGHT OUT, SEAL INFLATED, HANDLE IN CLOSED POSITION.”
4. “SEAT — ARMED TOP AND BOTTOM, CMD EJECT_______STRAPPED IN SIX WAYS”	“SEAT ARMED TOP AND BOTTOM, PILOT/MCO IN WINDOW (indicated) STRAPPED IN SIX WAYS”
5. “STAB AUG.”	“ALL ON.”
6. “ATLS”	“ON.”
7. “ALL CIRCUIT BREAKERS SET.”	“ALL IN.”
8. “MASTER TEST SWITCH”	“OFF.”
9. “BIDIRECTIONAL.”	“NORMAL.”
10. “COMPASS, STANDBY GYRO, AND ALTIMETER.”	“COMPASS SYNCHRONIZED, STANDBY GYRO ERECT ALTIMETER SET (local setting).”
CV — Approaching CAT on Director’s Signal.	
11. “WINGS.” (visually checked)	“20°, AUTO, BOTH LIGHTS OUT.”
12. “FLAPS AND SLATS” (visually checked)	AS REQUIRED.
13. “SPOILERS AND ANTISKID.”	“SPOILER MODULE ON, SPOILER BRAKES SELECTED” (field) “SPOILER. MODULE ON, SPOILER BRAKES OFF” (CV).
14. “TRIM.”	“0, 0, 0.” (field) “AS REQUIRED (CV).”
15. “HARNESS – “LOCKED.”	“LOCKED.”
16. “CONTROLS.” (RIO visually check for full spoiler deflection.)	“FREE, 33° AFT STICK, FULL SPOILER DEFLECTION LEFT AND RIGHT, HYDRAULICS 3,000 PSI.”
17. “ALL WARNING AND CAUTION LIGHTS OUT.”	“ALL WARNING LIGHTS OUT.”
18. “ANTISKID/SPOILER BRAKES.”	“BOTH.” (if operable)

Figure 7-5. Takeoff Challenge/Reply Checklist

1. CM failures on lower left corner of PTID — Check.

Note

Before correcting a malfunction, ensure available flycatcher/CM data is recorded.

2. Verify ACM, A/G — Not Selected.
3. OBC disabled on pilot MASTER TEST PANEL — Check.
4. Verify MASTER ARM WEAPON SELECT — OFF.
5. Computer address panel

   a. CATEGORY switch — SPL.

b. OBC BIT pushbutton — DEPRESS.

This will initiate the in-flight BIT. After approximately 90 seconds, the PTID will display OBC BIT followed by the acronyms of the failed aircraft systems and TEST COMPLETE.

WARNING

Failure of the CIA Class 1 OBC to run could be an indication of shorted master arm circuitry and possible failure of the LAU-7 detent to engage resulting in inadvertent AIM-9 separation from the aircraft during arrested landing.

c. CATEGORY switch — NAV.

7.4.14 Preland and Descent

1. HOOK/HOOK BYPASS — As Desired.
2. Exterior lights — As Desired.
3. Compass/BDHI — Check with Mag Compass.
4. Wing sweep mode switch — As Desired.
5. ANTI SKID SPOILER BK switch — BOTH (if operable, CV — OFF).
6. Altimeter — Set.
7. Radar altimeter — ON/BIT Check.
8. Fuel quantity and distribution — Check.
9. Armament — Safe.
10. CANOPY DEFOG/CABIN AIR lever — DEFOG.
11. ANTI-ICE switch — AUTO/OFF.
12. PDCP — Set.
13. ARA-63/ACLS — ON/BIT Check.
14. DECM switch — STBY.
15. CHAFF/FLARE dispenser switch — OFF.

WARNING

If LAU-7 mounted stores are loaded, perform steps 16 and 17 with the aircraft in a safe area and headed in a direction where inadvertent gunfiring would not cause damage.

16. Weapon select — Cycle to Gun then OFF.

WARNING

If HOT TRIG light illuminates with MASTER ARM switch OFF or CI/PSU acronym was displayed during in-flight OBC, perform step 17.

17. STA 1/8 AIM-9 REL PWR circuit breaker (6D4, 6D3) — Pull.
18. WCS — STBY.

WARNING

The RIO should place WCS switch to STBY or XMT (pulse) on final approach to prevent unnecessary exposure of flight deck personnel to RF radiation hazards.

19. **[T]** Resolution run — Completed.
20. **[T]** Frame switch — OFF.
21. **[T]** PAN switch — OFF.
22. **[T]** IRLS switch — OFF.
23. **[T]** FILM switch — OFF.

CAUTION

Before selecting system to OFF, delay 15 seconds for sensor shutdown, IR door to close, and mount to drive vertical.

24. **[T]** CPS switch — OFF.

7.4.15 Pattern Entry. Entry to the field traffic pattern will be at the speed and altitude prescribed by local course rules. When approaching the initial for the break, wings may be positioned manually full aft to facilitate multiplane entry and break deceleration. Break procedures shall comply with squadron, field, and/or CV standard operating guidelines.

7.4.16 Landing

7.4.16.1 Approach. At the abeam position for landing, the aircraft should be at the prescribed altitude, trimmed up to 15 units AOA with the Landing Checklist completed.

Indicated airspeed should be cross-checked with gross weight in wings-level flight to verify AOA accuracy. Direct lift control and the approach power compensator should be engaged as desired and checked for proper operation. The turnoff from the 180° position should be made based on surface wind conditions and interval traffic (type, pattern, touch-and-go, or final landing, etc.) so as to allow sufficient straightaway on final prior to touchdown.

The quality of the approach and touchdown is enhanced by starting from on speed and altitude. The low thrust required in the landing approach leaves little margin for corrections from a high, fast position. Therefore, the pilot must control these parameters precisely from the onset of the approach to touchdown. Inertia and tail movement in conjunction with engine thrust response characteristics dictate the use of small, precise corrections on the glideslope for the most effective control technique. Lateral overcontrol produces large yaw excursions that complicate lineup analysis. All turns should be coordinated with rudder inputs.

The landing should be planned for the downwind side of the runway with traffic behind, or opposite the nearest traffic on landing rollout, or on the turnoff side of the runway. When surface wind is not a factor, pilots should practice flying on the field optical landing aid system whenever possible. Fly the aircraft down to the deck without flaring so as to accurately establish a touchdown point and achieve initial compression of main gear struts to arm the spoiler brakes.

Note

Landing with DLC engaged will reduce the amount of aft stick deflection available. DLC should be deselected when established on landing rollout.

7.4.16.2 Touchdown. To avoid tail-ground clearance problems, pitch attitude should not exceed 15 units AOA. At touchdown, immediately retard throttles to IDLE and confirm spoiler brake deployment. Expeditiously lower the nosegear to the deck and, without allowing the nose to come up, position the stick full aft.

7.4.16.3 Rollout. The braking technique to be utilized with or without antiskid selected is essentially the same: a single, smooth application of brakes with constantly increasing pedal pressure. Do not pump the brakes. Directional control during rollout may require some differential braking.

Nosewheel steering may be used during rollout but it must be engaged with the rudder pedals centered to avoid a directional swerve upon engagement. Restrict the use of nosewheel steering during rollout until or unless required for directional control. Under conditions of normal braking (antiskid selected), the antiskid system is passive and has no effect on wheelbrake operation. However, if maximum deceleration is desired, commence braking as the nose is lowered and smoothly apply sufficient pressure to activate the antiskid system

When an impending skid is sensed, antiskid operation will result in a series of short wheelbrake releases and a surging deceleration. Constant pedal pressure should be maintained. Approaching taxi speed (about 15 knots), ease brake pressure and deselect antiskid.

CAUTION

- If brakes are lost, release brake pedals and secure antiskid.
- If antiskid is not deselected before 15 knots, continued hard braking could result in blown tires.
- Ensure feet are off brakes before crossing field arresting gear.

CAUTION

If nosewheel steering hardover is suspected upon engagement of NWS, deselecting NWS, lowering the hook, and/or differential braking may be required to regain directional control.

Note

If maximum-effort braking or antiskid is not required, or antiskid is not selected, delaying brake application until the aircraft aerodynamically decelerates below 80 knots greatly reduces the possibility of blown tires and overheated brakes.

Follow the Postlanding Checklist for proper configuration cleanup procedures. Clear the area behind before turning off across the runway. The right engine may be shut down to reduce residual thrust during low-gross-weight taxiing.

7.4.16.4 Touch and Go. For touch-and-go landings, MIL thrust is applied after touchdown while thumbing speedbrakes in manually to configure the aircraft for a go-around. Automatic retraction of speedbrakes occurs upon application of MIL thrust as a safety backup mode of retraction. Control for rotation is greater than experienced on takeoff, although the aircraft has the same basic lift-off characteristics. Fuel required per pass is normally 300 pounds, contingent on traffic pattern.

7.4.16.5 Minimum Descent Rate Landings. Minimum descent rate landings are required for heavyweight and landing gear emergency landings. Aircraft pitch attitude at touchdown is critical.

CAUTION

Do not exceed 10° pitch attitude/15 units AOA at touchdown to prevent speedbrake, ventral fin, and/or exhaust nozzle damage.

After touchdown, throttles should be immediately placed at the idle stops. The nosewheel should be lowered to the ground, fully compressing main landing gear struts. Delaying either action will delay the deployment of ground-roll braking spoilers and may increase landing rollout. Additionally, until ground-roll braking spoilers are deployed, lateral control remains responsive and may induce lateral, pilot-induced oscillation. Aerodynamic braking should not be used because speedbrake, ventral fin, and/or exhaust nozzle damage may occur.

The Fresnel lens may be used for precise glideslope control until arresting the approach rate of descent. Do not attempt to recenter a high ball in close. The approach should be flown on speed at 15 units AOA. At approximately 30 feet AGL (2 to 3 seconds prior to touchdown), arrest the rate of descent by a slight addition of power. Maintain approach attitude until touchdown. If the Fresnel lens is not available, fly a shallow approach to touchdown in the first 1,000 feet of runway. If runway length is critical, consideration should be given to reducing touchdown speed by flying a no-DLC approach.

7.4.16.6 Crosswind Landings. If landing is required at crosswind conditions above the limits or on a wet runway with crosswinds approaching the limits, an arrested landing should be made.

Crosswind landing tests with a 20-knot component with all spoilers extended have been completed. With this limit, crosswind landings present no unusual directional control problems with up to a 20-knot component with all spoilers extended. Touchdown should be on speed, firm, and within the first 500 feet. Lateral drift before touchdown must be eliminated by the wings-level crab or wing-down technique (this is especially important on a wet runway). Upon touchdown, lower the nose to the runway to improve the straight tracking characteristics. With a 20-knot component, the upwind wing will raise slightly. However, aerodynamic controls (rudders) will effectively maintain a straight track until approximately 80 KIAS where differential braking may be required. If directional control is marginal, nosewheel steering should be used to maintain control. Nosewheel steering will probably be required during crosswind conditions with a wet runway.

Crosswind landings may be accomplished using either the sideslipped or crabbed technique, up to the crosswind limit (20 knots). The roll rate command function and revised spoiler gearing of the DFCS spoiler gearing schedule results in nearly immediate spoiler breakout with lateral stick deflection from trim.

This spoiler breakout may result in an overly sensitive roll response during lineup corrections. Because crabbed approaches are flown without this offset lateral stick input and do not exhibit this characteristic, pilots may find this technique easier.

If a landing must be made in crosswind conditions in excess of the limits, the techniques must be changed. At some crosswind component the upwind wing will be raised excessively and, as a result, directional control will be marginal. It is estimated that this will occur with a greater-than-25-knot crosswind component. If after touchdown the wing is raised excessively, the spoiler brakes should be turned off and lateral stick applied to maintain a wings-level attitude. If the crosswind component is greater than 25 knots, do not arm the spoiler brakes for landing and again maintain a wings-level attitude with lateral stick. It must be realized that antiskid will not be available.

7.4.16.7 Landing on Wet Runways. If operable, antiskid shall be used on wet runways to minimize the possibility of skidding or blowing tires. Standing water greatly decreases braking effectiveness and may cause total hydroplaning in certain conditions (refer to Part V). Intermittent puddles may cause wheels to lock while braking with antiskid not engaged. As the locked wheel leaves the puddle and encounters a good braking surface, it will skid and blow unless brake pressure is released. The following procedures are recommended when landing on a wet runway:

1. Determine field condition before approach (braking action, crosswind component, arresting gear status).

2. If adverse wind and runway conditions exist, make a short-field arrested landing. In the event that the arresting gear is not engaged, execute a waveoff or bolter as appropriate.

3. Consideration should be given to reducing touchdown speed by flying a no-DLC approach. Plan the pattern to be well established on final in a wings-level attitude (crab, if required) on speed. Land on runway centerline using normal FCLP landing techniques.

4. If a rollout landing is desired, touch down on centerline within the first 500 feet of runway. Landing rollout procedures are the same as in a normal landing. When directional control is clearly established, utilize normal braking. During the highspeed portion of the landing roll, little or no deceleration may be felt. Do not allow the aircraft to deviate from a straight track down the runway. If a skid develops, release the brakes, continue aerodynamic braking, and use rudders or nosewheel steering for directional control. Reapply the brakes cautiously. If the skid continues and adequate runway remains, select power as required and fly away. If conditions do not permit flyaway, use the long-field overrun gear if required. If the aircraft is leaving the runway to an unprepared surface, secure both engines.

Note

A blown tire on landing rollout may result in directional control difficulties, particularly at high speeds. Refer to Part V for blown tire emergency procedure.

7.4.17 Landing Checklist. The placarded landing checklist should be completed in sequence prior to arriving at 180° abeam the touchdown point. All checklist items are essential elements to be checked prior to each landing. With the ICS on HOT MIC, the pilot should call out the accomplishment of each step so that the RIO can double-check that all items have been performed.

1. Wing-sweep mode switch — 20° AUTO.

   Check wings in AUTO sweep control mode and verify at 20°.

2. Wheels — Three DN.

   Check transition light out. Check for wheels-down indication on all three gear, LAUNCH BAR light, and that gear transition light is out. Check that brake accumulator pressure is fully charged.

   During aircraft carrier (CV) qualifications and other operations when the landing gear are not raised after catapult launch, the pilot shall check the LAUNCH BAR advisory light is off prior to each landing.

3. SAS — ON.

4. Flaps — Full DN.

   Check for flap and slat full-down indication and no FLAP light.

5. DLC — Checked.

6. Hook — As Desired.

   Transition light should be out.

7. Harness — Locked.

8. Speedbrakes — EXT (out).

   Check indicator for full speedbrake extension.

9. Brakes — Check.

10. Fuel — Check.

7.4.18 Postlanding — Pilot

1. Speedbrake switch — RET.

2. ANTISKID SPOILER BK switch — OFF.

3. Flaps and Slats — UP.

   Move FLAP handle UP and check for complete retraction of main flaps and slats and auxiliary flaps (flap indicator — 0° and no FLAP caution light). Check auto-deactivation of the outboard spoiler module. As soon as the auxiliary flaps are retracted (8 seconds), the wings will sweep aft if commanded.

4. WING SWEEP MODE switch — BOMB.

CAUTION

Ensure that EMERGENCY WING SWEEP handle and wings move to 55°.

5. EMERGENCY WING SWEEP handle — OV SW.

   Raise handle and move aft to 68°. Raise handle to full up extension and hold. When HZ TAIL AUTH caution light goes out and the OVER flag appears, move EMERGENCY WING SWEEP handle full aft (75° sweep position) and stow. Rotate handle guard to stowed position.

6. Avionics — OFF.

   Turn off all avionics (data link, radar altimeter, displays, tacan, ARA-63) except UHF radio.

7. DCP — Verify & record codes (FAIL, FLT, IBIT)

8. Right throttle — OFF.

Note

Care should be taken when shutting down the right throttle (with the left throttle at IDLE) to prevent inadvertent contact with the left throttle, moving it aft to the cutoff position.

9. HYD TRANSFER PUMP switch — SHUTOFF. (after BI-DI check)

   Check hydraulic transfer pump operation in the combined-flight direction with the HYD PRESS, OIL PRESS, R GEN, and R FUEL PRESS caution lights illuminated.

10. Ejection seats — Safe.

    Raise guards on face curtain and secondary firing handles to lock seat actuation devices.

11. Ordnance — Dearm (field).

    Dearm and safety ordnance in accordance with local operating procedures.

12. Wheels — Chocked.

13. Parking brake — Pull.

CAUTION

Do not pull parking brake subsequent to a field landing if the brakes have been used extensively.

14. UHF FUNCTION selector — OFF.

15. OXYGEN switch — OFF.

    After removing mask, turn oxygen off.

16. EMERG generator switch — OFF.

17. Standby attitude gyro — Cage.

18. Left throttle — OFF (alert RIO).

    Alert RIO and upon signal from plane captain, secure left engine.

19. Lights — OFF.

    Turn off internal and external light switches.

20. EJECT CMD indicator — Verify PILOT.

21. CANOPY handle — OPEN (alert RIO).

7.5 RIO PROCEDURES

7.5.1 Interior Inspection — RIO

WARNING

NATOPS prohibits the attaching or stowing of unauthorized equipment on or above the canopy rails during CV launch and arrestment, due to the potential for missile hazard.

1. Left and right circuit breakers — Set.

2. Left and right foot pedals — Adjust.

3. Harnessing — Fasten.

   a. Leg restraint lines and garters — Connect.

      Connect leg line bayonet fitting to leg garter quick-release buckle on the respective side. Assure that leg lines are not twisted.

   b. Personal services (vent and anti-g hoses) — Connect.

      Insert personal vent and anti-g hoses into seat block fittings. In the absence of a suit vent requirement, the seat block vent hose should be inserted into the seat back fitting to provide ventilation air through the seat and back cushions.

   c. Lap belt — Attach.

      Attach lap belt fittings and pull bucket straps snug in order to provide secure lap restraint for flight and seat kit suspension in the event of emergency egress or ejection.

   d. Shoulder harness — Attach.

      Attach shoulder harness release fittings to torso fittings. Check for proper positioning of parachute D-ring on left riser.

   e. Inertia reel — Check.

      Position the shoulder harness manual control knob forward to the lock position and check that both shoulder straps lock evenly and securely when leaning back. Position control knob full aft to unlock harness and release knob to the neutral position.

   f. Oxygen-audio connection — Attach.

      Attach composite fitting without causing unnecessary twisting of hard hose.

4. Oxygen — Check.

   Turn OXYGEN switch ON, purge with mask held away from face. Place mask to face and check for normal breathing and regulator and mask operation. Turn OXYGEN switch OFF, check for no breathing.

5. VENT AIRFLOW thumbwheel — OFF.

6. SYS TEST-SYS PWR ground check panel — Closed.

7. **[T]** CPS switches — OFF.

8. KY-58 — P/OFF.

9. ICS panel — Set.

   a. VOL knob — Set.

   b. Amplifier — NORM.

   c. Function selector — COLD MIC.

10. CDNU — OFF.

11. U/VHF MODE selector — OFF.

12. LIQ COOLING switch — OFF.

13. EJECT CMD lever — Set.

    Determined by squadron policy.

14. Data storage unit — Secure.

15. ARMAMENT control panel — Set.
    a. WPN type thumbwheel — OFF.
    b. ATTK MODE knob — MAN.
    c. DLVY MODE switch — RPL.
    d. DLVY MODE switch — SGL.
    e. ELECT FUZE knob — Safe.
    f. A/G GUN switch — OFF.
    g. MECH FUZE switch — Safe.
    h. SEL JETT switch — Safe.
    i. JETT OPTIONS switch — MER TER.
    j. INTERVAL — Set.
    k. QTY — Set.
    l. Station select switches l to 8 — Safe.
    m. MSL OPTIONS switch — NORM.
    n. MSL SPD GATE KNOB — NOSE QTR.
16. Standby attitude gyro — Caged.
17. NAV MODE knob — OFF.
18. PTID power switch — OFF.
19. Clock — Set and Wind.
20. WCS switch — OFF.
21. IR/TV power switch — OFF.
22. RECORD switch — OFF.
23. RADAR WARNING RCVR PWR switch — OFF.
24. DECM selector knob — OFF.
25. AN/ALE-39 PWR/MODE switch — OFF.
26. DATA LINK ON-OFF-AUX ON switch — OFF.
27. APX-76 — OFF.
28. INTERIOR LIGHTS panel — Check.
29. IFF MASTER knob — OFF.
30. MODE 4 switch — Out.
31. IFF ANT and TEST panel — Set.
    a. IFF ANT switch — Off (center).
    b. IND LT-DDI BIT switch — Off (center).
    c. GND CLG switch — OFF.
32. RADAR BEACON switch — OFF.
33. RADAR BEACON MODE switch — Single or Double.
34. POWER SYS TEST switch — OFF.
35. DATA/ADF switch — OFF.

7.5.2 Prestart — RIO. The following checks are performed by the RIO after starting air and electrical power are applied prior to starting engines.

CAUTION

- Starting air, which provides full ECS capability, must be connected to the aircraft with electrical power to cool temperature-critical avionics.
- If starting air is not available, a forced air ground cooling unit and servo air must be connected before turning on avionics equipment.
- If electrical power is not connected with spare starting air, the ECS will drive to full hot.
- To prevent overheating the outboard spoiler module, pull the OUTBD SPOILER PUMP circuit breaker (2B2) anytime external power is connected and the flaps are extended.
- Failure of the cooling air light to illuminate on external electrical power indicates a miswired or failed sensor. The COOLING AIR light will not be available to indicate a subsequent ECS turbine failure.

1. Seat, ICS, and U/VHF foot switches — Adjust.

   Adjust seat height such that the helmet can be placed against the headbox without face curtain handle interference. After seat height adjustment, adjust ICS and UHF foot pedal fore-aft position for sitting comfort.

2. External power and air — ON.

3. ICS — Check.

   Verify two-way communications between flight crewmembers and adjust volume to a comfortable level.

4. DL, tacan, and U/VHF — Set.

   Set communications/tacan/command control in accordance with mission and flightcrew operating procedures.

5. Fuel quantity — Check.

6. Lights — Check.

   Check for illumination of console and instrument lighting.

7. LTS test — Check.

   Check that all caution and advisory lights, ECM lights, and DDI lights illuminate.

Note

During pilot INST test, the RIO should observe fuel counter decrease to 2,000 pounds and MASTER CAUTION, FUEL LOW, and OXY LOW lights illuminate.

8. Ejection seats — Armed.

   Arm ejection seat by depressing locking tab on headbox and rotating alternate ejection handle safety guard downward. Visually check that pilot locking tab is depressed.

9. CANOPY handle — Close.

   RIO will normally close canopy. Ensure verbal clearance from pilot. Check that CANOPY light goes out with full-forward transition of canopy into the sill locks.

WARNING

Flightcrews shall ensure that hands and foreign objects are clear of front cockpit handholds, top of ejection seats, and canopy sills to prevent personal injury and/or structural damage during canopy opening or closing sequence. Only minimum clearance is afforded when canopy is transiting fore and aft.

Note

If CLOSE does not close the canopy, depress the grip latch and release and push handle outboard and forward into BOOST. If it is necessary to use BOOST, the handle shall be returned to CLOSE to avoid bleed off of pneumatic pressure.

10. Acknowledge — Ready To Start.

7.5.3 Engine Start — RIO. The RIO must monitor pilot procedures and plane captain signals to ensure maximum safety during the engine start sequence.

7.5.4 Poststart — RIO

Note

- The RIO will ensure that the EMERG GEN check is completed before commencing poststart procedures.
- Following engine start, ECS should be run for 3 to 5 minutes prior to avionics/ AWG-9 power-up.

1. CDNU — OFF.
2. DATA LINK — ON.
3. DATA LINK Mode — CAINS/WAYPT (CV Ops) TAC (Shore Based)

After CDNU SELF TEST complete:

4. NAV MODE Switch — ALIGN.
5. WCS switch — STBY.

   Verify that AWG-9 COND light illuminated.

6. PTID power switch — ON.

7. LIQ COOLING switch — AWG-9 OR AWG-9/AIM-54.

Verify that AWG-9 COND light goes off and that the AUTO BIT 2 is running.

8. CDNU — ENTER CURRENT POSITION/ DATE/TIME.

9. IR/TV power switch — IR/TV.

10. Communications — ON and SET.

11. **[T]** CPS system switch — RDY.

Observe DATA/MAN V/H light illuminated.

12. **[T]** IRLS switch — STBY.

Observe IR NR light illuminated for cooldown period maximum of 17 minutes.

13. TACAN/EGI select switch — EGI.

14. RADAR WARNING RCVR panel — SET.

15. DECM knob — STBY.

    a. When STBY light goes out, select HOLD 3 SEC, then ACT for OBC.

16. IFF MASTER knob — STBY.

17. AUTO BIT 2 — VERIFY COMLETE.

18. Verify pilot has OBC selected:

    a. Observe ALIGNMENT display on PTID.

    b. Observe FAILED acronyms on PTID in CM.

WARNING

If CIA acronym is displayed in CM after completion of OBC, aircrew must select maintenance display to determine type of failure in the AWG-15. The possibility of inadvertent stores release exists when this acronym is present.

    c. Observe test complete on PTID.

    d. Altimeter — RESET

19. CDNU — ENTER DATA/LOAD FLIGHT PLAN

20. **[T]** V/H Check:

    a. Manual V/H thumbwheel set 360 knots/1,800 feet

    b. V/H switch — TEST. Observe MAN V/H light out.

    c. V/H switch — MANUAL

21. **[T]** Vertical frame check:

    a. Manual V/H thumbwheel set 350 knots/1,800 feet

    b. Frame switch — VERT

    c. FILM switch — RUN. Observe exposure interval of 1.0 second and frame camera green light illuminated; check camera frame counter for proper operation.

    d. Film switch — OFF

    e. FRAME switch — OFF

22. **[T]** If directed by Maintenance, PAN BIT check:

    a. PAN switch — BIT/Release.

    Observe exposure interval of 1.0 second, green PAN light illumination, and counter decrease as five frames are exposed.

23. **[T]** PAN autocycle check

    a. PAN switch — CTR.

    b. FILM switch — RUN.

    Observe exposure interval of 1.0 second, green PAN light illumination, and check camera frame counter for proper operation.

    c. PAN switch — LEFT or RIGHT.

    Observe exposure interval of 2.0 seconds, PAN go light illuminated, and frame counter for proper operation.

    d. FILM switch — OFF.

24. **[T]** PAN pulse mode check

    a. Manual V/H thumbwheel set — 350 Knots/13,500 Feet

    b. PAN switch — CTR.

c. FILM switch — RUN.

Observe exposure interval of 5.0 seconds, green PAN light illumination, and check camera frame counter for proper operation.

d. FILM switch — OFF.

e. PAN switch — OFF.

25. **[T]** IR sensor check

Note

Before IRLS system check, observe IR NR light out following cooldown and BIT. Observe film counter movement by 1 foot.

a. IRLS switch — WFOV.

b. Manual V/H thumbwheel set — 350 Knots/600 feet.

c. FILM switch — RUN.

Observe green infrared line scanner (IRLS) light flashing at 5-second interval and check proper film counter operation.

d. FILM switch — OFF.

e. IRLS switch — STBY.

26. Computer address panel — Set.

27. DDD — Set.

28. PTID controls — Set.

a. CONTRAST — Set.

b. BRIGHT control — Set.

c. DATA LINK — As Required.

d. JAM strobe — As Required.

e. NON ATTK — As Required.

f. LAUNCH ZONE — As Required.

29. Multiple display indicator — Set.

a. TEST button — Depress and Check.

b. BRIGHTNESS — Set.

30. DATA/ADF switch — BOTH.

31. Hand control panel — Set.

a. Light test (all AWG-9 lights illuminate) — Depress and Check.

b. El Vernier (category radar position) — Set 0° EL.

32. AN/ALE-39 (as required) — Set.

33. CANOPY DEFOG-CABIN AIR lever — CABIN AIR.

34. D/L reply — As Required.

35. AAI control panel — Set.

a. TEST/CHAL CC switch — Test.

Check DDD display.

36. Indicator lights — Test.

37. DDI BIT — Test.

38. After alignment completed:

a. NAV mode — INS.

b. Program restart — Depress.

c. STBY/READY lights — OFF.

39. DEST data — Verify.

40. BRG/DIST to destination — Check.

41. OWN A/C groundspeed — Check.

42. MAG VAR — Check.

43. KY-58 — As Required.

44. Standby attitude gyro — Erect.

45. Notify pilot — Ready To Taxi.

7.5.5 Taxi — RIO. The RIO's primary responsibility during taxiing is to act as copilot-safety observer. BIT checks may be performed while taxiing, provided that RIO attention is not diverted from the copilot-safety observer duties.

1. Perform BIT confidence checks 2, 3, 4, 1 if not previously checked and record results on BER form.

Note

Perform BIT sequence 3 as a minimum to set ACM threshold.

a. CATEGORY switch — BIT.

b. BIT sequences — Select.

Observe failures.

2. OWN A/C groundspeed — Check on ECMD.

   Check own-aircraft ground speed when stopped. It should be equal to or less than 3 knots for satisfactory alignment.

3. **[T]** OWN A/C altitude — Check.

7.5.6 On-Deck Entry of Reference Points or Targets

1. Target LAT/LONG — Enter.
2. Altitude — Enter Altitude of Target Area.
3. NAV MODE switch (after alignment complete) — AHRS/AM.
4. Manual MAG VAR of target area — Enter.

Note

Manual MAG VAR must be reentered regardless of current value displayed.

5. **[T]** Heading (CGTL) — Enter.
6. **[T]** Target length of run (one-tenth of a mile) — Enter Via CAP Keyboard SPD Pushtile.

Note

- Maximum number of reference points is eight: three waypoints and one each of fixpoint, surface target, home base, hostile area, and defended point.
- IP may not be used as a TARPS reference point. The hostile area altitude is used as the lowest priority source for AGL calculations.

7. NAV MODE switch — INS.
8. **[T]** Manual MAG VAR of local area ENTER.

7.5.7 Own-Aircraft Altitude Correction (On Deck)

1. CAP — NAV Category.
2. Own aircraft — Hook.
3. Altitude pushtile — Select.
4. Field/ship elevation — Enter.

7.5.8 Own-Aircraft Altitude Correction (Airborne)

1. CAP — NAV Category.
2. Own aircraft — Hooked.
3. Altitude pushtile — Select.
4. Altitude — Enter.

   Enter PTID AGL altitude if over water.

7.5.9 Postlanding — RIO

Note

Before shutdown, run BIT. Note results on BER card.

1. Ejection seat — Safe.
2. EJECT CMD lever — PILOT.
3. Radar beacon — OFF.
4. IFF — Mode 4 Hold, then Off.
5. Data Link — OFF.
6. DECM switch — OFF.
7. CDNU — Record blended/GPS/Free Inertial Pos. Record RNAV Page data after aircraft parked, then OFF.
8. NAV MODE switch — OFF.
9. For VTR-equipped aircraft, RECORD switch — OFF.

   Requires at least 20 seconds to allow tape to unthread prior to removal of electrical power.

10. IR/TV power switch — OFF.

11. WCS — OFF.

12. PTID power switch — OFF.

13. LIQ COOLING switch — OFF.

14. Standby attitude gyro — CAGE.

15. OXYGEN switch — OFF.

16. U/VHF MODE selector — OFF.

17. **[T]** CPS switches — OFF.

18. Report — Ready for Shutdown.

    After shutdown of both engines:

19. CANOPY handle — OPEN.

    Alert pilot.

20. Flightcrew — Egress.

7.6 TARPS PROCEDURES

7.6.1 TARPS Mode Entry and Display Requirements

7.6.1.1 Pilot

1. **[T]** PDCP display mode — A/A or A/G.
2. **[T]** PDCP STEER CMD — DEST or MAN.
3. **[T]** HUD with A/G selected — Check On.
4. **[T]** VDI with A/A selected — Check On.

7.6.1.2 RIO

1. **[T]** CPS system switch — RDY.
2. **[T]** PTID menu select symbol — Hook.
3. **[T]** REC acronym on full PTID menu — Hook.
4. **[T]** Desired reference points — Check.
5. **[T]** MAG VAR — Check.
6. **[T]** ARMAMENT ATTK MODE — CMPTR PLT.

Note

- Chaff can be dispensed from the weapons rail adapter with ARMAMENT ATTK MODE in either MAN or CMPTR PLT. However, CMPTR PLT ATTK MODE must be selected if HUD steering displays are required.

- Momentary display of M or B indicates AWG-9 tape read to TARPS mode; flashing TARP acronym (TARP acronym will alternate with MAP acronym in MAP mode) indicates pilot has not selected A/G on the pilot display control panel.

7.6.2 In-Flight Reconnaissance System Check — RIO

En route to target area:

1. **[T]** FRAME switch — VERT.
2. **[T]** PAN switch — CTR.
3. **[T]** IRLS switch — WFOV.
4. **[T]** FILM switch — RUN.

   Run only long enough to check operation and observe FRAM, PAN, and IR LS green lights illuminated, and check frame and foot counters.

5. **[T]** FILM switch — OFF.
6. **[T]** IRLS switch — STBY.
7. **[T]** PAN switch — LEFT or RIGHT.
8. **[T]** FRAME switch — FWD.

Note

Prior to selecting FILM switch to RUN, delay 15 seconds for camera positioning.

9. **[T]** FILM switch — RUN.

Run only long enough to check operation and observe FRAME and PAN green lights illuminated and check for proper film counter operation.

10. **[T]** FILM switch — OFF.

11. **[T]** FRAME switch — OFF.

12. **[T]** PAN switch — OFF.

Note

Keep manual V/H thumbwheels matched with actual altitude and airspeed to avert possible degraded imagery if an automatic shift to the manual mode occurs.

7.6.3 Steering Display Requirements

7.6.3.1 Destination Steering (TARPS)

PILOT

1. **[T]** PDCP display mode — A/A or A/G.
2. **[T]** PDCP STEER CMD — DEST.

Note

TARPS steering will be presented on the HUD with A/G selected on the PDCP and on the VDI with A/A selected.

RIO

1. **[T]** PTID DEST switch — Any Position Except MAN.

   DEST switch position determines source of HSD/ECMD steering information.

2. **[T]** Desired reference point — Hook.
3. **[T]** Desired CGTL — Check.

Note

RIO selection of DEST MAN retains the current pilot HUD/VDI steering, regardless of what reference point or target the RIO may hook. To select a different point for pilot steering, the RIO must cycle out of MAN and hook desired reference point or target.

7.6.3.2 Direct Steering (TARPS). Pilot HUD/VDI steering direct to the hooked target without regard for the CGTL can be obtained by either of the following methods. The method utilized depends on the desirability of retaining HSD/ECMD steering to the point selected on the PTID DEST switch.

7.6.3.2.1 Direct Steering — HSD/ECMD Steering Not Required

PILOT

1. **[T]** PDCP display mode — A/G or A/A.
2. **[T]** PDCP STEER CMD — MAN.

7.6.3.2.2 Direct Steering — HSD/ECMD Steering Retained

PILOT

1. **[T]** PDCP display mode — A/G or A/A.
2. **[T]** PDCP STEER CMD — DEST.

RIO

3. **[T]** Desired target — Hook.
4. **[T]** Enter length of run (SPD) — Zero.

7.6.4 Airborne Entry of Reference Points/Targets (TARPS)

1. **[T]** Reference point which steering to — Hook.
2. **[T]** PTID DEST switch — MANUAL.
3. **[T]** Reference point to be changed — Hook.
4. **[T]** Reference point data — Enter.
5. **[T]** Reference point to which steering desired — Hook.
6. **[T]** PTID DEST switch — Any Position Except MAN.

7.6.5 Navigation Updates Via HUD

1. **[T]** Desired target symbol — Hook.
2. **[T]** Target — Visually Identified by Pilot.
3. **[T]** CAP — NAV Category
4. **[T]** TARPS NAV FIX CAP function button 3 — Depress.
5. **[T]** Target designate switch — Forward to Undesignate Target.
6. **[T]** Aircraft heading — Align CGTL With Target
7. **[T]** Target designate switch — Move Up/Down To Slew Diamond Over Target.
8. **[T]** Target designate switch — Forward To Redesignate Target
9. **[T]** Delta LAT/LONG — Evaluate.
10. **[T]** FIX ENABLE (if update desired) — Press.

Note

The accuracy of an update increases with greater look angles; low grazing angles may induce navigation errors.

7.6.6 Targets of Opportunity

1. **[T]** Hostile area altitude — Enter Estimated Target Altitude.
2. **[T]** PTID DEST switch — Any Position Except MAN.
3. **[T]** All reference points/targets — Unhook.
4. **[T]** Desired target — Visually Identified by Pilot.
5. **[T]** Target designate switch — Forward to Cage Diamond.
6. **[T]** Aircraft heading — Align CGTL with Target.
7. **[T]** Target designate switch — Move Up/Down To Slew Diamond Over Target.
8. **[T]** Target designate switch — Forward To Designate Target.
9. **[T]** Manual direct steering — Available.

Note

Selection of either LAT or LONG CAP pushbutton will display target of opportunity LAT/LONG on PTID.

7.6.7 Mapping Mode Entry

1. **[T]** IP function button — Hook.
2. **[T]** CAP SPD prefix button — Depress.
3. **[T]** Number of mapping lines (NL) required — Enter.
4. **[T]** CAP ALT prefix button — Depress.
5. **[T]** Map line separation distance (SD) — Enter.

Note

- Map line SD must be preceded by a positive symbol using CAP pushbutton N+E if map area is right of flight line or a negative symbol using CAP pushbutton S-W if map area is left of flight line.
- With IP hooked, valid entry of both NL and SD is indicated by a flashing MAP acronym. If A/G is not selected on pilot display control panel, the MAP and TARP acronyms will alternate.

6. IP function button — Unhook.
7. **[T]** Reference point/target to be mapped — Hook.
8. **[T]** Target length of run (CAP SPD prefix button) — Check.

Note

With valid length of run, entry into the MAP MODE is indicated by a steady MAP acronym, regardless of pilot display control panel switch position.

9. **[T]** Desired CGTL (CAP HDG prefix button) — Check.
10. **[T]** Target altitude — Check.
11. **[T]** Reference point/target — Unhook.

Note

Hook reference point target to be mapped when ready to begin mapping and while heading toward the reference point/target.

7.6.8 Unplanned Air-to-Air Photography

1. **[T]** AWG-9 — TARPS Mode.
2. **[T]** V/H selector switch — MAN.
3. **[T]** Manual thumbwheels — 30 Knots, 500 Feet.
4. **[T]** NAV MODE switch — AHRS.
5. **[T]** CAP category — NAV.
6. **[T]** OWN A/C function button — Hook.
7. **[T]** Altitude — 4,100 Feet, Enter.
8. **[T]** OWN A/C function button — Unhook.
9. **[T]** Any reference point — Hook.
10. **[T]** Altitude — 4,000 Feet, Enter.
11. **[T]** Radar altimeter — OFF.
12. **[T]** AWG-9 switch — STBY.
13. **[T]** CPS system switch — RDY.
14. **[T]** PAN switch — CTR.
15. **[T]** Exposure selector switch — As Directed by Target Scene.
16. **[T]** Pilot's bomb button — Depress at 1-Second Interval.
17. **[T]** Maneuver aircraft for proper positioning. Once own-aircraft altitude is set to 4,100 feet, do not increase actual barometric altitude by more than 500 feet. TARPS Altitude Source Determination.

7.6.8.1 Flycatcher 70-02132

1. **[T]** XXXX0000 — Radar Altimeter.
2. **[T]** XXXX0001 — AWG-9 Radar.
3. **[T]** XXXX0002 — Barometric Minus Hooked Target Altitude.
4. **[T]** XXXX0003 — Barometric Minus Hostile Area Altitude.

7.6.9 TARPS Pulse Search Enable — RIO

1. **[T]** DDD ECCM SPL pushtile — SELECT.

7.6.10 TARPS Mode Exit — RIO

1. **[T]** REC on partial PTID menu — Unhook.

   or

2. **[T]** REC on full PTID menu — Unhook.

   or

3. **[T]** CPS system switch — OFF.

Note

The following aircrew actions will also result in exiting the TARPS mode:

a. Selection of any WCS mode pushtile

b. DFM selection

c. Full action with radar selected on the hand control unit.

7.6.11 TARPS Degraded Mode Procedures

CAUTION

Prior to initiating corrective action on malfunctioning sensors, ensure that other sensors are either in OFF or STBY.

7.6.11.1 Serial Frame Camera Failure

1. **[T]** FILM switch — Cycle OFF/RUN/OFF.
2. **[T]** FRAME switch — Cycle OFF/VERT or FWD.
3. **[T]** FILM switch — RUN.
4. **[T]** FILM switch — OFF.
5. **[T]** V/H — Manual.
6. **[T]** Thumbwheels — Set High Vg/H Value.

7. **[T]** FILM switch — RUN.

If not corrected:

8. **[T]** FILM switch — OFF.
9. **[T]** FRAME switch — OFF.

7.6.11.2 Mount Failure

1. **[T]** FRAME switch — Cycle to Opposite Position.

If not corrected:

2. **[T]** FRAME switch — OFF.

CAUTION

- Initiate corrective action only one time.
- If mount light does not go off, secure sensor and wait 5 minutes to try again.

7.6.11.3 Panoramic Camera Failure

1. **[T]** FILM switch — Cycle OFF/RUN.
2. **[T]** FILM switch — OFF.
3. **[T]** PAN switch — Cycle OFF/CTR.
4. **[T]** FILM switch — RUN.

If not corrected:

5. **[T]** FILM switch — OFF.
6. **[T]** PAN selector — LEFT or RIGHT.
7. **[T]** FILM switch — RUN.

If not corrected:

8. **[T]** FILM switch — OFF.
9. **[T]** PAN selector — OFF.

CAUTION

Do not initiate BIT.

7.6.11.4 Manual V/H Failure

1. **[T]** Thumbwheels — 350 Knots/200 Feet.
2. **[T]** V/H switch — Test.
3. **[T]** MAN V/H light out — Good Test.
4. **[T]** MAN V/H light on — Thumbwheel Failure

7.6.11.5 IRLS Failures

7.6.11.5.1 Cooldown Malfunction (IRNR Light Illuminated)

1. **[T]** IRLS switch — OFF.
2. **[T]** IRLS switch — STBY.

   After cooldown is complete, IR NR light will be out (2 minutes) then illuminates for the remainder of BIT (80 seconds). If IR NR light remains on for more than 17 minutes, IR cooling system is malfunctioning; turn the system off.

7.6.11.5.2 Other IRLS Malfunctions (IRLS Light Illuminated)

1. **[T]** FILM switch — Cycle OFF/RUN/OFF.
2. **[T]** IRLS switch — OFF.

   If IR LS light remains illuminated, assume IR door malfunction and continue with checklist.

3. **[T]** IRLS switch — STBY.

   Observe IR NR light illuminated for cooldown period (17 minutes), then out for 120 seconds, then on for remainder of AUTO TEST (80 seconds).

Note

Note time IRLS light illuminates during BIT.

4. **[T]** IRLS switch — NFOV.
5. **[T]** FILM switch — Cycle RUN/OFF.
6. **[T]** V/H switch — MAN.
7. **[T]** Thumbwheels — 350 Knots/350 Feet.

8. **[T]** FILM switch — RUN.

If corrected:

9. **[T]** V/H switch — AUTO.

If not corrected:

10. **[T]** FILM switch — OFF.

11. **[T]** IRLS switch — OFF.

Note

For actual combat missions, fail indications may constitute abort criteria.

7.6.12 Preland and Descent — RIO

1. WCS switch — STBY or XMT Pulse.

WARNING

The RIO should place WCS switch to STBY or XMT (Pulse) on final approach to prevent unnecessary exposure of flight deck personnel to RF radiation hazard.

2. **[T]** Resolution run — Complete.

Note

Before reconnaissance system shutdown, run film leader to protect target imagery from inadvertent exposure during film download.

3. **[T]** FRAME switch — OFF.

4. **[T]** PAN switch — OFF.

5. **[T]** IRLS switch — OFF.

6. **[T]** FILM switch — OFF.

CAUTION

Before selecting system switch to OFF, delay 15 seconds for sensor shutdown, IR door to close, and mount to drive to vertical.

7. **[T]** CPS system switch — OFF.

7.7 HOT REFUELING PROCEDURES

Before commencing ground hot refueling operations, a qualified groundcrew shall inspect the exterior of the aircraft for any discrepancies that might be hazardous to refueling or further flight operations. One groundcrew shall remain in a position on the right side of the aircraft within view of both the pilot and refueling crew. Any hazardous condition requires the immediate termination of refueling operations.

After refueling, the flightcrew should refer to appropriate checklists to configure the aircraft for takeoff, depending on intentions.

1. Fire extinguishing equipment — Available.

2. All emitters — STBY or OFF.

3. Right throttle — OFF.

4. Wheels — Chocked.

5. Parking brake — Pull.

CAUTION

If heavy braking is used during landing or taxiing followed by application of the parking brake, normal brake operation may not be available following release of the parking brake if the brakes are still hot. Check for normal brake operation after releasing the parking brake and before commencing taxiing.

6. REFUEL PROBE switch — FUS EXTD/ALL EXTD (As desired).

7. WING/EXT TRANS switch — As Desired.

Note

- If external tanks or wings accept fuel in FUS EXTD, select ORIDE on WING/EXT TRANS switch.
- If wings or external tanks do not accept fuel in ALL EXTD, select FUS EXTD and turn WING/EXT TRANS switch OFF.

8. REFUEL PROBE switch — RET.

9. WING/EXT TRANS switch — OFF.

7.8 DECK-LAUNCHED INTERCEPT PROCEDURES

Note

These procedures assume that a quick reaction, full-mission-capable launch is essential. Prestart procedures and cockpit configuration may vary in accordance with airwing policy and specific EMCON conditions. All CNI equipment, as applicable should be placed in ON or STBY, all SAS switches ON, and the HYD TRANSFER PUMP switch should be in NORMAL before application of electrical power. The LTS, INST, EMERG GEN, and DFCS IBIT tests on MASTER TEST panel should be conducted and verified during periodic aircraft turn-ups. Compliance with the takeoff checklist is mandatory to ensure proper aircraft configuration before launch.

7.8.1 Pilot Procedures

1. External electrical power — ON.
2. Seat — ARM.
3. Fire detect — Check.
4. Left engine — IDLE.
5. Right engine — IDLE.
6. OBC — Select.
7. MSL PREP — ON.
8. SW COOL — ON.
9. OBC — Deselect.
10. Hook operation — Check.
11. Takeoff Checklist.
12. Ordnance crew — Arm.

7.8.2 RIO Procedures

1. NAV MODE — CVA.
2. Seat — ARM.
3. WCS switch — STBY.
4. CAINS/WPT — Select.
5. **[T]** CPS SYSTEM switch — RDY.
6. **[T]** IRLS switch — STBY.
7. Takeoff Checklist (complete non-OBC functions).
8. NAV MODE — INS AT READY (program restart).
9. Ordnance crew — Arm.

Note

- Sparrow tune occurs after CW is enabled and can complete after transmitter timeout.
- PH attack capability is present after launch, and Sparrow tune occurs automatically whenever CW is enabled.

7.9 ON-DECK, MAINTENANCE TROUBLESHOOTING

CAUTION

To ensure a safe in-cockpit maintenance troubleshooting evolution, the following procedures should be used.

1. Parking brake — Pull.
2. THROTTLE MODE switch — MAN.
3. Throttle friction lever — INC.
4. Ejection seats — SAFED, CMD-PILOT.
5. Flightcrew — Remain strapped in.

7.10 HOT SWITCH PROCEDURES

Increased potential hazards exist in hot switch operations when an engine is running with canopy open and front seat unoccupied. To minimize this potential hazard, minimum time should be spent in this condition.

Pilot switch should be expedited and crew unstrap should be done with canopy closed. Pilot-to-pilot brief should be accomplished with a pilot in the aircraft.

Note

The RIO will vacate the aircraft first. When the RIO is clear, the pilot will exit. This is particularly important during shipboard operations.

1. Parking brake — Pull.
2. HYD TRANSFER PUMP switch — NORMAL.
3. WCS switch — OFF.
4. IR/TV power switch — OFF.
5. RECORD switch — OFF.
6. **[T]** CPS system switch — OFF.
7. Left throttle — OFF.
8. ASYM LIMITER switch — ON (guard down).
9. ENG MODE SELECT switch — PRI.
10. THROTTLE MODE switch — MAN.
11. Throttle friction lever — Increase.
12. Ejection seats — Safe.
13. Flightcrew — Unstrap.
14. Cockpit — Check for FOD.
15. CANOPY handle — OPEN.
16. Flightcrews — Switch.
17. Flightcrew — Strap in.
18. Ejection seats — Armed.
19. CANOPY handle — CLOSE.
20. Fire DET/TEST — TEST.
21. THROTTLE MODE switch — BOOST.
22. Throttle friction lever — As Desired.
23. Left engine — Start.
24. WCS switch — STBY.

CAUTION

Ensure TARPS maintenance personnel have loaded sensors and cleared aircraft before initiating power to TARPS pod.

25. **[T]** CPS system switch — RDY.

Note

The Poststart Checklist shall be completed with respect to aircraft configuration and switch positions prior to taxi.

7.11 FIELD CARRIER LANDING PRACTICE

7.11.1 Preflight Inspection. A normal preflight inspection will be conducted with specific attention directed to tire condition, nosestrut extension, angle-of-attack probe conditions, and windshield cleanliness. Check that the hook bypass switch is in FIELD.

7.11.2 Takeoff. The takeoff will be individual.

7.11.3 Radio Procedures and Pattern Entry. A radio check with Paddles is advisable before pattern entry to confirm Charlie time. Approaches to the field for break will be controlled by the tower and then switched to Paddles for FCLP pattern control. At no time will an aircraft remain in the pattern without a UHF receiver. On each succeeding pass, the following voice report will be made at normal meatball acquisition positions:

1. Side number
2. TOMCAT
3. Ball/Clara
4. Fuel state
5. Type of approach if appropriate (AUTO, degraded, etc.).

7.11.4 Pattern. The pattern should be a race track with the 180° approximately 1-1/4 miles abeam at 600 feet above field elevation (see Figure 7-6). The length of the groove should be adjusted to give a wings-level descent on the glideslope of 20 to 25 seconds (approximately 1 mile). For maximum gross weight at touchdown, refer to Chapter 4. The turn to the downwind leg should be commenced after climbing to pattern altitude (600 feet AGL) utilizing 30° angle of bank and 150 KIAS. Turning from the 180° power should be adjusted to maintain optimum angle of attack. A gradual descent may be commenced at this position with a minimum altitude of 450 feet AGL at the 90° position and 350 feet AGL as a minimum until the pilot is receiving glideslope information. At approximately 45°, the meatball appears on the Fresnel lens. Fly a rate of descent such that the ball is centered as the aircraft arrives wings-level in the groove. For manual, auto, and DLC approach techniques, refer to Chapter 8.

7.11.5 Night FCLP. All provisions that apply to day FCLP also apply to night FCLP, plus the following items:

1. External lights steady — BRIGHT.

2. Hook bypass switch — FIELD.

When comfortably situated in the pattern, instruments should be flown as much as possible up to the 45° position.

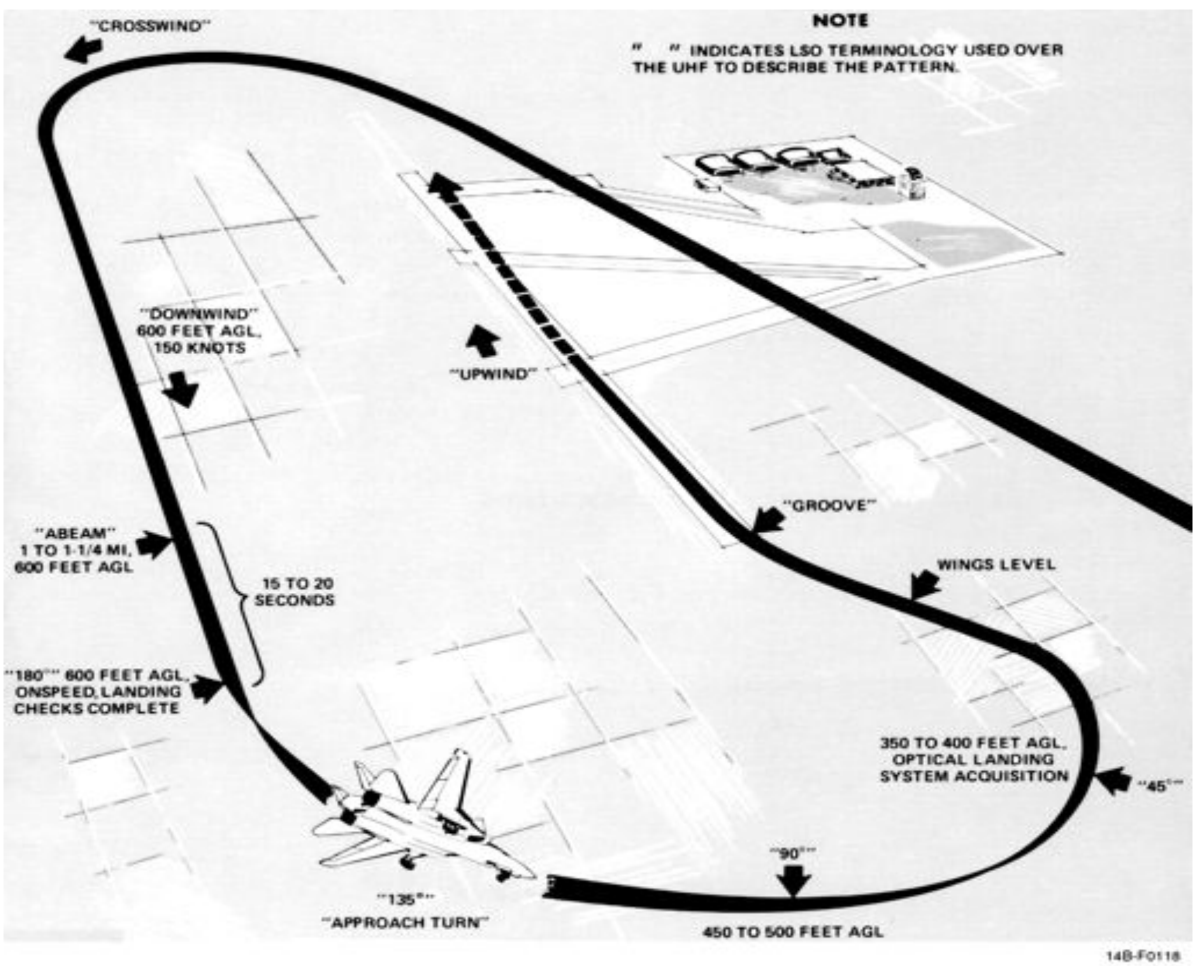

Figure 7-6. Field Carrier Landing Practice

CHAPTER 8

Carrier-Based Procedures

8.1 CARRIER PREFLIGHT

8.1.1 Launch. Applicable aircraft launching bulletins, the CV and LSO NATOPS Manuals, and the pertinent CV air operations manual shall be read by all flight crewmembers prior to carrier qualification. In addition, the pre-deployment lecture syllabus contained in Chapter 1 of the CV NATOPS Manual shall be completed.

8.1.2 Briefing. A thorough briefing shall be accomplished by the flight leader prior to launch. This briefing should call particular attention to current BINGO fields, emergency procedures peculiar to carrier operations, operating area NOTAMs, fuel management, and ships NAVAID status. Aircraft configuration, gross weight, expected WOD, and applicable launch trim settings will be verified prior to man-up.

8.1.3 Preflight. Preflight inspection should be accomplished with particular attention given to nose strut, main landing gear, tires, hook, and underside of the fuselage. Note carefully the actual wing sweep, the lateral spacing between parked aircraft, and the general direction of engine exhaust. Do not preflight the top of the aircraft topside aft of the bleed air doors if spotted with the tail outboard of the safety nets. In the cockpit, particular attention should be given to the flightcrew displays to ensure that the retaining devices have been installed. Ensure that the emergency WING SWEEP handle is secure in the oversweep position when applicable. If the wings are not in oversweep, ensure that the emergency WING SWEEP handle position corresponds with the actual wing position. Leave the emergency WING SWEEP handle guard up, extend the emergency WING SWEEP handle, and pull WING SWEEP DRIVE NO. 1 and WG SW DR NO. 2/MAN-UV FLAP circuit breakers (LE1, LE2). Crossbleed starts (other than at idle) should not be performed unless the area aft of the aircraft is clear. Tiedowns should not be removed and engine starts should not commence unless the auxiliary brake air pressure gauge indicates a full charge.

Note

To achieve a 3,000-psi charge of the accumulators using the cockpit handpump may require up to 374 cycles may be required.

8.2 START AND POSTSTART

Shipboard start and poststart procedure abbreviations of the shore-based checklists are as delineated for the poststart pilot procedures. Certain steps are omitted because aircraft are typically spotted too close together to allow the wings to be swept forward while the aircraft is tied down. Cranking the left engine prior to starting the right as outlined in the shore-based procedures will ensure that auxiliary brake pressure is available and that backup flight control module is full of hydraulic fluid prior to cycling.

8.2.1 Carrier Alignment. There are four methods of aligning the INS on the carrier deck: RF D/L, deck-edge cable, GPS and manual (hand-set) alignment. See Chapter 20 for detailed procedures.

8.3 TAXIING

Shipboard taxi operations differ slightly from the field. Taxiing aboard ship requires higher power settings and must be conducted under positive control of a plane director. Any signal from the plane director above the waist is intended for the pilot and any signal below the waist is intended for deck-handling personnel.

8.3.1 Nosewheel Steering. The nosewheel steering system characteristics are excellent and provide extremely tight cornering capability. At full nosewheel deflection (70°), the inside mainmount wheel backs down and turn radius will be restricted if the inside brake is locked. For a minimum radius turn, momentarily depress the brake on the inside wheel and then allow the inside wheel to roll freely while controlling the turn rate by braking the outside wheel. For normal turns, symmetric brake applications should be applied to control aircraft forward motion. Forward motion should be initiated before effecting a tight radius turn to reduce power requirements.

8.3.2 Taxi Speed. Taxi speed should be kept under control at all times, especially on wet decks and when approaching the catapult area. Be prepared to use the parking emergency brake should normal braking fail. While taxiing, both ejection seats should be armed, at top and bottom. The parking brake is an excellent feature that may be used to prevent leg fatigue during taxi delays. However, it should not be used once forward of the jet blast deflector.

8.4 CATAPULT HOOKUP (DAY)

Set the VDI and HUD to show level flight at normal strut extension. Proper positioning on the catapult is easily accomplished if the entry is made with only enough power to maintain forward motion and if the plane director signals are followed explicitly.

WARNING

Ensure the aircraft is properly armed, configured for flight, and the Takeoff Checklist completed before the launch bar is placed over the catapult shuttle spreader.

The catapult director will direct the pilot to approach the catapult track, using nosegear steering and brakes. Upon signal from the plane director and when positioned immediately behind the mount of the lead-in track, kneel the aircraft. If the launch bar is to be lowered from the cockpit, upon signal from the plane director, deflect the nosewheel, lower the launch bar, center the nosewheel, and disengage nosewheel steering. If the launch bar is to be lowered by the deck crew, no pilot action is required. After the hold-back bar has been attached to the aircraft and checked by squadron maintenance personnel, the catapult director will direct the aircraft forward until the hold-back bar is snug against the catapult buffer unit. The aircraft will be stopped in position for shuttle tension up. The HUD and VDI will show 2° to 3° nose down with the aircraft in the kneeled position

WARNING

Nosewheel centering can contribute to launch bar misalignment in the catapult shuttle, which could result in premature launch bar separation during launch. The nosewheel centering latching relay must be deactivated by depressing the nosewheel steering button after the hook check and before entering the catapult. It will also deactivate the nosewheel steering automatic disengagement function; nosewheel steering must be manually disengaged when entering the catapult.

CAUTION

- If the LAUNCH BAR light illuminates immediately upon selecting KNEEL with the NOSE STRUT switch, a malfunction in the system has occurred and the landing gear will not retract following the catapult launch.

- Nosewheel steering is designed to disengage and the NWS ENGA light goes off when deck personnel lower the launch bar on the catapult. The arresting hook must have been cycled on deck and the throttles set at IDLE to enable the system. This feature prevents the pilot from inadvertently damaging the launch bar during control checks after final tensioning.

8.4.1 Catapult Trim Requirements. The following requirements are applicable to clean aircraft or any combination of air-to-air store, external tank, gross weight combinations, and launch cg locations between 7.0 and 18.5-percent MAC.

Note

To determine center of gravity for a particular aircraft, refer to NAVAIR 01-lB-4, the Handbook of Weight and Balance.

The recommended catapult launch longitudinal trim settings are listed in Figure 8-1.

ANTICIPATED END AIRSPEED ABOVE MINIMUM (KNOTS)	LONGITUDINAL TRIM (DEGREES) TRAILING EDGE UP		
	CG BETWEEN 7% AND 11%	CG BETWEEN 11% AND 16%	CG BETWEEN 16% AND 18.5%
0 to 9	9	6	3
10 to 2	8	5	2
21 to 50	7	4	0

Figure 8-1. Catapult Launch Trim Requirements

8.4.2 Catapult Launch. Aircraft launch gross weight will be cross-checked and verified by signal with the flight deck personnel prior to kneel. If the aircraft is to be catapulted with a partial fuel load, the pilot should ensure that longitudinal trim settings are adjusted if necessary (Figure 8-2). Upon receipt of the "tension-up and release brakes" signal, release the brakes, ensure the parking brake is off, and advance the throttles to MIL. Ensure nosewheel steering is disengaged prior to performing control wipeout. When a turnup signal is received from the catapult officer, grip the throttles firmly, check engine instruments, ensure that the caution and advisory panel is clear, and the RIO is ready. When satisfied that the aircraft is functioning properly, salute the catapult officer. Normally, a 3- to 5-second delay will occur before the catapult fires. Optimum launch technique is to maintain a loose grip on the control stick while allowing it to move aft during the catapult stroke.

WARNING

Failure to allow the control stick to move aft during the catapult stroke will result in degraded pitch rate and excessive sink off the bow.

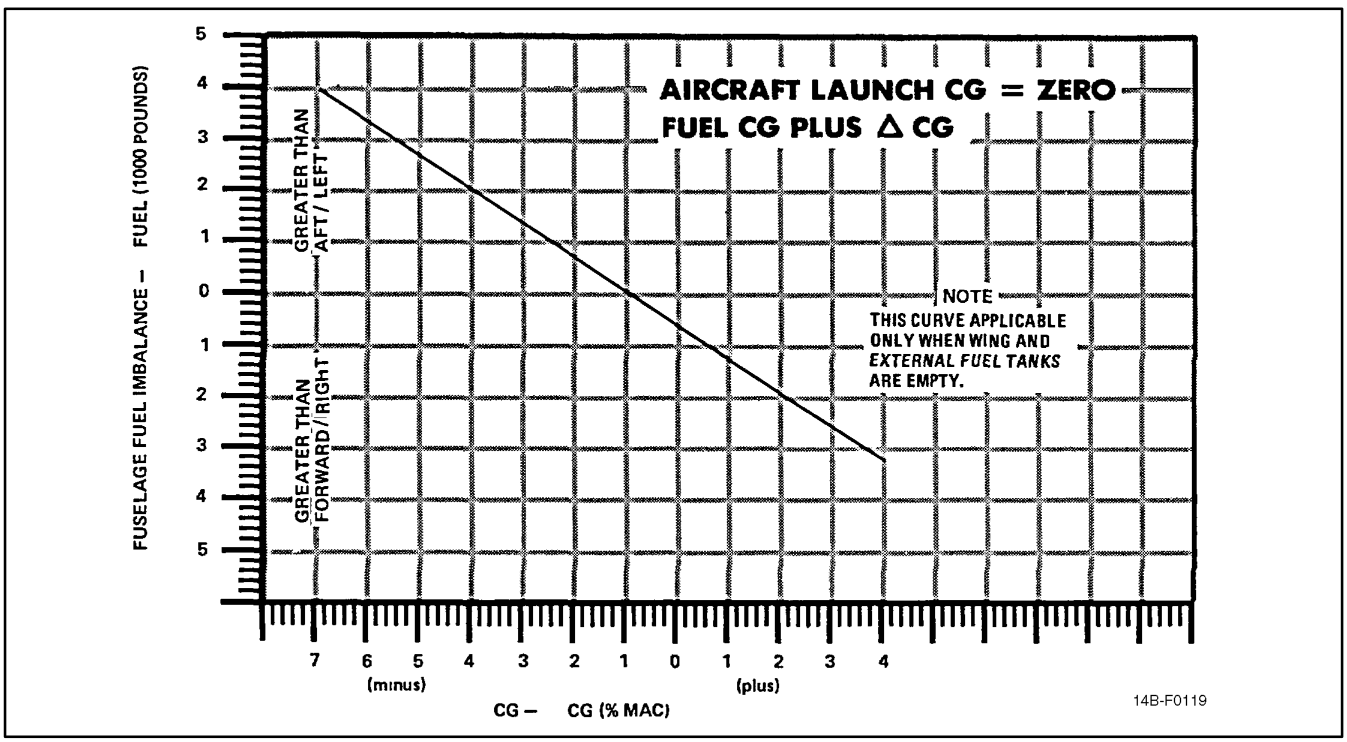

Figure 8-2. Center of Gravity Variation with Fuel Loading

CAUTION

Catapult launch with a partially filled external tank is not authorized.

Initial catapult firing results in a short-term vertical acceleration of 15g to 20g caused by full compression of the stored-energy nosestrut. Firmly restrain the throttles to prevent their aft travel during the catapult stroke.

The F-14 must be flown off the catapult by the pilot. At shuttle release, the energy stored in the nose strut is released, rotating the aircraft to the initial flyaway attitude of approximately 12 to 15° nose-up on the VDI and HUD. The aircrew should plan for the standard excess endspeed of 15 knots, unless notified otherwise. Lower excess endspeed than anticipated or a lower pitch trim setting than recommended will require the pilot to use backstick at the end of the catapult stroke to capture and maintain the desired climbout pitch attitude of 10°. Higher endspeed than expected or a higher pitch trim setting than recommended will require the pilot to stop the rotation at 10° with slight forward stick. While rotating to the flyaway attitude, the flightcrew will feel the aircraft settle approximately 5 feet before commencing a climb. For catapult launches with excess endspeed less than 15 knots, the AOA will rise abruptly to 17 units and then gradually decrease as airspeed increases during the flyway.

Aircrew coordination is particularly critical in this regime, since the aircrew must ensure that initial flyway parameters are maintained while remaining alert for any abnormal launch characteristics and engine malfunctions. High endspeed and/or single-engine flyaway with trim settings above 2° may require significant forward stick pressure. In all configurations, the use of afterburner and/or level rapid acceleration will require reduced nose trim settings. The RIO shall scan airspeed, altitude and attitude to confirm a positive rate of climb. The AVIA display may be used to provide additional information (AOA and positive rate of climb) during the initial flyaway. However, the VSI and AOA information displayed on the AVIA is particularly susceptible to lag and inaccuracies and should be used only as a secondary source of information. The RIO's primary scan should be airspeed, altitude and attitude from the conventional instruments.

Additional considerations exist for night/IFR catapult launches. Aircraft acceleration and the lack of external visual cues will cause the aircrew to sense that the nose is higher than actual and can result in spatial disorientation. Under these conditions, a vigilant instrument scan is required to ensure that the proper attitude is maintained throughout the launch and subsequent climbout. The aircrew should also be alert for power transients, which can temporally disable the pilot's primary attitude display (VDI) during and after the catapult stroke, and require transition to the standby gyro for attitude information.

8.4.3 Catapult Abort Procedures (Day). If after turnup on the catapult the pilot determines that the aircraft is down, the pilot gives the no-go signal by shaking his head from side to side. Simultaneously, the pilot should transmit on the Land/Launch frequency "Suspend CAT (applicable catapult)." Never raise the hand into view or make any motion that might be construed as a salute. After the catapult officer observes the pilot's no-go signal, he will cross his forearms over his head and then give the standard release tension signal. When the catapult is untensioned, the catapult officer will signal the pilot to raise the launch bar. The pilot shall ensure that the throttles are seated in the catapult detent and will raise the launch bar with the LAUNCH BAR ABORT switch.

CAUTION

To avoid damage to the launch bar retract mechanism, do not actuate the LAUNCH BAR ABORT switch with the nosewheel deflected off center.

When the launch bar is clear of the shuttle, the catapult officer will move the shuttle forward of the aircraft launch bar. At this point the aircraft is no longer in danger of being launched. The catapult officer will signal the pilot to lower the launch bar and then step in front of the aircraft and signal the pilot to throttle back.

CAUTION

- If the aircraft is down prior to it being pushed or pulled back for release from the holdback fitting and when directed by the catapult officer, the launch bar shall be raised by the LAUNCH BAR ABORT switch.

- Unkneeling the nosegear while the launch bar is in the catapult track or shuttle will damage the launch bar linkage and bungees. The pilot should unkneel the aircraft only when sure that the launch bar is free to rise and upon signal from the catapult officer or taxi director.

Note

The LAUNCH BAR ABORT switch is spring loaded and must be held in the ABORT position until the catapult officer signals to lower the launch bar.

If the aircraft is down after the go signal is given, transmit the words “SUSPEND, SUSPEND”; however, the flightcrew should be prepared for the catapult stroke and to perform emergency procedures if required.

8.5 LANDING

8.5.1 Carrier Landing Pattern (Visual Flight Rules).

The VFR carrier landing pattern (Figure 8-3) shall be in accordance with the CV NATOPS Manual. The pattern starts with the level break at 800 feet, and 300 to 350 KIAS. The break interval will be approximately one-half of the desired ramp interval time (15 to 17 seconds normal interval). When established wings level on the downwind leg, descend to and fly the pattern at 600 feet MSL. Engage DLC upon completion of flap extension.

Note

Selection of DLC during the flap extension cycle can generate excessive pitch rates. DLC is to be selected only upon completion of the flap cycle. DLC must be deselected prior to flap retraction to avoid an excessive pitch trim change with automatic DLC stowage during the flap retraction cycle.

Slow to 15 units AOA or computed on-speed (whichever is faster) and verify airspeed/AOA correlation. Engage APC if desired, check for proper DLC operation, and complete the Landing Checklist prior to reaching the 180° position. The 180° turn is commenced 1 to 1.2 nm abeam the LSO platform to arrive at the 90° position at approximately 450 to 500 feet MSL. The nominal bank angle throughout the turn should be 27° to 28°. Glideslope meatball acquisition will occur at approximately 0.6 nm. Do not descend below 300 feet prior to acquiring the ball. On rollout to final, slightly overshoot the ship’s wake. Optimum time on glideslope is approximately 15 to 18 seconds.

WARNING

- To ensure wind-over-deck requirements are met, the LSO and tower must be informed if the landing is to be made in any wing, flap, or engine configuration other than 20° wing sweep, flaps and slats down, and RATS operative.

- Unless field divert is not possible, shipboard landing with inoperative roll SAS and store asymmetry greater than 170,000 inch-pounds should not be attempted. (e.g., weapon rail at station 6 and AIM-54 missile at station 8 equals 170,000 inch-pounds). These conditions increase the danger of lateral pilot-induced oscillations in the approach.

Note

With the hook down, airspeeds in excess of 320 KIAS may cause the hook transition light to illuminate.

8.5.2 Manual Approach Technique.

The rapid engine response characteristics allow the pilot to make timely, small power changes to make glideslope corrections. Because of the rapid engine response and high throttle sensitivity, the pilot must avoid overcontrolling power. DLC should be engaged for all approaches. Approaches flown without DLC will degrade flying qualities resulting in significant glideslope and lineup deviations. Pitch compensation for DLC inputs is optimized for approach airspeeds. Activation of DLC at higher airspeeds will induce noticeable changes in pitch attitude. DLC may be employed by vernier or

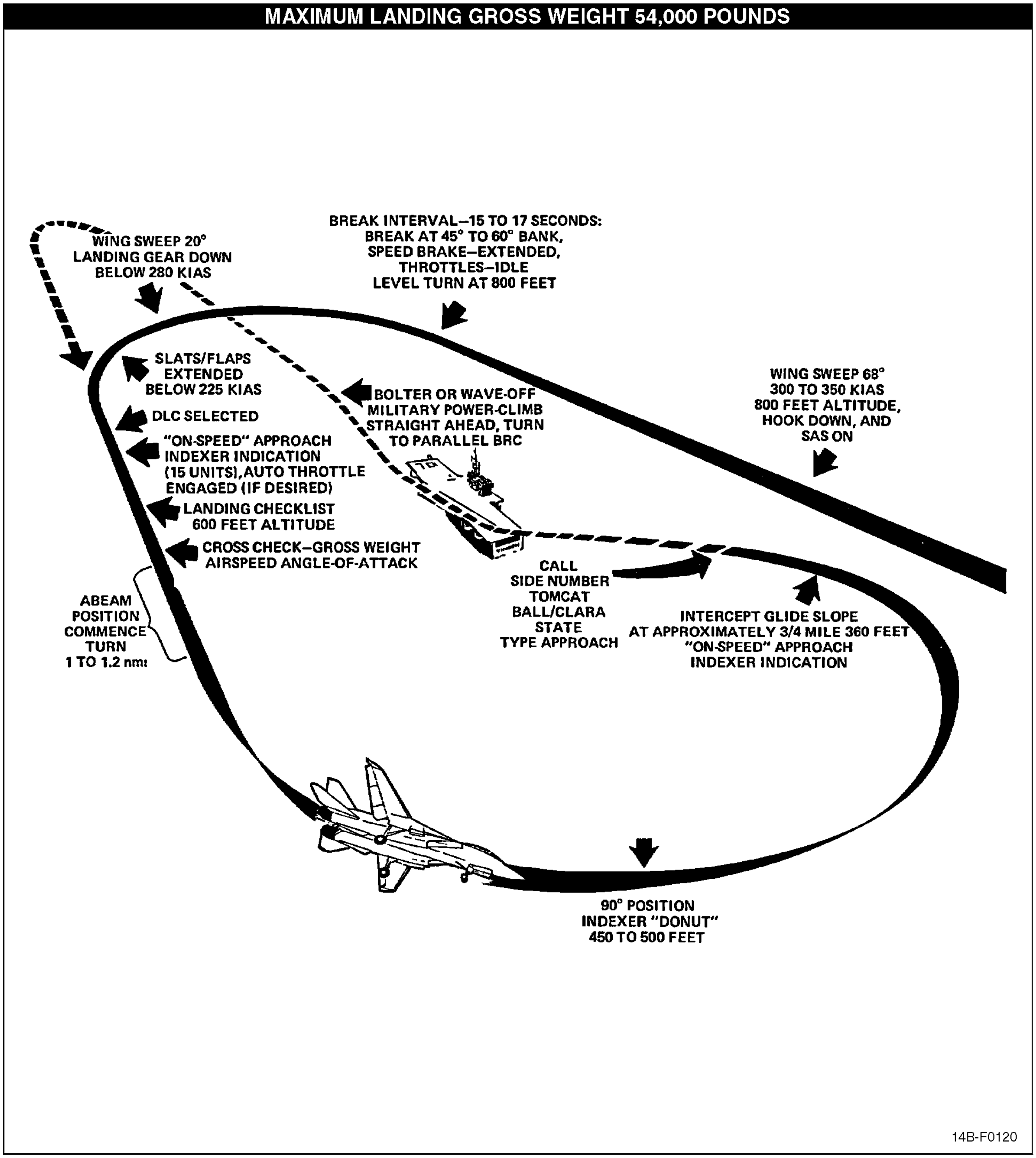

Figure 8-3. Carrier Landing Pattern

bang-bang control, depending on the extent of the correction required. DLC is most effective in correcting for glideslope deviations caused by gusty conditions or the ship's burble. Caution should be taken not to use DLC to compensate for a major overpowered or underpowered condition.

CAUTION

Caution must be taken to avoid sustained full-down DLC commands for a high condition at the ramp as this will result in excessive sink rates and subsequent hard landings.

Once established on glideslope, keep the scan going, cross-checking meatball, lineup, and AOA. Be alert for a waveoff. With rough seas and pitching decks, some erratic meatball movements may be encountered. If this is the case, average out meatball movements to maintain a smooth and safe rate of descent. To avoid being cocked up, arrest a come-down in close with power and up DLC. Attempts to arrest high sink rates with nose attitude alone could result in landing damage to the ventral fins and afterburner. Also avoid dropping the nose prior to touchdown as this significantly increases the chances of a hook skip bolter. Upon touchdown, add full MIL power, manually retract speedbrakes, and maintain aft stick pressure to minimize chances of a hook skip bolter. Selection of MIL power will automatically disengage DLC and retract the speedbrake.

A good start is imperative to minimizing lineup corrections while on the glideslope and will prevent the tendency to chase lineup. Small coordinated rudder inputs should be used to reduce the nose yaw that is typically generated by lateral stick inputs.

8.5.3 Approach Power Compensator (APC) Technique. Practice is required to develop the proper control habits necessary to use APC. For the APC to perform satisfactorily, smooth attitude control is essential. Large, abrupt attitude changes result in excessive power changes. APC use is not recommended in gusty conditions. The APC will overcontrol AOA fluctuations resulting in large airspeed and/or glideslope deviations. The APC system was designed to be used with the engines operating in the primary mode and is not recommended with either one or both engines in secondary mode.

As the initial turn from the 180° position is made, the aircraft will momentarily indicate up to 2 units slow. The APC will adjust power to correct back to on-speed condition throughout the remainder of the turn. Upon rollout on glideslope, the pilot must override the tendency for the nose to pitch up by maintaining slight forward stick. The aircraft will indicate 1 to 2 units fast, which will slow to on-speed within 5 seconds. The use of DLC in conjunction with small attitude changes to maintain glideslope will minimize AOA deviations and result in optimal APC performance. Timely use of DLC can also be used to more rapidly correct from a fast or slow condition. Close-in corrections are very critical. If a high, in-close situation develops, the recommended procedure is to stop the meatball motion and not try to recenter it. A low, in-close condition is difficult to correct with APC and often results in an over-the-top bolter. It may be necessary to disengage or manually override APC in order to safely recover from a low in-close situation. Throughout the approach, the pilot should keep his hand on the throttles in the event APC disengages inadvertently. A smooth throttle transition from AUTO to BOOST mode can be achieved by depressing the CAGE button on the outboard throttle grip.

Note

- Approaches that result in steep bank angles (greater than 30°) and/or short groove lengths should be avoided because of the large thrust reductions required and the short periods of time available to make proper corrections.

- Disengagement of APC by any means other than the throttle MODE switch, will result in illumination of the AUTO THROT light for 10 seconds.

8.5.4 Direct Lift Control (DLC) Technique. DLC should be engaged for all approaches (except for single engine, secondary mode). DLC is selected upon completion of the flap extension cycle. When the aircraft is established at approach AOA, the APC may be engaged and a quick check of the DLC thumbwheel controller is made to ensure an operable DLC.

Note

Automatic pitch compensation for DLC activation is optimized for approach angle-of-attack speeds. Activation of DLC at higher airspeeds will result in inducing noticeable changes in pitch attitude.

DLC may be employed by vernier or bang-bang control, depending upon the extent of correction required. Pilots should be cautious not to overuse DLC or to attempt to correct glideslope deviations that are the result of major power airspeed errors. DLC is most effectively used in an overpowered situation, in close to at the ramp to correct for a high or rising meatball. Selection of MIL will automatically disengage DLC.

Note

Selection of DLC during the flap extension cycle can generate excessive pitch rates. DLC is to be selected only upon completion of the flap cycle. DLC must be deselected prior to flap retraction to avoid an excessive pitch trim change with automatic DLC stowage during the flap retraction cycle.

8.5.5 Waveoff Technique. A waveoff shall be initiated immediately upon a signal or voice call from the LSO. MIL power should be used for all dual-engine waveoffs. Maintain the landing attitude until a positive rate of climb is established. Do not over rotate the aircraft in close as this significantly increases the chance of in-flight engagement.

WARNING

Dual-engine afterburner waveoffs are prohibited. Inadvertent arrestment or in-flight engagement in dual-engine afterburner would result in catastrophic damage to the aircraft and/or arresting gear.

Normally, waveoffs will be taken straight ahead, especially when close in. When using APC, waveoff technique is the same as for manual approaches except that a force of approximately 8 pounds is required to disengage the throttle torque switches. Disengagement of the APC by overriding the throttle forces results in the throttle MODE switch automatically returning in BOOST and illuminates the AUTO THROT light on the pilot left-hand ladder light assembly. A time-delay relay holds the AUTO THROT light on for 10 seconds following APC disengagement.

CAUTION

If a force in excess of 14 pounds is applied to break the throttles out of the auto mode, the throttle MODE switch will return to BOOST but the throttle mode will revert to manual. The switch must be cycled to MAN and back to BOOST to regain the BOOST mode.

8.5.6 Bolter Technique. The bolter maneuver is effected by selecting MIL and slight aft control stick until the desired flyaway attitude is established.

CAUTION

The use of excessive backstick on a bolter may cause the tail surface to stall, delaying aircraft rotation and causing the aircraft to settle off the angle.

8.5.7 Bingo Fuel. Fuel reserves should be programmed depending on distance of the field from the CV, aircraft configuration, and en route weather. This bingo fuel quantity should be set before takeoff.

8.5.8 Arrested Landing and Exit from the Landing Area. As the aircraft touches down, advance throttles to MIL. Upon completion of landing rollout, reduce power to IDLE. Raise the hook and flaps and select wing-sweep BOMB while allowing the aircraft to roll aft. Apply brakes on signal. Flap retraction requires approximately 7 seconds. When the flaps are fully retracted, the wings will sweep aft. Engage nosewheel steering and taxi forward on the come-ahead signal. If the wings sweep aft to 55°, auxiliary and main flap retraction has been verified and full-aft wing sweep may be selected using the emergency handle. The RIO should monitor wing-sweep position while taxiing. Oversweep should be selected prior to final spot and shutdown. The engines should remain running until the cut signal is given by the plane director. If at any time during this phase of operations a brake failure occurs, pull the parking-emergency brake. If the aircraft continues to roll, drop the hook, advise the tower, and signal for chocks to be installed (use nosewheel steering to ensure that the aircraft remains on the deck). Do not unstrap, dearm the ejection seat, or leave the cockpit until tiedowns have been installed.

Note

Aircrew shall inform tower in the event of RATS failure on landing.

8.5.9 Carrier-Controlled Approaches. Should these procedures conflict with the applicable CV air operations manual, the latter shall govern. Detailed pilot-controller voice procedures must be established in accordance with each ship's CCA doctrine. Figure 8-4 shows a typical carrier-controlled approach. Mode I, Mode IA, and Mode II ACLS approaches are described in Chapter 17, Automatic Carrier Landing System. Aircrew should have a thorough understanding of this chapter and the DFCS and APC portions of Chapter 2 prior to attempting a coupled ACLS approach.

8.5.10 Hold Phase. Five minutes before penetration, defogging shall be actuated and maximum comfortable interior temperature will be maintained to prevent possible fogging or icing on the windshield and canopy.

Note

Fuel dump is accomplished by gravity flow and is ineffective during the penetration descent. Fuel dump, if required, should be planned accordingly for the level leg.

1. Before descent, check shoulder harness handle locked, set lights in accordance with guidance for existing weather, and lower arresting hook.

2. Accomplish final changes to radio and IFF upon departing marshal or earlier. After these changes are made, the pilot should make no further changes except under emergency conditions.

3. When commencing penetration, initiate a standard descent: 250 KIAS, 4,000 fpm, speedbrakes as required.

WARNING

If a gear and/or flaps down penetration is required, ensure that the wings are programmed forward of 22° prior to lowering flaps. If flaps are lowered with wings swept aft of 22°, auxiliary flap extension will be inhibited resulting in rapid nosedown pitching rates.

4. Radar and barometric altimeters shall be cross-checked continuously when below 5,000 feet.

8.5.11 Platform. At 20 miles passing through 5,000 feet, aircraft descent shall be slowed to 2,000 feet per minute. At this point, a mandatory unacknowledged voice report will be broadcast by each pilot. The aircraft side number will be given and "platform" will be reported. Continue descent to 1,200 feet.

8.5.12 10-Mile DME Fix

1. Commence transition to landing configuration, unless otherwise directed by CCA, maintaining 1,200 feet.

2. Gear and flaps shall be down by 8 miles.

3. Complete the Landing Checklist. Check anti-ice, lights, and rain removal, as required.

8.5.13 6-Mile DME Fix. For a precision radar approach and unless otherwise directed, maintain 1,200 feet at approach speed until intercepting the glidepath at 3 to 3.25 miles unless otherwise directed.

For an air surveillance radar approach, a gradual descent of 600 fpm can be commenced when departing the 6-mile DME fix. Descend to and maintain 600 feet until the aircraft intercepts the center of the glideslope at 1-1/4 to 1-1/2 miles on a 3.5° slope. Commence descent of 500 to 700 fpm, using the following checkpoints:

1. 1 mile — 460 feet

2. 3/4 mile — 360 feet

3. 1/2 mile — 260 feet.

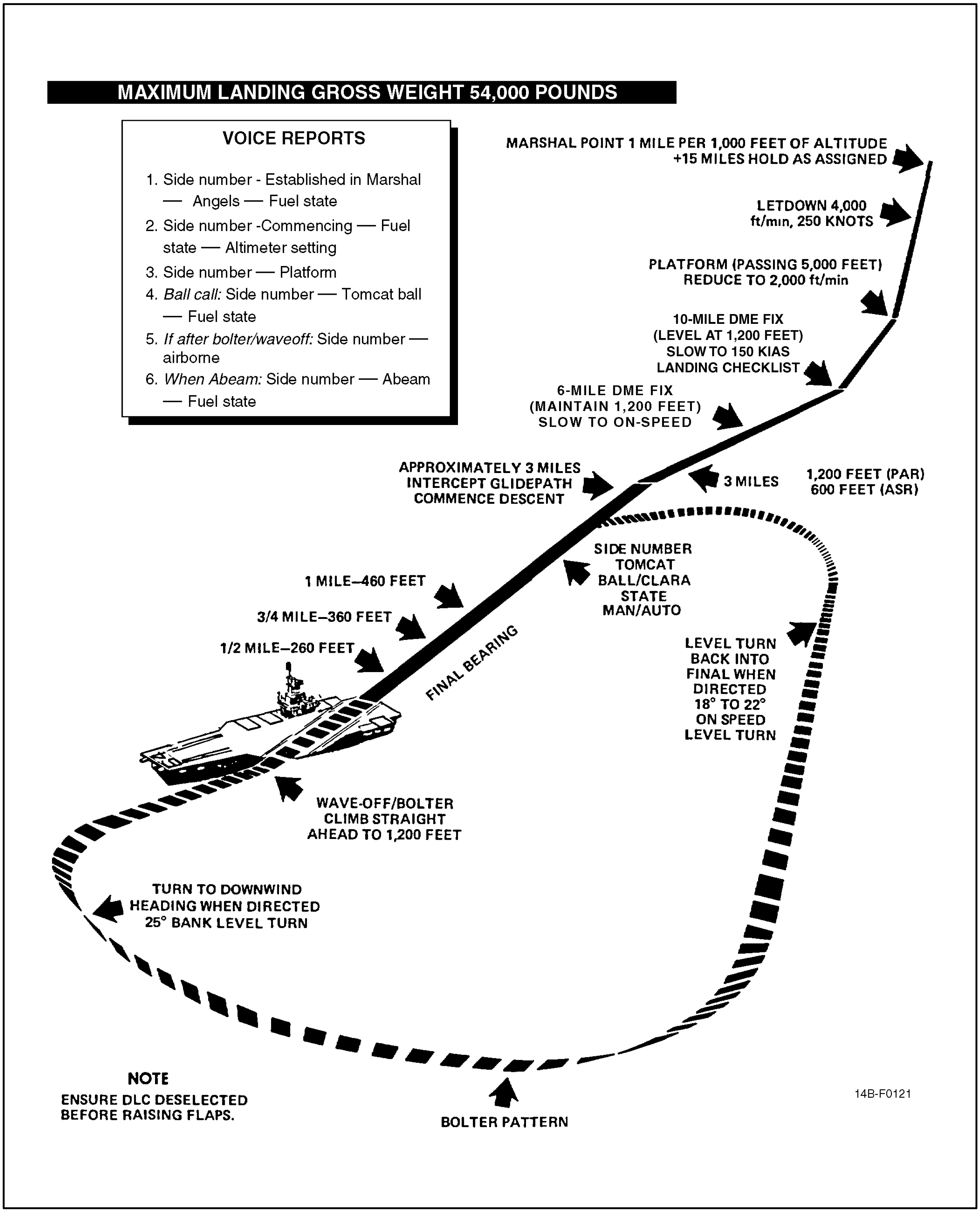

Figure 8-4. Carrier-Controlled Approach (Typical)

8.5.14 Meatball Contact. When transitioning to a visual approach, report call, side number, Tomcat, meatball or Clara (no meatball), fuel state, and type pass. The LSO will acknowledge, and the final controller will cease issuing instructions. Pilots are cautioned against premature contact reports and transition to visual glideslope during night recoveries when visibility permits sighting the ship beyond 2 to 3 miles. The vertical dimension of the entire lens or mirror optical beam at 1-1/4 miles is over 200 feet, and the true center cannot be distinguished. This, coupled with the relatively short length of the runway lights, will give the pilot the illusion of being high when, in fact, the aircraft may be well below optimum glideslope.

An additional advantage of delaying the meatball report (even though the ball is in sight) is that the final controller will continue lineup instructions that can greatly assist the pilot in establishing satisfactory lineup. Use the vertical velocity indicator to set up a rate of descent of 500 to 700 fpm. The AN/ARA-63 is an excellent aid during the approach and should be used whenever possible.

8.6 WAVEOFF AND BOLTER

In the event of a waveoff or bolter, climb straight ahead to 1,200 feet and maintain 150 KIAS. When directed by CCA, initiate a level turn to the downwind leg reporting abeam with fuel state. (If no instructions are received within 2 minutes or 4 miles DME, attempt radio contact; if unable to make contact, assume communications failure and initiate the downwind turn to the reciprocal of final bearing reporting abeam with fuel state. If no acknowledgement is received, start a turn at 4 miles or 2 minutes to intercept final bearing. A 20° bank angle at 150 KIAS on the upwind turn establishes the aircraft at the desired 2 miles abeam on the downwind leg.

CATCC clears the aircraft to turn inbound to intercept final bearing. A level, on-speed approach turn of 18° to 22° bank angle from the normal downwind position allows the aircraft to properly intercept final bearings at a minimum of 3 miles aft of the ship. Traffic spacing ahead may require that the aircraft continue on downwind leg well past the normal abeam position before being directed to turn to final bearing. No attempt should be made to establish visual contact with the ship when executing a CCA until the final approach turn has been completed.

Note

The radar beacon (AN/APN-154) should be turned off as soon as practicable after landing to avoid causing interference with AN/SPN-42 control of other aircraft in the pattern.

8.7 NIGHT FLYING

Night carrier operations will have a much slower tempo than daylight operations, and it is the pilot's responsibility to maintain this tempo. Normal day carrier operating procedures shall be used except as modified below.

8.7.1 Briefing. Before flight operations, all aircrew shall receive a briefing on the following procedures:

1. Flight deck
2. Catapult
3. Departure
4. Recovery
5. Arrested landing.

Individual flight briefings will include all applicable items outlined above with particular emphasis on weather and bingo fuel.

8.7.2 Preflight. In addition to normal cockpit preflight, ensure that external light switches are properly positioned for the poststart light check. Install night filters on applicable cockpit displays.

8.7.3 Poststart. Adjust cockpit lights to desired brightness. When ready for taxi, indicate with appropriate signal.

8.7.4 Taxi. Night deck-handling operations are of necessity slower than those used during the day. When a doubt arises as to the meaning of a signal from a taxi director, stop.

8.7.5 Catapult Hookup (Night). Procedures for aircraft catapult hookup at night are identical to those used during day operations. However, it is difficult to determine your speed or degree of motion over the deck. The pilot must rely upon and follow closely the plane director's signals.

8.7.6 Catapult Launch. On turnup signal from the catapult officer, ensure throttles in MIL and check all instruments. When ready for launch, place external light master switch ON (bright and steady). After launch, establish a 10° pitch angle on the VDIG, cross-checking the pressure instruments to ensure a positive rate of climb. Retract the landing gear. An altitude of 500 feet is considered to be minimum altitude for retraction of flaps. When well established in a climb, switch lights to flashing or as applicable for an instrument climbout. The standby indicator should be used in the event of a VDIG malfunction.

WARNING

- If wings are swept back manually, close attention should be paid to maintaining positive rates of climb. The loss of lift incurred by premature wing sweep aft can result in significantly decreased rates of climb, with very little change in pitch attitude and trim requirements.

- Failure of the CSDC will result in the loss of all primary attitude references on the VDIG, in which case the pilot must use the standby gyro and turn-and-bank indicator for attitude reference.

8.7.7 Catapult Abort Procedures (Night). The pilot's no-go signal for night launches will be to not turn on his exterior lights and to transmit on the land/launch frequency his aircraft side number, the catapult he is on, and the words "SUSPEND, SUSPEND." After the catapult is untensioned, the catapult officer will signal to raise the launch bar. The pilot shall ensure that the throttles are seated in the catapult detent or throttle friction is full forward before raising the launch bar with the LAUNCH BAR ABORT switch. When the launch bar is clear of the shuttle, the catapult officer will move the shuttle forward of the aircraft launch bar. At this point, the aircraft is no longer in danger of being launched. The catapult officer will signal the pilot to lower the launch bar and then step in front of the aircraft and signal the pilot to throttle back.

CAUTION

- If the aircraft is down prior to it being pushed or pulled back for release from the holdback fitting and when directed by the catapult launching officer, the launch bar shall be raised by the LAUNCH BAR ABORT switch.

- Unkneeling the nosegear while the launch bar is in the catapult track or shuttle will damage the launch bar linkage and bungees. The pilot should unkneel the aircraft only upon signal from the catapult officer or taxi director and when he is sure that the launch bar is free to rise and.

Note

The LAUNCH BAR ABORT switch is spring loaded and must be held in ABORT until the catapult officer signals to lower the launch bar. If the aircraft is down after the go signal is given, transmit the words "SUSPEND, SUSPEND"; however, the flightcrew should be prepared for the catapult stroke and to perform emergency procedures if required.

8.7.8 Arrested Landing and Exit from Landing Area (Night). During approach, all lights shall be on bright and steady. At the end of arrestment rollout, turn off external lights and follow the director's signals while effecting the normal aircraft cleanup procedures.

CHAPTER 9

Special Procedures

9.1 IN-FLIGHT REFUELING PROCEDURES

Note

Before commencing in-flight refueling operations, each flight crewmember shall become familiar with the NATOPS Air Refueling Manual (NAVAIR 00-80T-110) and the inflight refueling portion of Chapter 2.

9.1.1 In-Flight Refueling Controls. Regardless of fuel management panel switch positioning, at low fuel states the initial resupply of fuel is discharged into the left and right wing box tanks. Thereafter, distribution of the fuel to the forward, aft, wing, and external tanks is controlled by the WING/EXT TRANS switch position. The split refueling system to the left and right engine feed group provides for a relatively balanced center of gravity condition during refueling. Selective refueling of the fuselage or all fuel tanks is provided on the REFUEL PROBE switch with the probe extended. In the FUS/EXTD, normal fuel transfer and feed is unaltered. This position is used for practice plug-ins, fuselage-only refueling, or return flight with a damaged air-refueling probe. The ALL/EXTD shuts off wing and external tank transfer to permit the refueling of all tanks. The REFUELING PROBE switch circuit uses essential dc No. 2 power to control operation of the probe actuator through redundant-extend solenoids and a single-retract solenoid.

9.1.2 In-Flight Refueling Checklist. The In-Flight Refueling Checklist shall be completed before plug-in.

1. WCS switch — STBY
2. Arming switches — SAFE
3. DUMP switch — OFF
4. AIR SOURCE pushbutton — L ENG
5. REFUEL PROBE switch — As Desired (transition light off)
6. WING SWEEP MODE-MAN/wing-sweep angle — As Desired
7. Visors — Recommended Down.

WARNING

To prevent fuel fumes from entering the cockpit through the ECS because of possible fuel spills during in-flight refueling, select AIR SOURCE pushbutton to L ENG.

9.1.3 In-Flight Refueling Techniques

Note

The following procedures, as applied to tanker operation, refer to single-drogue tanker only.

Refueling altitudes and airspeeds are dictated by receiver and/or tanker characteristics and operational needs, consistent with the tanker's performance and refueling capabilities. This covers a practical spectrum from the deck to 35,000 feet, 170 to 300 KIAS, and wing-sweep angles of 20° to 68°. Optimum airspeed and wing-sweep position is 240 KIAS and approximately 40° of wing sweep. This configuration increases aircraft angle of attack enough to lower the receivers' vertical tails below the tanker jetwash and decreases bow wave effect. SAS-off tanking can most easily be performed at 200 KIAS with 40° of wing sweep.

9.1.3.1 Approach. Once cleared to commence an approach and with refueling checklists completed, assume a position 5 to 10 feet in trail of the drogue with the refueling probe in line in both the horizontal and vertical reference planes. Trim the aircraft in this stabilized approach position and ensure that the tanker's (amber) ready light is illuminated before attempting an approach. Select a reference point on the tanker as a primary alignment guide during the approach phase; secondarily, rely on peripheral vision of the drogue and hose and supplementary remarks by the RIO. Increase power to establish an optimum 3- to 5-knot closure rate on the drogue. It must be emphasized that an excessive closure rate will cause a violent hose whip following contact and/or increase the danger of structural damage to the aircraft in the event of misalignment; too slow a closure rate results in the pilot fencing with the drogue as it oscillates in close proximity to the aircraft nose. During the final phase of the approach, the drogue has a tendency to move slightly upward and to the right as it passes the nose of the receiver aircraft because of the aircraft-drogue airstream interaction. Small corrections in the approach phase are acceptable. However, if alignment is off in the final phase, it is best to immediately return to the initial approach position and commence another approach, compensating for previous misalignments by adjusting the reference point selected on the tanker. Small lateral corrections with a "shoulder probe" are made with the rudder, and vertical corrections with the horizontal stabilizer. Avoid any corrections about the longitudinal axis since they cause probe displacement in both the lateral and vertical reference planes.

9.1.3.2 Missed Approach. If the receiver probe passes forward of the drogue basket without making contact, a missed approach should be initiated immediately. Also, if the probe impinges on the canopy-lined rim of the basket and tips it, a missed approach should be initiated. Realization of this situation can be readily ascertained through the RIO. A missed approach is executed by reducing power and backing to the rear at an opening rate commensurate with the optimum 3 to 5 knot closure rate made on an approach. By continuing an approach past the basket, a pilot might hook the probe over the hose and/or permit the drogue to contact the receiver aircraft fuselage. Either of the two aforementioned hazards requires more skill to calmly unravel the hose and drogue without causing further damage than to make another approach. If the initial approach position is well in line with the drogue, the chance of hooking the hose is diminished when last-minute corrections are kept to a minimum. After executing a missed approach, analyze previous misalignment problems and apply positive corrections to preclude a hazardous tendency to blindly stab at the drogue.

9.1.3.3 Contact. When the receiver probe engages the basket it will seat itself into the drogue coupling and a slight ripple will be evident in the refueling hose. Here again, the RIO can readily inform the pilot by calling "Contact." The tanker's drogue and hose must be pushed forward 3 to 5 feet by the receiver probe before fuel transfer can be effected. This advanced position is evident by the tanker's amber ready light going out and the green fuel transfer light coming on. While plugged in, merely fly a close-tail-chase formation on the tanker. Although this tucked-in condition restricts the tanker's maneuverability, gradual changes involving heading, altitude and/or airspeed may be made. A sharp lookout doctrine must be maintained because of the precise flying imposed on both the tanker and receiver pilots. In this respect, the tanker can be assisted by other aircraft in the formation. The receiver RIO can also assist in maintaining a visual lookout since the receiver radar is in the STBY position.

9.1.3.4 Disengagement. Disengagement from a successful contact is accomplished by reducing power and backing out at a 3- to 5-knot separation rate. Care should be taken to maintain the same relative alignment on the tanker as upon engagement. The receiver probe will separate from the drogue coupling when the hose reaches full extension.

When clear of the drogue:

1. REFUEL PROBE switch — RET.
2. Probe transition light — OFF.
3. AIR SOURCE pushbutton — BOTH ENG.
4. Wing-sweep mode switch — AUTO.

Resume normal flight operations.

9.2 FORMATION FLIGHT

The following formation descriptions are recommended guidelines for F-14 multiplane positioning.

9.2.1 Parade Formation. The basic parade position is either left or right echelon, or a combination of both, as in a fingertip three-plane formation. The parade formation is used primarily for multiplane maneuvering at night, in IMC, or during entry into or exit from an airport traffic area.

Wing sweep: 20°

Configuration: Clean or dirty.

1. Line of bearing is determined by placing the upper leading edge of the lead aircraft's intake on the explosive seat warning triangle below the RIO cockpit.

2. Wingtip separation is determined by a position on the bearing line where the leading edges of the lead aircraft's ventral fins are aligned.

3. Stepdown is determined by aligning the lead's opposite engine nacelle just under the near engine nacelle.

This positioning should provide the wingman with approximately 5 feet of wingtip separation and 10 feet of stepdown.

9.2.2 Break Formation. The basic break formation is either left or right echelon, or a combination of both as in a fingertip three-plane formation. This formation is used primarily for multiplane entry into the overhead break pattern.

Wing sweep: 68°

Configuration: Clean.

1. Line of bearing is determined by placing the upper leading edge of the lead aircraft's intake on the explosive seat warning triangle below the RIO cockpit.

2. Wingtip separation is determined by a position on the bearing line where approximately 1 foot of the forward edge of the lead's opposite ventral fin shows in front of the near ventral fin.

3. Stepdown is determined by aligning the lead's opposite engine nacelle just under the near engine nacelle.

This positioning should provide the wingman with approximately 15 feet of wingtip separation and 10 feet of stepdown.

9.2.3 Diamond Four-Plane Formation. The diamond is the basic four-plane formation used for entry into the overhead break or for aerial fly-bys.

Wing sweep: 68°

Configuration: Clean.

Right and left echelon (dash-2 and dash-3, respectively):

1. Line of bearing is determined by placing the upper leading edge of the lead aircraft's intake on the pilot's helmet.

2. Wingtip separation is determined by a position on the bearing line where the trailing edge of the lead aircraft's ventral fins are aligned. At this position, the trailing edge of the exhaust nozzles should appear in line to the RIO.

3. Stepdown is determined by allowing approximately 6 inches of the lead's opposite engine nacelle to show below the near engine nacelle.

This positioning should provide the wingman with approximately 12 feet of wingtip separation and 12 feet of stepdown.

Slot (dash-4):

1. Line of bearing is determined by lining up on the lead aircraft's centerline.

2. Approximately 20 feet of nose-to-tail separation can be established by placing the wingman's canopy bow on the lead aircraft's exhaust nozzles.

3. Approximately 25 feet of stepdown should be used. This position may be cross-referenced placing the upper leading edge of dash-2's or dash-3's intake on the pilot's helmet.

9.2.4 Cruise Formation. Cruise is the basic formation used for multiplane transit to or from an operating area where increased maneuverability is desired.

Wing sweep: 20°

Configuration: Clean.

1. Line of bearing is determined by placing the upper leading edge of the lead aircraft's intake on the RIO's canopy bow.

2. A second line of bearing is determined by placing the lead aircraft's wingtip light on the forward upper UHF antenna.

3. Wingtip separation is determined by allowing approximately 1 foot of the lead's opposite

exhaust nozzle to show behind the near exhaust nozzle.

This position should provide the wingman with approximately 64 feet of wingtip separation and 10 feet of nose-to-tail separation.

9.2.5 Aircraft Lighting During Night Formation Flight. The lead aircraft anticollision lights will normally be off during night formation flight in parade. However, the possibility exists that the wing aircraft can inadvertently stray into a position aft of the normal bearing where only a single, white tail light on lead is visible. In this position, serious misjudgment of separation and closure rate can occur. To prevent this, lead aircraft anticollision lights should be on when the wing aircraft is not in normal parade and mission requirements permit.

9.3 BANNER TOWING

9.3.1 Ground Procedures. The following procedures are provided for guidance. Local course rules may dictate modification of these steps:

1. When tower clearance onto the duty runway has been received, tow aircraft taxis to position as directed by tow hookup crew. Tow pilot holds this position until released by tow hookup crew. Escort pilot maintains position on taxiway at approach end of runway.

2. When signaled to do so by tow hookup crew, tow pilot proceeds to taxi down runway.

3. Upon receipt of visual taxi signal from tow hookup crew to slow down, escort pilot relays this signal to tow pilot via UHF radio.

4. Upon receipt of visual taxi signal from tow hookup crew to stop, escort pilot relays this signal to tow pilot via UHF radio.

5. Upon receipt of signal from tow hookup crew that tow hookup is complete, escort pilot requests tow pilot to take up slack.

6. Tow pilot proceeds to taxi down the runway.

7. When banner moves forward onto runway escort pilot transmits, "Tow aircraft hold, good banner," and taxis onto runway abeam banner for takeoff.

8. When ready, tow RIO transmits, "Tower, FEZ 01 for banner takeoff, escort to follow banner."

9. After banner becomes airborne, escort pilot commences takeoff roll.

9.3.2 Shipboard Procedures. The following procedures are provided for guidance. Local rules may dictate modification of these steps:

1. When clearance has been received, tow aircraft taxis to the catapult shuttle in use as directed by flight deck personnel. Tow pilot holds this position until released by catapult director.

2. When signaled to do so, banner crew lays banner on flight deck 45 feet starboard of waist catapult centerline and 10 feet aft of unit horizontal stabilator (UHT) with banner bar perpendicular to the catapult centerline.

3. Banner crew sequentially positions nylon tow line bundle lengthwise and parallel to catapult track in position in front of banner. Nylon tow line, with prepared end facing banner buckle, is attached to banner using swivel and connecting link. Steel cable leader (75 feet of 3/16-inch diameter) is attached to forward end of nylon tow line bundle using connecting link.

4. Banner crew then unrolls leader forward, down angle deck, and parallel to catapult track to prevent entanglement and kinks. The forward end of leader is brought back and laid on deck near the aircraft right main landing gear. Forward end of leader has Mk 8 Mod 0 target release ring attached to it.

5. Upon clearance from catapult officer, banner crewmember will crawl underneath aircraft with leader in hand just aft of right ventral fin. He will then attach Mk 8 Mod 0 target release ring to banner tow adapter. Upon appropriate signals from flight deck director, pilot will lower hook to assure proper detachment of target release ring and then raise the hook. Banner crewmember will then reattach target release ring.

6. After hookup, banner crewmember will exit from beneath aircraft at same place he entered. He will then walk toward island and give thumbs-up signal to catapult officer. Banner, tow line, and leader are now ready for launch.

9.3.3 Flight Procedures. Flight tests have demonstrated no significant degradation of aircraft performance and handling characteristics when towing a banner.

CAUTION

Angle of bank should be limited to 30° or less to preclude contact between the tow cable and afterburner nozzle.

Note

Depending on the airspeed of the tow aircraft, the banner will normally hang 200 to 400 feet below the tow aircraft's altitude.

Refer to Chapter 4 for banner towing restrictions.

9.3.3.1 Takeoff. Normal takeoff procedures, including rotation speeds and techniques, are suitable for takeoff with the banner.

CAUTION

- Takeoff ground roll with banner can be estimated by adding a factor of 10 percent to basic aircraft takeoff performance. If aircraft lift-off will not occur prior to crossing the long-field arresting gear, the gear must be removed to preclude the banner being torn off.
- If the crosswind component is in excess of 10 knots, the take off roll should be made on the upwind side of the runway to prevent the banner from striking the runway lights on the downwind side of the runway.

Note

Adequate clearance exists to prevent contact between the tow cable and speedbrakes during ground operation. If takeoff is aborted, basic emergency procedures are applicable. The tow cable will be released when the tailhook is lowered.

After lift-off, continue rotation to 15° (maximum of 20°), while raising the landing gear. Do not exceed 17 units AOA. Climb out at 180 to 200 KIAS until the flaps are up, then continue climb at 200 to 220 KIAS.

Note

- Avoid use of afterburner to prevent damage to tow cable.
- Tow airspeeds in excess of 220 KIAS will result in excessive banner fraying.

For shipboard operations, after lift-off, rotate to 15° (20° maximum) not to exceed 17 units AOA while raising the gear and flaps. Prior clearance must be received from the tower for an unrestricted climb. Maintain heading until the banner is well clear of ship. Climb out at 180 to 200 KIAS until flaps are up, then continue to climb out at 200 to 220 KIAS.

Note

The maximum aircraft gross weight for a shipboard banner launch is 67,000 pounds.

9.3.3.2 Cruise/Pattern. No special pilot techniques are required when towing a banner. En route cruising speed of 180 to 220 KIAS will provide adequate energy for mild maneuvering while minimizing banner fray. If a low pattern airspeed is desired, extend flaps/slats if necessary to maintain AOA at or below 12 units. The tow aircraft must call all turns to allow the chase aircraft to position on the outside of the turn.

If the banner is shot off or falls off in flight, the remaining cable should be dropped in the gunnery area or in a confirmed clear area. After the cable is released, a chase aircraft should join to verify that the cable has been dropped.

WARNING

Without the banner, any remaining cable will flail unpredictably. The chase should approach the tow aircraft from abeam, avoiding a cone-shaped area defined by the tow's 4- to 8-o'clock positions.

9.3.3.3 Descent. Airspeeds of 160 to 220 KIAS should be used for descent. Flaps and slats may be utilized to increase the rate of descent as desired.

CAUTION

Speedbrakes should not be used while towing since limited clearance exists between the cable and speedbrakes during extension and retraction in flight.

9.3.3.4 Banner Drop. The tow aircraft should extend its flaps and reduce airspeed (140 to 160 KIAS, 12 units AOA maximum) for the drop. The banner should be dropped in wings-level flight at a minimum aircraft altitude of 1,000 feet AGL. The chase aircraft should ensure adequate clearance exists between the banner and ground obstacles during approach to the drop zone and should provide calls to assist in lineup. Release is normally called by the tower when the banner is over the center of the drop zone. Release is accomplished by lowering the tailhook. In most cases the banner will hit down range of the release point. However, high-wind conditions may require the tow aircraft to adjust the release point to avoid downwind travel of the banner. Following banner release, the tailhook should be raised.

9.3.3.5 Shipboard Banner Drop. The tow aircraft should extend its flaps and reduce airspeed (140 to 160 KIAS, 12 units AOA maximum) for the drop. The banner should be dropped in a clear area in wings-level flight at a minimum altitude of 1,000 feet MSL. If a clear area is not available, the banner should be dropped approximately 1 nm abeam the port side of carrier. Release is called by the air officer when the banner is over the drop zone. Banner release is accomplished by lowering the tailhook.

CAUTION

When the tailhook is lowered for banner release, ensure that the balance ball is centered or slightly right (left yaw). If any right yaw is present, tow cable/tailhook entanglement is possible.

9.3.3.6 Banner Release Failure. If the arresting hook fails to extend, the banner cannot be released. In this case, the following procedure is recommended:

1. In gunnery range (or other cleared area), descend to low altitude, extend flaps, slow to 140 to 160 KIAS, 12 units AOA maximum, and descend to 100 to 200 feet AGL. This will drag banner off on ground (or water). Have escort pilot confirm that banner breaks off on ground collision and determine length of remaining tow cable.

WARNING

The escort pilot must remain well clear of the remaining cable. The last 25 percent of the remaining cable will flail unpredictably.

2. If 100 feet or greater remaining tow cable length is confirmed by escort pilot, plan to touch down 1,000 to 1,500 feet long, runway length permitting.

CAUTION

Every effort must be made by the tow pilot not to drag the remaining tow cable across lines, fences, or other obstacles because of the property damage that will result.

Note

The long touchdown should be carefully planned because long field arrestment is impossible.

9.4 HUD ALIGNMENT CHECK

RIO

1. Acquire a TCS optical track on target greater than 1 nm.

PILOT

1. Select A/A on PDCP.
2. Select OFF or PH/SP on weapon select switch.
3. Place target approximately in center of HUD.
4. Verify gunsight reticle correlates with position of TCS target. Should not exceed 3 mils.

9.5 IN-FLIGHT COMPASS EVALUATION

The tactical software provides an accurate comparison of the inertial navigation system and the attitude heading reference set to the nearest tenth of a degree (+6 minutes), by comparing calculated magnetic variation (vC) to the RIO-entered manual magnetic variation (vM). The difference between the two (vC – vM) should not exceed +2° or –2°.

This procedure for in-flight compass evaluation produces best results if the EGI is aligned with either a Gyro Compass (GC) alignment (ashore) or a GPS alignment (afloat). Errors in the ship's navigation system are transferred to the aircraft navigation system during SINS alignment and can produce invalid results. Postflight closeout groundspeed should be less than 2 knots; otherwise, results will be invalidated. Closeout groundspeed of 2 knots or more indicates a bad EGI, or bad alignment. The results of the evaluation should be ignored until the INS problem has been resolved and the evaluation performed again.

Note

Before performing an in-flight evaluation, the aircraft should not be flown in a manner that would tumble the AHRS gyros.

The following steps should be performed and data recorded on a form similar to Figure 9-1.

9.5.1 Annual Compass Compensation In-Flight Evaluation

1. Flightcrew start engine.
2. WCS switch — STBY.
3. Obtain EGI FINE ALIGN COMPLETE.
4. Select INS on the NAV MODE SEL switch. Ensure Blended Aided (BD) is displayed as selected NAV mode.
5. Verify that AHRS caution light is not illuminated. AHRS light may illuminate momentarily during a power interrupt, or, depending on type of gyro, it may illuminate for as long as 3 minutes while displacement gyro is erecting.
6. Enter magnetic variation (vM) to nearest tenth of a degree.
7. Verify that value entered above is displayed on PTID as vM.
8. During routine flight, fly steady heading for 30 seconds. Update vMs, if required. On compass controller panel, set mode switch to SLAVED, and press and hold the HDG pushbutton until SYNC indicator nulls.
9. Hold heading as steady as possible and record PTID vC, vM, true heading, magnetic heading, and BDHI and standby compass headings.
10. Repeat steps 8 and 9 for various headings during flight, preferably two headings in each quadrant.
11. At completion of flight, calculate vC – vM and difference between PTID magnetic heading and standby compass heading.
12. For AHRS to meet annual compensation requirements, vC – vM should not exceed 2°.
13. Standby magnetic compass should be within ±5° of magnetic heading to meet requirements.
14. Verify BDHI magnetic heading is within ±2° of PTID/VDI/HSD heading.

9.6 FUEL MANAGEMENT SYSTEM OPERATIONAL CHECK

The following fuel management system operational check can be used by flightcrews to perform a check of the fuel transfer system, including FUEL FEED switch, WING/EXT TRANS switch, sump tank interconnect valve, fuselage motive-flow isolation valves, low-level thermistors, and box-beam vent valves. In addition, the procedure tests for proper functioning of the automatic electrical controls in the fuel feed system. The final four procedures (steps 5 through 8) can best be performed in a shore-based environment where minimum fuel-on-deck requirements are not a consideration.

9.6.1 Fuel Management System Operational Check Procedures. Initial conditions:

FWD/R & AFT/L — 3,000 pounds (approximately)

L & R FEED — 1,500 to 1,750 pounds (full)

L/R WINGS — Empty (0 to 200 pounds)

TOTAL — 6,000 pounds (approximately)

COMPASS EVALUATION

AIRCRAFT _______________ MODEL _______________ DATE ________________

1. Align EGI.
2. Enter magnetic variation to the nearest tenth.
3. Compass mode switch – SLAVED.
4. Establish eight specified headings.

Note

Press HDG pushbutton each time until SYNCH IND nulls, then release.

RECORD THE FOLLOWING:

		TRUE HDG	BDHI/PTID	STBY	MAG VAR		CORRECTIONS
					vM	vC	
N	000°						
NE	045°						
E	090°						
SE	135°						
S	180°						
SW	225°						
W	270°						
NW	315°						

MAINTENANCE NOTE: AHRS headings are to be within ±2° of correct heading. Standby compass are to be within ±5° of correct heading.

– MAG VAR is added to true heading for corrected heading.

+ MAG VAR is subtracted from true heading for corrected heading.

Pilot's compass correction card (AN 5823-1) will be filled out and placed in aircraft compass cardholder in aircraft and appropriate logbook entries made.

Note

Do not update the EGI during entire flight (shore-based).

FLIGHT CREW ____

Figure 9-1. Compass Evaluation

1. WING/EXT TRANS switch — OFF.

2. FUEL FEED switch — FWD/R.
   Monitor 500-pound split, AFT/L high.

3. FUEL FEED switch — AFT/L.
   Monitor 500-pound split, FWD/R high.

4. FUEL FEED switch — NORM.
   Verify FWD/R high split remains constant.

5. Monitor WING/EXT TRANS switch return to AUTO.

   AFT/L — 1,700±200 pounds, or
   FWD/R — 2,100±200 pounds.

6. Monitor tapes/feeds for system balancing.

Note

Balancing normally begins 6 to 9 minutes after WING/EXT TRANS switch returns to AUTO.

7. After landing, run both engines until R and L FUEL LOW lights illuminate. Verify:

   R FUEL LOW at L FEED — 1,000±200 pounds
   L FUEL LOW at R FEED — 1,000±200 pounds

8. Shut down right engine and pull R FUEL SHUT-OFF handle. Continue to run left engine to verify continued R FEED quantity decrease. Then shut down left engine.

9.6.2 Fuel Management System Operational Check Comments. Ensure 4,500 pounds on tapes for operation of FEED switch.

1. Switch should not move until auto-interconnect occurs — Verifies proper autoelectrical operation.

2. Verifies sump tank interconnect valve open via manual operation and aft fuselage motive flow valve shut off.

3. Same as 2 except forward fuselage motive flow valve shuts off.

4. Verifies system returns to isolated mode with no leaks.

5. Verify cell 2 or 5 low-level thermistor proper operation to trigger auto-interconnect function.

6. Verifies sump tank interconnect valve opens via auto operation and L/R box-beam vent valves open. Verifies proper operation of FWD/AFT motive systems.

7. Verifies proper operation of cell No. 2, 5, left box-beam, and right box-beam low-level thermistors.

8. Verifies sump tank interconnect valve remains open via left side motive flow pressure. This verifies proper operation of motive flow isolation valve.

CHAPTER 10

Functional Checkflight Procedures

10.1 FUNCTIONAL CHECKFLIGHTS

Functional checkflights will be performed when directed by and in accordance with OPNAVINST 4790.2 series and the directions of NAVAIR SYSCOM type commanders or other appropriate authority. Functional checkflight requirements and applicable minimums are described below. Functional checkflight checklists are promulgated separately.

10.2 CHECKFLIGHT PROCEDURES

A flight profile has been established for each checkflight condition and is identified by the letter corresponding to the purpose for which the checkflight is being flown (A, B, C). The applicable letter identifying the profile precedes each item in the functional checkflight checklist (NAVAIR 01-F14AAP-1F). Post-maintenance checkflight procedures are specific and are to be performed in conjunction with normal NATOPS operating procedures (Part III). Checkflight personnel shall familiarize themselves with the profile requirements before each flight. A daily inspection is required before each checkflight. An aircraft is considered high gross weight for profile purposes if over 56,000 pounds total weight. Aircrew shall be cognizant of the aircraft's configuration and the cumulative negative effects of weapons rails and external stores on aircraft stability.

Note

Shipboard constraints can preclude completion of some items on the applicable flight profile checklist.

10.2.1 General Conduct. Thorough, professional checkflights are a vital part of the squadron maintenance effort. Check crews perform a valuable service to the maintenance department by carrying out this function. The quality of service provided by check crews reflects directly in the quality of maintenance and subsequently enhances flight operations. The Commanding Officer shall ensure that thoroughness, professionalism, and safety are observed throughout the checkflight evolution and that check crews strictly adhere to the profile checklist. Safety is a primary consideration during all checkflights.

PROFILE

10.3 FUNCTIONAL CHECKFLIGHT PROCEDURES (PILOT)

10.3.1 Prestart

A BC 1. Fuel quantity and distribution. Check for proper fuel quantities in each system. Left tape 6,200 pounds maximum, right tape 6,600 pounds maximum, wings approximately 2,000 pounds each, and the external tanks approximately 1,800 pounds. Check total quantity.

	LEFT	RIGHT
FEED		
FUS		
WING		
EXT		
TOTAL		

A 2. ICS.

a. Normal.

b. Backup.

c. Emergency.

A 3. Refuel PROBE.

a. Extend (with handpump).

b. Retract (with handpump).

A 4. Seat adjustment — Check.

A 5. Canopy rigging.

a. Both cockpit handles in same position during operation.

b. BOOST not required to close.

10.3.2 Start

A BC 6. ENG CRANK switch — L (left engine).

Observe AUX and PARK brake pressure rise. Observe combined hydraulic system pressure rise.

A BC 7. ENG CRANK switch — OFF.

PROFILE

A BC 8. ENG CRANK switch — R (right engine).

Observe flight hydraulic system pressure rise.

A BC 9. ENG CRANK switch — OFF.

Note

Plane captain will bleed FLT and COMB HYD systems during steps 6 and 8.

A BC 10. EMERG FLT HYD switch — CYCLE.

a. EMERG FLT HYD switch — LOW.

Check that ON flag is displayed in the EMER FLT LOW hydraulic pressure window. Verify control over horizontal tail and rudder control surfaces as viewed on flight control surface position indicator.

b. EMERG FLT HYD switch — HIGH.

Check that ON flag is displayed in the EMER FLT HI hydraulic pressure window. Verify control over horizontal tail and rudder control surfaces and higher surface deflection rate as viewed on flight control surface position indicator.

c. EMERG FLT HYD switch — AUTO (LOW).

Check that OFF flags are displayed in both the EMER FLT HI and LOW hydraulic pressure windows.

CAUTION

Combined and brake accumulators should be charged prior to backup module checks. Checks should be made slowly enough to ensure continuous ON indication in the hydraulic pressure indicator.

A BC 11. BACKUP IGNITION switch — ON.

Note

With weight-on-wheels and BACKUP IGNITION switch ON, main high-energy ignition is disabled.

A BC 12. ENG CRANK switch — R (right engine).

Place the crank switch to the R position where the switch is solenoid held until automatically released to the neutral (OFF) position at the starter cutout speed of 45 percent rpm. Manual deselection of the switch to the OFF position will interrupt the crank mode at any point in the start cycle. Oil pressure and flight hydraulic pressure rise will become evident at 10 percent rpm.

Note

When using wells system air for engine start, manual deselection of starter crank switch may be required.

PROFILE

A BC

13. Right throttle — IDLE (20 percent rpm).

CAUTION

- Attempting a ground start at lower engine rotor speeds will aggravate hot-start tendencies. Exceeding 890 °C EGT constitutes a hot start. Advance the throttle from OFF to IDLE when the rotor speed exceeds 20 percent rpm; this action automatically actuates the ignition system. An immediate indication of fuel flow (300 to 350 pph) will be exhibited and light-off (EGT rise) should be achieved within 5 seconds, but no more than 20 seconds. The rapid rise in EGT should be carefully monitored for overtemperature tendencies. Peak starting temperatures will be achieved in the 40 to 50 percent rpm range when, after a slight hesitation, a reduction will return the EGT to the nominal 350 to 650 °C level. During the initial starting phase, the nozzle should expand to a full-open position indication of 100 percent.

- If an idle crossbleed start is attempted with high residual EGT (after hot start) and/or throttle is advanced from OFF to IDLE prior to 20 percent rpm, higher than normal EGT readings may occur. If the EGT appears to be rising abnormally, increasing the supply engine to 80 percent rpm may yield a normal start temperature.

Note

- If the engine has been shut down within the past 60 minutes, monitor it closely for a hot/hung start. If the start is aborted because of a hot start (EGT above 890 °C), motor the engine until the EGT is less than 250 °C.

- Loss of electrical power may result in smoke entering the cockpit via the ECS.

A BC

14. Right-engine instrument readings.

    a. RPM — 62 to 78 percent.

    b. TIT — 350 to 650 °C (nominal).

    c. FF — 950 to 1,400 pph (nominal).

PROFILE

d. NOZ position — 100 percent (open).

e. OIL — 25 to 35 psi (15 psi minimum).

f. FLT HYD — 3,000 psi.

A B C — 15. External power — Disconnect.

Removal of ground electrical power causes the right generator to supply power to the right and left main electrical buses.

A — 16. Tailhook — EMERG DOWN.

Check the mechanical release of the tailhook uplock without combined hydraulic power.

A B C — 17. ENG CRANK switch — L (left engine).

When combined hydraulic pressure reaches 3,000 psi, return switch to neutral (center) position

A B C — 18. HYD TRANSFER PUMP switch — NORMAL.

Hydraulic transfer pump will operate from flight side to maintain the combined side between 2,400 to 2,600 psi.

CAUTION

If the transfer pump does not pressurize the combined system within 5 seconds, immediately set HYD TRANSFER PUMP switch to SHUTOFF.

A B C — 19. ENG CRANK switch — OFF and check BI-DI.

Verify hydraulic transfer pump pressure operation with slight rudder inputs.

A B C — 20. HYD TRANSFER PUMP switch — SHUTOFF.

A B C — 21. Repeat steps 12, 13, and 14 for left engine.

A B C — 22. BACKUP IGNITION switch — OFF

A B C — 23. Starter air — Disconnect.

A B C — 24. ECS.

a. AIR SOURCE pushbuttons — L ENG, R ENG, OFF, BOTH ENG. There should be a no excessive interruption in cockpit airflow with single-engine air source changes. Selection of OFF should stop airflow and BOTH ENG should provide greatest airflow.

b. TEMP mode selector switch — Check MAN-AUTO. Cockpit temperature control and flow should be checked in both MAN and AUTO modes to ensure proper temperature control.

PROFILE

A BC 25. Right throttle — OFF, then immediately to IDLE.

Observe rpm decrease, then rise to IDLE rpm.

Note

Failure of the engine to relight above 59-percent rpm indicates a failure of the N_2 deceleration auto-relight logic.

A BC 26. Left throttle — OFF, then immediately to IDLE.

Observe rpm decrease, then rise to IDLE rpm.

Note

Failure of the engine to relight above 59-percent rpm indicates a failure of the N_2 deceleration auto-relight logic.

A BC 27. HYD TRANSFER PUMP switch — NORMAL.

A 28. Restore normal tailhook and raise.

A BC 29. Ground safety pins — Remove and stow

A BC 30. Idle engine instrument readings.

	LEFT	RIGHT	NOMINAL
NOZ Position			100% (open)
OIL (psi)			15 to 35 (30 minimum)
RPM (%)			62 to 78
EGT (°C)			350 to 650
FF (pph)			950 to 1,400

10.3.3 Poststart

A BC 31. MASTER TEST switch — EMERG GEN.

The DFCS caution/advisory lights may be illuminated prior to selection of EMERG GEN on the MASTER TEST panel. These lights should extinguish with a MASTER RESET with the possible exception of the FCS CAUTION light due to IMU/INS alignment (PQVM fault). Subsequent selection of EMERG GEN with the MASTER TEST switch may or may not illuminate DFCS caution lights. Following a good emergency generator check, (green 'GO' light) ensure that all lights clear with a MASTER RESET prior to deselecting the emergency generator. When the emergency generator is deselected, the resultant power interruption should cause the DFCS flight control computers to self-isolate due to voltage monitoring resulting in illumination of all the DFCS caution/advisory lights listed below. These lights will remain on when normal voltage is regained, requiring a MASTER RESET to re-engage the

PROFILE

DFCS flight control computers. The STAB AUG switches are mechanically held and should remain engaged during this test.

DFCS caution/advisory lights:

a. PITCH SAS.

b. ROLL DGR.

c. YAW DGR.

d. FCS CAUTION.

e. ARI DGR.

f. ARI/SAS OUT.

g. HZ TAIL AUTH.

h. RUDDER AUTH.

i. SPOILERS.

j. AUTO PILOT.

k. MACH TRIM

A BC 32. AFTC — Check.

a. L ENG MODE switch — SEC.

L ENG SEC light illuminates; left NOZ position indicator pointer is below zero.

b. L ENG MODE switch — PRI.

L ENG SEC light goes out; NOZ position indicator to 100 percent.

c. R ENG MODE switch — SEC.

R ENG SEC light illuminates; right NOZ position indicator pointer is below zero.

d. R ENG MODE switch — PRI.

R ENG SEC light goes out; NOZ position indicator to 100 percent.

e. Paddle switch — DEPRESS.

Observe both engines revert to SEC and throttles revert to MAN

CAUTION

Selecting secondary (SEC) mode closes exhaust nozzles increasing exhaust nozzle jet wake hazard.

PROFILE

Note

- Performing AFTC check during OBC inhibits AICS ramp from programming. Ramps must be reset before another OBC can be performed.
- NOZ position indication is lost in SEC mode.

A B C

33. MASTER TEST switch — WG SWP.

Wing sweep program must be in AUTO. Wing sweep program index moves from 20° to 44° and back to 20°. The following lights illuminate at start of test and are out at test completion (approximately 25 seconds): WINGSWEEP, FLAP, CADC, and REDUCE SPEED.

Note

- During the wing-sweep preflight test, both altimeters may fluctuate momentarily.
- The WING SWEEP advisory light illuminates 3 seconds after the test starts, then goes out and illuminates again 8 seconds into the test.
- The WING SWEEP, FLAP, CADC, and REDUCE SPEED lights are out at the end of the test. The RUDDER AUTH, HZ TAIL AUTH, and MACH TRIM lights illuminate for the entire test and remain illuminated at the end of the test.

A

34. UHF/VHF/ICS check.

Check complete operation of throttle communication switch — UHF 1, UHF 2, BOTH, ICS.

A B C

35. MASTER TEST switch — OBC (AUTOPILOT switch — ENGAGE).

Recommend running all OBC/IBITs with the WINGS — AUTO 20°, FLAPS — DOWN, ANTISKID/SPL BRK — OFF, AUTOPILOT — ON to fully test the system. Also recommend running one MAN DFCS BIT via the MASTER TEST panel. Running OBC by selection of OBC via the MASTER TEST switch will automatically run DFCS IBIT in addition to the standard OBC. Selection of DFCS BIT via the MASTER TEST switch will run only the DFCS IBIT. When the MASTER TEST switch is rotated to the OBC or DFCS BIT position an IBIT ARM acronym will flash in the DCP display indicating that a DFCS IBIT may be executed upon depression of the switch. In the IBIT ARM mode the AUTOPILOT switch may be engaged ON. If the INC/DEC pushbuttons are depressed during this period, the IBIT ARM display will be removed even though the system is still in IBIT ARM mode. When the MASTER TEST switch is depressed the display will indicate IBIT RUN and the DFCS BIT will commence as the AFC acronym begins to flash. After the DFCS IBIT has commenced, the AUTOPILOT switch cannot be ENGAGED ON and therefore will not be tested.

PROFILE

CAUTION

OBC commencement with nose down trim may result in a force link disconnect when the stick hits forward stick stop during the pitch parallel actuator checks.

Note

- An FCS CAUTION light at this point probably indicates a PQVM fault due to a lack of pitch and roll attitude inputs from the IMU. This fault will not affect DFCS IBIT results and can be extinguished with a MASTER RESET either before or after, but not during OBC.

- At least one IBIT must be performed with the wings at 20°, flaps extended and the autopilot engaged to fully exercise spoiler test logic and autopilot/ACLS.

a. Pull ALPHA COMP cb 7C8 (coordinate with RIO).

Verify LDG2 displayed in DCP under FAIL. Pulling the ALPHA COMP cb removes power from the landing gear handle position switch #2 relay resulting in a LDG3 FAIL code.

b. OBC — Initiate (coordinate with RIO and plane captain).

c. After ramps are extended — Select RAMPS to STOW.

d. Verify RAMP lights go out and INLET lights illuminate.

e. When OBC is completed:

(1) Verify FCS CAUTION light illuminated; AOAC and AC28 displayed in DCP under IBIT. AOAC and AC28 are detected as a result of the ALPHA COMP cb being pulled.

(2) Reset ALPHA COMP cb, both AICS cbs, and check INLET RAMPS switches — AUTO.

(3) Reinitiate complete normal OBC (AUTOPILOT switch — ENGAGE). Verify DFCS IBIT operation by flashing A/P REF and ACLS lights. Observe the following:

(a) 10 DFCS caution/advisory lights.

(b) Pitch trim check (slow longitudinal stick motion).

(c) Pitch parallel actuator check (rapid longitudinal stick motion).

(d) Individual spoiler operation (check in mirrors).

(e) Stab & rudder actuator check (horizontal tail and rudder movement).

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(f) Autopilot disengage check.

(g) Rudder pedal shaker check.

(h) DCP display LED check.

The standard DFCS IBIT will check the following in order. All DFCS caution/advisory lights will illuminate and the ACLS and A/P REF lights will flash upon commencement of the test. This will be followed by slow fwd/aft motion of the stick and stab (pitch trim) followed quick fwd/aft motion of the stab SAS actuators (no stick movement), and then rapid fwd/aft motion of the stick and stab (pitch parallel actuator). Following the rapid stick and stab motion the spoilers will extend individually in the order SP4R, SP3R, SP2R, SP1R, SP1L, SP2L, SP3L, and SP4L. Pilot should verify spoiler position indicator corresponds with spoiler deployment and note any discrepancies. This will be followed by rapid left/right motion of the differential stabilizer SAS actuators and left/right rudder SAS actuator checks. This will then be followed by AUTOPILOT switch disengagement, rudder pedal shakers, and the DCP display LED check.

f. Attempt MASTER TEST switch — DFCS BIT with ROLL SAS switch deselected. Verify IBIT does not run.

IBIT should not run with any STAB AUG switch deselected. Deselection of the ROLL and/or YAW SAS should result in an ARI/SAS OUT caution light. Deselection of the PITCH SAS should not illuminate any caution lights.

g. Check DCP fault codes using INC/DEC pushbuttons. Record IBIT fault codes and clear FAIL and FLT fault codes prior to takeoff.

Check the DCP fault codes FAIL/FLT/IBIT using INC/DEC pushbuttons. IBIT fault codes can only be cleared by running another IBIT. The FAIL codes can only be cleared by resolving the problem and depressing MASTER RESET. The FLT codes can only be cleared by simultaneous depression of the INC/DEC buttons for 6–7 seconds and is confirmed by a single line in the DCP display. These codes will not clear with the MASTER TEST switch in the IBIT ARM or IBIT RUN position.

A BC 36. Speedbrake Switch.

a. EXT-RET.

b. Verify stabilizers shift 1° nose down (clean) or 3° nose down (AIM-54 rails) on extension and opposite on retraction (ITS).

A BC 37. Flaps — Down.

a. Verify stabilizer shifts 3° noseup (ITS).

A BC 38. Wingsweep — 68° to 20° (not to exceed 9 seconds)

A BC 39. Flight controls — Trim

Verify full range of trim authority in all axes and power approach spoiler gearing with full left/right lateral trim and corresponding full left/right lateral stick (spoiler deflection should

PROFILE

be reduced to 35° deployment with full trim into stick displacement. Careful attention should be given to the operation and accuracy of the control surface position indicator during this test. This gauge is utilized routinely to determine DFCS flight control functionality airborne and any inaccuracies or friction in the indicator will impact the ability to resolve DFCS operation. A useful technique is to trim full authority in one direction, observe the position indicator and then move the control stick/rudder pedals slightly in the same direction of trim and release and note any change in the position indicator due to inaccuracy/friction in the gauge.

a. Trim — Full nose down, check 9° TED.

b. Stick full aft — Check for free movement.

c. Trim — Full nose up, check greater than 18° TEU (17 to 19 seconds).

d. Stick full forward — Check for free movement.

e. Yaw trim — 7° left to 7° right (12 to 14 seconds).

f. Trim — Full left, check 6° differential tail split.

g. Stick full left — Check power approach spoiler gearing and uniform 35° to 55° spoiler extension.

h. Trim — Full right, check 6° differential tail split (16 to 18 seconds).

i. Stick full right — Check power approach spoiler gearing and uniform 35 to 55° spoiler extension.

A BC

40. Flight controls — Cycle.

Verify full range of control surface authority. As above identify the operation and accuracy of the control surface position indicator. Note the 0.1 inch lateral stick deflection spoiler breakout in the power approach (PA) configuration. Spoiler breakout in the gear up configuration is 0.5 inch.

Observe the following:

a. Longitudinal — 36° TEU to 9° TED horizontal tail (33° to 12° without ITS).

b. Lateral — 24° total differential tail.

c. Directional — 30° rudder.

d. Longitudinal/Lateral combined — 35° TEU to 15° TED.

e. Spoilers — 55° extension.

Note

A stabilizer vibration may occur when the control system linkage is held in contact with a total tail stop during stick cycling checks. This vibration is acceptable, provided it damps when the control stick is moved to clear the stop in contact.

PROFILE

Clearance from the stop can best be verified by movement of the matching stabilizer indicator needle away from its maximum travel position.

A BC

41. Spoiler Checks.

a. DLC — Check.

Verify DLC engagement/operation and stabilizer shift upon engagement and subsequently upon “up” DLC commands via the thumbwheel.

(1) DLC — Engage. Verify stabilizer shifts 2 ¾° below trim. Inboard spoilers extend to 17 ½°.

(2) Full up DLC. Verify stabilizer returns to trim. Inboard spoilers go to –4 ½°.

(3) Full down DLC. Verify stabilizer remains 2 ¾° below trimmed position and inboard spoilers extend to 55°.

(4) Stick 2 inches left (check spoiler gearing). Left wing outboard +30° and inboard +55°. Left wing both inboard/outboard –4 ½°.

(5) Stick 2 inches right (check spoiler gearing). Right wing outboard +30° and inboard +55°. Right wing both inboard/outboard –4 ½°.

(6) DLC — Disengage.

b. SPOILER BK — Select.

SPOILER BK selection to verify ground roll braking operation.

c. SPOILER BK/Throttle interlocks — Check.

d. SPOILER BK — Deselect.

e. Pull O/B SPOILER MOD cb 2B2 (coordinate with RIO).

Pulling the O/B SPOILER MOD cb will de-energize the outboard spoiler module. The SPOILERS caution light will not illuminate until a lateral stick sweep is performed which will be detected by the DFCS as a failure of the outboard spoiler actuators and result in isolation of both left and right outboard spoilers. The DCP will only report fault codes in the FAIL group of the left or right outboard spoiler pair in the direction of initial stick displacement. MASTER RESET will reset the spoiler control logic and a subsequent initial stick displacement in the opposite direction will result in the DCP reporting FAIL codes for the other side. Reset cb and a MASTER RESET will extinguish the SPOILERS caution light and remove DCP FAIL codes.

(1) Verify no SPOILERS caution light.

(2) Perform lateral stick sweep. Observe SPOILERS caution light, verify DCP FAIL fault codes SP3 and SP4 (L or R on initial lateral stick input).

(3) Reset cb and perform MASTER RESET. Verify light and DCP fault codes removed.

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A 42. Radar altimeter — Test.

A 43. Displays — Check.

A 44. Tacan — BIT.

A 45. ARA-63 — BIT.

A 46. Gunsight — Check (manual mode).

a. Select PDCP — A/A, Weapon select switch — GUN.

b. Superimpose gunsight reticle over ADL. ELEV LEAD window should read 0 mils.

c. Set +46 mils.

d. Uncage gunsight.

e. Verify HUD display.

Horizontal displacement with respect to ADL is 2 mils left for reticle and 1 mil left for diamond.

f. Weapon select switch — OFF.

A B 47. Emergency disengage paddle.

The emergency disengage paddle will not disengage SAS operation nor will it deselect any STAB AUG switches.

a. Paddle switch — Hold depressed.

b. Verify throttles in manual mode, both engines in SEC.

10.3.4 Taxi

A BC 48. Turn needle/slip indicator — Check.

10.3.5 Engine Runup

A BC 49. Individual engine runup — Check at MIL (one engine at a time). Read out to RIO.

WARNING

Engine checks shall not be performed in tension and shall be performed with the shuttle forward of the launch bar.

PROFILE

CAUTION

- Shipboard ship use of MRT and minimum AB is restricted to a maximum of 30 seconds to prevent damage to the holdback bar and JBD. JBD cooldown requires both throttles at IDLE for 30 sec and may be necessary during these checks.
- Shipboard use of excessive asymmetric thrust may damage the holdback.

	LEFT	RIGHT	LIMITS
NOZ Position			3 to 10 nominal (closed)
OIL (psi)			25 to 65
RPM (%)			95 to 104 nominal (107.7 maximum)
EGT (°C)			935°
FF (pph)			9,000 to 12,000

Note

Ashore engine checks must be performed with opposing engine at IDLE for the brakes to hold.

a. Verify hook stowed and RATS light out.

b. Engine MODE — SEC.

c. Throttle — MIL.

Note acceleration time (less than 10 seconds).

d. Engine MODE — PRI.

Record engine parameters.

e. HOOK handle — DOWN.

Verify RATS light and 3 to 6 percent rpm decay.

f. Throttle — MIN AB.

Verify rpm increases 3 to 6 percent.

g. Throttle — MIL.

h. THROTTLE MODE switch — MAN.

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i. Throttle — IDLE.

j. THROTTLE MODE switch — BOOST.

k. HOOK handle — UP.

Verify hook is stowed and RATS light out.

l. Repeat steps b. through k. for other engine.

m. Perform AICS programmer reset.

10.3.6 Takeoff and Climb

A 50. Landing gear — Retract (9 to 15 seconds nominal).

A 51. Servo and radar altimeters — Check below 5,000 feet.

A 52. REFUEL PROBE switch — EXT-RET.

A B 53. AFTC — Check.

Note

- SEC mode transfer while in min AB may result in pop stalls. Non-emergency manual selection of SEC mode airborne should be performed in basic engine with the power set above 85 percent rpm.
- If the fan speed limiter circuit has failed, engine rollback may occur with the selection of SEC mode. In the event of engine rollback, PRI mode must be reselected above 59 percent rpm or flameout will occur and an airstart will not be possible.

a. L ENG MODE switch — SEC.

b. Left throttle — Check basic engine power response.

c. L ENG MODE switch — PRI.

d. R ENG MODE switch — SEC.

e. Right throttle — Check basic engine power response.

f. R ENG MODE switch — PRI.

g. Cycle AICS cbs at a constant subsonic Mach.

Note

Cycling AICS cbs while airborne may illuminate the FCS CAUTION and ARI DGR lights.

PROFILE

10.3.7 10,000 Foot Checks

A B C

54. In-flight OBC. Verify MASTER TEST switch — OFF (coordinate with RIO).

A B

55. ECS check (Airspeed 250 KIAS).

CAUTION

In CV environment, ensure external tanks are empty prior to ECS checks.

ECS check should be performed at altitude above 8,000 feet so cabin pressurization can be checked, but low enough to prevent large cockpit pressure changes when cockpit air is secured.

a. Cabin altitude approximately 8,000 feet.

b. Air distribution — CANOPY DEFOG/CABIN AIR.

c. WCS switch — STBY (coordinate with RIO).

d. AIR SOURCE pushbutton — OFF.

Cockpit pressurization will bleed off and cabin pressure altimeter should indicate aircraft altitude.

e. CABIN PRESS switch — DUMP.

Cockpit will completely depressurize.

f. RAM AIR switch — INCR (35 to 50 seconds to fully open ram air door).

As ram air door opens (up to 50 seconds to open fully), there will be an increase in cockpit airflow.

g. AIR SOURCE pushbutton — RAM.

With RAM selected, 400° manifold is re-pressurized, which maintains canopy seal, airbags, and antenna waveguides pressurization. As canopy seal re-inflates, cockpit pressurization available from ram air will be much more apparent.

h. RAM AIR switch — DECR/CLSD.

Observe reduction in cockpit airflow.

i. CABIN PRESS switch — NORM.

j. AIR SOURCE pushbutton — BOTH ENG.

k. WCS switch — XMT (coordinate with RIO).

PROFILE

10.3.8 15,000 Foot Checks

A BC

56. Fuel transfer — Check.

A C

57. Basic SAS checks (Airspeed 300 KIAS).

Deselection of the ROLL and/or YAW SAS switch should result in an ARI/SAS OUT caution light. Deselection of the PITCH SAS switch should not illuminate any caution lights.

a. Pitch pulse forward and aft — PITCH SAS OFF/ON.

Pitch pulse is executed with a partial fwd/aft motion and release of the control stick followed by observation of resultant aircraft motion. Observe increased damping of aircraft response with PITCH SAS ON.

b. Full stick roll — ROLL SAS OFF/ON.

Note ARI/SAS OUT light when ROLL SAS OFF. Note full extension of down wing spoilers. Check for 14° of differential stab split with ROLL SAS OFF, and >20° of stabilizer split with ROLL SAS ON. Full stick roll acceleration with ROLL SAS OFF will be significantly less than with ROLL SAS ON because of reduced horizontal tail authority. In addition residual aircraft motion will be less damped with the ROLL SAS OFF. Observe slight reduction in differential tail at high roll rates with ROLL SAS ON due to roll rate feedback limiting.

c. Rudder pulse left and right — YAW SAS OFF/ON.

Note ARI/SAS OUT light when YAW SAS OFF. Rudder pulse is executed with a partial left/right motion and release of the rudder pedals followed by observation of resultant aircraft motion. Observe Dutch roll response with YAW SAS OFF. Yaw excursions should cease immediately upon engagement of YAW SAS ON.

A C

58. Wing-sweep and maneuver devices check (Airspeed 0.5 IMN).

a. Lateral trim check. Observe < 2° differential tail split.

Trim aircraft for hands off level flight turn needle/ball and yaw string centered. Observe normal lateral trim requirement. Do not retrim during subsequent wing sweep checks. Aircraft horizontal stabilizer rigging should require < 2° differential tail split to maintain wings level flight throughout wing program schedule. (<500 lb wing fuel split or wings empty).

b. Maneuver devices — EXT.

c. WING SWEEP MODE switch — AFT (check that wings stop at 50°).

d. Maneuver flaps partial up with thumbwheel. Ensure that devices retract.

e. WING SWEEP MODE switch — BOMB.

(1) Verify maneuver devices automatically retract and then wings sweep to 55°.

f. WING SWEEP MODE switch — MAN FULL AFT

PROFILE

(1) Note whether aircraft requires retrim of rudder or differential stab to remain wings level/no sideslip.

(2) Release controls and measure elapsed time to 30° bank angle. If < 6 seconds, reattempt check with wing fuel cells empty.

g. WING SWEEP MODE switch — AUTO.

h. EMERGENCY WING SWEEP handle — Cycle 22°, 68°, 22°.

(1) Verify spider detent is engaged, emergency WING SWEEP warning light out.

(2) MASTER RESET pushbutton — Depress, check WING SWEEP advisory light out.

i. Maneuver devices — EXT.

j. Accelerate to > 0.79 IMN and check maneuver devices automatically retracted (maneuver devices start auto retract at 0.68±.02 IMN).

k. Decelerate to < 0.68 IMN and check maneuver devices remain retracted.

l. WING SWEEP MODE switch — AUTO. Verify wings are in AUTO mode.

A BC

59. ASYM LIMITER switch — Check (Airspeed 300 KIAS).

a. Throttles — MIL or LESS.

b. ASYM LIMITER switch — OFF.

c. Left throttle — MAX AB.

Observe full AB available.

d. ASYM LIMITER switch — ON.

Observe reduction to minimum AB (12 percent)

e. Repeat steps a through d for right engine.

A BC

60. High AOA Mach lever/AUTO MAN devices.

a. Throttles — IDLE.

b. Slowly increase aircraft AOA and allow aircraft to stabilize; maneuver devices extended at 10.5 units AOA.

This is the first comparison of ARI alpha nose-probe (radome) and ADD AOA side-probe (left fuselage) AOA inputs and any disparity could indicate potential limited DFCS functionality.

Note

The maneuver device AOA signal from the ARI alpha nose-probe to the CADC has a faster

PROFILE

response rate than the signal from the ADD AOA side-probe to the angle-of-attack indicator, causing a low reading (error) on the indicator. This error is directly proportional to the aircraft AOA maneuver rate. Therefore, to determine when maneuver device extension/retraction occurs, perform the high AOA maneuver device check by slowly increasing/decreasing aircraft AOA and allow aircraft to stabilize.

c. Recover to < 8 units AOA. Verify maneuver devices retract at 8 units AOA.

Maneuver devices should retract at 2 units less than extension to provide a “deadband” to reduce stress associated with automatic extension/retraction commands on the maneuver flaps/slats.

A BC

61. UA-ARI checks. Approaches to stalls.

a. Clean stall with maneuvering devices extended.

(1) Stabilize in level flight at 90 percent rpm, speedbrakes out, 12 units AOA.

(2) Verify maneuvering devices extended.

(3) Differential Tail Fadeout (DTFO)/Lateral Stick-to-Rudder Interconnect (LSRI) check.

(a) Stabilize at 12 units AOA. Make full lateral stick input, note no initial rudder deflection in direction of lateral stick and full differential tail available (> 20° split).

(b) Slowly decelerate to buffet onset. Observe light airframe buffet at 13 to 14 units AOA.

(4) Wing Rock Suppression (WRS) check. Continue deceleration to 22–25 units AOA.

WRS functionality is active between approximately 20 to 30 units AOA. The functionality is designed to prevent wing rock from starting and may only be marginally effective at reducing an established wing rock.

(a) Stabilize at 22–25 units AOA.

(b) Observe no wing rock.

(c) Select ROLL SAS switch — OFF, initiate mild wing rock with small stick and rudder inputs.

(d) Select ROLL SAS switch — ON, hold stick/rudder centered and observe reduction or elimination of wing rock. Observe flight control surface indicators.

(5) Differential Tail Fadeout (DTFO)/Lateral Stick-to-Rudder Interconnect (LSRI) check

DTFO/LSRI functionality is active between approximately 10 to 28 units AOA. The functionality reduces full lateral stick differential tail authority from a 24° to 4° split as aircraft AOA and Mach increase.

PROFILE

(a) Continue deceleration to stabilize at 25–28 units AOA.

(b) Make full lateral stick input, observe initial 19° rudder deflection in direction of stick input and reduced differential tail authority (10±4° total split). Observe roll in direction of stick input.

(6) Low Speed Cross Control (LSXC) check.

LSXC functionality is effective above 30 units AOA and below 0.4 Mach. During this maneuver the pilot should slowly continue to decelerate to full aft stick with the nose less than 30° pitch attitude. The pilot should then input full left lateral stick and observe the 4° differential tail fadeout and full 19° rudder in the direction of stick. When the pilot inputs full right rudder pedal the differential tail fadeout will be overridden and allow a 20° differential tail split LWD and a full 30° right rudder as commanded. The low speed cross control functionality will provide for a sluggish right roll/yaw response with rudder at high AOA.

(a) Continue deceleration to full aft stick, < 30° pitch attitude (>30 units AOA).

(b) Lateral stick — Full left. Observe 4° differential tail split LWD and 19° left rudder.

(c) Rudder pedal — Full right (with full aft/left stick). Observe sustained 20° differential tail split LWD, 30° right rudder, and aircraft right roll/yaw response.

Note

Reduction to original authorities can occur if AOA falls below 30 units or yaw rate exceeds 20°/sec as the LSXC functionality is overridden.

(7) Recover to < 15 units AOA, retract maneuvering devices when proper DFCS control inputs and right roll/yaw response observed or when aircraft < 30° nose down pitch attitude.

b. Clean stall with maneuvering devices retracted.

(1) Stabilize in level flight at 90 percent rpm, speedbrakes out, 12 units AOA.

(2) Ensure maneuver devices retracted using thumbwheel, maintain power setting.

(3) Slowly decelerate to buffet onset and note AOA (light airframe buffet at 12 to 13 units, increasing to moderate intensity at 15 units AOA).

(4) Continue deceleration to 28 units AOA. Note any abrupt or significant rolloff tendencies.

10.3.9 10,000 Foot Checks

A BC

62. Structural integrity check (Airspeed 0.9 IMN at 10,000 feet).

a. High-speed dash — MIL THRUST.

b. High-g turn.

PROFILE

c. Anti-g valve operation.

d. Accelerometer — Check.

10.3.10 Airstarts (20,000 Feet)

63. WCS switch — OFF (coordinate with RIO).

64. Spooldown airstart.

a. Stabilize at 300 KIAS.

b. Right throttle — OFF, then IDLE at 60 percent rpm.

Note

Sub-idle stall can be cleared by cycling the throttle to OFF and immediately returning it to IDLE.

c. Stabilize at 300 KIAS.

d. Left throttle — OFF, then IDLE at 60 percent rpm.

Note

- Sub-idle stall can be cleared by cycling the throttle to OFF and immediately returning it to IDLE.
- A left generator transient may cause a Mach fault illuminating the FCS CAUTION, ARI DGR, HZ TAIL AUTH, RUD AUTH and MACH TRIM lights. This should clear with a MASTER RESET.

65. WCS switch — STBY/XMT (coordinate with RIO).

10.3.11 Climb to 35,000 Feet

A B

66. Fuel management.

	LEFT	RIGHT
FEED		
FUS		
WING		
EXT		
TOTAL		

A B

67. ECS check.

a. Automatic cabin temperature control.

PROFILE

b. Manual cabin temperature control.

c. Cabin altitude schedule (approximately 14,000 feet at 35,000 feet).

A B 68. Afterburner light off — Check (Airspeed 210 KIAS).

a. ASYM LIMITER switch — OFF.

b. Throttles — MAX AB (verify AB light off within 10 seconds).

c. Throttles — Less than MIL.

d. ASYM LIMITER switch — ON.

A B 69. Wing sweep — Verify program.

Mach (IMN)	Wingsweep
0.4	20°
0.7	21°
0.8	40°
0.9	60°
>0.93	68°

A B

10.3.12 High-Speed Dash (35,000 Feet)

70. Engine instruments (engine MIL power at 0.9 IMN) — Monitor and read out to RIO.

	LEFT	RIGHT	LIMITS
OIL (psi)			25 to 65
RPM (%)			107.7 maximum
EGT (°C)			935°

A B 71. Idle lockup — Check.

a. Jam throttles — MAX AB.

b. Both throttles to IDLE at 1.1 IMN. Verify less than 2-percent rpm decay.

CAUTION

Monitor rpm decay while retarding throttles to idle to ensure proper idle lockup operation. Discontinue idle lockup check if rpm decays more than 2 percent above 1.1 Mach, place throttles to MIL and decelerate.

PROFILE

c. Jam throttles — MAX AB. Accelerate to 1.5 IMN.

d. Engine instruments — Monitor and read out to RIO.

	LEFT	RIGHT	LIMITS
NOZ Position (%)			50 to 60 (open)
OIL (psi)			25 to 65
RPM (%)			107.7 maximum
EGT (°C)			935°

e. Mach trim compensation — Check.

f. Compare pitot-static instruments (pilot and RIO). Pilot should report Mach in increments of 0.1 Mach. RIO should indicate 0.1 Mach less than pilot's Mach indication.

Note

A significant difference between front and rear airspeed indications may result in compressor stalls because of inlet ramp mispositioning.

g. Throttles — IDLE (MIL if idle-lockup check failed).

CAUTION

Monitor rpm decay while retarding throttles to idle to ensure proper idle lockup operation. Discontinue idle lockup check if rpm decays more than 2 percent above 1.1 Mach, place throttles to MIL and decelerate.

10.3.13 Zoom Climb (40,000 Feet)

A B 72. Pitch up to flight level 400.

A B 73. Cabin pressurization and ECS — Check (approximately 17,000 feet at 40,000 feet).

10.3.14 20,000 Foot Checks

A 74. Autopilot modes check (Airspeed 250 to 350 KIAS).

a. Attitude hold.

(1) Autopilot — Engage. Verify no transient.

(2) Check for smooth operation in CSS.

PROFILE

b. Heading hold

(1) Heading hold — Engage.

(2) Left and right pedal sideslip — Check return to reference heading.

(3) CSS left or right roll to 5° bank angle — Aircraft should return to 0° bank angle.

c. Altitude hold.

(1) ALT hold — Select. Verify A/P REF light illuminates.

(2) A/P REF/NWS pushbutton — Depress. Verify A/P REF light goes out.

(3) Check for altitude control.

(a) ±30 feet in level flight.

(b) ±60 feet in 30° bank angle.

(4) Check for stick force breakout function.

d. Ground track hold.

(1) GT hold — Select. Verify A/P REF light illuminates.

(2) A/P REF/NWS pushbutton — Depress. Verify A/P REF light goes out.

(3) Check A/P establishes crab into wind to hold selected track.

e. Emergency disengage paddle — Depress. Verify autopilot disengages, AUTOPILOT caution light illuminates, and clears with a MASTER RESET.

A 75. Air-to-Air check (coordinate with RIO).

a. Radar modes — Check.

b. PDCP — A/A, MASTER ARM switch — TNG.

c. Weapon select switch — PH (IFT).

(1) Attack steering — LAR-Vc.

(2) Collision steering.

d. Weapon select switch — SP (IFT).

(1) Attack steering — LAR-Vc.

(2) Collision steering.

(3) TCS HUD/VDI display.

e. Weapons select switch — SW (IFT).

(1) Attack steering — LAR-Vc.

(2) Collision steering.

PROFILE

f. WCS checks against suitable airborne target.

(1) VSL high.

(2) VSL low.

(3) Pilot VSL.

(4) MRL.

(5) PLM.

(6) PAL.

g. Gunsight — Check.

(1) Weapon select switch — GUN.

(2) Observe proper HUD display.

(3) Uncage gunsight.

(4) Fly level coordinated turn pulling enough g's to place the center of reticle 15 mils from the center of the ADL along the horizontal line of the ADL.

(5) Results should be 3 g turn in 45±6 seconds with reticle displaced 15 mils horizontally.

(6) Weapon select switch — OFF.

A BC

76. Negative alpha/FOD check (Airspeed 300 KIAS).

WARNING

It is imperative that the procedures in this check be followed exactly and negative-g maneuvering at high gross weight (over 56,000 pounds) should be avoided because of the high probability of engine stalls and/or aircraft departures.

a. Throttles — MIL.

b. Raise nose to 10° above the horizon, roll inverted (ensure wings level).

c. Smoothly apply forward stick pressure (not to exceed –1.0g).

d. Check for normal engine operation and FOD or loose gear.

e. Release forward stick and perform a coordinated roll to upright wings level attitude.

PROFILE

10.3.15 15,000 Foot Checks

A

77. Fuel dump check.

    a. Speedbrake switch — EXT.

    b. DUMP switch — DUMP (observe no fuel dump).

    c. Speedbrake switch — RET (observe fuel dump).

    d. DUMP switch — OFF (observe no fuel dump).

A

78. Fuel system transfer check (total fuel less than 8,000 pounds).

    a. WING/EXT TRANS switch — OFF.

    b. FUEL FEED switch — FWD/R.
    Monitor 500 pound split, AFT/L high.

    c. FUEL FEED switch — AFT/L.
    Monitor 500 pound split, FWD/R high.

    d. FUEL FEED switch — NORM.
    Verify FWD/R high split remains constant.

A BC

79. PA-ARI checks. DLC, autothrottles, and dirty stall.

    a. Approach configuration check.

    (1) Perform landing checklist.

    (2) DLC — Engage.

    (a) Observe no significant lateral trim requirements

    (b) Observe no significant pitching with DLC commands.

    (c) Observe proper stab motion with “up” DLC commands.

    (3) AUTO THROTTLE/DLC.

    (a) Response to longitudinal stick.

    (b) Response to turn entry, steady rollout.

    (c) Response to DLC (should be minimal).

    (d) Response in HOT/NORM/COLD.

    (e) AUTO THROT light.

    [1] Manual override.

    [2] CAGE/SEAM pushbutton.

PROFILE

b. Dirty Stall, 15,000 feet.

(1) Slowly decelerate in level flight to 16.5 to 17.0 units AOA.

(2) Throttles — MIL.

(3) Continue to decelerate to a maximum of 25 units AOA (NATOPS limit is 25.6 units above 5,000 ft AGL). Check lateral control effectiveness at 2 unit intervals up to 20 units AOA.

(4) Note pedal shaker at 20.5±1.5 units AOA.

(5) Note any abrupt or significant rolloff tendencies.

c. Attempt speedbrake extension at MIL power.

Verify throttle interlock does not permit speedbrake extension at MIL power.

A C

80. PA-ARI checks. LSRI, yaw damping, and spiral mode stability.

a. Lateral Stick-to-Rudder Interconnect check.

(1) Input lateral stick, ROLL SAS — ON;
Observe initial coordinating rudder in direction of lateral stick input.

(2) Input lateral stick, ROLL SAS — OFF;
Observe no initial rudder in direction of lateral stick input.

(3) ROLL SAS — ON.

b. Yaw Damping check.

(1) Perform rudder pulse, YAW SAS — ON;
Observe deadbeat yaw damping (no overshoot).

(2) Perform rudder pulse, YAW SAS — OFF;
Observe decreased yaw damping (approximately one overshoot).

(3) YAW SAS — ON.

c. Spiral Mode Stabilization check.

Trim airplane to stabilized wings level with ROLL SAS OFF to neutralize SAS actuators. Re-engage ROLL SAS switch to activate lateral stick roll rate command functionality. Stabilize in a 10° bank angle and release stick. Aircraft should maintain this bank angle and not deviate to double or half original bank angle in < 20 seconds. This functionality will be degraded at steeper bank angles.

(1) Trim laterally wings level, ROLL SAS — OFF.

(2) Select ROLL SAS — ON and smoothly stabilize left and right 10° bank angle, hands off stick.

(3) Observe approximately neutral spiral stability (test valid if time to double or half amplitude > 20 sec).

PROFILE

A

81. Air-to-Ground check (coordinate with RIO).

WARNING

Recovery from 30° dive delivery profiles should be a 5 g pull, started no later than 4,000 ft AGL.

a. Select PDCP — A/G, Weapon select switch — OFF.

b. Select COMPTR/TGT attack mode and MK-84L.

(1) Verify symbology.

(2) Execute 30° dive 12,000 foot AGL roll-in.

(3) Designate target, verify solution.

(4) Maneuver, verify designator remains on target.

(5) Complete 30° dive.

c. RIO selects COMPTR/PILOT attack mode.

(1) Verify symbology.

(2) Execute 30° dive 12,000 foot AGL roll-in.

(3) Fly impact point over target.

(4) Complete 30° dive.

d. Air-to-ground GUN sight — COMPTR/PILOT check.

(1) Weapon select switch — GUN.

(2) RIO select A/G GUN switch — OFF.

(3) Dive angle greater than 10°.

(4) Verify symbology when in range (gun — 6,000 feet) diamond disappears.

e. RIO select MANUAL attack mode.

(1) Verify symbology.

f. Exit A/G.

PROFILE

10.3.16 Approach and Landing

A BC 82. Landing checklist complete.

A BC 83. ACLS/ARA-63 — Check.

A BC 84. Airspeed and AOA (15 units AOA) — Check.

a. AOA, INDEXER, HUD.

- Gross weight ____________ pounds.
- Airspeed ________________ KIAS.

121 KIAS ±4 KIAS at 42,000 pounds gross weight.
Add 3 KIAS per 2,000 pounds over 42,000 pounds.

A BC 85. Approaches.

a. Perform nominal landing approaches followed by lateral offset or overshooting approaches that require centerline correction to verify proper function of DFCS PA-ARI control laws.

10.3.17 Touchdown

A BC 86. Exhaust nozzle check.

a. Verify less than 26 percent.

b. 3 to 7 seconds after touchdown, nozzles 100 percent.

10.3.18 Postlanding

A BC 87. Walkaround inspection — Complete.

10.4 FUNCTIONAL CHECKFLIGHT PROCEDURES (RIO)

10.4.1 Prestart

A 1. ICS.

a. Normal.

b. Backup.

c. Emergency.

A BC 2. IND LT — Test.

A 3. Seat adjustment — Check.

PROFILE

A 4. Canopy rigging.

a. Both cockpit handles in same position during operation.

b. BOOST not required to close.

10.4.2 Poststart

A BC 5. CDNU — Insert present position.

TIME	LATITUDE	LONGITUDE

A 6. Multiple display.

a. Verify navigation display, data block and ADF indication.

b. Verify PTID display,

c. Verify ECM display.

A 7. RADAR WARNING RCVR PWR switch — ON.

a. ALR-67-BIT.

b. ALQ-126-BIT-STBY.

A BC 8. Upon completion of OBC, record acronyms on PTID.

A 9. Servo altimeter — Set and Check, Record Error.

When the local barometric pressure is set, the altimeter should agree within 75 feet at field elevation in both modes, and the primary or standby readings should agree within 75 feet. In addition, the allowable difference between primary mode readings of altimeters is 75 feet at all altitudes.

10.4.3 Taxi

A 10. Compass — Cross-Check Heading.

A BC 11. WCS BIT 1 through 4 — Initiate and Record on BER Card.

A 12. INS — Check (at takeoff end of runway).

Groundspeed	Time	
	Latitude	Longitude
Blended		
GPS		
Free-Inertial		

A BC 13. WCS switch — STBY.

PROFILE

10.4.4 Takeoff and Climb

A B 14. Engine runup — Check at MIL.

	LEFT	RIGHT	LIMITS
NOZ Position (%)			Nominal 3 to 10
OIL (psi)			25 to 65
RPM			95 to 104 (107.7 maximum)
EGT (°C)			935°
FF (pph)			7,400 to 10,000

A 15. Airspeed — Check (200 KIAS).

PILOT	RIO
KIAS	TAS

A 16. Altimeter — Check.

INS	SERVO

A 17. Tacan and INS position — Cross-check.

A 18. INS navigation and radar mapping check.

a. Radar map — Check all range scales.

10.4.5 10,000 Foot Checks

A BC In-flight OBC — Run (coordinate with pilot MASTER TEST — OFF)

A B 19. ECS check.

a. Set WCS switch to STBY before pilot's ECS check.

10.4.6 15,000 Foot Checks

A BC 20. High AOA/auto maneuvering device checks

10.4.7 10,000 Foot Checks

A BC 21. Structural integrity check.

a. Anti-g valve operation

PROFILE

10.4.8 20,000 Foot Checks

A B 22. WCS switch — OFF (prior to airstarts).

A B 23. WCS switch — STBY (airstarts complete).

10.4.9 Climb to 35,000 Feet

A B 24. Engine instruments — Record 1.5 IMN high-speed dash.

	LEFT	RIGHT	LIMITS
NOZ Position (%)			50 to 60 open
OIL (psi)			25 to 65
RPM			(107.7 maximum)
EGT (°C)			935°

A 25. D/L — Check.

A 26. Select assigned frequency and address.

A 27. Receive D/L messages.

a. Steering symbols.

b. PTID target area.

c. DDI lights.

10.4.10 Descent/20,000-Foot Checks

A 28. RADAR BEACON — STBY or PWR

29. Air-to-air check.

a. Radar modes.

(1) PULSE.

(2) PD SRCH.

(3) RWS.

(4) TWS AUTO.

(5) TWS MAN.

(6) HRWS.

b. MLC switch — OUT-AUTO-IN (PD SRCH).

PROFILE

c. Navigation

(1) Tacan fix — Record (do not initiate update).

Δ LATITUDE	Δ LONGITUDE

(2) Radar fix — Record (do not initiate update).

Δ LATITUDE	Δ LONGITUDE

(3) Visual fix — Record (do not initiate update).

Δ LATITUDE	Δ LONGITUDE

d. IFT check

(1) Pilot Select PH, missile preparation, and TNG.

(2) RIO verify PH6 after PREP timeout.

e. WCS checks against suitable airborne targets.

(1) Intercept targets and set ASPECT switch to TAIL.

(a) Check operation in:

[1] PD SRCH.

[2] RWS.

[3] TWS MAN.

(b) Initiate PH attack and verify WCS MODE pushbuttons are set for:

[1] TWS AUTO.

[2] PDSTT.

PROFILE

(c) Observe transition to:

[1] PULSE STT.

(d) Return to PULSE SRCH.

(e) Close to visual range and verify DDD display.

[1] VSL mode HI-LO LOCK-ON.

[2] MRL mode CHECK LOCK-ON.

f. IFF — Check modes 1, 2, 3, and 3C.

A BC

30. Negative Alpha/FOD check (20,000 feet, 300 KIAS)

WARNING

It is imperative that the procedures in this check be followed exactly and negative-g maneuvering at high gross weight (over 56,000 pounds) should be avoided because of the high probability of aircraft departures.

a. Confirm throttles — MIL.

b. After pilot raises nose to 10° above horizon and rolls inverted wings level (not to exceed –1.0 g), check for FOD or loose gear.

A

31. Air-to-ground check — Coordinate With Pilot.

a. Select A/G.

b. A/G gun — OFF.

c. WPN TYPE — MK-84L.

d. Attack mode — CMPTR PILOT/TGT and MAN.

A BC

32. Perform WCS BIT sequence 1 through 4 and record on BER card (BITS 5 through 8 as required).

A

33. NAV MODE switch — AHRS.

a. Pilot check VDI display, maneuver aircraft, and fast erect.

b. Radar antenna scan — Check.

A BC

34. Verify pilot OBC disabled.

PROFILE

A BC

35. Perform airborne OBC.

Record acronyms:

10.4.11 Approach

A

36. Airspeed

a. Compare with pilot airspeed at 15 units AOA and record error________________ KIAS.

10.4.12 Landing

A BC

37. WCS switch — STBY.

10.4.13 In Chocks

A BC

38. INS and visual — Check in chocks.

a. Record:

Groundspeed	Time	
	Latitude	Longitude
Blended		
GPS		
Free-Inertial		

A BC

39. Call up OBC maintenance display.

Record acronyms:

10.4.14 Postflight

A BC

40. Walkaround inspection — Complete.

PART IV

Flight Characteristics

CHAPTER 11

Flight Characteristics

11.1 PRIMARY FLIGHT CONTROLS

Primary flight controls are devices that change the flight path of the aircraft. They consist of the differential horizontal stabilizer for pitch and roll control, the spoilers for supplementary roll control, and the rudders for directional control. A Stability Augmentation System is provided for the three axes of the aircraft motion.

11.1.1 Pitch Control. The horizontal tail is effective from under 100 KIAS to over Mach 2. Its effectiveness gives the aircraft several capabilities not enjoyed by other fighters, including low takeoff rotation speeds and the ability to reach or exceed limit load factor over much of the subsonic and supersonic envelope; it is also an excellent drag device below 100 KIAS on landing roll-out. The major disadvantages of the large horizontal stabilizer authority are that the pilot can generate high enough pitch rates (particularly in the nosedown direction) to cause coupling under certain conditions and that a pitch attitude sufficient to scrape tailpipes and ventral fins can be attained on landing rollout or takeoff rotation.

11.1.2 Roll Control. Differential deflection of the horizontal tail surfaces provides primary roll control throughout the flight envelope and is the only roll control when wings are swept aft of 62° (disabling the spoilers).

Spoilers are very effective at low to medium AOA for roll control and reduce the aft fuselage torsional loads induced by the differential tail. The spoilers are also the primary mechanism for direct lift control and spoiler braking. With flaps down, the spoiler provides the majority of available roll control power.

11.1.3 Directional (Yaw) Control. Twin rudders furnish directional control. Through strong dihedral effect (roll caused by sideslip), good roll control is also available from rudder inputs at medium and high AOA. Rudder power is sufficient to provide adequate control under all asymmetric store loading conditions.

11.1.4 Stability Augmentation System. Pitch SAS increases damping of the longitudinal, short-period dynamic response, but the aircraft can be operated safely throughout the flight envelope without it.

Roll SAS increases roll acceleration during the initial lateral stick input. The SAS reduces differential tail deflection to limit maximum roll rate to less than approximately 200°/sec to reduce aft fuselage loads and to prevent roll coupling in the transonic speed range. The DFCS ROLL SAS differential tail authority has been tailored to reduce structural loads and provide expanded, simplified rolling maneuver envelopes defined in Chapter 4. ROLL SAS differential tail inputs are automatically faded out over the airspeed range from approximately 400 to 500 KIAS. An undesirable by-product of the roll-rate limiting is an oscillatory roll rate perceived as a nonlinear roll response encountered in aggressive rolling maneuvers at medium subsonic speeds and higher. Because roll SAS provides structural protection, flight above 0.93 IMN is prohibited without roll SAS with wing-mounted AIM-54 (loadings 3B5, 3B6, 3C5, 3C6). Should tactical considerations necessitate violating this restriction, restrict rolls to less than full lateral stick deflection and to not more than 180° of bank angle change at one time. This minimizes the possibility of aircraft damage. Initial roll acceleration is slower without roll SAS. High AOA handling qualities are significantly improved by keeping ROLL SAS ON.

Over the majority of the flight envelope, yaw SAS is the most critical of the stability augmentation functions. Directional dynamic response (yaw oscillations or Dutch roll) is poorly damped without it. In regions of reduced directional stability above 24 units AOA or when super-sonic, the SAS dampens yaw rates that might otherwise cause loss of control or structural damage. Below 0.93 IMN, with yaw SAS OFF, normal maneuvering can be accomplished if extra care is taken to control yaw and sideslip excursions with rudder (maintain coordinated flight), but high AOA maneuvering (above approximately 15 units AOA) should be avoided due to increased provability of departure from controlled flight.

At high AOA flight conditions, both the roll and yaw SAS are required to provide automatic rudder interconnect (ARI) functions, which significantly improve the handling qualities, departure resistance, and recovery capability of the aircraft.

11.2 SECONDARY FLIGHT CONTROLS

Secondary flight controls affect the flightpath of the aircraft although they have other primary purposes, such as increasing lift or drag. Secondary flight controls of the aircraft include main, auxiliary, and maneuver flaps, leading-edge slats, speedbrakes, DLC, and the variable-sweep wing.

11.2.1 Maneuver Flaps and Slats. Maneuver flaps and slats provide increased turn performance (increased turn rate/decreased turn radius) when extended. Additionally, the extension of the maneuver slats decreases departure susceptibility by increasing positive dihedral effect (roll caused by sideslip). The longitudinal trim change upon extension and retraction of the devices is slight (2 to 4 pounds aft on extension, approximately 2 pounds forward on retraction).

11.2.2 Landing Flaps, Slats, and DLC. Trim changes during extension and retraction of flaps/slats are significant. During extension of flaps/slats at 200 KIAS, an initial push force of approximately 5 pounds is required followed by a pull force of up to 15 pounds. Engagement of DLC at approach speeds causes essentially no trim change. Forces during retraction of the flap/slats are generally opposite and of approximately the same magnitude. The force required during retraction of the flaps/slats may be less objectionable than those during extension, since the flaps are generally raised at a slower airspeed and, therefore, require less opposing force.

Note

Retracting the flaps with DLC engaged may require up to 30 pounds of push force to maintain pitch attitude when the DLC automatically disengages as the flaps pass 25°.

11.2.3 Speedbrakes. The speedbrakes provide some deceleration capability throughout the flight envelope. However, the most effective means to slow the aircraft is to reduce thrust while applying g, since the speedbrakes are marginally effective at moderate to low speeds. Extension and retraction of the speedbrakes results in a pitch trim change that varies with flight conditions. In general, this change is not objectionable except at higher airspeeds where the rapidity of change (1.5 seconds for full extension) may prevent fine (+3 mil) gunsight tracking and possibly lead to a minor case of pilot-induced oscillation.

11.3 GENERAL FLIGHT CHARACTERISTICS

11.3.1 Static Longitudinal Stability. Static longitudinal stability indicates the direction of the longitudinal stick force required with changing airspeed from a trim condition. At slow speeds where the wings are not sweeping, static longitudinal stability is slightly positive (forward stick is required for increasing speeds, aft stick is required for decreasing speeds). At speeds where the wings are automatically sweeping aft, static stability becomes neutral to slightly negative.

In the transonic region, from Mach 0.8 to 1.5, static longitudinal stability is essentially neutral. There is, however, a minor reversal in the stick force gradient (forward stick force may have to be relaxed to maintain level flight when accelerating) at approximately Mach 0.95. Above Mach 1.5, the stick force gradient becomes neutral. Since the engine line of thrust is below the aircraft cg, reducing power causes a slight nosedown pitch; power addition causes a noseup pitch.

11.3.2 Dynamic Longitudinal Response Characteristics. The initial response of the aircraft to a longitudinal stick input is greatly dependent on the dynamic longitudinal response or “short-period” characteristics. Dynamic longitudinal response to pilot inputs is somewhat sluggish in cruise and approach configurations when compared to most other modern-day fighters. In cruise configuration, this may not be evident until high gain, close coupled tasks such as fine gunsight tracking are attempted. Here pilot tendency is to overdrive the aircraft with the control stick resulting in a slight porpoising of the nose. This can be avoided by applying a longitudinal stick input and waiting for a nose response before applying a further correction. In approach configurations, the sluggish nose response will be most noticeable during approaches without DLC, since more nose movement must accompany the larger power adjustments required to maintain on speed AOA when flying the ball.

11.3.3 Maneuvering Stick Force. Maneuvering stick force or stick force per g of the aircraft is predictable throughout most of the flight envelope. That is, an increase in force commands a corresponding increase in g (approximately 4 pounds per g).

The stick force per g generally changes very little with altitude, airspeed, loading or cg position.

Stick displacements required during maneuvering are relatively large and may be uncomfortable to some pilots. While the stick forces are not especially high, the stick must be placed relatively close to the pilot's torso to attain a given g. This gives the pilot less leverage with his arm and is more tiring, especially at lower airspeeds and higher AOA, where stick-force-per g can be as high as 10 pounds per g.

11.3.4 Roll Performance. The roll performance (maximum roll rate attainable) is generally satisfactory, particularly at high airspeeds. At lower speeds, however, the high aspect ratio and roll inertia of the aircraft restrict its time-to-roll to considerably less than that of a smaller, more nimble tactical aircraft (A-4, F-16).

Note

Although DFCS improves maximum roll rate capability at low airspeed and high AOA, these flight conditions are definite tactical limitations.

Large aft stick inputs applied with lateral stick during supersonic rolling maneuvers result in increased adverse sideslip and should be avoided. High Mach number, high altitude rolling maneuvers may result in oscillatory sideslip and roll ratcheting during aggressive maneuvering with ROLL SAS OFF. Depending on the phasing of these dynamics, centering lateral stick may be insufficient to stop the rolling motion and opposite lateral stick may be required in order to terminate the roll.

CAUTION

Large sideslip angles generated during full lateral stick supersonic rolling maneuvers at high altitudes may result in engine stalls.

11.3.5 Roll Response. In the cruise configuration, the roll response to lateral stick inputs is tailored to reduce structural loads and provide expanded, simplified rolling maneuver envelopes as defined in Chapter 4. The resulting roll response is generally satisfactory throughout the flight envelope. The increased roll acceleration and peak roll rate attainable with ROLL SAS ON significantly improves tactical maneuvering capability. However, in the airspeed range from approximately 300 to 500 KIAS, the roll command augmentation (CAS) and roll rate limiting feature of the roll SAS can cause high roll accelerations and marked variations in roll rate during aggressive rolling maneuvers with large lateral stick inputs. This effect is most pronounced at high subsonic airspeeds (from approximately 0.7 to 0.93 IMN) and medium to low altitudes (below approximately 20,000 feet). This characteristic may lead to bank angle overshoots during maximum roll rate maneuvers at high airspeeds. Smoother and/or smaller lateral stick inputs will reduce or eliminate this oscillatory roll response at these flight conditions.

At high angles of attack, the up-and-away (UA) UA-ARI control functions dramatically improve the roll response of the aircraft. The roll reversal characteristic experienced without the ARI is eliminated throughout the majority of the available AOA range. Roll response is in the direction of commanded lateral stick up to and beyond 30 units AOA. Some variation in normal roll response may be seen due to aircraft control system and/or wing sweep and flap rigging tolerances, external store loading, or wing fuel imbalance. Maximum roll rate commanded by lateral stick decreases as AOA increases, decreasing to near zero above 30 units AOA without pilot commanded coordinating rudder inputs. Proper sense roll response can be attained at increasingly higher AOA through use of pilot coordinating rudder. At very low airspeed and high AOA conditions (less than 0.4 IMN and above 30 units), the Low Speed Cross Control feature (LSXC) can be safely utilized to obtain a transient roll maneuvering capability. This feature is enabled by applying rudder in the desired roll direction, while applying an opposite lateral stick input. Peak roll rate of approximately 60°/sec is available through the use of LSXC. If long duration inputs are utilized, the roll response may become oscillatory, with hesitations in bank angle and roll rate. Precise bank angle control is typically not possible with LSXC, but the feature can be effectively utilized during sustained slow speed/high AOA maneuvering such as a flat scissors engagement.

In the landing configuration, the power approach (PA-ARI) control functions and modified spoiler gearing provide a crisp roll response to pilot lateral stick inputs. Control gains are scheduled with AOA to provide a linear roll response of approximately 20°/sec roll rate per inch of lateral stick deflection. This responsiveness may lead to a tendency to overcontrol bank angle if large amplitude stick inputs are utilized. Therefore, relatively small stick deflections are required to perform these corrections. Once accustomed to the increased roll response in the landing configuration, pilot workload to perform lateral corrections and precisely maintain lineup will be significantly reduced, allowing the pilot to devote valuable time to controlling both glideslope and AOA.

11.3.6 Dutch Roll. Dutch roll is characterized by a wallowing, snakey motion of the nose that severely degrades heading and/or lineup control. Large lateral stick inputs can excite the Dutch roll mode of the aircraft in the cruise configuration, but the most severe degradation in flying qualities from the Dutch roll is in the approach configuration. The period of this motion is quite long and has the unfortunate result that the pilot perceives a heading error when referenced to centerline, when in fact the flightpath is correct. In the landing configuration, the PA-ARI control functions provide a nearly deadbeat directional response. Precise lineup control is exhibited due to the increased Dutch roll damping and the automatic stick to rudder interconnect function which provides coordinating rudder inputs with lateral stick deflection. Additional pilot coordinating rudder inputs are typically not required during approach, but may be used for aggressive bank and/or lineup corrections if desired.

11.3.7 Trim Characteristics. The trim rate in pitch is slow. During acceleration runs in MAX power at low altitude, trim may have to be run nearly continuously to maintain longitudinal stick force at or near zero. Lateral control authority and roll rates at slow speeds will be reduced by almost one-half with full stick deflection in the direction of full lateral trim because of decreased spoiler deflection (see spoiler gearing schedules in Figure 2-60). Therefore, when maximum lateral control authority is required, such as during asymmetric flap condition, trim in the direction of stick displacement should be avoided.

Runaway trim in any axis is controllable. During field landings, the aircraft can be recovered safely with runaway trim; however, carrier approaches with full runaway pitch trim may be difficult.

Trimming the aircraft longitudinally to level flight can be broken down into two areas. At airspeeds slower than those using automatic wing sweep programming, the aircraft is relatively easy to trim to level flight because it has positive longitudinal static stability. At airspeeds where the wings automatically move with a change in airspeeds, it becomes very difficult to achieve a hands-off trim. Because of the change in aircraft pitching moment caused by movement of the wings, the nose tends to pitch further down with each increase in speed or further up with each decrease in speed.

Trimming the aircraft laterally/directionally may be required to compensate for lateral asymmetry resulting from either asymmetric stores, wing fuel imbalance, or control surface rigging tolerances. Lateral trim requirements will result in a stick displacement and a corresponding differential tail split that will reduce the amount of effective differential tail authority in the direction of trim and increase the amount of effective differential tail authority opposite trim. As a result, aircraft response will be reduced for lateral stick deflections in the direction of trim and increased for lateral stick deflections opposite the direction of trim. The combined effects of lateral trim and any CG displacement associated with the asymmetry may result in increased departure susceptibility and severity.

CAUTION

Excessive lateral trim requirements will result in increased roll rates and structural loads during rolling maneuvers opposite the direction of trim. This is particularly evident at transonic and supersonic flight conditions. For this reason, trim yaw first, then roll.

Changes in thrust settings normally require a trim change, particularly in the approach configurations. A reduction in power causes a slight nosedown pitch.

In the landing configuration, the DFCS includes a roll rate command function. Pilot lateral stick deflection commands a desired roll rate, which is provided through differential tail and spoiler inputs. Once this commanded roll rate is achieved, roll SAS inputs will stabilize the aircraft at the commanded rate. Likewise, any roll rate not commanded by lateral stick deflection (gust, turbulence, lateral asymmetry, etc.) is sensed as a roll rate error. The roll SAS will automatically provide inputs through the roll series servos to stop this uncommanded rate. Sufficient gain exists in this control function to essentially provide an "auto-trim" capability in the roll axis for many lateral asymmetry situations. Because of this characteristic, precise lateral trim may be slightly more difficult to achieve in the landing configuration. In some cases, it may be possible to slowly move lateral stick trim from left to right with no appreciable change in aircraft bank angle or roll rate. Because much of the lateral trim is now being provided through biasing of the roll series servos in one direction, the aircraft may subsequently exhibit an asymmetric roll rate in response to pilot lateral stick inputs. Should this bias become objectionable, the aircraft can be trimmed both laterally and directionally with the ROLL SAS OFF, reselecting ROLL SAS ON once trim is established. This action should eliminate any bias present in the roll series servos and provide symmetric roll response.

11.4 ASYMMETRIC THRUST FLIGHT CHARACTERISTICS IN COMBAT AND CRUISE CONFIGURATION

11.4.1 General. With one engine inoperative, flight characteristics are considerably affected by the thrust asymmetry generated by the operating engine. The distance of the engines from the centerline produces flight control requirements and flying qualities not present in centerline thrust aircraft. Flight control requirements are a function of the thrust setting of the operating engine. The thrust required to maintain flight and, therefore, the magnitude of thrust asymmetry, is a function of the following.

11.4.1.1 Gross Weight. Heavier gross weights require higher thrust settings to maintain level flight and, therefore, larger control deflections to counter the greater asymmetric thrust.

11.4.1.2 Configuration. Aircraft configuration varies the amount of thrust required at a particular flight condition. At cruise configuration airspeeds, control requirements will be significantly reduced compared to landing configurations, which require significantly higher thrust settings and in turn larger control forces to maintain desired flightpath.

11.4.1.3 Airspeed. At maximum endurance airspeeds, minimum thrust is required to maintain level flight and, therefore, the smallest asymmetric moment is produced. Higher or lower airspeed will require higher power settings and, therefore, increased control forces. At airspeeds above maximum endurance, the greater asymmetry will be largely offset by the additional control power available. Minimum control speed is reached at the point when maximum rudder deflection is no longer sufficient to maintain directional control.

11.4.1.4 Altitude. Net thrust is strongly dependent on altitude. For a constant throttle setting, the asymmetric thrust is considerably higher at sea level than at higher altitudes.

11.4.1.5 Bank Angle. Bank angle increases induced drag and, therefore, requires higher thrust settings to maintain level flight. The higher thrust setting demands increased rudder deflection in a turn compared to that required in level flight at the same airspeed. Turn direction into or away from the failed engine significantly affects rudder requirements. In straight line flight, some amount of rudder deflection will be required to offset the yawing moment from asymmetric thrust at zero bank angle. A 5° bank angle into the good engine will introduce a sideforce component countering the thrust asymmetry and thereby reducing the rudder requirement.

11.4.1.6 Asymmetric Thrust Limiting System. With operative ATLS, the magnitude of any asymmetric thrust in MAX power will be reduced, thereby reducing the control requirements to maintain the flight condition or reducing time to recover if a departure has occurred. ATLS should be engaged from startup to shutdown. ATLS can be turned off if required for tactical considerations such as single-engine ACM bugout.

11.4.2 Engine Stalls and Flameout. The F110 engines demonstrate exceptional operability throughout the flight envelope. No hung stalls have been observed in flight test. Self-clearing pop stalls that produce an audible bang may occur above 35,000 feet when below 100 KIAS in MAX power and usually occur in conjunction with afterburner blowout. To date these stalls have resulted in no engine damage, are self-clearing in approximately 1 second, and have required no pilot action for engine recovery. However, throttles should be reduced to idle when subsonic (MIL when over 1.1 IMN) to minimize the possibility of engine damage during all engine stalls. A supersonic stall may cause inlet buzz resulting in a rough, bumpy ride (+2.5g to –1g at 6 cycles per second). Inlet buzz should subside when decelerating below 1.2 IMN.

When supersonic, any wing drop tendencies should be controlled with lateral stick alone.

11.4.2.1 Medium and High Subsonic Airspeed. Above approximately 100 KIAS, sufficient controllability exists to control a maximum AB stalled engine thrust asymmetry with operating ATLS. Aircraft response to an engine failure is generally mild and is characterized by slow buildup in yaw rate followed by slowly increasing roll-off in the same direction as yaw. This response is insidious since the aircrew will notice primary control to offset yawing movement from asymmetric thrust. Higher airspeeds provide more rudder effectiveness and increase pilot ability to control yaw caused by asymmetric thrust.

WARNING

The use of lateral stick to offset the uncommanded roll caused by yaw from asymmetric thrust at high AOA will generate adverse yaw and aggravate the yaw because of asymmetric thrust. The result may be a yawing, rolling departure. Although DFCS reduces this effect due to differential tail fadeout and automatic stick-to-rudder interconnect functions, departure could still result.

Yaw rate increase after an engine stall or failure may be completely masked by roll if the pilot does not recognize that the engine malfunction has occurred and that aircraft motion is the result of that malfunction. Therefore, when any uncommanded rolloff or yaw rate occurs during maneuvering flight with maximum thrust, the pilot should reduce AOA, reduce thrust, counter with rudder, and avoid the use of lateral stick alone.

11.4.2.2 Low Subsonic Airspeed. As aircraft speed approaches zero, flight control effectiveness also approaches zero and maximum thrust asymmetry could generate a rapid yaw rate buildup if corrective action is not taken. If thrust asymmetry is encountered, the pilot should immediately retard both throttles smoothly to IDLE while maintaining neutral control.

These actions should prevent yaw rate buildup and allow the aircraft nose to fall through and regain flying speed. After throttles are reduced, the pilot should lock his harness in anticipation of possible departure.

WARNING

Loss of thrust on one engine while maneuvering at low airspeed must be dealt with immediately since flight control effectiveness may be insufficient to counter the yaw rate generated by asymmetric thrust.

If both engines are stalled after retarding throttles to IDLE, at least one engine must be secured immediately to prevent turbine damage and provide maximum potential for an airstart. If possible, secure the engine that did not stall initially (the second engine to stall). The cause of the first engine stall may not be known at this point; however, it is possible that the second stall may have been induced during the throttle transient to IDLE. Leaving one engine in hung stall minimizes the likelihood of total loss of hydraulic and electrical power (emergency generator). See Chapter 14 for detailed discussion of compressor stall and airstart emergency procedures.

11.5 HIGH ANGLE OF ATTACK FLIGHT CHARACTERISTICS

Several characteristics of the F–14 affect its behavior in high angle-of-attack flight. Among these are directional stability, dihedral effect, stores loading, the stability augmentation system, and maneuver flaps/ slats.

11.5.1 Directional Stability. Directional stability is the tendency of the aircraft to returned to trimmed, zero sideslip flight when disturbed. At low angle of attack, the aircraft exhibits positive directional stability; if sideslip is generated by a control input or turbulence, the aircraft will return to the trimmed, zero sideslip condition.

As angle of attack increases, directional stability begins to drop and, for clean aircraft, becomes negative at approximately 20 to 22 units AOA. At high AOA, with negative directional stability the aircraft becomes more difficult to fly because the pilot or stability augmentation system must control sideslip with rudder inputs.

11.5.2 Dihedral Effect. Dihedral effect is the tendency of the aircraft to roll in reaction to sideslip being generated. The F-14 exhibits positive dihedral effect throughout the positive AOA envelope (tending to roll away from sideslip), but negative dihedral effect at negative AOA. This tendency is shown by the aircraft response to a rudder input. When right rudder is applied from straight and level flight condition, the aircraft sees sideslip from left and so rolls to the right, or away from the sideslip. Positive dihedral effect is a stabilizing influence in the area of reduced directional stability (high AOA). At negative AOA, dihedral effect is negative such that a right rudder input will produce a left roll. In the PA configuration, negative AOA can be encountered at 1 g flight at the higher limit airspeeds for the configuration.

11.5.3 External Stores. As external stores are added to the aircraft, the high AOA flying qualities degrade because of a decrease in directional stability. Flight tests have shown that no one store is significant by itself. Rather, each store causes a small decrease in directional stability that accumulates as additional stores are loaded. In addition to degrading directional stability, external stores increase aircraft basic weight. As aircraft weight is increased, more AOA is required to produce the same normal acceleration or g. As AOA increases above 12 to 14 units AOA, directional stability decreases. Therefore, external stores may have a two-fold effect on directional stability. DFCS (all SAS On) flight tests at high AOA have shown that no high AOA maneuvering limits are imposed with a fully operational DFCS system. No significant change in flying qualities occurs because of aft cg location.

CAUTION

Maneuvering with significant external store loadings should be approached with caution if the pilot is used to maneuvering the clean aircraft, since the high AOA flying qualities will be degraded from the clean aircraft.

11.5.4 DFCS Stability Augmentation System. The effect of the SAS on aircraft high AOA flight characteristics ranges from minor to very significant. With the PITCH SAS OFF, the nose will be slightly more sensitive during close controlled tasks such as gunsight tracking. During large amplitude maneuvers, slightly higher AOA may be reached. In general, PITCH SAS ON or OFF will not significantly influence departure characteristics or recovery and no limitations concerning its use are necessary. With the ROLL SAS OFF, or with a complete roll SAS failure as indicated by illumination of the ROLL DGR, ARI DGR, and ARI/SAS OUT caution lights, maximum differential tail authority commanded by lateral stick is ±7°. High AOA maneuvering should always be conducted with both the ROLL and YAW SAS ON, as control functions in both axes are required to provide a fully operational UA-ARI. Departure-inducing differential tail inputs are faded out at high AOA, while beneficial coordinating rudder inputs are automatically provided with lateral stick deflection to preserve proper sense roll response throughout the majority of the available AOA range. Roll rate feedback is provided to the roll and yaw axes to damp divergent wing rock above 20 units AOA and improve air-to-air tracking capability. Finally, yaw rate feedback to the differential stabilizer and rudders provides an enhanced departure/spin recovery capability by automatically commanding these control surfaces to oppose yaw rate buildup. Thus, above 30 units AOA and greater than 20° per second yaw rate, 19° rudder opposite and ±5° differential tail into the turn needle are commanded. Unless otherwise noted, the DFCS high AOA flight characteristics discussion assumes both ROLL and YAW SAS are ON.

11.5.5 Maneuvering Flaps and Slats. Maneuver flap and slat extension delays buffet onset below 0.7 IMN, reduces the intensity of the buffet, reduces the effects of adverse yaw at high AOA through increased positive dihedral effect (roll because of sideslip), and increases the sustained g available. Above 0.7 IMN, buffet onset occurs prior to the maneuver-slat extension threshold, but once the slats are fully extended, buffet is reduced. Maneuver slats will not extend above 0.85 IMN because of wing sweep interlocks. Maneuver slats may increase the severity of the wing rock between 20 and 28 units AOA, particularly at low airspeeds. Damping of the wing rock mode is provided by the DFCS. However, in some cases minor wing rock may still develop during sustained high AOA maneuvering, particularly above 30 units AOA. If this occurs, the wing rock may be damped by neutralizing the lateral and directional controls or momentarily reducing AOA to below 20 units. Since maneuver flaps and slat extension and retraction is fully automatic, no changes in high AOA flying techniques are required. Maneuver flaps/slats should be utilized in the auto mode from takeoff to landing.

CAUTION

- Maneuvering with inoperative maneuvering flaps/slats should be approached with caution if the pilot is used to maneuvering the aircraft with automatic flaps/slats, since departure resistance will be degraded from the automatic flap/slat aircraft. If maneuvering flaps/slats are inoperative, maintain coordinated flight with lateral stick inputs and rudder.

- Inoperative maneuver flaps/slats could be indicative of a malfunctioning primary AOA sources.

11.5.6 Lateral Control Reversal. Since roll control is provided by wing-mounted spoilers and differential stabilators, the aircraft exhibits proverse yaw throughout the flight envelope (yaw in the direction of the lateral stick input). The DFCS fades out differential tail inputs at high AOA while providing automatic coordinating rudder inputs through the lateral stick-to-rudder interconnect function (LSRI). Essentially, the DFCS uses lateral stability (dihedral effect) to roll the aircraft at high AOA. Proper sense roll response to lateral stick is generally exhibited up to and beyond 30 units AOA. Other factors such as external store loading, lateral asymmetry, and control surface rigging tolerances may degrade system performance enough to cause neutral to slightly adverse roll response (i.e., roll reversal) above 30 units AOA. Additional pilot coordinating rudder inputs at high AOA can reduce this tendency and improve roll response.

Note

Through use of pilot coordinating rudder inputs, it is possible to command rudder deflection in excess of total control surface authority. If this occurs, the rudder pedal will “kick back” to reduce the pilot’s input while maintaining maximum rudder authority.

At extremely high AOA and low airspeed conditions (above 30 units AOA and less than 0.4 IMN), where rudder effectiveness is significantly reduced due to fuselage blanking effects, adequate roll rate may not be available through the combination of lateral stick and coordinating rudder. In this region, the low speed cross control (LSXC) feature can be utilized to cross control the aircraft (rudder in direction of roll, lateral stick opposite) and obtain a transient roll maneuvering capability. The LSXC permits up to 10° differential tail deflection by overriding the AOA-scheduled differential tail fadeout and LSRI functions. It should be understood that a LSXC maneuver is basically an intentional departure from controlled flight and should not be utilized unless insufficient roll response is obtained with “proper sense” lateral stick and coordinating rudder. However, at these flight conditions the airspeed is low enough that rapid yaw rate buildup is not experienced. If the LSXC input is maintained for a long duration (more than about 3 seconds), a ratcheting roll response will occur causing hesitations in roll rate, bank angle, and yaw rate.

11.5.7 Miscellaneous. Speedbrake position has no effect on high AOA flight characteristics. Wing sweep angles aft of the AUTO schedule reduce buffet intensity, but departure resistance is reduced and more altitude is required for dive pullout when recovering after a departure. Therefore, the AUTO sweep schedule is best for high AOA maneuvering.

11.5.8 Stall Characteristics. The 1 g level stall (maneuver flaps/slats retracted) is characterized by the onset of light airframe buffet at 12 to 13 units AOA. This increases to moderate intensity at 15 units AOA with essentially no change in intensity at AOA as high as 60°. Buffet is not a satisfactory cue to determine airspeed or AOA during high AOA maneuvering. If deceleration is continued to full aft stick deflection, AOA will stabilize at approximately 35° to 45° depending upon stores loading. The cockpit AOA indicator pegs at 30 units AOA, which is equivalent to approximately 25° true AOA. Pitch attitude at stall is between 10° to 20° above the horizon with no external stores and 10° to 15° below the horizon with maximum external load. Some longitudinal porpoising may occur at full aft stick.

Maneuver flaps and slats delay buffet onset to 13 to 14 units AOA and reduce the magnitude of buffet in high AOA flight.

Satisfactory lateral and directional control is maintained beyond the AOA where the basic airframe directional stability becomes negative. Lateral stick and rudder inputs can be used to adjust and maintain desired bank angle throughout the stall. Control inputs are provided to suppress wing rock motion up to 30 units AOA, but some mild wing rock may still occur. Above

30 units AOA, the wing rock suppression feature is inhibited and rudder effectiveness decreases sharply. Large rudder or lateral stick inputs produce an increase in AOA as sideslip increases.

The clean stall is defined as the application of full aft stick combined with rates of descent up to 9,000 fpm. As much as 5,000 feet is required for recovery from the fully developed stall.

11.5.9 Vertical Stalls. If the aircraft is allowed to decelerate to zero airspeed in a vertical or near vertical attitude, it will slide backward momentarily, then pitch over (usually backward) to a near-vertical dive. Aircraft motions during the initial fall will be predominantly inertial with random pitching and yawing as the aircraft accelerates. After the initial nosedown pitch, the aircraft may pass through the vertical to near-level flight attitude, yaw in one direction, and then return to vertical dive attitude. This may occur more than once. This tendency is more pronounced at aft wing sweeps, but can usually be controlled with longitudinal control inputs. Some recoveries may be accompanied by large random yawing and/or rolling motions that will generally dampen without pilot action as the aircraft accelerates. The controls should be released when airspeed decreases below 100 KIAS in the vertical stall to prevent inadvertent inputs that may lengthen recovery time. Control inputs should not be applied until the aircraft is nose down and accelerating. Rudder and lateral stick are also effective in damping oscillations once the aircraft is nose low and accelerating. The aircraft is very responsive to longitudinal stick inputs at all AOAs at speeds above 100 KIAS.

Refer to paragraph 11.4.2.2, Low Subsonic Airspeed, for procedures to follow in the event of an engine stall. Refer to Part V, Chapter 14, for vertical stall recovery procedures.

During flight tests, vertical stalls in maximum afterburner power sometimes resulted in afterburner blowouts on one or both engines possibly followed by pop stalls that may or may not be audible to the pilot. All the stalls were self-clearing with no tendencies for EGT to rise out of limits. As the aircraft recovered and airspeed increased, the afterburner relit if the throttles remained in the afterburner detent. When practicing vertical stalls, basic engine settings are recommended to avoid inducing engine afterburner transients that have unknown effect on engine life. Maximum engine stall margin for the F110 is obtained at IDLE power.

11.5.10 DFCS Degraded Control Modes. The DFCS has the capability to function in several degraded modes of operation. Air sensor data failures, actuator failures, or DFCS computer failures can all affect the high AOA flying qualities of the aircraft. Failure modes, which would significantly affect high AOA flight characteristics, are discussed below. It should be understood that the failures listed do not comprise all possible failure modes, but are examples of those types which would have the most significant effect on high AOA flight.

11.5.10.1 Air Data Failures. Actual air data failures could occur at any point in the flight envelope due to associated failures of the SCADC, AICS, or AOA computer inputs to the DFCS. However, transient or nuisance air data sensor failures due to input miscompares (Mach number or AOA inputs) are more likely to be experienced during maneuvering flight at high AOA than at low AOA or high airspeed conditions. In general, single failures of the air data sensors have negligible or only minor effects on high AOA flying qualities.

Failure of a single AOA input does not result in a functional downgrade, only a loss of redundancy, since the AOA input is triplex. Single failure of the Mach number inputs (SCADC or AICS) will downgrade the UA-ARI to a fixed-gain Mach control mode. In this mode, the wing rock suppression and LSXC control functions are inoperative. Therefore, wing rock tendency will be increased and the aircraft will be difficult to roll above 30 units AOA. The differential tail fadeout, LSRI, and spin recovery functions remain operational.

Dual failure of either the Mach or AOA inputs causes loss of all UA-ARI functions except the spin recovery function. This will cause the aircraft to be more prone to wing rock and less resistant to all types of control-induced and asymmetric thrust induced departures. DFCS spin recovery capability is retained.

11.5.10.2 Actuator Failures. Failure of the pitch series servos or any of the spoiler actuators has little effect on high AOA flight characteristics. Single failure of any roll or yaw series servo will result in degraded UA-ARI performance (i.e., decreased departure resistance, increased wing rock tendency) in the associated axis due to the decreased control authority, however all UA-ARI functions are retained.

Dual failure of both roll or both yaw series servos results in a complete loss of all UA-ARI functions, and significantly degrades the high AOA flying qualities. With a dual roll series servo failure, all roll axis functions are inhibited and the yaw axis downgrades to "basic SAS" mode (loss of ARI functionality). In the event of a DFCS dual roll series servo failure or manually selecting the ROLL STAB AUG switch to OFF, the maneuvering limits described in Chapter 4, "Maneuvering Limits," must be observed. Failure of both yaw series servos, or manually selecting the YAW STAB AUG switch to OFF, inhibits all yaw and roll axis UA-ARI and SAS functions, resulting in a severe degradation in high AOA flying qualities.

WARNING

Maneuvering with YAW SAS OFF or inoperative shall not be conducted above 15 units AOA with landing gear retracted. The aircraft will be prone to departure from controlled flight.

11.5.10.3 DFCS Computer Failures. Each of the three DFCC's contains two distinct computer processors called computing segregations, one "A" segregation and one "B" segregation in each axis. Each segregation commands different series servo and/or spoiler sets. If a computing segregation fails, all actuators commanded by that segregation are rendered inoperative. Similarly, all sensor information associated with that segregation is declared invalid. Functionality loss associated with each of the segregations, and effect on high AOA flying qualities, are discussed below.

Pitch A — Half authority pitch SAS, no inboard spoilers, single AOA failure, single Mach failure. Inoperative wing rock suppression and LSXC functions.

Pitch B — Half authority pitch SAS, no outboard spoilers, single Mach failure. Inoperative wing rock suppression and LSXC functions.

Roll A — Half authority roll SAS/ARI, no inboard spoilers, single AOA failure, single Mach failure. Degraded UA-ARI performance due to loss of the roll A series servo. Inoperative wing rock suppression and LSXC functions.

Roll B — Half authority roll SAS/ARI, single Mach failure. Degraded UA-ARI performance due to loss of the roll B series servo. Inoperative wing rock suppression and LSXC functions.

Yaw A — Half authority yaw SAS/ARI, single AOA failure. Degraded UA-ARI performance due to loss of the yaw A series servo.

Yaw B — Half authority yaw SAS/ARI, no outboard spoilers, single AOA failure. Degraded UA-ARI performance due to loss of the yaw B series servo.

Combined failure of any two segregations results in combined loss of all associated functions, actuators, and in most cases, additional failures. High AOA flying qualities are significantly degraded in all multiple segregation failure cases.

11.6 DEPARTURE FROM CONTROLLED FLIGHT

11.6.1 General. Although the F-14 is an honest aircraft with moderate departure resistance, departures can be induced by large or sustained control inputs that generally feel unnatural to the pilot. Since the aircraft has an essentially unrecoverable flat spin mode, yaw rate must be controlled before it can build and the aircraft transitions to the flat spin mode. In general, departures are characterized by increasing yaw rate with oscillations in roll and yaw. Yaw rate is masked by the roll rate and is not evident to the pilot until approximately 90°/sec yaw rate (2 "eyeball out" g) is reached.

A predominant stability characteristic of the F-14 is positive dihedral effect, which is the tendency for the aircraft to roll to reduce sideslip. This effectively serves to delay yaw rate buildup associated with loss of directional stability at high AOA.

In an upright departure at approximately 50°/sec yaw rate or less, if full forward stick is applied to reduce AOA the aircraft will generally recover. At over 50°/sec yaw rate, lateral/directional control inputs (rudder opposite yaw, lateral stick into yaw) are required to recover the aircraft. If these inputs are not made, the yaw rate will continue to build and the aircraft may enter the flat spin. DFCS will significantly enhance these recovery characteristics.

The time to reach 50°/sec yaw rate after control input or engine failure is very critical. If 50°/sec yaw rate is reached in 5 seconds or less, the pilot may not have enough time to neutralize, analyze, and apply recovery control before the aircraft enters a flat spin (depending on type and severity of departure, altitude and AOA entry, and aircraft configuration). The time to reach 50°/sec yaw rate for various aircraft configurations as a result of lateral stick or cross-control inputs is presented in Figure 11-1 and Figure 11-2. These figures are applicable to DFCS with ROLL SAS OFF or a complete roll axis failure as indicated by illumination of the ROLL DGR, ARI DGR, and ARI/SAS OUT caution lights. Generally, the most severe departures are induced through the differential tail, which is commanded by lateral stick. Rudder inputs, asymmetric thrust, and inertia coupling can cause or contribute to the severity of departures.

In addition to the enhanced departure resistance, the DFCS automatically provides anti-spin rudder and differential tail inputs to the maximum roll and yaw SAS authority limits as a function of yaw rate. This increases aircraft spin resistance. Flight tests indicate that the aircraft will recover from high yaw rates without pilot-commanded lateral/directional control inputs, due to these automatic rudder and differential tail inputs. Refer to paragraph 11.6.9 for discussion of departure recovery characteristics.

11.6.1.1 Mach and AOA Effects. As Mach number increases, flight control-induced departure susceptibility and severity increases. Generally, as AOA increases, the severity of the departure increases. For example, a lateral stick input at 0.9 IMN, 30 units AOA, will produce a more violent departure than the same input at 0.9 IMN, 20 units AOA. The one exception is rudder induced departures. As AOA is increased to about 30° (over 30 units AOA), rudder effectiveness decreases as the rudder is washed out and rudder-induced departures become less severe.

11.6.1.2 Maneuver Flaps/Slats. Extended maneuver flaps and slats can significantly decrease departure susceptibility and severity through increased positive dihedral effect.

11.6.1.3 External Stores. As external stores are added, departure susceptibility and severity increase. No one store is significant in and of itself. Rather, each store causes a small degradation in flying qualities that accumulates as additional stores are added. In general, fuselage-mounted stores have less effect than pylon or nacelle-mounted stores.

11.6.1.4 Asymmetric Fuel/Stores. Flying qualities with asymmetric stores are most affected by the store weight imbalance which results in a redistribution of lateral control power (differential tail) due to the trim required. There are no significant differences due to aerodynamic asymmetries at high AOA. Therefore, rudder inputs generate similar aircraft response both into and away from the store(s). However, the aircraft response to large lateral stick inputs, at AOA's where lateral stick generates a roll response opposite to the direction of the input (roll reversal AOA), can vary significantly from the symmetric stores case depending on the amount of store asymmetry.

The maximum asymmetry which has been flight tested thus far is 189,000 in-lbs, which resulted in a lateral trim bias of 40 to 90 percent of available trim authority, depending on trim airspeed. This asymmetry is equivalent to a 900-pound wing fuel split.

Due to the lateral trim required to offset the asymmetry, the amount of lateral stick displacement (and therefore differential tail) which can be commanded from the trimmed stick position is greater into the store asymmetry than away from the asymmetry. Aircraft response to large lateral stick inputs is thus amplified for stick deflections into the stores and reduced for stick deflections away from the stores.

Lateral stick-induced departures are caused by the inadvertent application of differential tail at high AOA. The greater the amount of differential tail commanded, the greater the aircraft response, and potentially the more severe the departure. Since the direction of a laterally induced departure is opposite to the direction of the lateral stick input, departures away from the store asymmetry can be more severe. For example, a right-wing heavy aircraft will depart faster in the nose-left direction. The degree of this asymmetric response varies in proportion to the amount of asymmetry, and also the magnitude and duration of the control input. This same effect is present during the use of cross controls (rudder in direction of roll, lateral stick opposite) to further augment roll response of the aircraft at high AOA and can lead to potentially more severe departures. Caution should be exercised when cross-controlling to increase high AOA roll response away from the store asymmetry. Use of cross controls to roll into the store asymmetry will be less effective than normal.

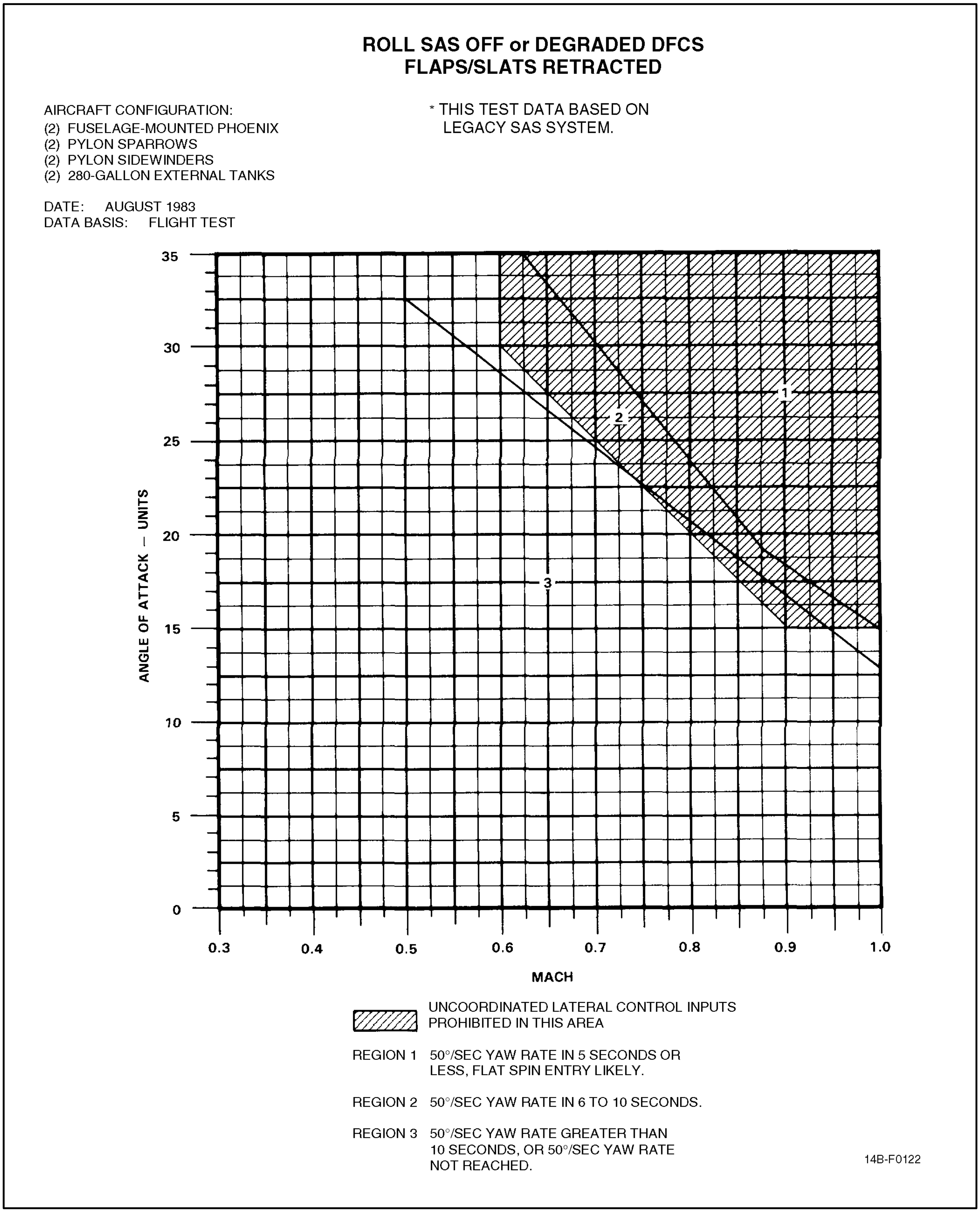


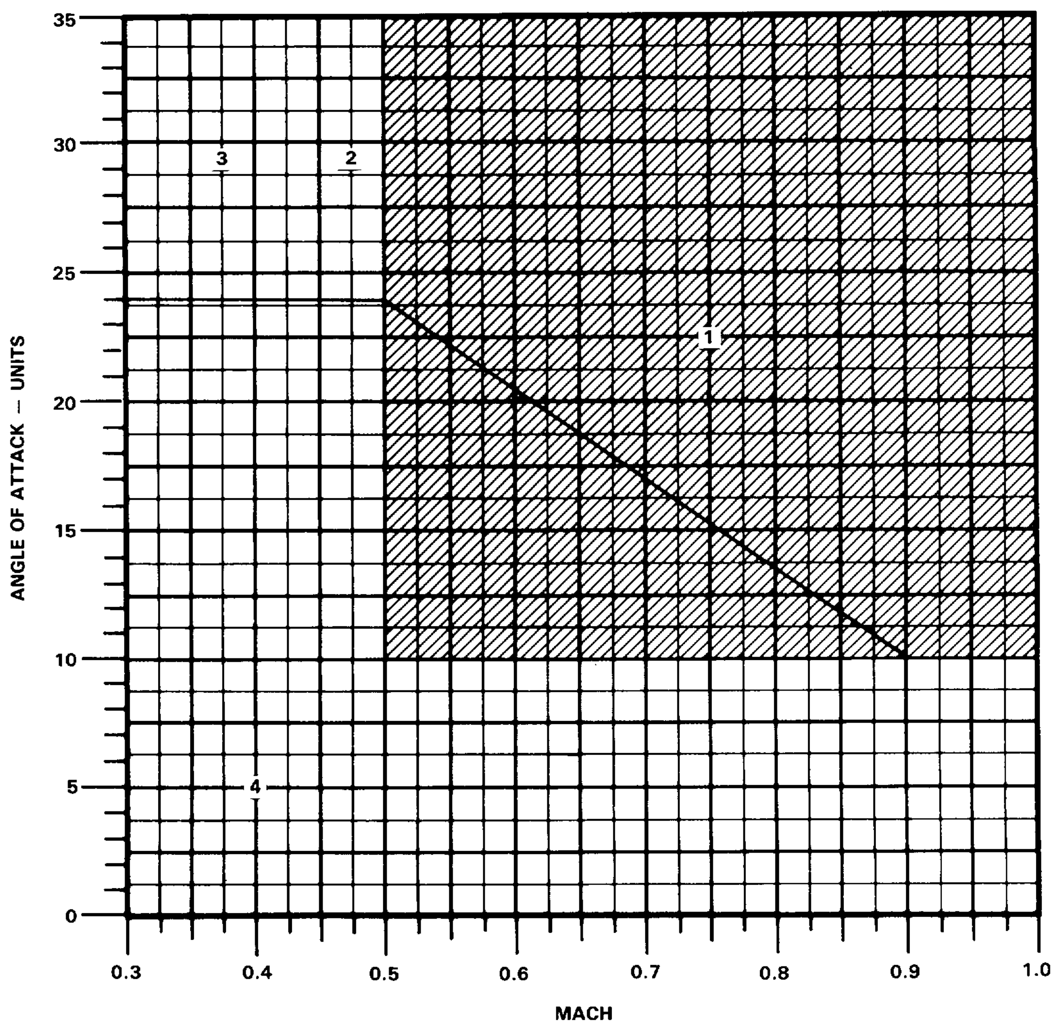
Figure 11-1. Lateral-Control-Induced Departure Areas

ROLL SAS OFF or DEGRADED DFCS
FLAPS/SLATS AUTO OR RETRACTED

AIRCRAFT CONFIGURATION: :
(2) FUSELAGE-MOUNTED PHOENIX
(2) PYLON SPARROWS
(2) PYLON SIDEWINDERS
(2) 280-GALLON EXTERNAL TANKS

DATE: AUGUST 1983
DATA BASIS: FLIGHT TEST

* THIS TEST DATA BASED ON LEGACY SAS SYSTEM



CROSS CONTROL INPUTS PROHIBITED IN THIS AREA.

REGION 1 50°/SEC YAW RATE IN 5 SECONDS OR LESS, FLAT SPIN ENTRY LIKELY.

REGION 2 50°/SEC YAW RATE IN 6 TO 10 SECONDS.

REGION 3 50°/SEC YAW RATE IN 11 SECONDS OR MORE, OR 50°/SEC YAW RATE NOT REACHED.

REGION 4 NOT TESTED

14B-F0123

Figure 11-2. Cross-Control-Induced Departure Areas

11.6.2 Lateral Stick-Induced Departures. Roll and yaw in direction of lateral stick command is typically retained up to 30 units AOA, due to the combined effects of differential tail fadeout and stick-to-rudder interconnect functions provided by DFCS. Maximum roll rate commanded by lateral stick decreases as AOA increases, decreasing to near zero above 30 units AOA without pilot commanded coordinated rudder inputs. Some variation in AOA at which neutral roll response occurs and/or mild roll reversal may be expected due to effects of external stores, wing fuel state, or flight control system rigging tolerances. During flight tests, only mild roll reversal departures were experienced. These departures were characterized by a mild roll and yaw opposite the lateral stick command. With maneuver flaps retracted, there was no appreciable degradation in departure resistance. No high AOA maneuvering restrictions regarding lateral stick inputs are required for flight with a fully operational UA-ARI.

11.6.3 Rudder Induced Departures. Full rudder inputs at high AOA produce a roll and yaw rate in the direction of the rudder input. At moderate AOA (approximately 15 to 25 units), this response is oscillatory and a definite hesitation in roll and yaw rate will be noted for long duration inputs. Inertia coupling effects will also cause pitch rate and AOA oscillations. As AOA increases to 30 units, the response is less oscillatory but remains in the direction of the rudder input. Above 30 units, rudder effectiveness is significantly reduced and little response is obtained from a full rudder input. The departure resistance features of the UA-ARI limit maximum yaw rate to less than 50°/sec over the majority of the high AOA flight envelope. However, at airspeeds above approximately 250 KIAS and low to moderate AOA (less than 25 units), rapid yaw acceleration can occur in response to a sustained full rudder input such that 50°/sec yaw rate can be initially exceeded. Flight test data indicate that yaw rates decreased to less than 50°/sec even when sustained full rudder inputs were maintained for 10 sec. Roll response using lateral stick alone in this airspeed and AOA range is typically sufficient, such that large rudder inputs should not be required to obtain desired roll performance.

CAUTION

Sustained large rudder inputs at high airspeeds (above 250 KIAS) can cause high yaw acceleration and yaw rate.

11.6.4 Multi-Axis Control-Induced Departures. Combined lateral stick and rudder control inputs can produce oscillatory aircraft response and high yaw rates at some flight conditions.

11.6.4.1 Cross Control-Induced Departures. Sustained cross control inputs produce oscillatory roll and yaw rates in the direction of the rudder input. The amplitude of the oscillations decreases as AOA increases. Differential tail fadeout and lateral stick to rudder interconnect functions limit maximum control authorities to ±2° diff tail and ±11° rudder, causing maximum yaw rate to remain below 50°/sec at all flight conditions. At very low airspeed and high AOA flight conditions (less than 0.4 IMN and above 30 units AOA), the low speed cross control function (LSXC) is enabled to provide a transient roll and yaw maneuvering capability. LSXC permits the pilot to command up to ±10° differential tail and ±30° rudder deflection during cross control maneuvers. Peak roll rate of approximately 60°/sec is available through the use of LSXC. If long duration inputs are utilized, the roll response will become oscillatory, with hesitations in bank angle and roll rate. Precise bank angle control is typically not possible with LSXC, but the feature can be effectively utilized during sustained slow speed/high AOA maneuvering such as a flat scissors engagement. The spin recovery function will start to reduce these control authorities at approximately 20°/sec yaw rate and will apply the maximum reduction in control authority back to the ±2°/ ±11° limits at approximately 25°/sec yaw rate to preserve departure resistance.

11.6.4.2 Coordinated Control-Induced Departures. During flight tests, full sustained coordinated lateral stick and rudder inputs produced high roll and yaw rates in the medium to high airspeed regime (above 250 KIAS) at low to moderate AOA (less than 25 units). However, no tested condition resulted in sustained yaw rate above 50°/sec. The roll and yaw rates are in the direction commanded and produce highly oscillatory, potentially disorienting motion with significant nose-up coupling in the pitch axis. At these flight conditions, roll response due to a pure lateral stick input (no pilot-commanded coordinating rudder) is satisfactory and additional coordinating rudder should not be required to obtain desired roll performance. At lower airspeeds and/or increased AOA, coordinated lateral stick and rudder inputs produced a smoother, less oscillatory roll and yaw response. In this flight regime, coordinating rudder can be used to supplement lateral stick for increased roll rate.

CAUTION

Sustained large rudder inputs at high airspeeds (above 250 KIAS) can cause high yaw acceleration and yaw rate.

11.6.5 Asymmetric Thrust-Induced Departures. Asymmetric thrust-induced departures are similar to those induced by the flight controls. At high altitude (greater than 20,000 feet), asymmetric thrust results in a mild departure characterized by mild roll and yaw rates into the dead engine if the airspeed is above 100 KIAS. The yaw rate is usually masked by the roll rate. If no pilot action is taken, the aircraft usually stabilizes at some moderate yaw rate from which recovery is easily accomplished. On occasion, the yaw rate will continue to increase slowly, taking 20 seconds or more to reach 50° per second. At lower altitudes (15,000 feet), yaw rate may reach 50° per second in 10 seconds because of increased thrust asymmetry. Departures induced by asymmetric thrust alone below 100 KIAS or when airspeed drops below 100 KIAS in the departure are characterized by mild roll and a smooth gradual increase in yaw rate that will attain values well over 50° per second. The DFCS spin recovery function automatically commands recovery differential tail and rudder inputs to oppose yaw rate buildup and reduces the severity of asymmetric thrust induced departures. These inputs are most effective if airspeed remains above 100 KIAS. Departures induced by asymmetric thrust are still capable of reaching 50°/sec yaw rate at low altitudes, however, the yaw rate onset is much less severe, allowing the pilot more time to counter rate.

CAUTION

The pilot's natural tendency is to oppose uncommanded roll with lateral stick, but this can aggravate the departure.

During maneuvering flight, uncommanded roll should be countered by rudder and a reduction in AOA. DFCS automatically provides coordinating rudder with lateral stick deflection which decreases departure susceptibility. See additional discussions on asymmetric thrust flight in this chapter.

11.6.6 Accelerated Departures. Accelerated departures are initially characterized by a rapid increase in lateral acceleration, but may become violently oscillatory about all three axes. Flight tests with legacy SAS (pre-DFCS) have shown aircraft rates in excess of 120° per second in roll and 70° per second in yaw. Pitch rates oscillate up to ±30° per second and lateral acceleration oscillates up to ±0.8g. These oscillations may cause pilot disorientation, and proper recovery controls may not be obvious. If this occurs, the proper response would be to neutralize rudders and lateral stick, apply forward longitudinal stick, and lock shoulder harness. Recovery indications should become apparent within two turns.

11.6.7 Inertia Coupling. Coupling occurs when motions in more than one axis interact. Combined motion in two axes will always result in motion in the third axis. The F-14, like all high performance aircraft capable of producing high-rate, multiple axis motion is susceptible to coupling. High rate, multiple axis motions, particularly at high AOA, can produce violent coupled departures. In flight tests with legacy SAS (pre-DFCS), a guns-defense/collision-avoidance maneuver using full rudder followed by full coordinated lateral and aft stick produced violent coupled departures with up to 66° per second yaw rate in less than 2 seconds. Yaw rates of this magnitude require prompt positive recovery inputs by the pilot. External stores contribute to the severity of the departure by decreasing directional stability and increasing inertia. This departure mechanism is essentially identical in DFCS equipped aircraft. Most coupled departures in the F-14 are induced by combined high pitch and roll rates (causing a rapid departure in yaw). Typically, these departures are initiated at comparatively low AOA (below 15 units) where the aircraft is capable of generating both high pitch and roll rates. It should be noted that since the roll SAS will remain ON, this will provide increased roll control authority throughout the flight envelope.

Note

In flight tests, the DFCS did not prevent this type of departure from occurring. However, the DFCS spin recovery function prevented excessive yaw rate buildup.

No DFCS flight test departure maneuvers exceeded 70°/sec yaw rate, preventing rapidly increasing yaw rate and progression into the flat spin mode following this type of departure.

WARNING

Avoid high-rate, multiple-axis motion because of possible violent departure.

11.6.8 Departure Recovery. Before recovery controls are applied, the crew must analyze flight conditions to determine the departure mode entered. The turn needle indicates only the direction of yaw and not magnitude of yaw rate, since it pegs at 4°/sec yaw rate. An upright departure is indicated by AOA pegged at 30 units; an inverted departure by AOA of 0 units. Generally, an increasing airspeed and AOA sustained between 0 and 30 units is indicative of a recovery as is positive aircraft reaction to pilot control inputs.

11.6.9 Upright Departure Recovery. Recovery from upright departures is positive and generally rapid. The high control power that allows the pilot to depart the aircraft also enables the pilot to recover when controls are properly applied and sufficient altitude is available for recovery

Successful upright departure recovery depends on recognition of the departure from controlled flight, application of appropriate recovery control inputs, and subsequent recognition of when the aircraft has recovered. Departure from controlled flight is usually characterized by an uncommanded roll/yaw or an abrupt noseslice or nosepitch. Common examples of these motions are lateral control reversal at high AOA or uncommanded roll and yaw resulting from asymmetric thrust. When appropriate recovery controls are applied and maintained as discussed in detail below, recovery from an upright departure will be indicated by decreasing yaw rate, decreasing AOA, and increasing airspeed. The decrease in AOA and increase in airspeed during recovery will be evident to the pilot by the aircraft response to control inputs. The aircraft may stop rolling because of sideslip and begin to roll because of differential tail commanded by the pilot or DFCS for recovery from higher yaw rate departures. A nosedrop and associated unload may occur, and the roll rate may increase under these conditions.

Note

The most important action of any upright departure recovery is reducing the AOA. This is enhanced by timely application of forward stick and countering the yawing motion of the aircraft with rudder.

If the AOA is pegged at 30 units or increasing rapidly, smoothly apply forward stick as required to reduce AOA. Full forward stick may be required. In an upright departure where less than 50°/sec yaw rate is observed, if full forward stick is applied to reduce AOA, throttles are retarded to idle, and rudder is applied opposite the yaw direction, the aircraft will generally recover, as shown in Figure 11-3. Cockpit indications of yaw direction are the pilot turn needle and the PTID spin arrow (Figure 11-4). Refer to paragraph 11.6.9.1 for a detailed discussion of spin arrow operation. An additional noninstrument indication of yaw direction is the roll direction. In an upright departure, the aircraft yaw rate is in the same direction as the roll rate. Typically, roll rate is much more evident to the pilot than yaw rate. The turn needle and PTID spin arrow may be backed up by referencing the roll direction.

Reducing thrust asymmetry during recovery by retarding the throttles to IDLE removes any possible thrust asymmetry, places the engines in the region of greatest stall margin, and reduces time to recover. Maintaining a thrust asymmetry, particularly with the good engine in MAX A/B, will delay recovery at high altitudes and may prevent recovery at low altitudes since the flight controls may not be powerful enough to overcome asymmetric thrust. Asymmetric thrust has its greatest effect upon upright departure recovery at low airspeed, where flight controls are not as effective, and low altitude, where asymmetric engine thrust is the where flight controls are not as effective, and low altitude, where asymmetric engine thrust is the largest.

WARNING

Retarding throttles to idle during a departure or high AOA maneuvering may induce a compressor stall on the operating engine. If both engines are stalled, one engine must be immediately secured (while maintaining the correct departure/spin recovery inputs) to prevent turbine damage and provide maximum potential for a successful airstart.

Recovery from slightly higher yaw rates (approximately 60 to 70°/sec) is possible with forward stick and opposite rudder alone, due to the automatic anti-spin differential tail and rudder inputs provided by the spin

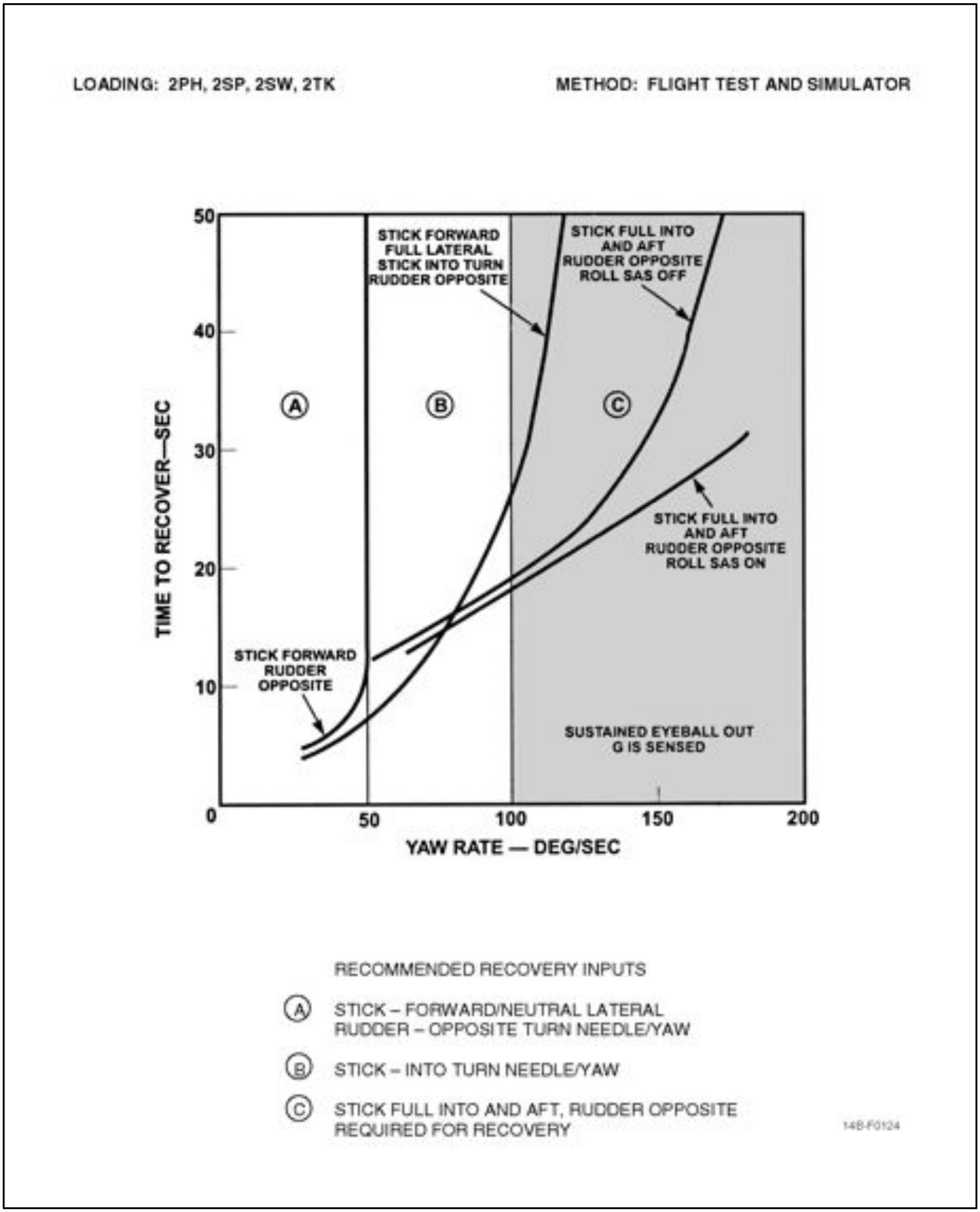


Figure 11-3. F-14 Upright-Departure Recoveries

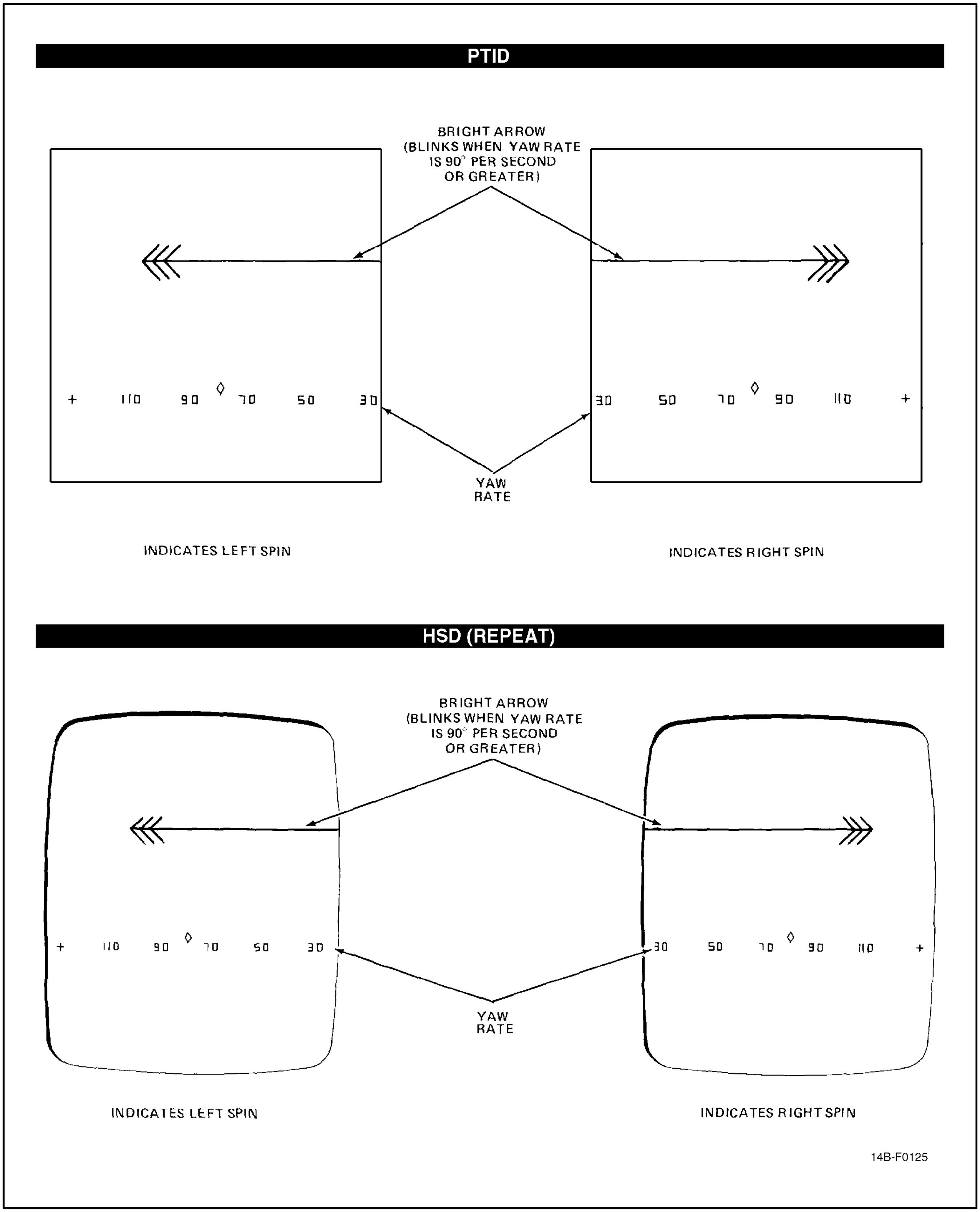


Figure 11-4. Spin Display

recovery function. Above these yaw rates, additional pilot-commanded lateral stick into yaw rate/turn needle will likely be required to recover the aircraft. Yaw rates of 100°/sec or more can be identified by sustained eyeball-out g. During recovery from departures where yaw rates of 50 to 100°/sec are experienced, the aircraft may stop rolling because of sideslip and begin to roll because of differential tail commanded by the pilot or DFCS for recovery. A nosedrop and an associated unload may occur. These are indications of a positive recovery in progress.

During flight tests with DFCS, a sustained mild "auto-roll" tendency was exhibited during recovery from some intentional departure maneuvers. This motion typically occurred when the pilot failed to input enough forward stick to reduce and maintain AOA below 20 units. With neutral controls or slightly forward stick only (no pilot rudder or lateral stick input), the aircraft can continue to roll and yaw mildly in the direction of the original departure. These rates are approximately 40°/sec in roll and 20°/sec in yaw. AOA is sustained between 20 and 25 units. Aircrew should recognize that the departure is substantially recovered at this point, as indicated by the sustained AOA below 30 units, blanked spin arrow, and a nose low attitude with increasing airspeed. Any subsequent positive pilot control input will cause the aircraft to cease the auto-roll motion. This can be accomplished by applying enough forward stick to reduce and maintain AOA below 20 units, applying opposite rudder and/or lateral stick, or a combination of any of these three inputs.

Once recovery indications from a low yaw rate departure (less than 50°/sec) are verified, the forward longitudinal stick should be relaxed to maintain 17 units AOA, which will minimize altitude loss for recovery and avoid negative g as airspeed builds. Rudders should be neutralized as rotation stops. As recovery from higher yaw rate departures is indicated, the lateral stick that was held into the turn direction should be neutralized, and the forward longitudinal stick should be relaxed to minimize altitude loss for recovery and avoid negative g as airspeed builds. The aircraft is very responsive to longitudinal stick inputs at all AOA at speeds above 100 KIAS. Pullout should be accomplished at 17 units AOA. Rudder may be used to counter any remaining roll and yaw oscillations.

Centrifuge tests indicate the pilot begins to sense eyeball-out g at about 2g, which occurs at approximately 90 to 100°/sec yaw rate. If sustained eyeball-out g is sensed, it is likely that 100°/sec yaw rate has been exceeded and optimum recovery controls are full rudder opposite the yaw rate/turn needle, full lateral stick into the turn needle and as much aft stick as possible (while maintaining full lateral stick. The DFCS provides the capability to command full ROLL SAS ON differential tail authority for recovery as a basic feature of the UA-ARI. Refer to Chapter 14 for upright departure/flat spin emergency procedures. Recovery controls should be applied and maintained until recovery is indicated, ejection is reached, or increasing eyeball-out g threatens aircrew incapacitation.

As yaw rate decreases during recovery from very high yaw rate departures (above 100°/sec, or where sustained eyeball-out g is sensed), the aft and full lateral stick recovery controls result in somewhat different recovery characteristics. If these recovery controls are maintained below a yaw rate of approximately 100°/sec, large AOA oscillations may be experienced as well as oscillations in roll and pitch. The overall recovery may feel very rough and oscillatory. If these recovery controls are maintained below approximately 80°/sec, recovery will be delayed and the potential for a yaw rate reversal and progressive departure in the opposite direction is greatly increased. For these reasons, the control stick that was maintained aft and into the turn should be moved forward and into the turn when sustained eyeball-out g is no longer sensed or spin arrow yaw rate has decreased below 100°/sec. Further recovery can then be accomplished as previously described.

WARNING

Maintaining aft and lateral stick recovery controls below approximately 100° per second yaw rate can result in large AOA excursions and oscillations in roll and pitch that may complicate recognition of recovery from an upright departure and delay recovery. Maintaining these controls below approximately 80° per second will delay recovery and increase the potential for a yaw rate reversal and progressive departure in the opposite direction.

11.6.9.1 PTID Spin Arrow. The spin arrow display (Figure 11-4) is available to the pilot only with PTID REPEAT selected. The spin arrow display will not override ECM or NAV display selections on the HSD. At yaw rates over 30° per second, the PTID display is blanked and the spin arrow appears pointed in the direction of yaw. If the yaw rate exceeds 90° per second, the spin arrow will flash at a 4-times-per-second rate. A fixed scale from 30° to 110° per second increasing in the direction of yaw in increments of 20 will be displayed below the spin arrow. A diamond will be positioned above the numbers to indicate the existing yaw rate. For yaw rates in excess of 110° per second, the diamond will travel past 110 and will be positioned over a "+" sign.

Note

The primary reference for the spin arrow is the INS, which is valid for yaw rates up to 160° per second. The AHRS, the backup reference, has a hardware limitation of 55° per second.

If the IMU and the AHRS or the CSDC fail while the spin arrow is displayed, the spin arrow will remain on the PTID and a breakaway "X" will replace the yaw rate indication. If the IMU and AHRS or the CSDC fail prior to entering high yaw rates (greater than 30° per second), the spin arrow will not appear on the PTID.

The algorithm that provides yaw rate and direction-of-turn information for the spin arrow displays has not been flight-test validated at all aircraft attitudes and rates. Hence, the spin arrow may not operate properly at extreme aircraft attitudes and rates. The spin arrow has operated properly, providing accurate yaw rate and direction information to the aircrew, during flight test where nominal aircraft departures were encountered.

11.6.10 Flat Spin. The only true, upright, fully developed spin in the F-14 is the flat spin. It is recognized by the flat aircraft attitude (approximately 10° nose down with no pitch or roll oscillations), steadily increasing yaw rate, and high longitudinal acceleration (eyeball-out g). It may develop within two to three turns following a departure if yaw is allowed to accelerate without rapid, positive steps to effect recovery. High yaw rate departures are usually induced by aerodynamic controls, resulting in inertia coupling and possibly aggravated by a thrust asymmetry. The aircraft may first enter an erect oscillatory spiral as airspeed rapidly decreases. Frequent hesitations in yaw and roll may occur as yaw increases. The turn needle and the PTID displayed arrow are the only valid indications of yaw and spin direction as they always indicate turn direction correctly, whether erect or inverted. AOA will peg at 30 units, and airspeed will oscillate between 0 and 100 knots. The aircraft may also depart by entering a coupled roll where yaw rate may build up without being noticed to the point that, when roll stops, yaw rate is sufficient to sustain a flat spin. A large, sustained thrust asymmetry at low airspeed (particularly at low altitude) may also produce sufficient yaw rate to drive the aircraft into a flat spin if proper recovery controls are not used. In all instances, proper recovery should be accomplished by prompt application of departure recovery procedures to reduce angle of attack and control yaw.

Regardless of the method of entry, once the flat spin has developed, the flat aircraft attitude (10° nose down), steadily increasing yaw rate, and buildup of longitudinal g forces not accompanied by roll and/or pitch will be apparent to the flightcrew. AOA will be pegged at 30 units, yaw rate will be fast (as high as 180° per second), and altitude loss will be approximately 700 feet per turn. Longitudinal acceleration (eyeball-out g) at the pilot station will be 5.5g to 6.5g and at the RIO station, 3.5g to 4.5g. Time between aircraft departure and flightcrew recognition of a fully developed flat spin depends on the nature of the entry (accelerated departure, low-speed stalled engine, etc.). The time between recognition of a flat spin and buildup of incapacitating longitudinal g forces is dependent on aircraft loading, thrust asymmetry, flight control position during spin entry, locked or unlocked harness, tightness of the lap restraints, and flightcrew physical condition and stature. Test data indicate that following recognition of a flat spin, the pilot may be able to maintain antispin controls for 15 to 20 seconds (approximately 7 to 10 turns) but may severely jeopardize his ability to eject because of the incapacitation that occurs as the g forces build. Consistent F-14 flat-spin recovery procedures have not been demonstrated; therefore, once the aircraft is confirmed to be in a flat spin, the flightcrew should jettison the canopy and eject. This decision should not be delayed once the flat spin is recognized.

It is important to understand that longitudinal g forces can be present in accelerated departures from controlled flight and ejection initiated solely because of longitudinal g forces is premature.

To preclude premature ejection from a recoverable aircraft, verify that the aircraft is not rolling or oscillating in pitch or is not in a coupled departure. If any of these characteristics is evident, then a flat spin has not developed and departure recovery procedures should be continued.

11.6.11 Negative AOA Departures. During flight test, a negative AOA departure mode has been experienced. Cross-control inputs in the low to medium Mach (less than 0.6 IMN) and low to medium AOA (AOA less than 25 units) area resulted in rapid transition to negative AOA with up to 2.5 negative g. Inertia coupling effects will cause a nose-down pitch and AOA decrease any time roll and yaw rates are generated in opposite directions. A cross control input at low AOA, where the aircraft still rolls in the direction of lateral stick, is capable of producing this type of motion. The motion is very disorienting, uncomfortable, and confusing. Neutralizing controls would produce a recovery from this departure; use of aft stick would speed recovery.

CAUTION

Use of cross-control in the low to medium Mach (less than 0.6) and low to medium AOA (AOA less than 25 units) may result in negative AOA departures.

11.6.12 Inverted Stall/Departure. As in normal stall approaches, there is no clearly defined inverted stall. A moderate rate application of full forward stick in inverted flight results in a negative AOA of about –30°.

CAUTION

Dynamic forward stick inputs of moderate rate may exceed the negative-g limit of –2.4g. Indicated AOA will show zero beyond about –5° true AOA.

Dihedral effect is negative at negative AOA. Therefore, a right rudder input produces right yaw, but left roll. This feels natural to the pilot in inverted flight and enables raising a wing with opposite rudder when inverted. At negative AOA, oil pressure will indicate zero and illuminate the OIL PRESS caution light and MASTER CAUTION light.

WARNING

Zero-g or negative-g flight in excess of 10 seconds in afterburner or 20 seconds in military power or less depletes fuel feed tanks (cell Nos. 3 and 4), causing flameout of both engines.

Recovery from an inverted stall is performed by applying full aft stick, while neutralizing lateral stick, to return to positive g flight. Recovery from negative-g conditions will usually occur immediately. Return to level flight can then be performed from the resultant nosedown attitude by rolling erect with rudder and/or lateral stick and pulling out at 17 units AOA.

Excessive negative-g maneuvering can also exceed the aircraft lift limit and cause departure. Aircraft motion following departure will be very erratic and disorienting; any induced yaw rate can result in upright or inverted spin entry. Aircraft at high gross weights with external tanks and stores require a relatively minor negative load to induce this type of departure.

WARNING

Negative-g maneuvering at high gross weights should be avoided because of a high probability of departure.

11.6.13 Inverted Spin. An inverted spin may be encountered if the aircraft unloads while there is a yaw rate present. In flight tests, the inverted spin has been caused by holding full forward stick while inverted, applying full rudder, and holding this combination through 360° of roll. Prospin controls need not be held to maintain the aircraft in a spin. The inverted spin is primarily identified from cockpit instruments by less than zero g and an AOA of zero units. Since the inverted spin is quite disorienting, spin direction must be determined by observing the turn needle deflection. Altitude loss during the inverted spin is 800 to 1,800 feet per turn and time per turn is 3 to 6 seconds. Nose attitude in the inverted spin is approximately 25° below the horizon. Warning of possible inverted spin usually occurs sufficiently in advance for the aircrew to take corrective action. Warning is usually very noticeable in the form of a nosedown pitch (negative g) with a yawing and possible rolling motion that is quite uncomfortable to the aircrew. In the fully developed inverted spin, rudder opposite yaw/turn needle is the strongest antispin control. Aft stick is a strong antispin control during the incipient spin phase and a weak antispin control in the inverted spin. In the absence of asymmetric thrust, the antispin control inputs will recover a fully developed inverted spin within one turn. Lateral stick opposite yaw is an antispin control; however, it is not included in the recovery procedures because opposite rudder recovers the aircraft so effectively. If opposite rudder and lateral stick are used, the recovery would occur very rapidly and a postrecovery departure in the direction of stick and rudder would be highly probable. Refer to Chapter 14 for inverted departure/spin procedures.

11.7 TAKEOFF AND LANDING CONFIGURATION FLIGHT CHARACTERISTICS

11.7.1 Baseline Flight Characteristics. The aircraft exhibits a sluggish pitch response to longitudinal stick inputs. Frequent power adjustments are required in conjunction with longitudinal stick inputs to properly maintain glideslope on approach. DLC is very effective for making glideslope corrections while at the same time minimizing the need for nose movement and/or power corrections. During full flap takeoffs, more longitudinal stick is required to rotate the aircraft as compared to either the flaps up or maneuver flap takeoff configurations. Pitch sensitivity and over-rotation tendency is more pronounced with maneuver flaps or flaps up, particularly with aft CG locations.

The PA-ARI control functions combine to provide a crisp roll response and essentially deadbeat Dutch roll damping. Additionally, the PA spoiler gearing relationship is modified to eliminate the non-linear roll response by moving the spoiler breakout point to only one-tenth inch lateral stick deflection. The aircraft is very responsive to lateral inputs and some tendency to overcontrol bank may be experienced. The DFCS also provides automatic coordinating rudder inputs with lateral stick deflection such that the vast majority of lateral corrections can be made with “feet on floor.” An undesirable by-product of this improved coordination is a minor pitch-up in response to moderate to aggressive lateral inputs, which requires pilot compensation to maintain constant AOA. This effect is more pronounced with DLC off. Finally, DFCS neutrally dampens the spiral mode such that the aircraft will tend to hold a constant bank angle once established in a turn.

11.7.2 Crosswind Landings. Crosswind landings may be accomplished using either the sideslipped or crabbed technique, up to the crosswind limit (20 knots). The PA-ARI roll rate command function and revised spoiler gearing affect crosswind landing flight characteristics. The DFCS commands roll SAS inputs to achieve a commanded roll rate which is proportional to the pilot’s lateral stick input. During a sideslipped approach (“wing down, top rudder”), the pilot applies a constant lateral stick input which is not intended to command roll rate, in order to hold the aircraft in a steady slip. To accommodate this technique, roll SAS inputs are faded out as the pilot applies rudder pedal. However, the spoiler gearing schedule results in nearly immediate spoiler breakout with lateral stick deflection from trim (0.1 inch lateral stick input). This spoiler breakout may result in an unpredictable or overly sensitive roll response during tightly-controlled tasks such as fine lineup corrections late in the approach. Because crabbed approaches are flown without this offset lateral stick input and do not exhibit this characteristic, pilots may find this technique easier. Method of crosswind approach is pilot’s option.

11.7.3 Normal Stalls. During deceleration in a level, 1g stall approach, light buffet starts at about 19 units AOA. Buffet does not significantly change thereafter as the AOA is increased and provides no usable stall warning. For this reason, with the landing gear handle down, DFCS incorporates rudder pedal shaker beginning at approximately 21 units AOA to alert the pilot. A reduction in stick force is felt between 24 and 28 units AOA. At 25 units AOA, divergent wing rock and yaw excursions define the stall. Sideslip angle may reach 25° and bank angle 90° within 6 seconds if the AOA is not lowered. Lateral stick inputs result in significantly reduced adverse yaw and continue to provide excellent roll response up to 25 units AOA. Above 25 units, the ARI is disabled and DFCS control laws revert to basic SAS in each axis. Extending the speedbrakes slightly aggravates the stick force lightening at 24 units AOA but improves directional stability significantly, reducing the wing rock and yaw tendency at 25 units AOA. Stall approaches should not be continued beyond the first indication of wing rock. When wing rock occurs, the nose should be lowered and no attempt should be made to counter the wing rock with lateral stick or rudder. Stalls with the landing gear extended and flaps up are similar to those with flaps extended. Buffet starts at 16 to 18 units AOA and wing rock at 26 units AOA. Figure 11-5 shows stall speeds for standard day temperature at sea level with slats/flaps extended and gear down.

Note

Maximum allowable AOA gear down is 20.6 units below 5,000 feet AGL.

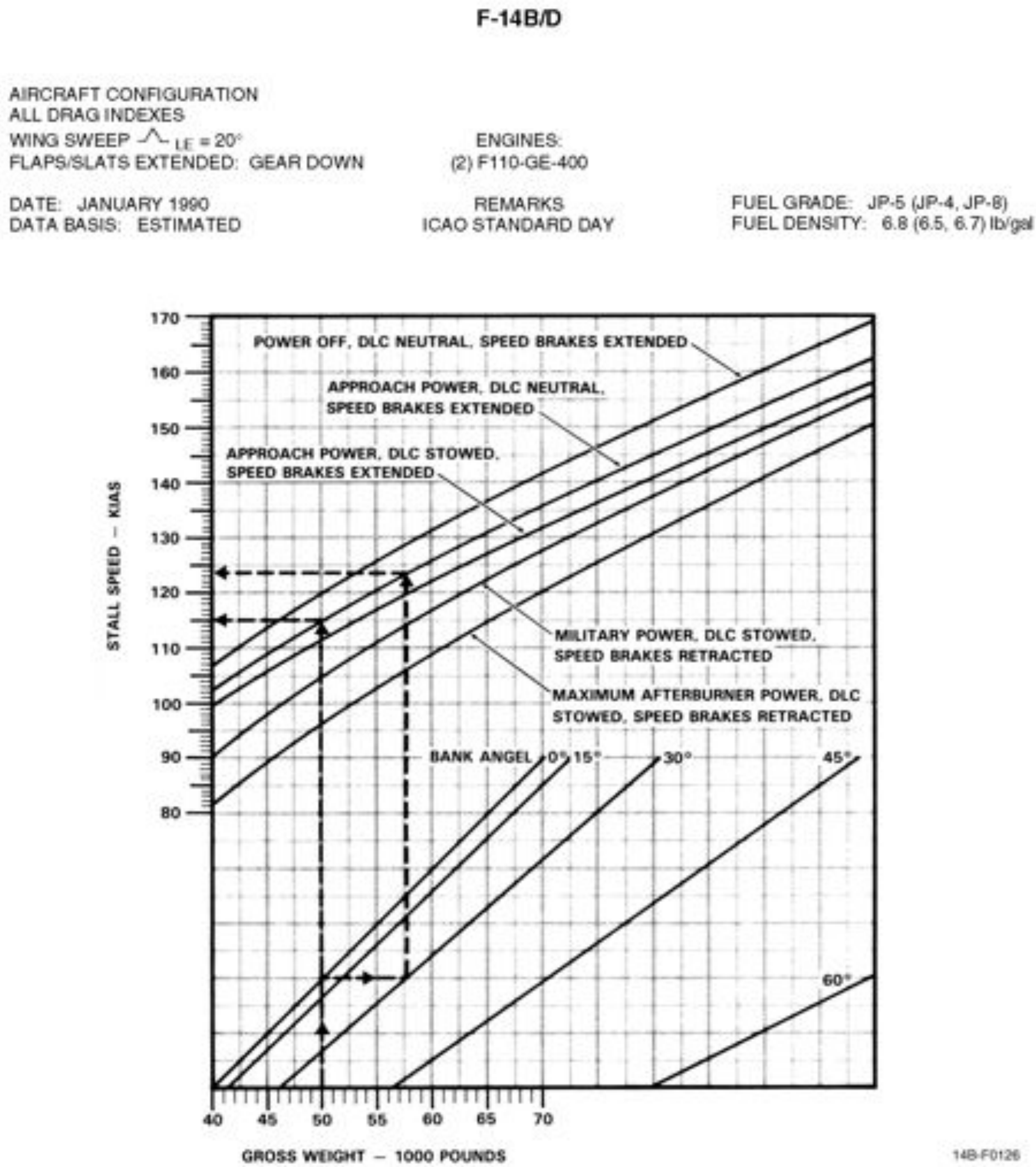


Figure 11-5. Stall Speeds for Wing Rock at 25 Units AOA

11.7.4 Stall Recovery. Stall recovery is easily accomplished by relaxing aft stick force and easing the stick forward, if necessary, to decrease AOA to less than 16 units. Maintain 15 to 16 AOA units and stabilized military or afterburner thrust during recovery to level flight. Recovery to level flight requires about 1,000 feet of altitude.

WARNING

Avoid high-rate, multiple-axis motion because of possible violent departures and engine stalls.

CAUTION

Use of cross-control in the low- to medium-Mach (less than 0.6) and low- to medium-AOA (AOA less than 25 units) area may result in negative-g departures.

11.7.5 Asymmetric Thrust Flight Characteristics

11.7.5.1 Takeoff Configuration. Afterburner takeoffs are prohibited specifically because of controllability concerns in the event of engine failure during takeoff. An engine failure during a MIL power takeoff with the F110 engine will produce significant thrust asymmetry. The high compression ratio of the compressor section results in rapid spooldown during and engine failure, and rotor lock can be anticipated within several seconds of the engine failure. Rapid nose movement in the direction of the failed engine will result and the pilot's first impression is usually that the aircraft will depart the runway. Even if the aircraft's heading swerve is corrected, the aircraft may continue to skid sideways across the runway. The wing on the side of the failed engine may rise 10° to 15°. This is noticeable to the pilot but easily corrected with lateral stick. If the airspeed is high enough to allow correction of the heading swerve, all lateral drift can be stopped.

Aircraft controllability during asymmetric thrust takeoff emergencies is influenced primarily by rudder position, thrust asymmetry, airspeed nosewheel steering, and pilot reaction time, with pilot reaction time being the most critical factor. During the takeoff roll, rudder control power increases, thus improving the pilot's ability to control an asymmetric thrust condition. Below minimum control groundspeed (VMCG), insufficient rudder control power will be available (nosewheel steering OFF), and large lateral runway deviations will be experienced if the takeoff is continued. The lower the airspeed at which the asymmetry occurs, the larger the deviation. Longer pilot reaction times result in dramatically larger lateral deviations. VMCG speeds (takeoff continued) for the F-14B are presented in Figure 11-6. Even if the takeoff is aborted, significant runway lateral deviations may occur before the aircraft is brought back under control. Use of nosewheel steering up to 100 KIAS will reduce the amounts of deviation during the abort. For example, if the engine fails at 90 KIAS, the lateral deviation will be 10 to 15 feet with nosewheel steering engaged and approximately 50 feet with nosewheel steering disengaged.

If the single-engine failure occurs during or after liftoff, or catapult launch, the aircraft is controllable if proper aircrew techniques are employed. Airborne rudder effectiveness is presented in Figure 11-7. Rudder is the primary control for countering yaw caused by asymmetric thrust. Beneficial coordinating rudder is automatically applied with a lateral stick input and helps to limit yaw rate and sideslip buildup. However, pilot-commanded rudder remains the required recovery control for the DFCS. At the first indication of an engine failure, the pilot should not hesitate to apply up to full rudder to counter roll and yaw. Above 100 KIAS, rudder effectiveness without nosewheel steering is sufficient to control this deviation adequately. In addition, use of nosewheel steering is undesirable above 100 KIAS because of a directional pilot-induced oscillation tendency and the potential for a cocked nosegear if takeoff is continued.

THRUST ASYMMETRY	FLAP POSITION	VMCG SPEEDS MAXIMUM 50 FT LATERAL DEVIATION
Military/IDLE	Extended	132 to 138 KIAS
Military/IDLE	Retracted	135 to 140 KIAS

Figure 11-6. Minimum Control Groundspeed (VMCG)

SEA LEVEL – STANDARD DAY

AIRCRAFT CONFIGURATION:
FLAPS UP OR DOWN
ALL GROSS WEIGHTS

DATE: JANUARY 1990
DATA BASIS: ESTIMATED

REMARKS
ENGINE(S): (2) F110-GE-400
LOCKED ROTOR: N_1 = ZERO RPM; N_2 = ZERO RPM

FUEL: JP-5 (JP-8, JP-4)
FUEL DENSITY: 6.8 (6.7, 6.5) lb/gal

STATIC MINIMUM CONTROL AIRSPEED – VMC STATIC

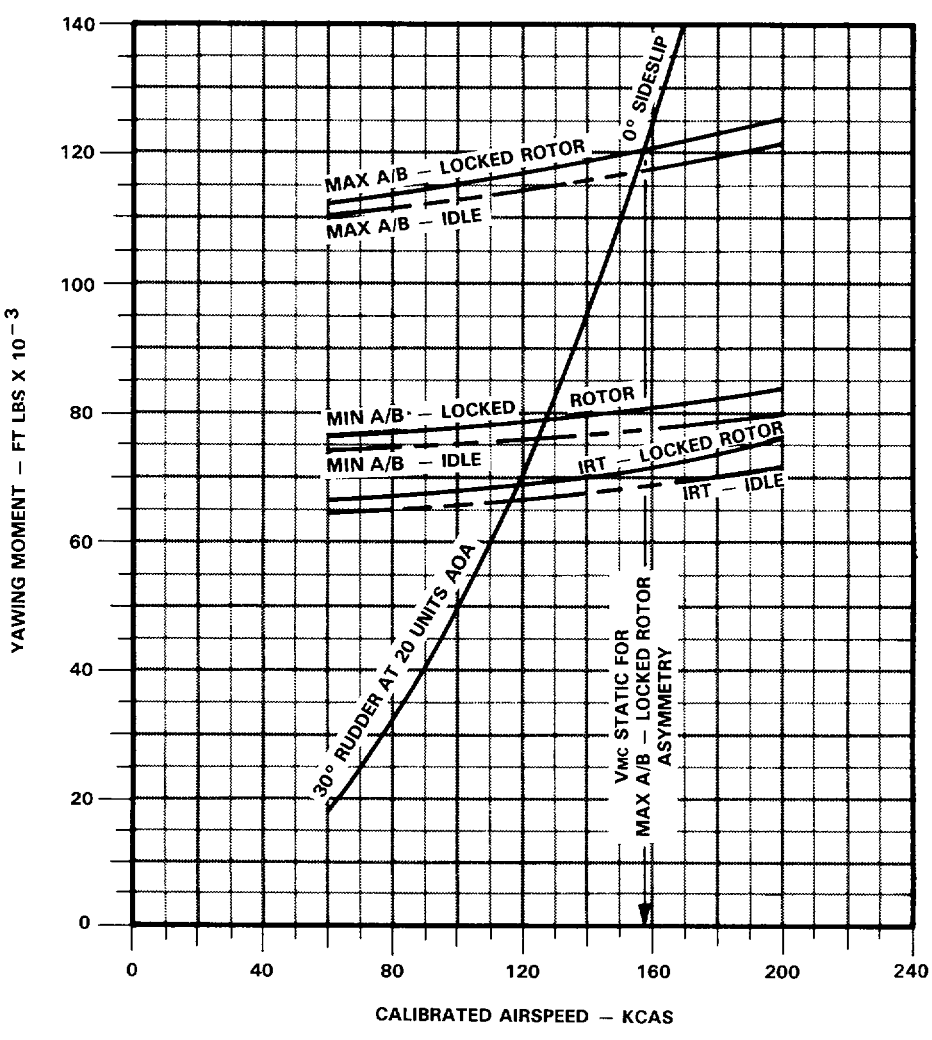


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Figure 11-7. Rudder Effectiveness

WARNING

Failure to limit pitch attitude will place theaircraft in a regime of reduced directional stability, rudder control, and rate of climb. The aircraft may be uncontrollable at AOA above 20 units. Smooth rotation to 10° pitch attitude (approximately 14 units AOA) will provide good initial flyaway attitude, ensure single-engine acceleration, and generate adequate rate of climb. See Chapter 13 for single-engine takeoff emergency procedures and NAVAIR 01-Fl4AAP-1.1 for single engine performance data.

11.7.5.2 Landing Configuration — General. Asymmetric thrust flight in the landing configuration must be approached with caution. Gross weight should be reduced prior to landing in order to improve waveoff performance. Rudder trim, augmented as necessary by additional rudder pedal deflection, should be used to counter thrust asymmetry.

Speedbrakes should remain retracted during actual single-engine approaches. A straight-in approach should be flown. Avoid turns into the dead engine. Steep angle of bank turns into the dead engine reduce climb performance and may result in rudder requirements exceeding available control deflection causing loss of control. The pilot may have to reduce thrust on the operating engine to regain control, which may not be feasible at low altitude. By performing turns away from the failed engine, both thrust and rudder requirements will be reduced. Any maneuvering required prior to final approach should be accomplished using a maximum of 20° angle of bank in turns away from the failed engine.

Note

The role of the RIO is critical in this regime. He should closely monitor airspeed, bank angle, and AOA throughout the approach.

Refer to Chapter 15 for single-engine landing emergency procedures and NAVAIR 01-Fl4AAP-1.1 for single-engine performance data. For additional discussions of landing configurations and techniques, see paragraph 11.7.5.3 and 11.7.5.4. For additional discussion of asymmetric thrust flight characteristics, see Asymmetric Thrust Flight Characteristics paragraph 11.7.5.

11.7.5.3 Landing Configuration — Engine In Primary. DLC will not be available with the left engine secured. With the left engine operating in primary mode and 3,000 psi combined hydraulic pressure, DLC should be engaged when established on final approach. Any maneuver required prior to rolling out on final approach should be accomplished using 12 units AOA or less. Once established on final approach, fly 15 units or faster (DLC engaged) or 14 units or faster (no DLC) to provide additional control power.

Note

While shipboard recoveries mandate the use of the minimum recommended approach airspeed because of aircraft and arresting gear structural limitations, field recoveries benefit from slightly faster airspeeds because of the increased control power and reduced apparent thrust asymmetry.

Airspeed control for a 14-unit approach is difficult; therefore, there may be a tendency to overcontrol power. An effective technique is to have the RIO provide airspeed calls (i.e., “2 knots slow/fast”) to the pilot during final approach. With DLC engaged, minimize use of the throttle in close and use DLC for fine glideslopes corrections. Decreasing the amount of throttle activity will limit excitation of the Dutch roll. RATS will engage on touchdown, but does not significantly affect CV bolter performance. Minimum A/B (ATLS on) may be used if required. During a bolter, apply rudder simultaneously with power addition to maintain centerline. Adequate directional control power exists to prevent drift on bolter.

Military thrust waveoff performance in primary mode is good, averaging 30 to 40 feet of altitude loss from a nominal 600 fpm sink rate. Waveoff performance from high sink rates is improved using minimum A/B (ATLS on). Altitude loss is minimized by maintaining approach AOA (slight, gradual pitch rotation required).

Note

Altitude loss during a single-engine waveoff is minimized by maintaining approach AOA until a positive rate of climb is established. Avoid overrotating in close as this will increase the change of an in-flight engagement. Minimum afterburner (ATLS on) may improve waveoff performance from high sink rates.

Sufficient rudder control power exists to maintain control of the aircraft during MIL and minimum-A/B single-engine waveoffs, provided AOA is not allowed to increase above 18 units. Simultaneously add rudder (approximately two-thirds to three-fourths deflection) with power to counter the asymmetric thrust and track centerline. If a yaw rate develops into the failed engine, immediately apply full opposite rudder to arrest the yaw rate and then reduce rudder as required to track centerline. Rudder may be supplemented by small lateral stick inputs. The use of maximum A/B offers little or no improvements in single-engine waveoff performance and is prohibited. The aircraft is extremely difficult to control in maximum A/B and large bank angles into operating engine are required to maintain centerline. Late or inadequate control inputs during a maximum A/B waveoff can result in large lateral flightpath deviations. If unable to control yaw rate during A/B waveoff (possible ATLS failure), immediately reduce power to MIL.

11.7.5.4 Landing Configuration — Engine in Secondary. Approaches in single-engine SEC mode are considered extremely hazardous. Thrust response in secondary mode is nonlinear and very sluggish. At military power, thrust in secondary mode can vary from as little as 65 percent to as much as 116 percent of primary mode thrust at MIL power. Although the majority of engines produce greater than 90 percent of primary mode thrust (at MIL power), the possibility exists that in the full-flap configuration, a low-thrust engine will not provide enough thrust for level flight. Engine acceleration times can also vary and can be as much as three times longer than in primary mode. Aircraft should recover ashore. Shipboard landings should only be attempted as a last resort and only in performance is adequate. See Chapter 15 for performance check and specific emergency procedures.

DLC should not be engaged for any single-engine SEC mode approaches. Any maneuver required prior to rolling out on final approach should be accomplished using 10 units AOA or less. Once established on final approach, fly 13 units or faster to improve waveoff capability and provide additional control power.

Note

While shipboard recoveries mandate the use of the recommended approach AOA because of aircraft and arresting gear structural limitations, field recoveries benefit from slightly faster airspeeds because of the increased control power and reduced apparent thrust asymmetry.

Airspeed control for a 13-unit approach is difficult; therefore, there may be a tendency to overcontrol power. An effective technique is to have the RIO provide airspeed calls (i.e., “2 knots fast”) to the pilot during final approach. Extreme care should be used when working off a high and/or fast condition as any large power reduction could result in a situation requiring military power for correction. Use small throttle movements and small attitude adjustments for glideslope corrections. Avoid nosedown attitude changes just prior to touchdown as this will minimize the chance of a hook-skip bolter. In the event of a bolter, rotate a 10° pitch attitude, not to exceed 14 units AOA. During a bolter, apply rudder simultaneously with power addition to maintain centerline. Adequate directional control power exists to prevent drift on bolter.

Waveoff performance in secondary mode may be poor, and high sink rates must be avoided. The poor engine acceleration in SEC mode makes engine rpm at waveoff initiation a major factor in waveoff performance. Grossly underpowered conditions must be avoided. During single-engine waveoffs in secondary mode, rotate the aircraft slightly to capture/maintain 14 to 15 units AOA as this will help to break the rate of descent.

WARNING

Single-engine waveoff performance with operating engine in SEC mode will be severely degraded. Extreme care should be used to avoid an underpowered, high-rate-of-descent situation.

11.7.6 Degraded Approach Configuration. Refer to Chapter 15 for degraded approach emergency procedures.

11.7.6.1 No Flaps, No Slats, and Wings at 20°. If a no-flap, no-slat landing is anticipated, a straight-in approach should be performed because of the narrow margin afforded between 15 units AOA and the onset of airframe buffet. The approach is flown at 15 units AOA. Airframe buffet will occur at 16 to 17 units AOA with wing drop (5° to 10°) and/or an increase in sink rate occurring at 16.5 to 17.5 units AOA. Spoiler effectiveness is slightly degraded because of the absence of the aerodynamic slot formed when the flaps are extended. Precise airspeed control is essential for a no-flap/no-slat approach. Fast or high/fast approaches result if timely throttle adjustments are not made throughout the approach. The pilot must wave off approaches that result in large throttle reductions (to near idle) in close.

CAUTION

Nose attitude control is more sensitive during a no-flap approach, and care must be exercised not to overcontrol nose corrections in close. Cocked-up, high-sink landing can result in damage to ventral fins and/or afterburners.

11.7.7 Outboard Spoiler Module Failure. When the wings are forward of 62°, loss of outboard spoilers results in a decrease in roll authority and in lateral control effectiveness. Such loss causes no significant degradation in approach handling characteristics and is generally only apparent when large bank angle changes are commanded, such as during roll into and out of the approach turn. If the outboard spoiler module fails when the flaps and slats are down, the spoilers may float up and lock at some position above neutral. This may be accompanied by him changes in all three axes, which can be trimmed out. Approach speed will increase slightly if a spoiler float occurs. If the failure occurs when the flaps are up, spoiler float is minimized.

WARNING

In the event of outboard spoiler module failure, do not engage ACLS.

11.7.8 SAS OFF. Approach characteristics with either roll or YAW SAS OFF will be significantly degraded compared to the baseline PA-ARI flying qualities. Failure of either roll or yaw SAS (or selecting either ROLL or YAW STAB AUG switch OFF) will revert the DFCS from the PA-ARI control mode to "basic SAS" control mode (loss of ARI functionality). Directional damping and roll response to lateral stick inputs will both be significantly reduced compared to baseline performance.

11.7.9 Aft Wing Sweep Landings. The aircraft may be safely landed with the wings as far aft as 40° (CV) and 68° (field). If the wings fail to respond to command, the emergency wing sweep handle should be used to match the captain bars (commanded position) with the wing sweep position tape. Matching the captain bars with the position tape ensures the commanded position is the same as the actual position, removing hydraulic pressure from the wing sweep motors (hydraulic pressure will still remain present at the wing sweep control servo valve/four-way valve). This reduces the likelihood of hydraulic failure or asymmetric wing sweep because of the failure of the crossover shaft. Optimum AOA for shipboard aft wing sweep approaches is 15 units. AOA may be increased up to 17 units maximum for field landings to minimize approach airspeed for normal field landings or to remain within published field arresting gear limitations for short-field arrested landings. At wing sweep angles of 51° and greater, each one-unit increase in approach AOA reduces approach airspeed by approximately 5 knots. Airspeeds for various configurations are shown in Figure 11-8.

With the wings frozen forward of 50°, the main flaps/slats should be used. A normal 15-unit approach should be used in this configuration and approach speeds will remain within field arresting gear limitations. If main flaps/slats are not available, maneuvering flaps should be used. Extension of the main flaps/slats only will result in a flap light with wings aft of 20°.

WARNING

If maneuver flaps are used, the pilot must ensure that the maneuver flap thumbwheel is not actuated during the approach.

Note

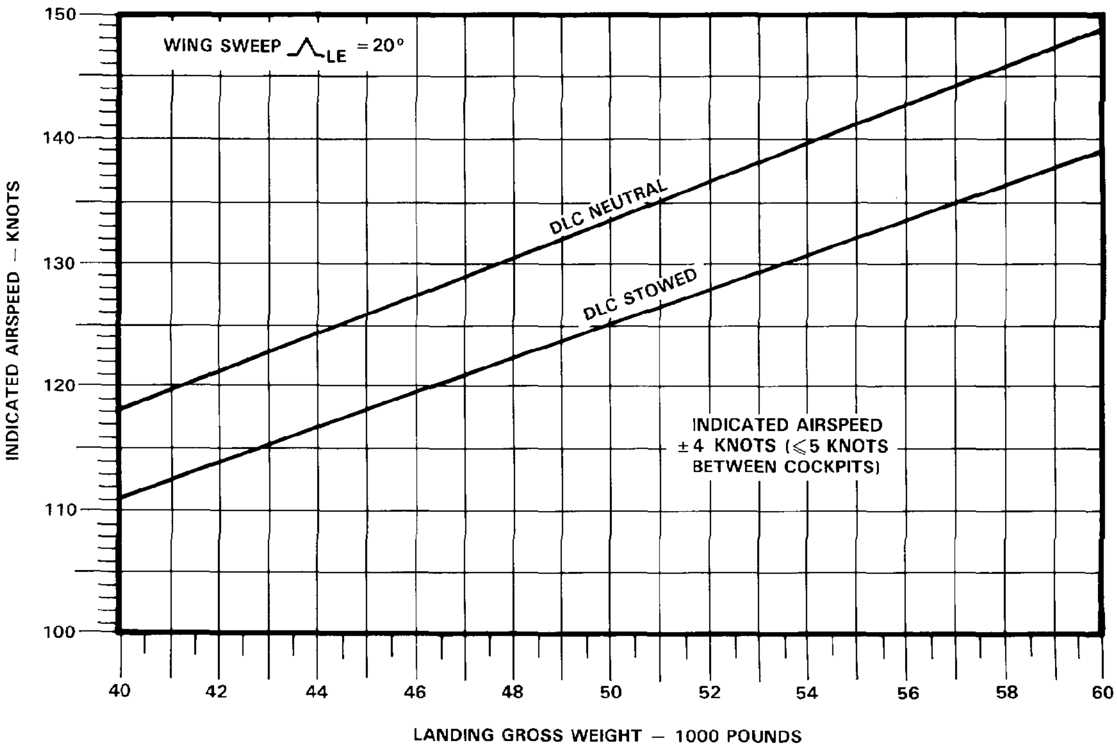
Main flaps/slats extension with the wings aft of 20° will result in a large nosedown pitch transient.

DLC should not be engaged because it increases final approach speeds. APC gains are not optimized for wing sweeps other than 20° and therefore APC should not be used. Reducing gross weight will reduce approach speed by about 3.5 knots for each 2,000-pound reduction in gross weight at the 68° wing-sweep position. Pilot over-the-nose visibility is

AIRCRAFT CONFIGURATION:
ALL DRAG INDEXES

DATA: MAY 1976
DATA BASIS: FLIGHT TEST

FUEL GRADE: JP-5 (JP-4, JP-8)
FUEL DENSITY: 6.8 (6.5, 6.7) lb/gal



EMERGENCY OPERATION (WING SWEEP LESS THAN OR EQUAL TO 50°)			
AIR SPEED CORRECTION TO BE ADDED TO DLC STOWED APPROACH SPEED			
WING SWEEP (°)	AUXILIARY FLAPS RETRACTED (KIAS)	ALL FLAPS/SLATS RETRACTED (KIAS)	SLAT RETRACTED MANEUVER FLAPS EXTENDED (KIAS)
20	6	27	22
25	14	33	28
30	20	38	33
35	25	44	39
40	30	49	44

EMERGENCY OPERATION (WING SWEEP GREATER THAN 50°) AIRSPEED CORRECTION TO BE ADDED TO DLC STOWED APPROACH SPEED		
SWING SWEEP (°)	15 UNITS AOA (KIAS)	17 UNITS AOA (KIAS)
51	55	45
60	58	48
68	60	50

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Figure 11-8. Landing Approach Airspeed (15 Units AOA) adequate at both 15 and 17 units AOA. The RIO will lose sight of the ball because of the higher pitch attitude at 16 to 17 units AOA on the standard 3.25° field glide-slope.

Flying characteristics in aft wing-sweep configurations are dependent on wing-sweep angle and AOA. As wing-sweep angle increases, trimmed stick position moves aft. At 68° sweep, roll performance is sluggish but adequate at up to 17 units AOA with SAS roll engaged. At up to 62° wing sweep, differential tail is augmented with spoiler for roll control. The aircraft exhibits a very strong dihedral effect with the wings swept aft, so rudder may be used to augment roll performance if desired. Crosswind landings have not been evaluated at or near the aircraft crosswind limit, but a crabbed approach is recommended vice the wingdown-top-rudder technique. Ensure that the fuselage is aligned with the runway prior to touchdown.

Although pitch control is adequate, maintaining trim airspeed is increasingly difficult with increasing sweep angle because of low stick force cues for airspeed deviations. This necessitates close monitoring of airspeed by the aircrew since the approach indexes are unusable above 16 units AOA. As wing sweep progresses further aft, stall becomes less clearly defined. There is no strong aircraft buffet when AOA is increased beyond 17 units. Aircraft waveoff performance is adequate at both 15 and 17 units AOA. During single-engine operation, up to maximum power may be required to arrest aircraft rate of descent during a waveoff. Single-engine approaches with aft wing sweep have not been tested and rudder control power may be limited in this condition. Fuel permitting, aircraft handling and stall characteristics as well as waveoff performance should be evaluated at altitude prior to commencing an aft wing-sweep approach.

If using an approach AOA greater than 15 units, nozzle clearance at touchdown is reduced. Additionally, the high rate of descent (approximately 1,000 fpm on a 3.25° glideslope) and the high touchdown speed place high stress on the main landing gear tires. The recommended technique for field landings is to maintain a maximum of 17 units AOA while attempting to minimize the rate of descent just prior to touchdown. Do not attempt to flare the landing and do not aerobrake.

CAUTION

Nozzle clearance is reduced at elevated approach AOA. Ensure that a maximum of 17 units AOA is maintained at touchdown.

Aft wing-sweep, touch-and-go performance has not been flight tested; however, rotation speeds approaching or possibly exceeding tire limitations should be expected. Nose tire limitations, runway remaining, status of long-field arresting gear, and tire pressurization must all be factored into a decision to go around following a hook skip. If committed to landing following a hook skip with operative hydraulics, consideration should also be given to securing the starboard engine in order to reduce residual thrust.

Engaging speeds listed in the emergency field arrestment guide are groundspeeds. Headwind may be subtracted from final approach airspeed; tailwinds must be added; and compensation must be made for field elevation (add approximately 10 knots to arresting gear limit for a 4,000-foot field elevation).

If speedbrakes are not available, thrust requirements on glideslope are decreased and judicious throttle management is more critical.

WARNING

If maneuver flaps are used, the pilot must ensure that the maneuver flap thumbwheel is not actuated during the approach.

11.7.10 DFCS Degraded Control Modes. The DFCS is capable of operation in numerous degraded mode control configurations. Description of all possible degraded modes is not practical; however, several of these modes are listed below with a description of resulting functionality and effect on approach flying qualities.

11.7.10.1 DFCS Computer Failures. Each of the three DFCC's contains two distinct computer processors called computing segregations, one "A" segregation and one "B" segregation in each axis. Each segregation commands different series servo and/or spoiler sets. If a computing segregation fails, all actuators commanded by that segregation are rendered inoperative. Functionality loss due to failure of each of the segregations and effect on takeoff and landing flight characteristics are as follows:

Pitch A — Half authority pitch SAS, no inboard spoilers, no DLC. Slightly decreased pitch damping, decreased roll performance.

Pitch B — Half authority pitch SAS, no outboard spoilers, no DLC. Slightly decreased pitch damping, decreased roll performance.

Roll A — Half authority roll PA-ARI/SAS, no inboard spoilers, no DLC. Decreased roll performance.

Roll B — Half authority roll PA-ARI/SAS. Slightly decreased roll performance.

Note

Autopilot control modes, including ACLS, are not available with any pitch or roll segregation failed.

Yaw A — Half authority yaw PA-ARI/SAS. Decreased directional damping. This may only be apparent during moderate to aggressive maneuvering, since the gain in the yaw channel B is doubled to compensate for the loss of the yaw A series servo. Full yaw SAS performance is thus retained up to the authority limit of the remaining yaw series servo (±9.5° rudder).

Yaw B — Half authority yaw PA-ARI/SAS, no outboard spoilers, no DLC. Decreased directional damping, but only for aggressive maneuvers as previously described for the yaw A segregation. Decreased roll performance.

A normal landing approach can be flown with any single segregation failure. Combined failure of any two segregations results in combined loss of all associated functions, actuators, and in most cases, additional failures. Failure of both pitch or both roll segregations results in loss of all spoilers and severely degraded roll performance. Failure of both roll or both yaw segregations results in loss of PA-ARI and downgrade to “basic SAS” mode in the remaining axes. This will be manifested by significantly decreased roll performance and significantly decreased directional damping. A straight-in approach with as little crosswind as possible is recommended. Lateral stick inputs may require coordinating rudder to obtain adequate roll response and to minimize Dutch roll disturbances.

11.7.10.2 DFCS Air Data Failures. Failure of the Mach number or AOA inputs to the DFCS results in degraded mode operation for several PA-ARI control functions. These control modes still provide excellent flying qualities such that a normal approach can be flown, but are somewhat degraded from the fully operational PA-ARI performance.

A DFCS Mach failure will always occur due to failure of the SCADC, but may also occur independently from a SCADC failure. Mach failure results in a nearly transparent degrade in directional damping, which may become noticeable at conditions slower than on-speed. A single AOA failure results in no degradation in flying qualities, only a loss of redundancy, since the input is triplex. Dual AOA failure results in decreased directional damping, decreased roll performance, and decreased spiral mode damping.

Note

Significant PA-ARI functionality is retained with dual Mach or dual AOA failures as compared to UA-ARI. For this reason, ROLL DGR and ARI/SAS OUT caution lights will be automatically extinguished upon selection of the landing gear handle from the up to the down position.

11.7.10.3 Series Servo Failures. Reduced authority and rate damping performance will be experienced in the affected axis. Failure of both roll or both yaw series servos results in loss of PA-ARI and downgrades the DFCS to the “basic SAS” control mode in the remaining axes. Decreased roll performance and decreased directional damping will be exhibited. A normal approach can be flown with any single failure, a dual pitch, or a dual roll series servo failure. In case of dual failure of the yaw series servos, recommend a straight-in approach using smooth lateral inputs with coordinating rudder to minimize Dutch roll disturbances.

11.7.10.4 Spoiler Failures. As described under DFCC computer failures, failure of four of the six segregations will result in loss of a spoiler set (inboard or outboard) and associated decreased roll performance. DLC is not functional with any inboard spoiler failure, but is available with any or all outboard spoilers failed. Failure of any single spoiler panel will result in "mirror-image" spoiler operation of the remaining spoilers, as long as the failed spoiler responds to the automatic isolation command (returns to stowed position). For example, failure and successful isolation of the Left No. 4 spoiler panel also results in automatic isolation of the Right No. 4 spoiler panel. Symmetric, but slightly degraded roll performance will be evident. A normal approach can be flown in this case. If a spoiler failure results in a stuck-up spoiler, normal control of the "mirror-image" panel will be automatically restored to provide maximum roll control power to counter the rolling moment induced by the stuck-up spoiler. Refer to Spoiler Malfunction emergency procedures for landing in this configuration.

11.7.10.5 Sensor Failures. Single failure of any DFCS sensor input does not result in a flying qualities downgrade, only a loss of redundancy, since all sensor inputs are triplex. Dual failure of a sensor input causes loss of the functions associated with that sensor. A list of these sensor inputs and associated dual failure functionality loss are as follows:

Pitch Rate — No pitch SAS. Decreased pitch damping. A normal approach can be flown.

Roll Rate — No roll SAS, no PA-ARI. Decreased roll performance and decreased directional damping. A normal approach can be flown.

Yaw Rate — No yaw SAS, no PA-ARI. Decreased roll performance and significantly decreased directional damping. Recommend straight-in approach using smooth lateral inputs with coordinating rudder to minimize Dutch roll disturbances.

Lateral Acceleration — No yaw SAS, no PA-ARI. Decreased roll performance and significantly decreased directional damping. Recommend straight-in approach using smooth lateral inputs with coordinating rudder to minimize Dutch roll disturbances.

Lateral Stick Position — No roll SAS, no PA-ARI, no spoilers. Severely degraded roll performance and decreased directional damping. Recommend straight-in approach with as little crosswind as possible. Lateral stick inputs may require coordinating rudder to obtain adequate roll response.

Rudder Pedal Position — No pedal fadeout for lateral stick to rudder interconnect or roll rate command functions in the PA-ARI control mode. These pedal fadeout features are incorporated to improve the pilot's ability to command a steady sideslip condition during a slipped (i.e., wing-down-top-rudder) crosswind approach. With a pedal position failure, precisely controlling bank angle during a slipped approach is more difficult than with the baseline system. A crabbed technique is recommended.

Landing Gear Handle Position — No PA-ARI, downmode to UA-ARI control mode for all flight configurations. During normal operation, mode switching between the PA-ARI and UA-ARI control modes is controlled by sensing of the landing gear handle position. If a dual failure of this triplex input fails, the DFCS can no longer accurately determine the actual gear handle position.

The fail-safe condition in this case is to revert to the UA-ARI (i.e., gear up) control mode. This results in decreased roll performance and decreased directional (Dutch Roll) damping. A normal approach can be flown.

Note

If a dual failure of the landing gear handle position input to the DFCS occurs, the ARI/SAS OUT caution light will illuminate when flaps are lowered past the 25° position. This indicates loss of normal PA-ARI function.

11.8 ASYMMETRIC WING SWEEP

11.8.1 Wing Sweep Design Limitations. An understanding of the wing sweep design limitations is necessary to cope successfully with an in-flight asymmetric wing condition to avoid the possibility of structural damage and to minimize the possibility of loss of aircraft control. The following discussion is therefore offered:

The wing sweep feedback position and interlock functions for the auxiliary flaps, main flaps/slats, and spoiler cutout are controlled by the left wing sweep actuator. Cockpit wing sweep position indication and the glove-vane schedule are controlled by the right wing sweep actuator.

The existence of wing sweep position feedback on the left wing only can have a definite impact during a jammed wing sweep actuator/failed synchronizing shaft condition. A jammed right wing sweep actuator will result in normal left wing operation because wing sweep commands are nulled out by the left wing sweep actuator position. A jammed left wing sweep actuator in an intermediate position in conjunction with a wing sweep command will result in a constant command to the right wing sweep actuator that cannot be nulled since the right wing has no position feedback. In this case, the right wing will travel to the overtravel stop (19° or 69°) in the direction of the last command. The right wing can be positioned in either the 19° or 69° position only, but not in any intermediate position since there is no way to null out the command. A condition similar to a jammed wing sweep actuator occurs when one hydraulic system has failed in conjunction with a synchronizing shaft failure.

A temporary actuator jam on one side while the wings are sweeping in conjunction with a broken synchronizing shaft will result in resumption of operation with asymmetrical wing positions. Symmetrical wing position, within 1°, can be achieved again by commanding the wings full forward or full aft (20° or 68°). The direction to command the wing is dependent on whether the right wing is forward or aft of the left position. The right wing position will be displayed by the wing position tape on the cockpit wing sweep indicator. If, for example, the right wing is forward of the left wing, the wings should be commanded full forward to 20°. The right wing will drive to the 19° overtravel stop and remain there until the left wing reaches 20°, nulls the command, and hydraulic power is shut off. If the right wing is aft of the left wing, the wings could be commanded full aft to 68°. The right wing will drive to the 69° overtravel stop and remain there until the left wing reaches 68°, nulls the command, and hydraulic power is shut off.

Normal symmetrical wing sweep operation within 1° should follow. Some jeopardy exists during aft command operation since spoiler control will be lost when the left wing obtains 62°.

Note

A mechanical jam in the wing sweep system may prevent the wings from being resynchronized. This may be due to the failed synchronizing shaft jamming an actuator.

The auxiliary flap/main flap interlocks are controlled by the left wing sweep actuator. This means that during asymmetric wing conditions it is possible to satisfy the interlock requirements with the left wing and damage aircraft structure with the off-schedule right wing. For example, if the left wing is at 20° and the R/H wing is at 35°, the 21° interlock in the auxiliary flap system is satisfied by the left wing. Lowering the flaps without inhibiting auxiliary flaps will drive the auxiliary flaps through the fuselage in the vicinity of the flight hydraulic system. Pulling the AUX FLAP/FLAP CONTR circuit breaker (7G3) will remove electrical power to the auxiliary flaps and prevent auxiliary flap deployment.

Note

Extending the main flaps with the auxiliary flaps inhibited will result in a large nose-down trim change.

The wing sweep control drive servo is powered through WING SWEEP DRIVE NO. 1 (LE1) and WG SWP DR NO. 2/MANUV FLAP (LE2) circuit breakers. Pulling these circuit breakers inhibits all electrical command paths to the wing sweep control valve. Manual commands to the valve are available through the emergency wing sweep handle. Pulling the WG SWP DR NO. 2/MANUV FLAP (LE2) circuit breaker removes power from the maneuver devices and inhibits automatic retraction of the maneuver devices with landing gear handle extension.

The maneuver devices should be commanded up prior to pulling the WG SWP DR NO. 2/MANUV FLAP circuit breaker. It may also be necessary to utilize emergency up on the flap handle to achieve full flap and slat retraction.

The glove vanes are controlled electrically through the GLOVE VANE CONTR (LE3) circuit breaker. Pulling this circuit breaker interrupts electrical power to the glove vanes and allows the internal mechanical bias to the glove-vane actuators to retract the vanes. The GLOVE VANE CONTR circuit breaker should be pulled to avoid any longitudinal control destabilizing tendencies and/or approach airspeed variations.

11.8.2 Asymmetric Wing Sweep Flight Characteristics. Asymmetric wing sweep failures will be manifested as a wing heaviness accompanied by a WING SWEEP advisory light, indicating a failure of the primary wing sweep channel. A subsequent failure of the backup wing sweep channel will illuminate the WING SWEEP warning light.

Flight tests have shown that the aircraft may be safely landed with asymmetric wing sweep as long as spoiler control is retained following the wing sweep failure. The aircraft is not controllable for landing with a wing asymmetry such as the left wing aft of the spoiler cutout angle (62°) and the right wing forward at 20°. The maximum asymmetry is landable if spoilers are operational (i.e., the left wing is at 20° and the right wing is at 68°). The high-approach speeds coupled with reduced lateral control authority obtained with asymmetric sweep become limiting factors for aircraft carrier (CV) operations. If at all possible, the flightcrew should attempt to divert for a field landing. In-flight refueling was not evaluated during flight tests. Cruise configuration flying qualities in the normal refueling airspeed range (approximately 250 KIAS) were qualitatively assessed to be suitable for the task. The effects of asymmetric sweep are diminished as airspeed increases (decreasing angle of attack) so that using a higher than normal tanking speed may decrease pilot workload. Lateral and directional trim should be utilized to decrease lateral stick force during refueling and cruise flight.

Note

The use of lateral trim to reduce stick force during approach and landing should be avoided, however, because it reduces the amount of spoiler available for roll control.

Asymmetric wing sweep is primarily a lateral control problem, increasing in severity as angle of attack increases and as flap deflection increases. The aircraft will roll toward the aft wing and yaw toward the forward wing. For example, right wing forward of left wing causes left wing down roll and nose right yaw. The resultant sideslip angle is favorable from a controllability standpoint and should be removed with rudder only if it is uncomfortable to the pilot. Rudder trim into the forward wing may be utilized, if desired, to increase sideslip angle and generate a restoring rolling moment via dihedral effect (right rudder trim for right wing forward of left and vice versa). Lateral stick force will be accordingly reduced.

Main flaps should be utilized to decrease approach airspeed for asymmetric sweep landings if both wings are forward of 50° sweep. During flight tests, a flap setting of 20° to 25° was found to provide the best flying qualities in comparison to the other flap settings tested (0°, 10°, 35°). Safe landings may be performed, however, with all the flap configurations evaluated. In the flaps-up configuration, undesirable prestall buffet is experienced at 16 to 16.5 units AOA for all wing asymmetries.

Stall-induced buffet is not experienced in flaps-down configurations because the leading edge slat delays wing stall. Airframe buffet may occur, however, because of the turbulent airflow that passes through the auxiliary flap hole that impinges on the horizontal tails. This buffet increases with increasing flap deflection and is significantly worse with 35° flaps as compared to 10° or 20°. In addition to increased buffet levels, the 35° flap configuration is prone to lateral PIO during high-gain tasks such as close-in lineup corrections. This is primarily due to the increased spoiler effectiveness obtained with power approach spoiler gearing. Raising the flaps only causes the spoilers to move from the "drooped" position to the zero position, retaining power approach spoiler gearing. This configuration is not flight tested for DFCS.

All asymmetric wing configurations require precise monitoring of AOA during lateral maneuvering because of the existence of significant pitch-roll coupling. This is especially critical with flaps up. In general, the aircraft tends to increase angle of attack when rolling toward the forward wing and decrease angle of attack when rolling toward the aft wing. In order to provide adequate maneuvering margin below the stall buffet region, recommended approach AOA is 14 units for all flaps-up asymmetric wing configurations up to 40° differential split (Figure 11-9). A landing with the maximum possible asymmetry of 20°/68° will require 13 to 14 units AOA to provide adequate control for approach and landing as long as spoilers are available (left wing at 20°, right wing at 68°). Recommended approach AOA is 15 units for all flaps-down asymmetric wing configurations (Figure 11-9).

If the left wing is positioned aft of the spoiler cutout sweep angle (62°), the spoilers are inoperative and lateral control is limited to differential tail only. Flight tests indicate that the maximum controllable asymmetry at 14 units AOA in this configuration is a 15° differential split. The preferable action in this case is to attempt to move the left wing forward of the spoiler cutout angle to regain spoiler control. If this is not possible, an attempt should be made to command the right wing as far aft as possible in order to minimize the wing asymmetry and then perform a slow flight check at altitude to determine the minimum control speed. The pilot must then determine if the configuration provides a reasonable approach airspeed.

Sideslip-induced pitot static system errors may be experienced with all asymmetric wing sweep

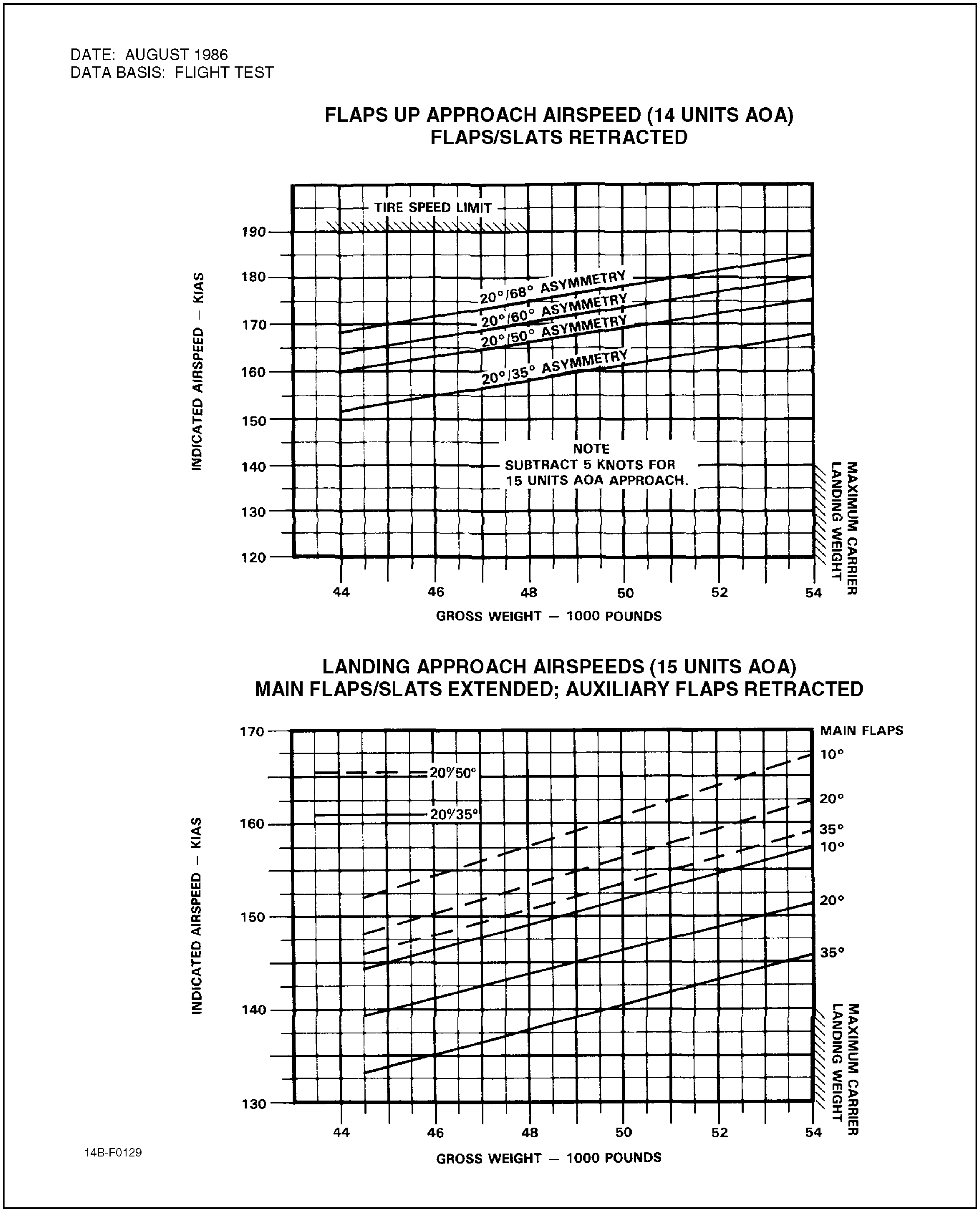


Figure 11-9. Asymmetric Wing-Sweep Landing Approach Airspeed

configurations. Accurate airspeed/AOA indications may be obtained by bringing the aircraft to a zero sideslip condition. A wingman may provide an airspeed check prior to landing.

11.9 DUAL HYDRAULIC FAILURES/BACKUP FLIGHT CONTROL MODULE FLIGHT CHARACTERISTICS

11.9.1 General. Several factors work in concert to affect the handling qualities of the F-14 when operating with a dual hydraulic failure. The first is the total loss of the stability augmentation system (SAS) in all three axes. Since the bare airframe is lightly damped in both uncommanded responses or oscillations, the pilot's general impression is that the aircraft is sloppier in all axes and precise control is more difficult. The pilot does have some control over these characteristics as they are very dependent on configuration and airspeed.

The second factor is the capabilities of the remaining flight control system. The inboard spoilers, speedbrakes, and auxiliary flaps are inoperative, and the inboard spoilers and speedbrakes can be expected to float. The degree of spoiler float will be a function of airspeed, AOA, slidslip, flap setting, and the mechanical condition of individual spoiler actuators. During flight tests, changes in float are very slow and do not generate any abrupt rolling moments but do impose significant lateral trim changes. Outboard spoilers remain fully functional because of the independent nature of the outboard spoiler module, which also serves to power the main flaps and slats via either the flap handle or the maneuver flap thumbwheel. Lastly, only the rudders and horizontal stabilizers are powered by the BFCM. Because of the low output of the BFCM, the stabilizers are dramatically reduced in their ability to respond to pilot commands. The stabilizers are rate limited to 10° per second in HIGH and 5° per second in LOW as opposed to a normal rate of 36° per second. This can be a severe limitation to the pilot's ability to control the aircraft, depending on the abruptness of the pilot commands.

Each of these factors influences the handling qualities in different regions of the flight envelope. Handling qualities at speeds in excess of 200 KIAS are primarily constrained by the absence of pitch SAS and the limitations of the BFCM. At approach speeds, the handling qualities are primarily affected by floating spoilers and the loss of yaw SAS, although rate limiting of the stabs can occur.

11.9.1.1 Rate Limiting. The pilot will observe rate limiting both in the feel of the control stick and in the response of the aircraft. In the F-14 flight control system, the stick is mechanically connected to the stab. With normal hydraulics, there is virtually no time delay between the pilot's command and the stab moving in response to the command. With the BFCM providing significantly less hydraulic flow at a substantially reduced pressure, the stab moves so slowly that it is possible for rapid pilot inputs to exceed the stab maximum deflection rate. When this happens, the pilot will feel an abrupt increase in stick force until the stabs catch up to the pilot's command. If the pilot feels an abrupt increase in stick forces, the stab is operating on its rate limit. This can be observed during the prestart BFCM checks and is most severe in LOW.

The pilot's perception of the aircraft response is likewise affected by rate limiting because of slower response of the stabs to deflection commands. If slow control inputs are made, the delay is insignificant, aircraft response appears normal, and control is unaffected. If control inputs are abrupt, however, with many reversals in direction (such as might be required to tank, land, or fly close formation), the pilot and the stabs can be out of phase with one another, and a divergent pilot-induced oscillation will develop that results in loss of control. This occurs in pitch caused by larger deflections available but may be aggravated by large lateral or directional flight control inputs that further reduce the flow available to command the stabs and, therefore, increase the susceptibility to rate limiting in pitch. LOW mode is extremely limited in its ability to accommodate rapid control inputs, while the HIGH mode can accommodate moderate pilot control inputs.

The abrupt degradation that occurs with rate limiting makes the handling qualities hazardous. The handling qualities of the aircraft while operating with the BFCM in HIGH are generally good for moderate gain tasks, and it is virtually transparent to the pilot that his flight control system is degraded.

However, when operating near the rate limit of the system, very small increases in pilot gain will result in an abrupt and dramatic loss of control and the task being performed must be aborted (i.e., the aircraft cannot be controlled adequately to continue the task). Uncontrollable pitch attitude oscillations of ±10° can develop in less than 3 seconds. Regaining control is simply a matter of loosely releasing the stick, permitting the oscillations to dampen, and then smoothly reapplying control to restore the aircraft to the desired flight condition. In summary, if the system is not rate limited, the handling qualities are good; if the system is rate limited, the aircraft rapidly becomes uncontrollable.

11.9.1.2 Task Performance. There are four variables that the aircrew can control to maximize the probability of successfully completing mission tasks. Selection of an appropriate motor speed is the first controllable variable. Tightly controlled tasks such as landing, close formation, and in-flight refueling require the control rates available with HIGH mode. Judicious selection of airspeed can also influence successful task performance. With SAS off, the sensitivity of the aircraft increases significantly with airspeed. The slower the airspeed, the slower the response. For tightly controlled tasks, the flight control system must be capable of responding faster than the natural dynamic character of the aircraft, or the pilot must accept undesirable overshoots and oscillations. The flight control system capabilities with the BFCM in either LOW or HIGH are very restricted. Part of the solution is to slow down the aircraft and its response as much as is practicable to give the flight control system the best chance of keeping ahead of the aircraft. The third variable is configuration, some of which are more suited to specific tasks. Lastly, pilot technique may limit the ability of the aircraft to perform some tasks. The slower and smoother the input, the less likely rate limiting will be encountered. Flight tests performing each of the following tasks have revealed the mixture of the above variables whereby successful recovery of the aircraft can best be ensured.

11.9.2 LOW Mode Cruise and Formation. Cruise handling qualities in LOW mode are degraded but satisfactory. Roll response is very sluggish and some overshoots can be expected when trying to establish a bank angle. In pitch, any abrupt pitch input at 250 KIAS or faster will result in multiple oscillations when trying to precisely set a pitch attitude. Flying very loose formation is fairly easy, provided tight control is not attempted. Any attempt to finely control vertical elevation relative to a lead aircraft (±2 feet) will result in rate limiting the stabs and loss of control. Control can be reestablished by relaxing the grip on the stick, allowing the oscillations to dampen, and then smoothly reapplying control. Slower airspeeds (200 KIAS) provide for more predictable control as discussed in paragraph 11.9.1. Do not attempt IMC formation, close night formation, in-flight refueling or landing while in LOW mode. LOW mode control is satisfactory for the performance of configuration changes such as lowering gear and flaps.

WARNING

A pitch PIO will develop if any tight longitudinal control is attempted. Control can easily be regained by relaxing the grip on the stick, allowing any oscillations to dampen, and then smoothly reapplying longitudinal stick to reestablish the desired flight condition. Do not attempt IMC formation or close night formation while in LOW mode.

Note

Airspeeds less than 250 KIAS while operating in LOW mode will reduce the susceptibility to rate limiting.

11.9.3 HIGH Mode Cruise and Formation. Up-and-away flying qualities in HIGH mode are generally excellent, with the only noticeable degradation being a slight sluggishness in roll response. Cruise and formation tasks are very easy, provided that very tight tolerances are not attempted (±1 foot). Higher speeds (>250 KIAS) will increase the probability of rate limiting during parade formation. Close IMC or night formation is possible but not advisable because the divergent PIO occurs very abruptly with no warning. The F-14 with the hydraulic failure should lead any formation flight except as required for in-flight refueling.

11.9.4 In-Flight Refueling. In-flight refueling can be safely performed but is very dependent on flight condition, configuration, and pilot technique. The best success can be expected at 180 KIAS with maneuvering flaps and a smooth technique. There are two reasons for the strong influence of airspeed. First of all, tanking is easier to perform at slower speeds because the aircraft is much less sensitive, the bow wave is considerably reduced, and the probe position can be more predictably and smoothly controlled, reducing the necessity for aggressive plays to seat the probe. Secondly, the BFCM has an easier job keeping up with aircraft dynamics, decreasing the likelihood of rate limiting. Any attempt to tank faster than 200 KIAS will result in loss of control. Tanking handling qualities are unaffected by landing gear position and are improved with aft wing sweeps in the event that the wings are trapped aft. Flaps should be selected to 10° with the maneuver flap thumbwheel, which still functions normally with outboard spoiler module power. Lastly, the influence of technique is that the rate limiting is caused by abrupt control inputs and counter corrections. The 2 seconds surrounding contact are the critical phase since the controls can be three times more active than during the approach or stabilized refueling. While spotting the basket is common throughout the F-14 community, it is the surest way to place excessive demands on the flight control system during the second or two prior to contact and provoke a loss of control. The best way to avoid abrupt inputs is for the pilot to resist spotting the basket and instead rely on the RIO's directive commentary. Since the stabilized refueling is easy and requires only moderate flight control activity, the airspeed can safely be increased to 200 KIAS once engaged if additional airspeed is required to obtain proper store operation (as might be required with ram-powered buddy stores such as the D-704 or D-301). While not flight tested, a very low gain technique must be used at the minimum airspeed attainable by the tanker if the only resource is a large-body tanker such as the KC-10 for which 180 KIAS might be impossible. The pilot must respond to any undesired motion by loosely releasing the stick and allowing the aircraft to dampen itself.

WARNING

- Any abrupt control input to effect engagement can rate limit the stabilizers and result in loss of control. To avoid rate limiting, the pilot should resist spotting the basket and instead rely on RIO commentary to perform engagement.

- If any undesirable motions or oscillations occur during or after engagement, the pilot must immediately release the stick and permit the motions to dampen before resuming active control.

- Do not attempt in-flight refueling from wing-mounted stores of large-body tankers (VC-10 Canberra) where nose-to-tail overlap is present. The basket does trail adequately aft of the tail for KC-130 and airwing assets.

Note

If the air refueling store does not adequately transfer fuel at 180 KIAS once engaged, the airspeed can safely be increased to 200 KIAS to improve the transfer rate.

11.9.5 Landing. Landing handling qualities are primarily affected by the loss of SAS, inboard spoilers, speedbrakes, auxiliary flaps, and DLC, rather than limitations of the BFCM itself. Longitudinal control is generally good provided no large abrupt pitch changes are attempted. Lateral control is degraded by virtue of the inoperative SAS and inboard spoilers. Spoiler float and its impact on lateral control is considerably aggravated by slower airspeeds and increased flap deflections. Consequently, field landings should be performed with the maneuver flaps down and the No. 2 wing-sweep/maneuver flap circuit breaker pulled to lock them down (LE2). Airspeed control is degraded because of the dramatically decreased drag and low approach power setting. Any airspeed from 15 units to 180 KIAS should be considered acceptable with the wings at 20°; waveoff performance is dramatically improved if some additional speed is carried. Fifteen units should be used if the wings are trapped significantly aft. Speeds in excess of 180 KIAS on final should otherwise be avoided because of the increased susceptibility to rate limiting. Lateral control is degraded but satisfactory, and a straight-in approach to an arrested landing should be performed. The very low drag, runway length, long field gear, and length of time while operating on the BFCM must all be considered in choosing a game plan for handling bolters. The nose must smoothly be rotated to the fly-away attitude if a go-around is elected. Flaps can be selected to full once on deck to obtain the additional drag from the outboard flap panels and ground roll braking from the outboard spoilers.

WARNING

Aggressive nose movement in close or on bolter can rate limit the stabs resulting in low-altitude loss of control. Do not use APCS. Glideslope is satisfactorily controlled with appropriate use of power and smooth pitch inputs, allowing airspeed to vary within the recommended range. Smoothly rotate nose to fly-away attitude on bolter.

CAUTION

Waveoff performance from low power settings is very poor. Carrying extra speed during approach will improve waveoff performance by permitting smooth rotation to 15 units AOA to break the rate of descent while engines are spooling up.

Carrier landings with a dual hydraulic failure are very hazardous and should not be attempted because of the abrupt and unpredictable nature of rate limiting. Control would most probably be lost between the in-close and at-the-ramp positions when neither the pilot nor LSOs could avert a catastrophic flight deck mishap.

11.9.6 BFCM Thermal Durability. The thermal behavior of the BFCM and its isolated hydraulic loop determine the durability of the system. With the motor operating in LOW, the temperature of the motor and the fluid will stabilize and the motor can run indefinitely. In HIGH, however, the motor can heat up within 8 minutes to temperatures at which it might fail. The motor should be selected to HIGH only after the aircraft is on final with intent to land, unless tanking is required. The motor should be selected to LOW once safely airborne following waveoff, missed approach, or bolter, and then HIGH reselected on final. The elapsed time on HIGH must be closely monitored if in-flight refueling is required. Once disengaged, LOW must be immediately selected.

WARNING

Operations of more than 8 minutes total in HIGH may fail the BFCM motor. Extended LOW operation (>30 minutes) after in-flight refueling will permit several additional minutes of use for subsequent landing.

11.10 FLIGHT CHARACTERISTICS WITH AFT CG LOCATIONS

11.10.1 Store Effects on Cg Location. The normal NATOPS cg limits are expressed relative to a reference condition known as zero fuel gross weight (ZFGW). This configuration is defined as wings at 20°, gear and flaps down, and zero fuel on board. Adding fuel or raising the gear and/or flaps will move the cg position forward from the ZFGW position. The limit for ZFGW cg locations with tunnel-mounted stores is 17.0-percent MAC. On a typical fleet aircraft, one Mk 84 2,000 pound bomb placed on station 4 or 5 results in a ZFGW cg aft of 17.0-percent MAC, possibly as far aft as 18.5 percent to 19-percent MAC. Two aft hung Mk 84s can produce a ZFGW cg of up to 22-percent MAC. Aft wing sweep can be used to move the neutral point of the F-14 aft and restore normal static longitudinal stability margin and normal flying qualities even with extremely aft cg locations. In flight, actual cg location varies as fuel is burned but remains relatively constant at its most forward position between 5,000 to 10,000 pounds. Below 5,000 pounds, the cg moves aft toward the ZFGW position. Wing-mounted AIM-7/9s move the ZFGW cg location slightly forward, while external tanks have no effect on the cg location.

11.10.2 Wing-Sweep Effects on Stability. Static stability of an aircraft is determined by the difference in location of the neutral point, where the lift component can be assumed to act, and the cg position. A positive static margin exists as long as the neutral point remains aft of the cg location. As the wings of the F-14 sweep aft, the cg location also moves slightly aft but the greatest change is in the neutral point position that moves further aft as well. Aft wing sweep can be used in conjunction with an aft cg position to restore the normal margin between the neutral point and the cg, producing the same level of stability and normal flying qualities.

11.10.3 Cruise and Combat Flight Characteristics with Aft Cg. Flying qualities at aft cg locations up to 22-percent MAC with gear and flaps up are only slightly degraded. This degradation will probably not be apparent to the pilot. No change in flying qualities is noted during dive recoveries between 400 and 500 KIAS. Stick force per g remains relatively nominal even with 4,000 pounds of aft hung bombs. No degradations to any aspect of flying qualities are noted above 300 KIAS as the wings remain sufficiently aft on the normal wing-sweep schedule to produce a positive static margin for even the most aft cg locations. At 20° of wing sweep, 250 KIAS, and a ZFGW cg of 18.6-percent, the aircraft exhibits some reduction in static stability and is slightly more responsive to pitch inputs, although this increase in responsiveness may not be significant enough to be noticed during normal flight operations. Wing-mounted stores or external tanks have no adverse effects on aft cg flying qualities.

11.10.4 Takeoff and Landing Configuration Flight Characteristics with Aft Cg. With the gear and flaps lowered and 20° of wing sweep with a ZFGW cg location of 18-percent MAC or greater, the static margin is greatly reduced from normal and can be negative for the extremely aft cg locations produced by 4,000 pounds of bombs on the aft weapon stations. The aircraft is extremely susceptible to pilot-induced oscillations during closely controlled tasks such as close formation or flying the ball. Loss of control is likely. With a wingsweep of 25° for ZFGW cg locations up to 18.6-percent MAC, normal static margin is restored and normal flying qualities are regained. For ZFGW cg location greater than 18.6-percent MAC, 30° of wing sweep is sufficient for normal handling qualities to be regained.

Wing-mounted stores and external tanks reduce lateral-directional stability in the takeoff and landing configuration slightly, although the difference in flying qualities is not significant and may not be noticeable. Once established in the optimum wing-sweep configuration appropriate for the amount of ordnance hung on the aft stations, normal approach techniques can be used. However, a straight-in approach should be flown as power requirements in a turn with aft wing-sweep are significantly different than normal and could produce a severely underpowered approach. No abnormalities in aircraft response or performance are apparent during landing approaches at 15 units, even with 4,000 pounds of aft hung ordnance. APC is not optimized for aft wingsweep landings and should not be used. DLC should not be used as it adds 8 knots to recovery WOD requirements and has improper pitch trim response at aft wing sweep. Expect on-speed airspeed for 25° of wing sweep to increase 6 knots over the normal DLC on 20° of wing sweep approach speed, and 12-knot increase if wings are at 30°. For CV arrestments, the appropriate recovery bulletin should be consulted. Ashore, a field arrestment is recommended with spoiler brakes dearmed because of the large noseup pitch occurring at spoiler deployment. If a field arrestment is not possible, expect to use full forward stick to counter the noseup pitching moment and to maintain forward stick until below 80 KIAS with a resultant longer rollout.

PART V

Emergency Procedures

Page No.

CHAPTER 16 — EJECTION AND BAILOUT

CHAPTER 12

Introduction/Ground Emergencies

12.1 INTRODUCTION

This section covers the recommended procedures for coping with emergencies and malfunctions that may be encountered during aircraft operations. Knowledge of the aircraft systems and emergency procedures must be reviewed on a regular basis to ensure that the flightcrew will take the correct course of action under adverse conditions.

Each emergency presents a different problem that requires positive, specific, remedial action in accordance with recommended procedures and good airmanship. Judgment, precision, and teamwork are essential during emergencies. The flightcrew must weigh all the factors of a given situation and then take appropriate action. This section discusses the preplanned, likely courses of action and recommended procedures for certain emergencies. As soon as possible, the pilot should notify the RIO, flight leader, and flight and ground station in as much detail as possible of the existing emergency and of the intended action.

12.1.1 Critical Procedures. Procedures marked with asterisks (*) are considered critical. Flight crewmembers should be able to accomplish asterisked procedures without reference to the checklist. Critical procedures are presented in an abbreviated, easy to remember form in NAVAIR 01-F14AAP-1B.

WARNING

Failure to lock shoulder harness during in-flight emergencies could result in inability to initiate ejection.

12.2 ON DECK EMERGENCIES

12.2.1 Engine Fire on the Deck

PILOT

*1. Both FUEL SHUT OFF handles — Pull.

*2. Both throttles — OFF.

3. If conditions permit — Windmill Engine.

4. BACKUP IGNITION switch — Check OFF.

CAUTION

Excessive windmilling of engine with oil system failure may increase combustion/smoking (blue/white) and result in greater difficulty extinguishing, causing further damage to engine.

If fire light and/or other secondary indications:

5. Fire extinguisher pushbutton (related engine) — Depress.

6. Egress.

RIO

1. Notify ground and/or tower.

2. Egress.

12.2.2 Abnormal Start

1. Throttle (affected engine) — OFF.

2. BACKUP IGNITION switch — Check OFF.

Note

If hot start on deck, windmill engine until EGT is below 250 °C before attempting restart.

Note

If wet start, continue cranking until tailpipe is clear of fuel.

12.2.3 START VALVE Light After Engine Start

1. Ensure ENG CRANK switch — OFF.

2. AIR SOURCE pushbutton — OFF.

3. Throttle (affected engine) — OFF.

CAUTION

- If the starter valve does not close during engine acceleration to idle rpm, continued air flow through the air turbine starter could result in catastrophic failure of the starter turbine.

- If the START VALVE caution light illuminates after the ENG CRANK switch is off or if the ENG CRANK switch does not automatically return to the off position, ensure that the ENG CRANK switch is off by 60-percent rpm and select air source to OFF to preclude starter overspeed.

12.2.4 Uncommanded Engine Acceleration on Deck. Uncommanded engine acceleration may or may not be associated with throttle movement. Uncommanded throttle(s) are characterized by increased or decreased throttle settings caused by failures of the throttle control system.

Uncommanded engine acceleration without throttle movement is a result of an AFTC or MEC failure normally associated with one engine. Selection of the ENG MODE SELECT switch(es) to SEC may restore throttle authority.

*1. Paddle switch — Depress and Hold.

*2. Throttle(s) — As Desired.

*3. ENG MODE — SEC.

Note

In SEC mode, nozzle is commanded full closed.

*4. THROTTLE MODE switch — MAN.

If engine(s) still uncommanded and aircraft is not in catapult tension:

5. Throttle(s) — OFF.

6. FUEL SHUT OFF handle(s) — Pull.

Note

- Approximately 50 pounds of force must be applied to the throttles to override the boost system to ensure disengagement of APC BIT self-test.

- The quickest and most reliable method to secure uncommanded engines is to revert the throttle system to the manual mode and secure the throttle(s). Since manual is by design a backup mode, the throttle rigging may not be the same as the boost mode. It may take a hard snapping motion to position the throttle into OFF. If throttle(s) are misrigged in manual mode, the OFF position may not secure fuel flow to the engine.

- Both throttles cannot be secured simultaneously; however, reverting to manual mode will allow both throttles to be returned to IDLE simultaneously.

12.2.5 Brake Failure at Taxi Speed

*1. ANTI SKID SPOILER BK switch — SPOILER BK or OFF.

2. Nosewheel steering — Engaged.

3. Parking brake — Pull (if required; parking brake will lock both main wheels).

WARNING

Complete loss of hydraulic fluid through the wheelbrake hydraulic lines will render the parking brake and nosewheel steering ineffective.

If brakes still inoperative:

4. HOOK — DN.

CAUTION

After lowering hook, nosewheel steering will be automatically centered and will remain centered until nosewheel steering is cycled.

5. External lights — ON.

6. Notify ground or tower.

7. Both throttles — OFF (if required) (if collision is imminent, DO NOT delay step 7).

WARNING

During shipboard operations, aircrew should not delay ejection decision if departure from the flight deck is imminent.

12.2.6 Ground Egress Without Parachute and Survival Kit. Methods and routes of ground egress will vary with the situation. In all cases, kneeling the aircraft (conditions permitting) via the nose strut switch will facilitate a safer exit for the aircrew. If sufficient time does not exist for ground personnel to deploy the boarding ladder, aircrew should egress to the rear of the aircraft, over the horizontal stabilizers or wings, or directly to the deck from the cockpit if tail over water. In the case of fire, the location and intensity of the fire will dictate the safest escape route. If electing to egress directly from the cockpit, aircrew should grasp the canopy rail with both hands, hang to full body extension, and drop to the ground. A parachute landing fall maneuver may be required to minimize the risk of injury. Spacing of pitot static probes along both sides of the forward fuselage will allow for an unobstructed egress.

WARNING

- Standing and jumping from the cockpit or attempting to slide down the nose of the aircraft during ground egress can result in severe injury.
- If the ANTI-ICE switch is in the ORIDE position, touching the pitot probes with bare skin will cause burns.

1. Kneel aircraft (if possible)

2. Canopy — Open or Jettison

3. Parking brake — Pull

4. Ejection seat — Safe (safe by pulling emergency restraint release and with the face curtain locking tab).

5. All fittings — RELEASE (restraint fittings and oxygen hose).

Note

To retain survival kit, do not release lapbelt restraint fittings.

12.2.7 Emergency Entrance. See Figure 12-1 for procedures for entering the cockpit for emergency rescue.

12.2.8 Weight On-Off Wheels Switch Malfunction. There are weight on-off wheels switches on the left and right main gear that interact with many aircraft subsystems to provide safety interlocks. The interlocks prevent operation of various component or systems on deck or in flight, as appropriate.

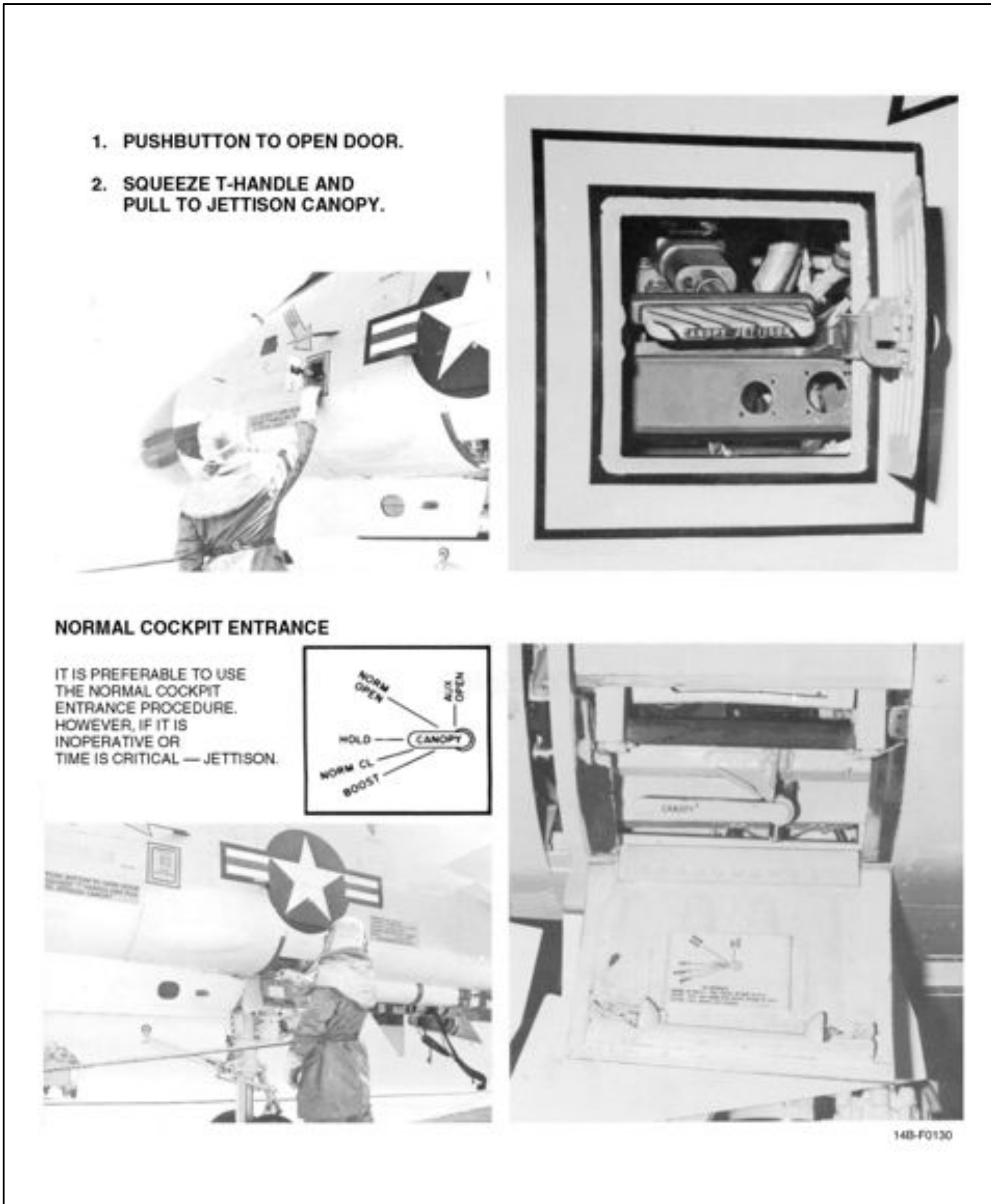


Figure 12-1. Emergency Entrance

CAUTION

Failure of the left or right weight on-off wheels switches to the in-flight mode can cause loss of engine ejector air to the IDGs and hydraulic heat exchangers causing thermal disconnect and/or heat damage to the generators and aircraft hydraulic systems.

12.2.8.1 Failure of Weight On-Off Wheels to In-Flight Mode

INDICATIONS:

1. WOW acronym is displayed.
2. Approach indexers are illuminated.
3. Nozzles may be partially closed at idle rpm.
4. Nosewheel steering is inoperative.
5. Launch bar light is illuminated (if nosegear turned >10°).
6. Ground-roll braking is inoperative.
7. Wing-sweep MASTER TEST is disabled.
8. Oversweep is disabled.
9. Outboard spoiler module on FLAP handle is up (wings less than 62°).
10. Aircraft will not kneel.

If two or more of the preceding anomalies are detected, the following action should be taken:

PILOT

1. Clear runway (if applicable).
2. Generators — OFF.
3. Throttles — OFF (after downlocks are in place).

CAUTION

Failure of the left or right weight on-off wheels switches to the in-flight mode can cause loss of engine ejector air to the IDGs and hydraulic heat exchangers causing thermal disconnect and/or heat damage to the generators and aircraft hydraulic systems.

RIO

1. WCS switch — OFF.

WARNING

With failure of the weight on-off wheels switch to the in-flight mode, the following functions are enabled:

a. AWG-9 can scan and radiate.

b. ALQ-126 can transmit.

c. Probe heaters will be on in AUTO.

d. ALQ-167 can radiate (TARPS).

e. BOL chaff can dispense.

12.2.9 Binding/Jamming Flight Controls On Deck

1. Hold light pressure against binding/restriction to facilitate maintenance troubleshooting procedures.

CAUTION

Do not attempt to free controls by force as further damage to flight control system may result.

2. Abort mission.

CHAPTER 13

Takeoff Emergencies

13.1 ABORTED TAKEOFF

Emergencies during takeoff are extremely critical and require fast analysis and quick decision by the pilot. The decision to abort should not be delayed just because emergency arresting gear is available at the end of the runway. Whether to abort or continue the takeoff depends on the length of runway remaining, refusal speed, best single-engine climb speed, and the arresting gear available. Failure of either engine, a fire warning light, or a blown tire during takeoff dictates an immediate abort if enough runway is available. The ejection seats will provide safe escape at ground level and low airspeeds. Therefore, if a safe aborted takeoff cannot be performed and takeoff is impossible, eject.

In an aborted takeoff, aerodynamic ground-roll braking is assisted by simultaneous deflection of all spoilers (flaps down) or inboard spoilers only (flaps up) to 55° when both throttles are retarded to IDLE.

Note

Moving flap handle down activates outboard spoilers to assist in aerodynamic ground-roll braking.

When securing the starboard engine, use caution to prevent inadvertent shutdown of both engines. If both engines are shut down, hydraulic pressure is lost along with antiskid, nosewheel steering, spoiler braking, and normal braking. Full aft stick is used to augment aerodynamic braking. Care should be taken while positioning the stick aft to avoid any nose rotation. The aircraft's tendency to rotate is accentuated with the flaps up because of increased longitudinal control effectiveness, and aft stick must be applied at a slower rate to avoid rotation.

WARNING

Maximum braking effort in aborts initiated near rotation speed at takeoff gross weights may result in blown tires even with antiskid engaged.

CAUTION

Rolling over an arresting wire with brake pressure applied may result in blown tires.

If arresting gear is available, use it to avoid rolling off the runway. Always inform the control tower of your intention to abort the takeoff and engage the arresting gear so that aircraft landing behind you can be waved off. Lower the hook in sufficient time for it to fully extend (normally 1,000 feet before engagement). Use nosewheel steering to maintain directional control and aim for the center of the runway. At night, use the taxi light to see the arresting gear. If off center just before engaging the arresting gear, do not turn the aircraft but continue straight ahead, parallel to the centerline.

If aborting with a blown nosewheel tire, it is likely that either or both engines have FOD. In the event of any blown tire during an aborted takeoff, the flaps should not be moved until they can be inspected for FOD.

Aircraft control following loss of an engine during the takeoff roll is a function of thrust setting and airspeed. In most cases, an aborted takeoff will be required. See Chapter 11 for additional discussion of takeoff-configuration, asymmetric-thrust flight characteristics.

13.1.1 Aborted Takeoff Procedure

*1. Throttles — IDLE.

*2. Speedbrakes — EXT.

*3. Stick — Aft.

Note

The stick should be positioned fully aft at a rate that will not cause any nose rotation.

*4. HOOK — DN (1,000 feet before wire).

*5. Brakes — As Required.

*6. Right engine — OFF (if required).

CAUTION

Aircrew should expect hot brakes following heavy gross weight, high-speed aborts. Application of the parking break could cause the brake assembly to fail and result in a brake fire.

Note

If performing no flap/maneuvering flap takeoff, lowering the flap handle slightly during an abort will deploy all spoilers for ground roll braking if spoiler brake or both is selected, assisting in decelerating the aircraft.

13.2 SINGLE-ENGINE FAILURE FIELD/ CATAPULT LAUNCH/WAVEOFF

Initial aircraft controllability is highly dependent on timely and proper rudder usage. Rudder is the primary control for countering yaw because of asymmetric thrust since lateral stick inputs alone will induce adverse yaw in an already critical flight regime. Compounding the situation, visual cues for ascertaining yaw excursions may be absent at night. While roll because of yaw will always be apparent, yaw excursions during night/IFR conditions may be first indicated by the turn-and-slip indicator and heading indicator if in near wings-level flight. The pilot should be prepared to apply up to and including full rudder at the first indication of an engine failure. Do not rotate aircraft below 130 KIAS in any configuration. Refer to NAVAIR 01-F14AAP-1.1, Part XI, Chapter 2, for higher rotation speeds. Additional areas for consideration are discussed below.

13.2.1 Angle-of-Attack/Endspeed Consideration. Failure to limit AOA will place the aircraft in a regime to reduce directional stability, rudder control, and rate of climb. The aircraft may be uncontrollable at AOA above 20 units. Smoothly rotating to 10° pitch attitude and approximately 14 units indicated AOA provides the best compromise between controllability, good initial flyaway attitude, and adequate single-engine performance. For compromise, normal 15-knot excess endspeed catapult launches (mandatory from catapult No. 4 and highly recommended from catapult No. 3) will place the aircraft in the approximate 14 unit AOA regime. Zero excess endspeed launches on hot days, where single-engine performance is marginal, will place the aircraft in the approximate 18 unit AOA regime and will require the pilot to precisely fly the aircraft away from the water avoiding sudden pitch control inputs.

13.2.2 Rate of Climb Consideration. Rate of climb may be increased by selecting afterburner with ASYM LIMITER switch in ON. Only minimum AB is available. Use of maximum AB is prohibited. The most adverse drag condition is with the wings level on a constant heading, but techniques used by traditional multiengine aircraft (such as raising the dead engine with 5° angle of bank) are applicable for the F-14. Airspeed and angle of bank control will also greatly affect rate of climb. (Refer to NAVAIR 01-F14AAP-1.1, for all of these effects.)

Under normal circumstances, 180 KIAS is used as the flaps up speed. However, if during a single-engine take-off the aircraft has achieved a safe flying speed and a positive rate of climb but has difficulty achieving flap speed, moving the flaps up in increments prior to 180 KIAS will enhance acceleration and climb capabilities.

13.2.3 Stores Jettison Considerations. If an acceptable rate of climb cannot be maintained or deceleration cannot be countered by thrust alone, jettison should be selected. The benefits of an instantly lighter aircraft and lower drag configuration always produce positive effects on performance. Separation characteristics of the external tanks in this configuration, however, have never been verified by flight tests and consequently may result in stores-to-aircraft collision with unknown consequences. The use of ACM jettison, which will selectively bypass nonselected stores, could be utilized but does not offer the same gross weight reduction and requires the additional interlocks of gear handle plus ACM guard up.

13.2.4 Aircrew Coordination. Each launch must be made with the aircrew prepared for the worst case. Even when mentally prepared to handle this emergency, the F-14 crew faces a difficult task in executing a safe flyaway. Of paramount importance is a knowledgeable understanding by both pilot and RIO of what to expect when confronted with an engine failure during launch. Both must have already determined during a preflight briefing the points to be considered (i.e., controllability, AOA/pitch attitude, engine, rate of climb, and jettison considerations). The pilot will probably be the only one to know if an engine fails during launch. The RIO will probably be the only one in a position to successfully initiate ejection prior to departing the ejection envelope.

13.2.5 Single-Engine Failure Field/Catapult Procedures/Waveoff

*1. Set 10° pitch attitude (14 units AOA maximum).

*2. Rudder — Opposite Roll/Yaw Supplemented by Lateral Stick.

*3. Both throttles — As Required for Positive Rate of Climb.

*4. Landing gear — UP.

*5. Jettison — If Required.

6. If banner tow, Hook — Down.

7. If unable to control aircraft — Eject.

8. Establish 10 unit AOA climb.

9. Climb to safe altitude.

10. Flaps — UP.

11. Refer to Single-Engine Cruise Operations, paragraph 14.5.3.3.

13.3 BLOWN TIRE DURING TAKEOFF

If a tire blows during the takeoff roll and an abort is impossible, do not raise the landing gear or flaps. Leave the landing gear down to avoid fouling the blown tire in the wheelwell. Leave the flaps down; they may be damaged by pieces of ruptured tire. Also, climbing with the gear and flaps down is an optimum flight attitude for emergency fuel dumping.

13.3.1 Blown Tire During Takeoff, Takeoff Aborted, or After Landing Touchdown

*1. Nosewheel steering — Engaged.

*2. ANTI SKID SPOILER BK switch — SPOILER BK.

CAUTION

- Do not delay engaging nosewheel steering in order to center rudder pedals.
- The aircraft should have ground locks installed and engines secured before moving aircraft.

Note

Antiskid will sense a constant release on a dragging blown tire.

13.3.2 Blown Tire During Takeoff, Takeoff Continued, or After Landing Go-Around

*1. Throttles — As Required.

*2. Landing gear and flaps — Leave as Set for Takeoff.

3. HYD isolate switch — FLT.

Note

This will require bending the cam on the gear handle in order to move the HYD isolate switch to FLT.

CAUTION

Blown tire(s) can cause engine FOD and/or structural damage.

4. Refer to BLOWN TIRE LANDING PROCEDURES, paragraph 15.5.

CHAPTER 14

In-Flight Emergencies

14.1 COMMUNICATIONS FAILURE

1. Check mikes and earphone plugs.
2. Check oxygen mask connections and oxygen hose disconnect.
3. RIO check console connector adjacent to shoulder harness control lever. Pilot check console connector aft of g valve.
4. Increase ICS volume and attempt B/U and EMERG positions.
5. Attempt intercommunications with VHF/UHF transceiver.
6. If cockpit altitude is safe, oxygen mask can be removed so that when helmet earmuff is held open, verbal communications can be maintained.

14.1.1 Flightcrew Attention Signals. When no other method of communicating exists, the following signals should be used:

1. Pilot will attract RIO by rocking of wings.
2. RIO will attract pilot by shouting, "#, &, !"
3. Acknowledgment will be thumbs-up, high on left-hand side of cockpit, and future communications will be conducted by visual hand signals using HEFOE code.

14.1.2 COMM-NAV Emergency Procedures

14.1.2.1 Lost (Without Navigation Aids or Radio Receiver)

1. Pilot select running lights on FLASH.
2. RIO squawk mode 3 code 7600.
3. Attempt homebase location by radar mapping or DR to best known position. Attempt marshal pattern location by APX-76 interrogation.
4. Drop four bundles of chaff at 2-mile intervals, then complete series of four standard left-hand 360° turns at 20-second intervals.
5. If no chaff, fly minimum of two triangular patterns to left with 1-minute legs.
6. Repeat patterns at 20-minute intervals.
7. Conserve fuel throughout and facilitate radar pickup by maintaining highest feasible altitude consistent with situation.
8. Be alert for aircraft attempting to join.
9. After joining, communicate with appropriate hand or light signals.

14.1.2.2 Lost (Without Navigation Aids but With Radio Receiver)

1. Same as without radio, but make turns to right.

14.1.2.3 No Radio (With Navigation Aids)

1. Proceed to alternate marshal.
2. Energize ID function at least once each minute.
3. Commence penetration or letdown at expected approach clearance time. If not given EAC, commence approach at ETA.
4. Be alert for aircraft vectored to join.

14.2 PITOT-STATIC SYSTEM FAILURES

If the altimeter and Mach airspeed indicators are erroneous, pitot pressure, static pressure, and total temperature inputs to the central air data computer may also be inaccurate. Placing the ENG/PROBES ANTI-ICE switch in ORIDE or AUTO may restore operation if the malfunction was caused by icing.

Note

- Pitot-static system failures caused by icing may input an erroneous Mach number to the air inlet control system programmer, which will result in the ramps being in the wrong position for the actual Mach number (engine stall may result).
- With known or suspected pitot-static malfunctions, limit airspeed to 0.9 IMN or less.
- Pitot-static failures will generally be detected by the DFCS and may result in an FCS CAUTION light as another secondary indication. If the condition causing the failure is resolved, the fault may be cleared with a MASTER RESET.

If it is apparent that icing is not the problem, use the AOA indicator in place of airspeed for flight conditions as shown in Figure 14-1. Descend to an altitude below 23,000 feet. When cabin altitude stabilizes at 8,000 feet, aircraft altitude will be approximately 23,000 feet. Below 23,000 feet, aircraft altitude can be determined by dumping cabin pressure and using the cabin altitude indicator above 5,000 feet. Below 5,000 feet, use the radar altimeter.

Reduce airspeed and set wing sweep to 20° using the emergency wing-sweep mode. The landing should be without the auto throttle engaged. If the AWG-9 computer computations are affected, the RIO can manually enter estimated wind direction and velocity through the computer address panel.

14.3 EMERGENCY JETTISON

All stores including external fuel tanks (station Nos. 2 and 7), except Sidewinder missiles (AIM-9), are jettisoned in a fixed interval between sequenced stations to avoid store-to-aircraft collision. See Figure 14-2 for external stores jettison table.

1. EMERG STORES JETT pushbutton — Depress.

FLIGHT CONDITION		ANGLE-OF-ATTACK Units
CATAPULT (15 KNOTS EXCESS)		
Transition From Catapult	MRT	14.0
	AB	13.0
MILITARY POWER CLIMB		
All Drag Index	Sea Level	6.0
	Combat Ceiling	9.5
MAXIMUM POWER CLIMB		
All Drag Indexes	Sea Level	5.0
	Combat Ceiling	8.0
CRUISE AT ALTITUDES BELOW 20,000 FEET (All Gross Weights)		
Drag Index = 8		8.0
Drag Index = 100		9.0
CRUISE AT OPTIMUM ALTITUDE		
All Drag Index		8.0
MAXIMUM ENDURANCE		
All Drag Indexes, All Altitudes		10.0
IDLE DESCENT		
250 KCAS		9.0
Maximum Range		10.0
GEAR AND FLAPS EXTENSION		
Safe Gear Extension (Flaps UP) at 280 KIAS		6.5
Safe Flap Extension (Gear DN) at 225 KIAS		9.0
APPROACH		
CCA/GCA Pattern; 220 KCAS; Gear UP; Flaps UP; 54,000 pounds.		9.0
Final ON SPEED Approach (Gear DN): Two Engines (All Flap Configurations)		15.0
Single Engine/PRI:		
FULL FLAP, DLC ENGAGED		15.0
FULL FLAP, DLC STOWED		14.0
NO FLAP		14.0
Single Engine/SEC:		
FULL FLAP (CV ONLY)		13.0
NO FLAP (FIELD ONLY)		15.0
DRAG INDEX CONFIGURATION		
8 (4) AIM-7		
100 (6) AIM-54		
(2) 267-gallon external tanks		

Figure 14-1. Airspeed Indicator Failure

Note

- WHEN JETTISONING MER/TER WITH OR WITHOUT STORES, JETT OPTIONS SWITCH MUST BE IN MER/TER POSITION, UNLESS IT IS DESIRED TO JETTISON INDIVIDUAL STORES.
- FOR AUXILIARY, SELECT ONLY ONE STATION AT A TIME.
- FUZING SAFED IN ALL JETTISON MODES. (DOES NOT PRECLUDE INADVERTENT ARMING OF MECHANICAL FUZES.)
- SIDEWINDER CANNOT BE JETTISONED.

JETTISON MODE	TYPE OF STORES					REMARKS
	EXTERNAL TANKS	PHOENIX	SPARROW	SIDE-WINDER	AIR TO GROUND	
EMERGENCY (PILOT)	✓	✓	✓	—	✓	(✻) VERIFY SWITCH OFF DURING LTS CHECK PRESTART — PILOT ❶
ACM (PILOT)	✓	✓	✓	—	✓	(✻) SEQUENCE JETTISON SELECTED STATIONS ❷ ❹ ❺
SELECTIVE (RIO)	✓	✓	✓	—	✓	❷ ❸ ❺
AUXILIARY (RIO)	—	—	—	—	✓	GRAVITY DROP. SELECTED STATION RELEASES IN SALVO. ❷ ❸ ❺

INTERLOCKS	(✻) JETTISON SEQUENCE
❶ WEIGHT OFF WHEELS (EITHER RIGHT OR LEFT MAIN GEAR)	STATIONS 1B, 8B, 2, 7, –4D, –5D, –4A, –5A, –4C, –5C, 4B, –5B, –3D, –6D, –3A, –6A, –3C, –6C, –3B, –6B
❷ LANDING GEAR HANDLE UP	**Note**
❸ MASTER ARM SWITCH ON	• THE TIME INTERVAL BETWEEN STATIONS INDICATED BY (–) IS 100 MS.
❹ ACM COVER UP	• SUBSTATIONS A, B, C, AND D OF RAIL ARE NUMBERED CLOCKWISE, LOOKING DOWN AT RAIL WITH “A” THE LEFT REAR STATION ON EACH RAIL.
❺ STATION SELECT	• STATIONS 18, 8B, 2, AND 7 ARE JETTISONED SIMULTANEOUSLY.

Figure 14-2. External Stores Jettison

WARNING

- With landing flaps and slats down, do not fire Sidewinder missiles.
- If jettisoned during takeoff emergency, external fuel tanks may collide with the aircraft because of their unstable characteristics.
- A weight-off-wheels signal from the left or right main wheel is sufficient to enable emergency jettison.
- A complete emergency store jettison sequence can take 1.7 seconds.
- The MASTER CAUTION light and the EMERG JETT caution light illuminate when the EMERG STORES JETT push-button is activated.

Note

The EMERG STORES JETT pushbutton indicator remains illuminated until the push-button is depressed again.

If step 1 fails, proceed with ACM jettison procedure.

14.3.1 ACM Jettison. ACM jettison will release all stores selected except Sidewinder missiles.

1. LDG GEAR handle — UP.
2. Station select switches — As Required.
3. ACM — On (cover up).
4. ACM JETT — Depress and Hold (at least 2 seconds).

Note

- ACM jettison follows the same sequence as emergency jettisoning but requires individual selection of stations to be released. Station not selected is skipped.
- When jettisoning bombs from stations 3, 4, 5, and 6 the interval between sequenced stations is automatically designated at 100 milliseconds to avoid store-to-store and store-to-aircraft collision.

14.4 FIRE LIGHT AND/OR FIRE IN FLIGHT

Fire may be accompanied by other indications such as explosion, vibration, smoke, or fumes in the cockpit, trailing smoke, or abnormal engine instrument indications.

A fire in flight precipitated by a failure in the engine can be catastrophic in an extremely short period of time. The shrapnel generated by the engine can rupture fuel and/or hydraulic lines, resulting in a raging fire. The sequence of events for the failure could include all or some of the following.

1. A low-amplitude vibration and noise.
2. Intermittent bursts of white sparks near aft edge of the overwing fairing.
3. Sparks turning to flames.
4. Continuous yellow sparks in an area of increasing size.
5. Flames and/or smoke spreading forward to wing pivot point and encompassing the area of the overwing fairing.
6. Flames, smoke, and/or heat crossing the center-line of aircraft and exiting in the other overwing fairing area.

These indications may or may not be accompanied by a FIRE light. The midship passage of heat and flames could be through the area containing the flight control system control rods that run fore and aft through the back of the aircraft. Heat and flames progressing through this area would impinge on the longitudinal and lateral directional control rods causing possible distortion or failure. Loss of aircraft may follow. The flightcrew faced with this type of fire in flight must react immediately.

*1. Throttle (affected engine) — IDLE.

*2. AIR SOURCE pushbutton — OFF.

If light goes off (and no other secondary indications):

Note

Fire detection test is not available on the emergency generator.

*3. MASTER TEST switch — FIRE DET TEST.

If light remains illuminated, FIRE DET test fails, or there are other secondary indications:

*4. FUEL SHUT OFF handle (affected engine) Pull.

*5. Throttle (affected engine) — OFF.

*6. Climb and decelerate.

*7. Fire extinguisher pushbutton — Depress.

Note

Ensure BACK UP IGNITION switch is OFF.

8. Refer to Single-Engine Cruise Operation, paragraph 14.5.3.3.

9. Land as soon as possible.

10. If fire persists — Eject.

14.5 ENGINE EMERGENCIES

14.5.1 Compressor Stall. A compressor stall is an aerodynamic disruption of the airflow through the compressor. Compressor stalls may occur at any altitude/airspeed combination, including supersonic, and can be identified by any one or a combination of the following indications.

1. Loud bangs or vibrations
2. Rapid yaw or nose slice
3. Increasing TIT
4. Rpm rollback and/or thrust loss
5. Lack of throttle response
6. Inlet buzz (supersonic only)
7. Fireball emanating from the exhaust and/or intake.

*a. Unload aircraft (0.5g to 1.0g).

If greater than 1.1 IMN:

*b. Both throttles — MIL.

When 1.1 IMN or less:

*c. Both throttles — Smoothly to Idle.

Note

If above 1.1 IMN, monitor minimum rpm to ensure proper functioning of idle lockup to avoid inducing a stall.

If EGT is above 935 °C and/or engine response is abnormal:

*d. Throttle (affected engine) — OFF.

If EGT is normal and/or airstart is successful:

e. Perform engine operability check.

Note

After any stall, throttle movement should be minimized until engine operability checks are performed. Engines should be exercised at 10,000 feet in cruise and then at approach speeds, one at a time, to ensure stall-free performance is available for landing. If engine performance is abnormal, set power as necessary and avoid further throttle movement. Land as soon as practical.

Flight test operations have not produced any fully developed engine stalls. Pop stalls have been observed and were self-clearing with no adverse operational impact. Engine ground testing has shown that a hard stall (characterized by loud bang) can result in substantial damage to the IGV system. There have been cases of F110 AB stalls in ground test cells that damaged the IGV linkage system. The damage resulted in complete detachment of the IGV from the external linkage. There was no FOD.

When the IGV linkage breaks, the IGVs assume a fixed aerodynamic trailing position. This position is near normal for MIL or AB power settings but is too far open at lower throttle positions. This reduces fan stall margin with the greatest reduction halfway between IDLE and MIL. Airborne, a hard stall may result in similar damage and will likely have been the result of an AICS malfunction and/or fuel/engine control system failure. If a stall occurs during AB operation, the asymmetric thrust limiting circuit should reduce the good engine to minimum AB. Asymmetric thrust may produce adverse flying qualities under low airspeed and/or high angle-of-attack conditions.

WARNING

Do not delay securing an overtemped engine. Undue delay will greatly increase the likelihood of severe turbine damage and decrease the chance for a successful airstart. If both engines are overtemped, one engine must be secured immediately to provide maximum potential for a successful airstart.

Note

Airspeed and altitude will determine whether both engines can be safely shut down (with dual compressor stalls), or whether one should be secured and relit prior to shutting down the other. If airspeed is insufficient to provide windmill rpm for hydraulic pressure, one engine should be left in hung stall.

There is a threefold danger present when one engine has experienced a compressor stall. The most serious danger manifests itself at slow airspeeds and high-power settings, where the sudden thrust asymmetry (a stalled engine yields negligible thrust) will induce or aggravate a departure and may produce sufficient yaw rate to cause a flat spin if proper recovery controls are not used.

The other two dangers from a compressor stall are that the stalled engine may suffer overtemperature damage and that the good engine may also stall. Although the emergency procedures are designed to address all three dangers, the pilot must understand that aircraft controllability takes priority over engine considerations and involves both throttle position and flight controls. Reference to the engine instruments will probably be required to determine the stalled engine. If the aircraft has departed controlled flight, this should not be at tempted until the pilot has ensured that thrust asymmetry has been minimized and that yaw rate and AOA are under control. The rationale for each individual step in the emergency procedure is as follows:

Step 1: Unload the aircraft (0.5g to 1.0g). — Unloading the aircraft reduces the likelihood of a departure while providing more normal engine inlet airflow. It is not intended that the pilot push the stick full forward or produce negative g but merely that any g-load on the aircraft be reduced to as near 1.0g as possible. In the nose-high, slow airspeed case, the pilot may temporarily lose control effectiveness. This should not be cause for alarm, and the pilot should be able to expeditiously establish a wings-level, nose-low attitude as long as step 2 is performed immediately.

Step 2: Both throttles — Retard to MIL. Retarding the throttles to MIL will both help reduce the asymmetric thrust developed during the stall and potentially help the engine to recover from the stall. It is not recommended to retard the throttle to below MIL until the aircraft is below 1.1 IMN. The engine may automatically switch to secondary mode, and a throttle setting below MIL may result in inlet buzz (idle speed lockup is lost in SEC mode), compounding the stall problem and potentially inducing a stall in the operating engine.

Step 3: Throttle(s) — Retard smoothly to IDLE. During a departure, retarding both throttles to IDLE will help recover the aircraft by minimizing the asymmetric thrust. In the case of a violent slicing departure involving asymmetric thrust, reduction of throttles to IDLE is the most critical step and must be done immediately. If control of the aircraft is not in question, there is no need to retard the throttle on the operating engine. Retarding only the stalled engine throttle reduces the remote probability of inducing a dual-engine stall. In addition, thrust from the operating engine may be required during low-altitude emergencies. Minimizing asymmetric thrust at high AOA and low airspeed shall be accomplished whenever possible. Obviously, there are situations (landing pattern, catapult launch, low altitude and airspeed) where idle power is unacceptable and emergency procedures must be tempered by pilot judgment.

Step 4: Stalled Engine, Throttle OFF — When an engine stalls, the combustor flame does not extinguish. Airflow through the engine and cooling flow to the turbine blades are severely reduced, and the turbine blades may suffer overtemperature damage. Securing the stalled engine to OFF extinguishes the combustor flame, thereby reducing the turbine blade temperature.

14.5.1.1 Supersonic Airspeed. Subsonic compressor stalls will produce inlet buzz. This results in a rough, bumpy ride (+2.5 to –1g at 6 cycles per second). The proper technique to recover from a supersonic compressor stall is to smoothly retard throttles to MIL, keep feet on the deck, and control any wing drop tendencies with lateral stick. The stall normally recovers as the aircraft decelerates through 1.2 IMN.

14.5.1.2 Dual Compressor Stall

WARNING

- During recovery from a dual-engine compressor stall (with both engine-driven generators having dropped off line), flight control inputs may temporarily reduce the combined hydraulic system pressure. If combined hydraulic system pressure drops to between 2,000 and 1,100 psi, the emergency generator will automatically shift to the 1-kVA mode and power only the essential No. 1 buses. If the combined hydraulic pressure continues to fall, the essential No. 1 buses will drop off line, resulting in a total electrical failure.
- Complete loss of electrical power will result in loss of ICS, engine instruments, spin direction indicators (spin arrow and turn needle), and displays.
- If combined hydraulic system pressure recovers, the emergency generator should automatically reestablish 1-kVA power to the essential No. 1 buses. The emergency generator switch must be cycled through OFF/RESET to NORM to regain the 5kVA mode to the essential No. 2 buses.

WARNING

Engine instruments are powered by the essential No. 1 bus but may be automatically restored with the 1-kVA mode. It may be necessary to cycle the emergency generator switch through OFF/RESET to NORM to regain lost engine instruments.

If both engines are stalled after retarding throttles to IDLE, at least one engine must be immediately secured to prevent turbine damage and provide maximum potential for an airstart. If possible, secure the engine that did not initiate the event (the second engine to stall). The cause of the first engine stall may not be known at this point; however, it is highly probable that the second stall may have been induced during the throttle transient to IDLE. Leaving one engine in hung stall minimizes the likelihood of total loss of hydraulic and electrical power (emergency generator).

WARNING

Leaving one engine in hung stall may catastrophically damage the turbine. It is, therefore, imperative that the pilot expeditiously secure and relight one engine to prevent turbine damage. Attention should be given to the remaining stalled engine as soon as possible.

14.5.2 Airstart. The most likely reasons to perform an airstart are that the engine has shut down because of control system failure, hardware failure, fuel feed failure, FOD, or engine stall. The AFTC contains diagnostic logic to identify primary (PRI) engine mode failures and automatically transfers to secondary (SEC) mode when required. If the shutdown was not pilot commanded, the engine may switch to SEC mode automatically. The first airstart attempt should be made in the engine mode selected by the AFTC (either PRI or SEC). If an initial PRI mode airstart is unsuccessful, the ENG MODE SELECT switch should be in SEC for any subsequent airstart attempts.

If an engine flames out, the automatic relight feature will attempt to restart the engine immediately; however, if rpm is decaying below the throttle-commanded level, spooldown airstart procedures should be initiated immediately. If engine flames out because of an automatic shutdown caused by an overspeed greater than 110 percent, it will not re-light automatically. To regain fuel flow, the throttle must be cycled to OFF then to IDLE.

Note

An overspeed condition in excess of 110 percent will result in momentary loss of rpm indication until N2 rpm falls below 110±0.5 percent. EGT and FF indicators will continue to function normally.

There are three airstart phases: spooldown, crossbleed, and windmill. Spooldown is the first phase and provides the best opportunity for a rapid start. Windmill is the last phase and is available only in very high energy conditions.

Spooldown airstarts should be initiated immediately when it is apparent that an engine has lost thrust and that rpm will decay below the throttle-commanded level. High rpm, high airspeed, and low altitude increase the likelihood of a successful spooldown start. See Figure 14-3. The best conditions for both PRI and SEC mode spooldown starts are below 30,000 feet, above 300 knots, and with rpm greater than 30 percent. Spooldown airstarts that light-off with rpm as low as 30-percent can take up to 90 seconds to accelerate to idle, and 20 seconds when initiated at 50 percent or greater.

When initiating a spooldown airstart to clear a stall, cycle the throttle OFF then to IDLE with the engine in either PRI or SEC mode. EGT and rpm indications should rapidly decrease when the throttle is OFF, confirming throttle position. If OFF is selected to secure an engine stall, the throttle should remain in OFF for a few seconds until the stall clears. Typically, airstarts are characterized by a rapid light-off and initial EGT rise with a slow initial increase in rpm. In the low-rpm range, it may take up to 10 seconds to observe an apparent increase in rpm. The RPM display should be flashing if the rpm is increasing.

Hung starts are characterized by rpm stagnating below idle. The current EIG will stop flashing if the next higher segment is not reached within 10 seconds. A low-range (less than 45 percent) hung start can be overcome with the assistance of crossbleed air. A midrange hung start at sub-idle rpm (50 to 60 percent) can be corrected by cycling the throttle OFF then IDLE. Above 45 percent, the starter will not engage. At the completion of the start sequence, the engine responds to actual throttle position.

14.5.2.1 Dual-Engine Airstart (or Airstart of One Engine With the Other Engine Secured). Dual-engine redundancy and automatic re-light makes this situation extremely unlikely. Dual-engine windmill airstart procedures after unsuccessful automatic and manual spooldown airstart attempts should be considered tertiary and performed with serious consideration given to airspeed, altitude, and safe ejection limitations. Flight test data indicate nominal windmill airstart airspeed requirements to be near 450 KIAS. Depending on airspeed and altitude available at windmill airstart profile commencement, a dive angle of up to 45° may be required to achieve nominal airstart airspeeds.

WARNING

Dive angle should not exceed 45°. At 7,500 feet AGL and less than 450 KIAS, commence a smooth 2g pull, converting airspeed to altitude, and eject when less than 350 KIAS.

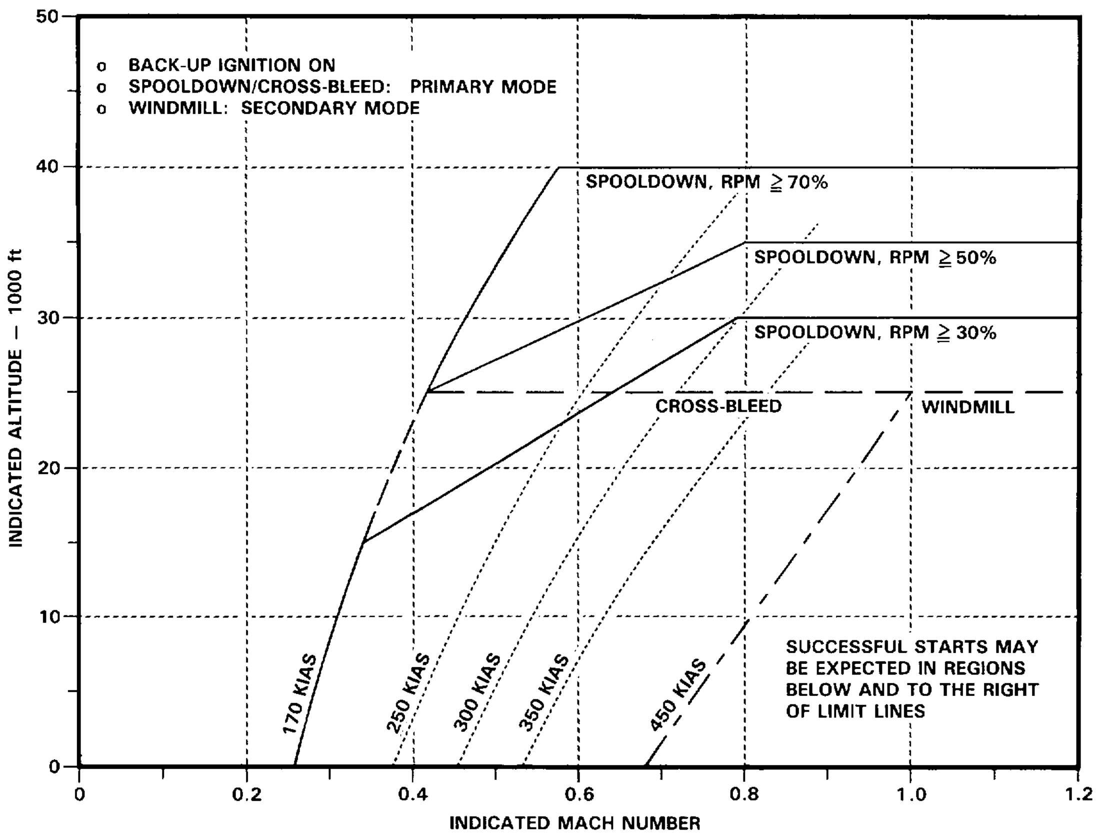
Once established at 450 KIAS, approximately 15° nose down is required to maintain constant airspeed. While attempting airstarts, flight control authority is critical. As rpm decreases, sufficient hydraulic pressure for smooth flight control inputs should be available with one engine windmilling above 18 percent or two engines windmilling above 11 percent. At 450 KIAS, 15° dive, a 2g pull to level flight should be initiated at 2,000 feet. Once the windmill airstart is considered to be unsuccessful, the airstart shall be decelerated to less than 350 KIAS and ejection performed before controllability is lost.

CAUTION

When advancing both throttles from OFF, cycle the right throttle first to a position above IDLE to avoid the throttle-quadrant locking-pin feature.

F110-GE-400 ENGINE

DATE: NOVEMBER 1988
DATA BASIS: FLIGHT TEST



NOTES

- WINDMILL RESTARTS SHOULD BE PERFORMED IN SECONDARY MODE. SECONDARY MODE PROVIDES HIGHER WINDMILLING RPM AND FASTER ENGINE ACCELERATION.
- THE OPTIMUM RESTART RPM IS 15% OR GREATER. RESTARTS FROM 10% RPM ARE SUCCESSFUL BUT ACCELERATE VERY SLOWLY AND ENGINE LIGHT OFF IS HARDER TO DETECT.
- IF THE WINDMILL RESTART IS DELAYED MORE THAN 2 MINUTES FROM SHUT-DOWN THE LEFT ENGINE WILL REQUIRE UP TO 500 KIAS IN ORDER TO MAINTAIN A MINIMUM 10% RPM. THE RIGHT ENGINE WILL MAINTAIN 15% RPM AT 450 KIAS.

14B-F0131

Figure 14-3. Airstart Envelope

CAUTION

Main generators drop off at 55-percent rpm. The emergency generator will drop off at 11- to 12-percent rpm. Engine ignition will not be available below 10 percent.

Note

Airstart can be performed on both engines simultaneously.

14.5.2.2 Engine Flameout

*1. Throttle (affected engine) — IDLE or Above.

*2. BACKUP IGNITION switch — ON.

Note

Spooldown airstart can take up to 90 seconds to reach idle rpm if light-off occurs at low rpm, low airspeed, and high altitude.

If hung start or no start:

*3. Throttle (affected engine) — Cycle OFF, Then IDLE.

If still hung or no start:

*4. ENG MODE SELECT switch — SEC.

If one engine is operable, perform a crossbleed airstart.

If both engines are flamed out/inoperative or crossbleed is not possible:

WARNING

A dual-engine compressor stall may result in a total electrical failure, rendering the ICS, engine instruments, spin direction indicators (spin arrow and turn needle), and displays inoperative.

WARNING

- If sufficient hydraulic pressure restores 1kVA mode of the emergency generator, it may be necessary to cycle the emergency generator switch through OFF/RESET to NORM to regain lost engine instruments.
- With existing ejection seat design limitation, the decision to exceed 350 KIAS rests with the aircrew.
- Sufficient hydraulic pressure for smooth flight control inputs should be available with one engine windmilling at 18-percent rpm or two engines at 11 percent.
- Dive angles should not exceed 45°. At 7,500 feet AGL minimum, commence a smooth 2g pullup to a 20° dive, maximum. At 2,000 feet AGL minimum, pull up to level flight. If the airstart is unsuccessful, convert airspeed to altitude and eject at 350 KIAS or less before controllability is lost.

*5. Airspeed — 450 KIAS (altitude permitting).

When start is complete:

6. BACKUP IGNITION — OFF.

7. ENG MODE SELECT switch — PRI.

When primary mode is restored:

8. Maintain constant subsonic airspeed in level flight.

9. Affected L or R AICS cb (LF2 LEFT or LG2 RIGHT) — Cycle.

WARNING

If WING SWEEP advisory light is illuminated, cycling L AICS cb (LF2) may cause unintentional wing sweep unless WING SWEEP DRIVE NO. 1 (LE1) and WG SWP DR NO. 2/MANUV FLAP (LE2) cbs are pulled.

14.5.2.3 Crossbleed Airstart

1. Throttle (bad engine) — OFF.
2. FUEL SHUT OFF handle — Check in.
3. Throttle (good engine) — 80-Percent Rpm (minimum).
4. BACK UP IGNITION switch — ON.
5. ENG CRANK switch (bad engine) — ON.
6. Throttle (bad engine) — IDLE Immediately.

Note

Quickest lightoff is achieved with throttle to IDLE at less than 10-percent rpm. Lightoffs can take as long as 45 seconds.

If hung start:

7. Throttle (bad engine) — OFF Then IDLE.

If still hung:

8. ENG MODE select switch — SEC.

When start is complete:

9. BACK UP IGNITION switch — OFF.
10. ENG MODE SELECT switch — PRI.

When primary mode is restored:

11. Maintain constant subsonic airspeed in level flight.
12. Affected L or R AICS cb (LF2 LEFT or LG2 RIGHT) — Cycle.

WARNING

If WING SWEEP advisory light is illuminated, cycling L AICS cb (LF2) may cause unintentional wing sweep unless WING SWEEP DRIVE NO. 1 (LE1) and WG SWP DR NO. 2/MANUV FLAPS (LE2) cbs are pulled.

14.5.3 Single-Engine Operations

14.5.3.1 Single-Engine Flight Characteristics. Single-engine flight characteristics are dependent on gross weight, configuration, angle of attack, wing sweep, and maneuvering requirements. In the cruise configuration with one engine inoperative at military power settings, rudder deflection and/or trim is required to prevent yaw toward the failed engine. However, single-engine performance capabilities can be significantly restricted by adverse flying qualities in approach power configuration, particularly at high-gross weights in turning flight, because of the effects of thrust asymmetry at normal approach speed. This degrades with turns into the failed engine such that rudder requirements to maintain level flight can exceed available rudder control. Flight in this configuration should be planned to avoid turns into the failed engine with bank angles limited to 20° maximum and AOA limited to 12 units. The aircraft design is such that no one system (flight control, pneumatic, electrical, etc.) depends on a specific engine. Therefore, loss of an engine does not result in loss of any complete system as long as the HYD TRANSFER PUMP is operative. Refer to NAVAIR 01-F14AAP-1.1 for single-engine performance data.

14.5.3.2 Single-Engine Failure During Flight. It is uncommon to encounter compressor stalls that require immediate engine shutdown. Occasionally, mechanical failure of F110 engine components results in engine failure. These failures may be obvious as when accompanied by severe engine vibration, or may be subtle as indicated by a lack of engine response to throttle changes. Turbine failure, for example, may appear only as an apparent loss of thrust and/or the inability to obtain a successful airstart. For confirmed mechanical failures, the engine should be secured and the FUEL SHUT OFF handle pulled.

WARNING

If an engine fails or a mechanical malfunction has been determined, the respective FUEL SHUT OFF handle shall be pulled immediately after engine shutdown to reduce the possibility of fire or fuel migration.

14.5.3.3 Single-Engine Cruise Operations

1. FUEL SHUT OFF handle (inoperative engine) — Pull.

2. If on final approach or landing, refer to Single-Engine Landing.

When either fuselage tape reaches 4,500 pounds of fuel or less:

3. WING/EXT TRANS switch — OFF.

Note

WING/EXT TRANS switch automatically returns to AUTO if refuel probe is placed to ALL EXTEND, DUMP is selected, or 2,000 pounds of fuel remain on the low side. WING/EXT TRANS switch OFF can be reselected after a 5-second delay, refuel probe is retracted, or dump is secured.

4. FEED switch — Operating Engine Side.

When pilot workload permits close monitoring of fuel distribution:

5. FEED switch — Inoperative Engine Side.

If the fuselage quantity on the inoperative engine side begins to increase:

6. FEED switch — Immediately Move to Operating Engine Side.

CAUTION

An increase in fuel quantity on the inoperative engine side indicates that the sump tank interconnect valve is not open. Fuel available is limited to the quantity on the operating engine side.

If the fuselage fuel quantity on the inoperative engine side begins to decrease:

7. FEED switch — Remain on Inoperative Engine.

8. WING/EXT TRANSFER switch — AUTO.

9. Refer to appropriate hydraulic system failure.

14.5.4 Engine Overspeed (N_2 107.7-Percent Rpm)

1. Throttle (affected engine) — IDLE.

If overspeed continues:

2. ENG MODE SELECT switch — SEC. Verify ENG SEC light illuminated.

If overspeed condition persists:

3. Throttle (affected engine) — OFF.

Note

- Fuel flow is automatically secured when rpm reaches 110 percent. To regain fuel flow, the throttle must be cycled OFF then IDLE.

- An overspeed condition in excess of 110 percent will result in momentary loss of rpm indication until N_2 rpm falls below 110±5 percent. EGT and FF indicators will continue to function normally.

4. Refer to Single-Engine Cruise Operations, paragraph 14.5.3.3.

5. Land as soon as practicable.

14.5.5 Engine START VALVE Light

1. Ensure ENG CRANK switch — OFF.

2. AIR SOURCE pushbutton — OFF.

Note

If operational necessity dictates, AIR SOURCE L ENG or R ENG may be selected provided the START VALVE light remains out. Crossbleed airstarts may not be available to the affected engine after a START VALVE light illuminates because of possible overspeed damage.

If airborne:

3. ENG START cb (RE1) — Pull.

If on deck:

4. Throttle (affected engine) — OFF.

14.5.6 Engine Transfer to Secondary Mode

CAUTION

In secondary mode, idle lockup protection is lost. Decelerate below 1.1 IMN before retarding throttle to idle to avoid supersonic inlet buzz and possible compressor stall.

Note

- AC generator failure, indicated by loss of rpm and nozzle gauge indications, will shift the engine into SEC mode without illuminating the SEC light. Main high-energy ignition will be inoperative. Backup ignition is required for airstarts.

- SEC mode transfer while in AB may result in pop stalls. Non emergency manual selection of SEC mode airborne should be performed in basic engine with the power set above 85-percent rpm.

If engine transfers to secondary mode:

1. Throttle (affected engine) — Less Than MIL.
2. ENG MODE SELECT switch — Cycle.

If PRI mode restored:

3. Maintain constant subsonic airspeed in level flight.

WARNING

If WING SWEEP advisory LT is illuminated, cycling L AICS CB (LF2) may cause unintentional WING SWEEP unless WING SWEEP DRIVE NO. 1 (LE 1) and WG SWP DR. No. 2/MANUV FLAP (LE2) cbs are pulled.

4. Affected L or R AICS cb (LF2 left or LG2 right) — Cycle.

If engine remains in SEC:

5. ENG MODE SELECT switch — SEC.
6. Avoid abrupt throttle movements.
7. Land as soon as practicable.

CAUTION

Landing in SEC mode may increase landing roll because of loss of nozzle reset. If runway length or braking conditions warrant, make an arrested landing.

14.5.6.1 Transfer to Secondary Mode Results

1. SEC mode transfer from AB may result in pop stalls.
2. Nozzle fully closed (higher taxi thrust).
3. Stall warning is inoperative (engine overtemp warning is still available).
4. No nozzle position indication.
5. No AB capability.
6. Decrease stall margin at low rpm.
7. 65- to 116-percent basic engine thrust available (see Figure 14-4).
8. Main engine ignition continuously energized.
9. No idle lockup protection.
10. IGV fixed fully open.
11. RATS is inoperative.

14.5.7 Uncommanded SEC Mode Rpm Decay

WARNING

Engine will flame out if transfer is delayed below 59-percent rpm.

1. ENG MODE SELECT switch — PRI.

If PRI mode is restored:

2. Maintain constant subsonic airspeed in level flight.

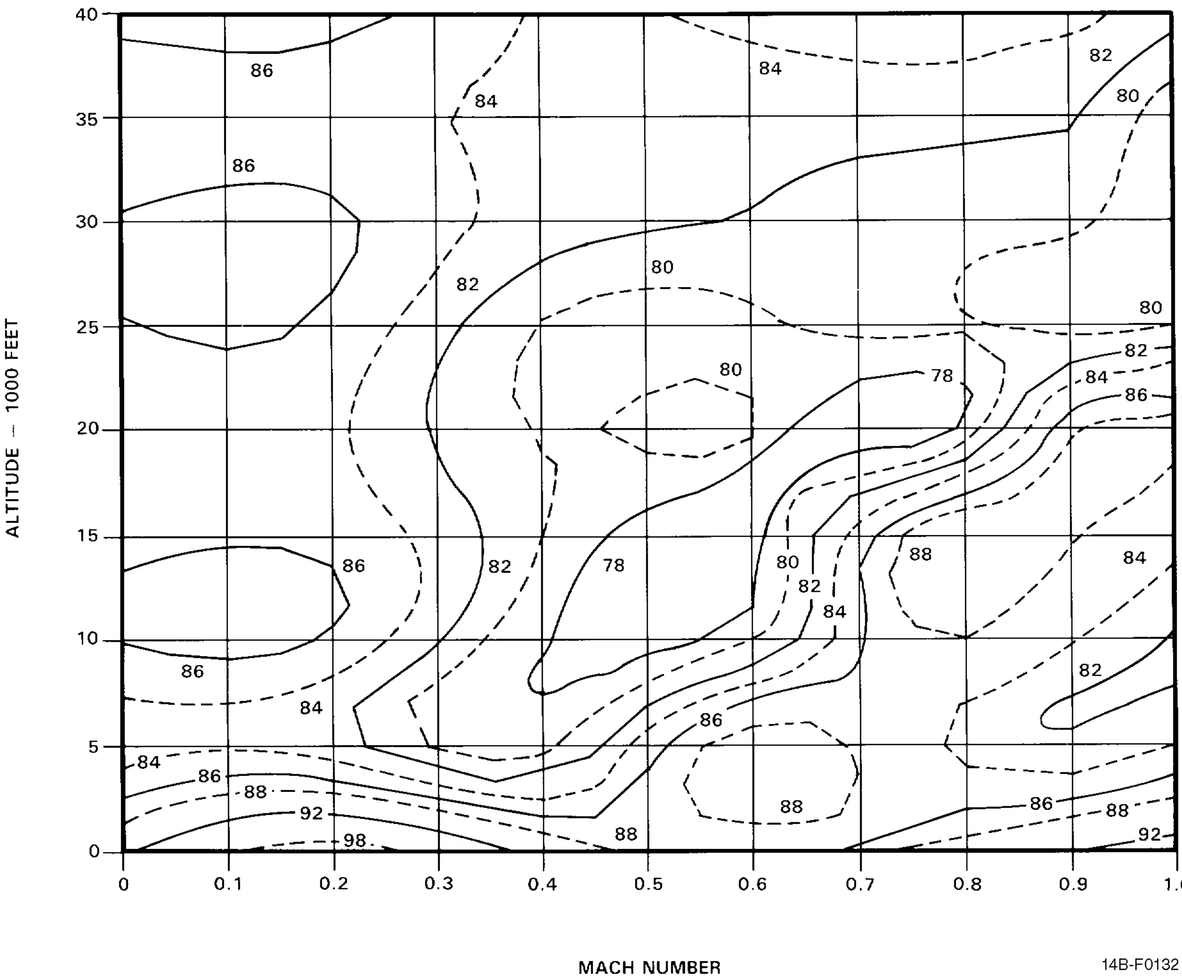


Figure 14-4. Secondary Mode Thrust Levels

WARNING

If WING SWEEP advisory light is illuminated, cycling L AICS circuit breaker (LF2) may cause unintentional wing sweep unless WING SWEEP DRIVE NO. 1 (LE1) and WG SWP DR NO. 2/MANUV FLAP (LE2) cbs are pulled.

3. Affected L or R AICS cb (LF2 left or LG2 right) — Cycle.

14.5.8 Uncommanded Engine Acceleration Airborne (No Throttle Movement). Uncommanded engine acceleration is characterized by an increase in thrust without throttle movement as a result of an AFTC or MEC failure normally associated with one engine. Selection of the ENG MODE SELECT switch(es) to SEC may restore throttle authority.

WARNING

If the APC cutout switch is shorted, attempting to disengage auto throttles using a breakout force of greater than 11 pounds or via the APC cutout switch (CAGE/SEAM button) may not be effective. Disengage the auto throttles with the paddle switch or by placing the throttle mode to manual.

1. ENG MODE SELECT switch(es) — SEC.

If dual-engine uncommanded acceleration associated with CADC failure, normal primary mode may be regained by reselecting PRI mode with the gear handle down.

If engine is still uncommanded and engine shutdown is necessary:

2. Throttle (affected engine) — OFF.

3. Refer to Single-Engine Cruise Operations, paragraph 14.5.3.3.

14.5.9 Exhaust Nozzle Failed (No Nozzle Response to Throttle Movement). Nozzle position is hydraulically operated by engine oil from a separate compartment in the oil storage tank. A rupture in this system could render the nozzles inoperative and would generally cause the nozzles to blow open. This could result in engine mislight, AB blowout, and low thrust. Exhaust nozzles failed closed could result in engine stalls if afterburner is selected, and excess residual thrust will be present on landing rollout. An exhaust nozzle electrically failed open may be closed by selecting SEC mode.

1. Monitor engine oil pressure/rpm.

2. Throttles — Basic Engine Only (use minimum power required).

Note

- SEC mode transfer while in AB may result in pop stalls. Nonemergency manual selection of SEC mode airborne should be performed in basic engine with the power set above 85-percent rpm.
- If the fan speed limiter circuit has failed, engine rollback may occur with the selection of SEC mode. In the event of engine rollback, PRI mode must be reselected above 59-percent rpm or flameout will occur and an airstart will not be possible.

3. ENG MODE SELECT switch — SEC.

Note

In SEC mode, nozzle indicator is inoperative.

4. Obtain visual inspection.

If nozzle is open in SEC mode or abnormal response:

5. ENG MODE SELECT switch — PRI.

6. Assume mechanical failure and land as soon as practicable.

If nozzle is closed or a visual inspection is not possible:

5. ENG MODE SELECT switch — Remain in SEC.

6. Assume electrical failure and land as soon as practicable.

14.5.10 Stuck/Jammed Throttle(s). One or both throttles may become jammed in the afterburner range because of misadjustments or FOD within the throttle quadrant. Selection of SEC mode may be required to control rapid fuel consumption and airspeed and/or altitude. If the problem cannot be corrected, engine shutdown with the fuel shutoff handle may be necessary to abort a takeoff, to control a stalled engine, or to effect a safe landing. If the afterburner detent lever is misadjusted, the right throttle may not move inboard through the AB detent into the basic engine range.

In addition to the above, a failure mode has been identified that may cause one or both throttles to become stuck in the basic engine range. If a large idler bearing in either electro-mechanical rotary actuator fails, it can jam the gear train and create side loads on the mechanical clutch sufficient to lock it and prevent further throttle movement. Failure may occur at any power setting between idle and military and is more likely to be observed when throttles are retarded. While failure will prevent the affected throttle from being retarded any further, it may be possible to move it forward.

14.5.10.1 Stuck or Jammed Throttle(s) in Afterburner

Note

- Spoiler brake will be inoperative with either throttle stuck above idle.
- Speedbrake and DLC will be inoperative with either throttle stuck above military.

1. L ENG and/or R ENG MODE select switch(es) — SEC.
2. Apply maximum inboard force on throttles and retard as required.

If throttle(s) will not retard below minimum AB:

3. Match throttles.
4. Relax aft pressure on throttles.
5. While forcing throttles apart laterally:
   a. Pull throttles straight aft to MIL detent.
   b. Move throttles inboard and aft.
6. Do not reselect afterburner.

If right throttle will not retard:

7. Right FUEL SHUTOFF handle — Pull (if required).
8. Right throttle — MAX AB (after shutdown).

Note

Failure to move the right throttle full forward may limit the left throttle to 88 percent or less after it is retarded below the MIL stop.

9. Refer to single-engine procedures.

If left throttle will not retard:

10. Left FUEL SHUT OFF handle — Pull (if required).
11. Refer to single-engine procedures.

14.5.11 AICS Malfunctions

14.5.11.1 RAMPS Light/INLET Light

*1. Avoid abrupt throttle movements.

*2. Decelerate to below 1.2 IMN.

*3. Affected INLET RAMPS switch — STOW.

Note

A RAMPS light should always be accompanied by an INLET light when the LDG GEAR handle is UP.

If RAMPS light remains illuminated:

4. Throttle (bad engine) — 80 percent or less.

WARNING

If WING SWEEP advisory light is illuminated, cycling L AICS (LF2) cb may cause unintentional wing sweep unless WING SWEEP DRIVE NO. 1 (LE1) and WG SWP DR NO. 2/MANUV FLAP (LE2) cbs are pulled.

5. Affected L or R AICS cb — Pull (LF2 left or LG2 right).

Note

Pulling the AICS cb while airborne may illuminate the FCS CAUTION and ARI DGR lights. Above about 600 KIAS, the PITCH SAS and ROLL DGR lights will also be illuminated. These should clear with a MASTER RESET following a programmer reset.

6. Affected INLET RAMPS switch — AUTO.
7. Land as soon as practicable.

INLET light only illuminated — attempt AICS programmer reset:

4. Decelerate below 0.5 IMN.

WARNING

If WING SWEEP advisory light is illuminated, cycling L AICS (LF2) cb may cause unintentional wing sweep unless WING SWEEP DRIVE NO. 1 (LE1) and WG SWP DR NO. 2/MANUV FLAP (LE2) cbs are pulled.

5. Affected L or R AICS cb — Cycle (LF2 left or LG2 right).

Note

Pulling the AICS cb while airborne may illuminate the FCS CAUTION and ARI DGR lights. Above about 600 KIAS, the PITCH SAS and ROLL DGR lights will also be illuminated. These should clear with a MASTER RESET following a programmer reset.

If INLET light goes off:

6. Affected INLET RAMPS switch — AUTO.

If INLET light remains illuminated:

6. Affected L or R AICS cb — Pull (LF2 left or LG2 right).

Note

Pulling the AICS cb while airborne may illuminate the FCS CAUTION and ARI DGR lights. Above about 600 KIAS, the PITCH SAS and ROLL DGR lights will also be illuminated. These should clear with MASTER RESET following programmer reset.

7. Affected INLET RAMPS switch — AUTO.

8. Remain below 1.2 IMN.

CAUTION

If wing sweep drive cbs (LE1, LE2) were pulled, reset when AICS programmer reset attempts are completed.

14.5.11.2 INLET ICE Light

1. ENG/PROBE ANTI-ICE switch — ORIDE/ON.

When clear of known icing conditions:

2. ENG/PROBE ANTI-ICE switch — AUTO/OFF.

WARNING

Ice may form on inlet and ramp surfaces without any other visual indications, which may cause compressor stalls and/or FOD.

CAUTION

The formation of ice on pitot-static sensors may result in DFCS detected failures that may not clear with a MASTER RESET.

14.5.12 Oil System Malfunction. Malfunctions in the oil system are indicated by an L or R OIL HOT light, OIL PRESS light, or by oil pressure below or above normal.

If oil pressure is over 65 psi, retard power until pressure is within the normal range. If pressure cannot be reduced, the engine should be shut down to avoid rupturing oil lines. If oil pressure is less than 15 psi, bearing wear can be minimized by maintaining a constant throttle setting and avoiding unnecessary aircraft maneuvers. Bearing failure is normally characterized by vibration, increasing in intensity with bearing deterioration. When vibration becomes moderate to heavy, engine seizure is imminent if engine is not shut down. Continued operation of an engine with oil pressure less than 15 psi is likely to result in illumination of OIL HOT light or an engine seizure. If conditions permit, it is advisable to shut down the engine to reduce damage and to save it for emergency use.

14.5.12.1 OIL PRESS Light and/or Abnormal Oil Pressure

1. Throttle (affected engine) — IDLE.

If oil pressure is below 15 psi or above 65 psi, or engine vibration:

If shutdown is feasible:

2. Throttle (affected engine) — OFF.

3. Refer to Single-Engine Cruise Operations, paragraph 14.5.3.3.

If shutdown is not feasible:

2. Rpm — Set Minimum Rpm.

3. Avoid high-g or large throttle movements.

4. Land as soon as possible.

14.5.12.2 L or R OIL HOT Light

CAUTION

Illumination of an OIL HOT caution light may be an indication of above-normal gearbox scavenge oil temperature or high supply temperature. Continuous engine operation will result in reduced gearbox life and lubrication degradation.

Note

On deck, OIL HOT light may be caused by underservicing or by excessive temperature on deck. Normally advancing throttles out of IDLE will extinguish light.

1. Oil pressure — Check.

2. Throttle (affected engine) — 85-Percent Rpm.

If after 1 minute light is still illuminated:

3. Throttle — OFF.

4. Land as soon as possible.

5. Refer to Single-Engine Cruise Operations, paragraph 14.5.3.3.

6. Re-light engine for landing if necessary.

14.5.12.3 RATS Operation in Flight

1. Tailhook — Down.

If conditions permit:

2. Anti-ice/hook control cb (7C2) — Pull.

WARNING

- Pulling the anti-ice/hook control cb (7C2) disables RATS. Inform CV of increased wind-over-deck requirements and gross weight settings for a non-RATS arrestment.

- With the cb in and RATS operating, there is reduced thrust available for approach and use of afterburner may be required to arrest sink rate.

CAUTION

Cb (7C2) must be in prior to hook transition. Avoid icing conditions and rain with 7C2 pulled.

Note

If RATS secures when the hook is raised with no other weight-on-wheels indication, failure is internal to the RATS circuitry.

14.6 FUEL SYSTEM MALFUNCTIONS

14.6.1 FUEL Pressure Caution Lights. Afterburner operations place an extreme demand on the engine fuel feed system. Aircraft maneuvers in the –0.5g to 0g flight regime aggravate the effect and may generate a situation where afterburner blowout and engine flameout occur. The first indication of this condition may be a fuel pressure light.

14.6.1.1 L and/or R FUEL PRESS Light(s) On

1. Both throttles — Military Power or Less.
2. Restore aircraft to 1.0g flight.

If both lights remain on:

3. Increase positive g's to greater than 1.0g.
4. Descend to below 25,000 feet.
5. Maintain cruise power settings or less.
6. Land as soon as possible.

WARNING

- Illumination of both lights may be indicative of a total motive flow failure. Zero or negative-g flight should be avoided.
- Complete loss of motive flow will result in the sump tank interconnect and the engine feed crossfeed valve remaining in the closed position, thus isolating the forward and aft systems. Consequently, single-engine operation will cause fuel on the opposite side to be unavailable.

If one light remains on:

7. No afterburner above 15,000 feet.
8. Fuel distribution — Monitor (balance if required).

WARNING

If the sump tank interconnect valve has failed, selecting AFT or FWD on the fuel FEED switch could result in fuel migration to the inoperative side. If the fuel migration occurs after selecting AFT or FWD on the FEED switch (as indicated by a 100- to 300-pound-per-minute increase on the inoperative side), immediately return the FEED switch to NORM.

9. Land as soon as practicable.

14.6.2 L or R FUEL LOW Light

1. DUMP switch — OFF.
2. Fuel distribution — Check (balance if required).

If wing and/or external fuel remaining:

3. WING/EXT TRANS switch — ORIDE.
4. Land as soon as practicable.

14.6.3 Fuel Transfer Failures

Note

Fuel management panel will be inoperative if FUEL MGT PNL cb (RC1) is out.

14.6.3.1 Wing Fuel Does Not Transfer. If wing fuel fails to transfer:

1. WING/EXT TRANS switch — ORIDE.

If one wing still does not transfer:

2. FEED switch — Select High Fuselage Tape Side.

If wing fuel does not decrease after 2 minutes or wing fuel transfer is completed:

3. FEED switch — NORM.

14.6.3.2 External Tanks Fail to Transfer or Transfer Slowly

1. WING/EXT TRANS switch — ORIDE.

If fuel continues to transfer improperly or does not transfer:

2. REFUEL PROBE switch — All Extend, Then Retract.
3. Apply cyclic positive or negative g's.
4. AIR SOURCE pushbutton — OFF then RAM then ON (below 35,000 feet, less than 300 KIAS).

Note

With AIR SOURCE pushbutton selected OFF, external fuel tanks will not transfer.

5. If conditions permit, descend below the freezing level and periodically check for good transfer.

WARNING

CV arrestment, CV touch-and-go, or normal field landings with full or partial fuel in the external tanks are not authorized because of overload of the nacelle backup structure. Only minimum-rate-of-descent landings are authorized.

Note

CSDC flycatcher 71-00031 displays free airstream temperature; if first digit is an even number, temperature is above freezing.

14.6.3.3 Wings Do Not Accept Fuel With Switch in All EXTD Position

1. REFUEL PROBE switch — FUS EXTD.

2. WING/EXT TRANS switch — OFF.

14.6.3.4 Wings Accept Fuel With Switch in FUS EXTD Position

1. WING/EXT TRANS switch — ORIDE.

14.6.4 Uncommanded Dump

1. DUMP switch — Check OFF.

2. FUEL FEED/DUMP (RD1) cb — PULL.

WARNING

Pulling the fuel feed/dump circuit breaker (RD1) isolates the right and left fuel systems. It also deactivates the function of the feed switch, the automatic balance functions, and the fuel dump system. Should single engine operation subsequently become necessary, useable fuel will be limited to only what is available on the operating side.

14.6.5 Fuel Leak. In the absence of actual visual detection, a fuel leak resulting from a malfunction or failure of a fuel system component will usually result in a split in the fuel quantity tapes or feeds. The flightcrew must determine from available instruments (fuel flow and total fuel quantity) whether the aircraft is losing more fuel than the engines indicate they are using. Corrective steps are based on confirmation of the leak. Upon confirmation of abnormal decrease in fuel quantity:

1. Land as soon as possible.

CAUTION

Use of afterburner with fuel leak should be limited to emergency use only.

2. WING/EXT TRANS switch — OFF.

If abnormal fuel quantity decrease ceases, fuel leak is in wing/wing pivot or attachment points for auxiliary tanks:

3. If leak is not stopped, it is in engine/nacelle area.

Proceed immediately with next step.

4. FUEL FEED/DUMP (RD1) cb — Pull.

WARNING

Pulling the fuel/dump circuit breaker (RD1) isolates the right and left fuel systems. It also deactivates the function of the feed switch, the automatic balance functions, and the fuel dump system. Should single engine operation subsequently become necessary, useable fuel will be limited to only what is available on the operating side.

Note

Enough time should be allowed for quantity tapes/feeds to develop split so that leak can be isolated to left or right feed group. Affected side will be low side.

5. Throttle (affected side) — OFF.

6. Conditions permitting, allow rpm to decelerate to windmill rpm.

7. FUEL SHUT OFF handle — Pull.

8. Refer to Single-Engine Cruise Operation, paragraph 14.5.3.3.

Setting the WING/EXT TRANS switch to OFF stops motive flow to the wings and inhibits external tank transfer and fuselage tank pressurization. Pulling the FUEL FEED/DUMP circuit breaker (RD1) isolates the right and forward system and the left and aft fuel system. This aids in determining the location of the leak and prevents loss of fuel from the good side via the fuel system interconnects. The circuit breaker also deactivates the function of the FEED switch, the automatic balance functions, and the fuel dump system. Securing the engine and, if necessary, pulling the FUEL SHUT OFF handle should stop most engine leaks.

14.7 ELECTRICAL FAILURE

14.7.1 Generator Failure. A mechanical generator failure or an overheating automatically causes the CSD unit of the generator transmission to decouple from the engine. Once disengaged, the CSD cannot be reconnected in flight. Either generator by itself is capable of supplying the electrical requirements of the aircraft. Even double generator failure will not cause total loss of electrical power: the 5-kVA emergency generator will automatically pick up the load for the essential ac and dc buses No. 1 and No. 2.

If the bi-directional pump is operating and pressure drops to between 2,000 and 1,100 psi (dependent upon the load placed on the generator), the emergency generator will automatically shift to the 1-kVA mode and power only the essential ac and dc No. 1 buses. If combined system hydraulic pressure subsequently recovers, the emergency generator switch must be cycled through OFF/RESET to NORM to regain the essential No. 2 ac and dc buses. Figure 14-5 lists the equipment available with only the emergency generator operating.

With both engines inoperative, windmilling engines provide hydraulic pressure for both the flight controls and the emergency generator. However, the flight controls have first priority and may cause the emergency generator to loiter when low airspeeds reduce engine windmilling rpm. Approximately 290 KIAS must be maintained to ensure adequate engine windmilling rpm for hydraulic pressure.

14.7.1.1 L or R GEN Light

1. Generator (affected generator switch) — OFF/RESET, Then NORM.

Note

If the generator fault is corrected, the generator will be reconnected and the caution light will go off.

If generator does not reset:

2. Generator (affected generator switch) — TEST.

If the light goes off with the switch in TEST, the fault is in the respective electrical distribution system. If light remains illuminated, the generator has been disconnected automatically and the fault is in IDG or generator control unit.

14.7.1.2 L or R GEN and TRANS/RECT Lights

1. Generator (affected generator switch) — OFF/RESET, Then NORM.

2. If L GEN and TRANS/RECT lights remain illuminated, select EMERG GEN on MASTER TEST panel.

3. Land as soon as practicable.

14.7.2 Double Generator Failure

1. Both Generator switches — Cycle.

   When operating on emergency generator, the following important systems are inoperative:

   a. Emergency flight hydraulics

   b. Outboard spoiler module and emergency flap activation.

2. If temporary loss of combined system pressure causes emergency generator to shift to 1-kVA mode:

   EMERG generator switch — Cycle.

ESSENTIAL BUSES NO. 1 (1 kVA MODE)

ACM Control
AICS Ramp Stow
Airspeed Indication
Altitude Low Warning
Angle-of-Attack Indication
Approach Lights
AWG-15
Barometric Altimeter
ECM Destruct
Engine Back Up Ignition
Engine Instrument Group
Engine Stall Tone
Engine Stall Overtemp Warning
Fire Detection
Fire Extinguishing
Flap/Slat Position Indicators
Fuel Quality Indicators
Hydraulic Pressure Indication (Flight and Combined)
ICS
IFF
Jettison (Emergency)
KY-58
Master Arm
Missile Release
Pilot Instrument Light
Radar Altimeter
Red Floodlights
Standby Attitude Indicator
Turn and Slip Indicator
VHF/UHF (Receiver-Transmitter Antenna Selection, Remote Indicator, Cryptographics)
Wing Position Indications

ESSENTIAL BUSES NO. 2

ACM Panel Lights
ADF
Advisory Lights
DFCS
AHRS
AICS
Air Conditioning
Air Source Control
Antiskid Control
Arresting Hook Control
ARI AOA System
Auxiliary Flap Control
BDHI
Beacon Augmentor
Cabin Pressure Dump
CADC
Caution Lights
Cockpit Temperature Control
Control Surface Position Indicator (Tail, Rudder, and Spoilers)
CSDC
ECM (Navigational Aids, IFF Interrogator, and Transmitter)
Eject Command Indicator
Electronic Cooling
Emergency Generator Test
Engine:
Anti-Ice
Fan Speed Limiting Circuit of AFTC
Nozzle Reset
Oil Cooling (GRD only)
Oil Pressure Indicators
Starting (Ground Use or Crank)
Fuel Control
Fuel Control Indicators
Flight Control Trim
Fuel Feed/Dump/Transfer
Fuel Management Panel
Ground Roll Braking
HUD
Hydraulic Valve Control
Ice Detection
ILS
In-Flight Refueling Probe Light
Launch Bar
PMDIG (Display Panel)
Nose Landing Gear Kneeling
Nosewheel Steering
Oxygen Quantity Indicators
Probe Anti-Ice (Angle-of-Attack Total Temperature, and Pitot)
Radar Beacon
Servo-pneumatic Altimeter
Speed Brakes
Spoiler Control
Tacan
Utility/Map Lights
VDIG
Warning Lights
Wheels and Speed Brakes Position Indicator
Windshield Air
Windshield Anti-Ice
Wing Sweep

Figure 14-5. Emergency Generator Distribution

CAUTION

A shift to 1-kVA mode will cause loss of all DFCS functions and spoilers without illumination of caution lights. If the 5-kVA mode is regained, a MASTER RESET will be required to regain SAS, spoiler, authority stop, and ARI functions.

Note

DFCS synchronization can take up to 2 seconds following a power interrupt. If the MASTER RESET pushbutton is depressed during the synchronization time, an additional depression of the MASTER RESET pushbutton will be required to restore spoiler functionality.

3. Land as soon as practicable.

14.7.3 Double Transformer-Rectifier Failure. The 5-kVA emergency generator will automatically activate and power the essential ac and dc No. 1 and No. 2 and AFCS buses. See Figure 14-6 for listing of inoperable dc-powered equipment.

14.7.4 TRANS/RECT Light. The TRANS/RECT light will illuminate if either or both T/R malfunction. If one T/R fails, the operating T/R will assume the dc load. If both T/Rs fail, the emergency generator will go on the line and tie to essential dc buses No. 1 and No. 2. Land as soon as practicable.

Popped circuit breakers should not be reset more than once or be held depressed unless the associated equipment is absolutely required by operational necessity. A popped circuit breaker indicates an equipment malfunction or an overload condition. Repeated resets or forced depressions of popped circuit breakers can result in equipment damage and/or serious electrical fire.

The loss of one generator and failure to tie the ac main buses will illuminate the affected GEN light. The TRANS/RECT light will also illuminate because the affected generator's associated T/R is not receiving ac power to convert. Upon observing a TRANS/RECT light, the pilot can check that the aircraft is actually experiencing a T/R failure and not a bus tie failure. If the seat adjust, white floods, or instrument lights are still operative with the R GEN light illuminated, the bus is tied. If the throttles are operating on the boosted mode with an L GEN light illuminated, the bus is tied.

If the hydraulic transfer pump is operating and pressure drops to between 2,000 and 1,100 psi (dependent upon the load placed on the generator), the emergency generator will automatically shift to the 1-kVA mode and power only the essential ac and dc No. 1 buses. If combined hydraulic pressure subsequently recovers, the EMERG generator switch must be cycled through OFF/RESET to NORM to regain the essential ac and dc No. 2 and AFCS buses.

14.7.5 Electrical Fire. Electrical fires may be indicated by visual or audible arcing or an ozone odor in the cockpit and popping circuit breakers. Electrical fires produced by 400 °F air leaks can result in any one or combination of the following:

1. Pinballing caution/advisory lights and instrument indications.
2. CADC associated caution/advisory lights.
3. Uncommanded movement of electrically controlled components (SAS, spoilers, wing sweep, and throttles).
4. Complete electrical failure.
5. Smoke, fumes, and/or heat in the cockpit.

14.7.5.1 Extinguish Electrical Fire. The most effective method to extinguish an electrical fire is to secure all electrical power. However, some conditions may not permit securing the emergency generator after both main generators are secured. Night/IFR flight or ECS duct-leak-induced electrical fires are cases where securing all electrical power is not feasible.

*1. L and R generators — OFF.

If Uncommanded SAS or spoiler inputs present:

*2. PITCH, ROLL, and YAW STAB AUG switches — OFF

If associated with any other direct or indirect indication of ECS malfunction, perform ECS Leaks/Elimination of Smoke and Fumes procedure, paragraph 14.8.1.

AIM-7 Motor Fire	EGI*	Master Test
AIM-54 Missile	Electronic Cooling	Mechanical Fuzing STA 5 and 6
ALE-39 Chaff/Flare Dispenser	Emergency Generator Control	Mechanical Fuzing STA 3 and 4
AMC BIT		Mechanical Fuzing STA 1 and 2
AMCS Enable	FEMS	Missile Auxiliary Subsystems
Antenna Lock Exciter	Fuze Function	Monitor Bus Control
APX-72 Test Set		
Auto Throttle	Ground Power	Outboard Spoiler Control
	Ground Test	
Control Display Subsystems	Gun Armed Power	Radar Subsystems
Cooling Interlock	Gun Clear Power	Right dc Test
Counting Accelerometer	Gun Control Power	
	Gyro Power	STA 1A, 1B, 8A, 8B AIM-9 Power
Data Link		STA 1, 8A, 8B, AIM-9 Cooling Power
DDI/Annunciator Panel Dim Control	IFF Air to Air	
Dehydrator Unit	Integrated Trim	TARPS
Digital Data Indicator	Interruption-Free dc Bus For No. 1 and 2	TCS
		Windshield Defog Control
	L and R AIM-7 Battery Arm	
	Liquid Cooling Control	

* The EGI will remain powered by the Navigation Power Supply battery for a period of a few minutes after loss of both T–Rs. The exact length of time is dependent on the state of the battery's charge at the time of failure.

Figure 14-6. Failure of Both Transformer-Rectifiers — Equipment Inoperative List

CAUTION

An electrical fire may affect the CADC and AICS system, causing random movements of the wings and ramps.

If conditions permit:

3. EMERG generator switch — OFF.

Note

Securing all electrical power while airborne causes the ECS to go full cold.

If cause of fire can be isolated:

4. Pull cbs of affected equipment.

5. All generators — NORM.

If cause of fire cannot be isolated:

6. Secure all unnecessary equipment.

7. EMERG generator switch — NORM.

8. Land as soon as possible.

CAUTION

Do not operate engines on the ground without electrical power. Ground-cooling fans are shut off, causing hot bleed air to cook off oil and hydrocarbons in the ECS ducting, resulting in smoke in the cockpit and possible damage to the ECS turbine compressor.

14.7.6 Total Electrical Failure

1. Descend or climb to known VFR conditions.

CAUTION

All DFCS functions and spoilers will be lost. This will have an adverse effect on flying qualities. Terminate aggressive maneuvering immediately and remain subsonic. Expect minimal damping of oscillations in pitch and yaw and severely degraded roll control with flaps extended. Perform controllability check.

Note

- The standby attitude gyro is capable of providing reliable attitude information (within 6°) for up to 9 minutes after a complete loss of power.
- Cabin pressure will be lost and ECS will go full cold.

2. Attempt to contact radar facilities or other aircraft by hand-held survival radio.
3. Make arrested landing as soon as possible.

The following systems are still available:

a. Airspeed indicator

b. Altimeter (STBY mode)

c. Cabin pressure altimeter

d. Vertical velocity indicator

e. Arresting hook (emergency extension only)

f. Standby attitude gyro (9 minutes)

g. Emergency wing sweep

h. Landing gear

i. Standby compass

j. Main flaps/slats.

WARNING

Ground engine operation without electrical power supplied by either the generators or external power may cause 20-mm ammunition detonation because of excessive heat in the gun ammunition drum.

CAUTION

Do not operate engines on the ground without electrical power. Ground cooling fans are shut off, causing hot bleed air to cook off oil and hydrocarbons in the ECS ducting, resulting in smoke in the cockpit and possible damage to the ECS turbine compressor.

Note

- Total electrical failure will cause the sump tank interconnect, engine crossfeed, and motive flow isolation valves to close, fully isolating both tank systems. Wing and external fuel will transfer into fuselage.
- If possible, section IFR descent should be conducted to VFR conditions for landing.

14.8 ECS MALFUNCTIONS OR FAILURES

14.8.1 ECS Leaks/Elimination of Smoke and Fumes. Bleed air leaks, hot air leaks, and ECS turbine failures have similar indications and results and shall be treated as one failure: ECS leaks. All can cause unsurvivable damage when not recognized and corrected expeditiously. Bleed air leaks in the engine compartment illuminate the appropriate FIRE warning light, and FIRE light procedures apply. Bleed air leaks outside the engine compartment illuminate the BLEED DUCT caution light. Hot air leaks also illuminate the BLEED DUCT caution light. Illumination of the appropriate caution/warning light should be the first indication of an ECS leak. ECS turbine failures can cause hot air leaks. After a compressor-side failure, catastrophic thermal damage can be caused by heat generated during turbine wind-down. Wire bundles, flight control rods, and SMDC lines are in the vicinity of the ECS turbine and hot air manifold. Both turbine and compressor side failures may cause a whining noise emanating from below and behind the right side of the RIO cockpit, and other indications of an ECS air leak follow.

If warning or caution systems do not function, the first indication of an ECS leak can vary. The presence and order of appearance of indications depend on the size and location of the leak. Any of the following direct and indirect indications (their sequence may vary) should be treated as ECS leaks.

If associated with any other direct or indirect indication of ECS malfunction, proceed with ECS Leaks/Elimination of Smoke and Fumes procedure.

Direct and indirect indications are listed below in represented order of appearance; however, they can appear in any sequence. The presence of any one direct indication or any two indirect indications shall be treated as an ECS leak.

Direct indications:

1. BLEED DUCT caution light
2. FIRE warning light
3. Smoke or fumes in the cockpit
4. Heat emanating from behind aft right corner of RIO cockpit
5. Complete loss of ECS airflow.

Indirect indications:

1. Audible pop or squeal from ECS
2. Rapid drop in cockpit airflow
3. Electrical fire indications
4. Any ECS advisory light (AWG-9 COND, MSL COND, or COOLING AIR).

When an ECS duct leak is indicated or ECS turbine whine is heard, AIR SOURCE should be immediately selected OFF. ECS leaks may melt wiring splice junctions and create conditions that may induce an electrical fire. If an associated electrical fire occurs, smoke, fumes, heat, and damage to the surrounding aircraft structure may intensify. Since electrical fire procedures are not compatible with measures to eliminate smoke and fumes, canopy jettison may become necessary as a last ditch procedure.

WARNING

- Failure to immediately select AIR SOURCE OFF upon indication of an ECS leak may result in severe aircraft damage and loss of aircraft.
- Selection of AIR SOURCE to RAM allows bleed air to circulate throughout the 400 °F manifold system.

CAUTION

If ECS airflow continues, ensure that AIR SOURCE CONTR circuit breaker (RC2) is in. If circuit breaker has popped, control of the ECS is lost.

Note

Selecting AIR SOURCE OFF eliminates pressurization to the service system (canopy, g-suit, external fuel tanks, pressure/ ventilation, and airbag seals). Rain removal, defog, and heating systems are also eliminated.

*1. AIR SOURCE pushbutton — OFF.

*2. If smoke or fumes are present:

a. Altitude — Below 35,000 Feet.

b. CABIN PRESS switch — DUMP.

*3. RAM AIR switch — INCR.

Note

RAM air door may take up to 50 seconds to fully open.

4. Airspeed — Below 300 KIAS/0.8 IMN.

5. Nonessential electrical equipment — Secure.

6. CANOPY DEFOG/CABIN AIR lever — CANOPY DEFOG.

7. Land as soon as possible.

If electrical fire:

8. Follow electrical fire procedures, paragraph 14.7.5.

CAUTION

The emergency generator switch should be left in NORM unless there are overriding considerations that mandate turning the emergency generator off.

Note

- If ECS airflow continues, ensure AIR SOURCE CONTR cb (RC2) is in. If cb RC2 has popped, ECS control is lost
- Securing all electrical power while airborne closes cockpit dump valve and cabin hot air valve, opens bleed air shutoff valves and dual pressure regulator, and the ram air door remains at its last commanded position (ram air door takes up to 50 seconds to open). This results in full cold air to the cockpit, uncontrolled bleed air to circulate, and the loss of normal cabin dump capability. Minimize low speed (less than 0.25 IMN) and ground operations as the heat exchanger cooling fan will be inoperative and ECS overheat condition will result.
- Elimination of smoke or fumes without electrical power may be accomplished by ECS airflow. To obtain maximum smoke/fume removal capability under this condition, fly below 8,000 feet MSL and set the throttle to maximum practical position. This will open the cabin regulator valve for maximum ECS airflow. If smoke or fumes are not eliminated, it is most probable that smoke/fumes are being regenerated by an ECS air leak. As a last resort, jettison the canopy.

14.8.2 Cooling Air Light

14.8.2.1 On Deck

1. AIR SOURCE pushbutton — Check L ENG, R ENG or BOTH ENG.

2. Throttles — Advance Without Closing Nozzles.

3. CANOPY DEFOG/CABIN AIR lever — CANOPY DEFOG.

4. ECS — MANUAL/FULL HOT.

If light goes out:

5. Throttles — IDLE.

6. ECS — As Desired.

If light remains illuminated:

5. Secure systems.

14.8.2.2 In Flight

1. AIR SOURCE pushbutton — OFF.

WARNING

Failure to immediately select AIR SOURCE pushbutton OFF upon indication of an ECS leak (bleed air or hot air leak indications) or upon hearing ECS turbine whine may result in an uncontrollable electrical fire, catastrophic ECS component failure, and/or loss of flight controls.

If associated with any other direct or indirect indication of ECS malfunction:

2. Perform ECS Leaks/Elimination of Smoke and Fumes procedure, paragraph 14.8.1.

If not associated with any other direct or indirect indication of ECS malfunction and operational requirements dictate temporary reselection of RAM to regain lost service systems (EXT fuel transfer, cabin pressure, rain removal, engine anti-ice, etc.):

3. AIR SOURCE pushbutton — RAM.
4. RAM air switch — Full INCR.
5. AIR SOURCE — OFF (when service system no longer required).
6. Land as soon as practicable.

14.8.3 TARPS ECS Lights Illuminate

1. TARPS sensors — OFF.
2. SYSTEM switch — OFF.
3. Pull TARPS cbs:
   a. RECON ECS CONT DC (8G7)
   b. RECON ECS CONT AC (2E2)
   c. RECON HTR PWR PH A (2B1)
   d. RECON HTR PWR PH B (2D1)
   e. RECON HTR PWR PH C (2F1)
   f. RECON POD (1F4)
   g. RECON POD CONTR (8F7)
   h. RECON POD DC PWR NO 2 (8F1)
   i. RECON POD DC PWR NO 1 (8F2).
4. Ask for visual check of pod by wingman.
5. Land as soon as practicable.

14.8.4 AWG-9 COND Light Illuminated and/or Pump Phase Circuit Breakers Popped or AWG-9 PM Acronym

1. LIQ COOLING switch — OFF.
2. WCS switch — OFF.
3. ANT SVO HYD PH A, B, C (1F2, 1F4, 1F6) cbs — Pull.
4. AN/AWG-9 PUMP PH A, B, and C (2G3, 2G6, 2G7) cbs — Pull.

If associated with any other direct or indirect indication of ECS malfunction, perform ECS Leaks/Elimination of Smoke and Fumes procedure, paragraph 14.8.1.

5. Land as soon as practicable.

14.8.5 MSL COND Light (AIM-54 Aboard)

1. LIQ COOLING switch — Check.

If LIQ COOLING switch is in AWG-9/AIM-54 position:

2. LIQ COOLING switch — AWG-9.
3. STA 3/6 AIM-7/AIM-54 PUMP PH A, B, and C (1D1, 1D3, 1D7) cbs — Pull.
4. MSL HTR PH A, B, and C (2G2, 2G5, 2G8) cbs — Pull.

If associated with any other direct or indirect indication of ECS malfunction, perform ECS Leaks/Elimination of Smoke and Fumes procedure, paragraph 14.8.1.

5. Land as soon as practicable.

14.8.6 Cockpit Temperature Control Malfunction

1. TEMP mode switch — MAN.

2. TEMP thumbwheel — As Desired.

If temperature control is not regained:

CAUTION

Reduce airspeed to 350 KIAS or 1.5 IMN, whichever is lower, to prevent ram air at temperature above 110 °F from entering aircraft. After ram air flow is stabilized, airspeed may be increased as required for flightcrew comfort, or to increase flow to electronic equipment.

3. VENT AIRFLOW thumbwheel — OFF.

4. AIR SOURCE pushbutton — RAM (below 35,000 feet).

5. RAM AIR switch — INCR (select amount of ram air desired for flightcrew comfort).

CAUTION

High cockpit temperature and smoke during ground operation indicate ECS cooling fan shutdown. This will occur with an external air source (start cart) without electric power on the aircraft. This results in an overtemperature condition caused by operating without ground cooling fans.

14.8.7 Cockpit Overpressurization on Deck. Cockpit overpressurization is sensed by the aircrew and verified by lower normal cockpit pressure on the cabin pressure altimeter. This condition could be caused by a faulty cabin pressure controller or regulator.

1. AIR SOURCE pushbutton — OFF.

2. CABIN PRESS switch — DUMP.

3. Canopy — OPEN (when cockpit pressure altimeter equals the field elevation).

WARNING

The canopy may explosively leave the aircraft upon unlocking of the canopy sill locks if cockpit overpressure is not reduced.

14.8.8 CABIN PRESS Light

1. Oxygen mask — ON.

If below 15,000 feet:

2. CABIN PRESS switch — Cycle.

14.8.9 WSHLD HOT Light

1. WSHLD AIR switch — OFF.

If light remains illuminated:

2. Reduce airspeed to less than 300 KIAS or 0.8 IMN.

3. AIR SOURCE pushbutton — OFF (below 35,000 feet).

Note

If light remains illuminated after air source is off, the indication is faulty. Turn ECS on and land as soon as practicable.

4. RAM AIR switch — INCR.

5. Land as soon as practicable.

14.9 OXYGEN SYSTEM FAILURE

1. Oxygen quantity — Check.

2. If possible, descend to cabin altitude of less than 10,000 feet.

WARNING

With mask removed, loss of cabin pressure above 10,000 feet MSL can rapidly cause hypoxia.

3. If not possible to descend, actuate emergency oxygen.

WARNING

Once emergency oxygen is actuated, the oxygen flows until the emergency bottle is depleted (approximately 10 minutes).

Note

Normally, it is desirable to conserve the emergency oxygen for landing.

14.9.1 OXY LOW Light (RIO Only)

1. Notify pilot
2. Oxygen quantity — Less Than 2 Liters.
3. Cabin altitude — Less Than 10,000 Feet.
4. Oxygen masks — Release One Side.

WARNING

With mask removed, loss of cabin pressure above 10,000 feet MSL can rapidly cause hypoxia.

5. OXYGEN switch — OFF.

Before landing:

6. OXYGEN switch and masks — ON.

14.10 CANOPY LIGHT OR LAD/CNPY LIGHT AND/OR LOSS OF CANOPY

In the event of canopy loss in flight, the pilot will be adequately shielded by the forward windscreen to maintain control of the aircraft. Vision may be impaired briefly by dust in the cockpit, and moderate head buffet may occur that can be alleviated by lowering the seat and/or leaning forward. The RIO will be exposed to a significantly more hazardous and disorienting environment, which will include vision impairment, loss of communications, wind blast injury, and breathing difficulties. The degree to which these will be experienced is directly related to airspeed and seat height. In addition, the possibility of helmet loss becomes greater as airspeed increases above 300 KIAS. ICS and RIO VHF/UHF communications will probably be impossible above 200 KIAS, although the pilot will be able to effectively utilize UHF at airspeeds up to approximately 400 KIAS. After lowering his seat, the RIO should lean forward to take advantage of the wind blast protection provided by the detail data display and instrument panel, while the pilot decelerates the aircraft by utilizing idle power, speedbrakes, and moderate g. The RIO should deselect HOT MIC ICS to prevent interference with UHF communications because of wind blast across his oxygen mask microphone. Helmet loss will result in severe disorientation because of total loss of communications and vision impairment caused by windblast.

If canopy loss is experienced at high speed or if helmet loss appears to be possible because of windblast or buffeting, retain the helmet by pulling down on the visor cover (keeping arms close to the body).

14.10.1 CANOPY Light or Canopy Loss

*1. Canopy handle — BOOST (canopy remaining).

*2. EJECT CMD lever — Pilot.

3. Airspeed and altitude — Below 200 KIAS/15,000 Feet.
4. Seats and visors — Down.
5. If canopy has departed aircraft — Perform Controllability Check.
6. Land as soon as possible.

14.10.2 LADDER Light

1. Airspeed — Minimum Safe Operating
2. Obtain in-flight visual check if possible.
3. Land as soon as practicable.

14.11 HYDRAULIC SYSTEM MALFUNCTIONS

14.11.1 Combined Pressure Approximately 2,400 to 2,600 Psi

WARNING

If hammering (cavitation) is experienced in the hydraulic system, component rupture is imminent. Turn the hydraulic pump switch (BIDI) OFF.

1. HYD ISOL switch — FLT.

Note

Monitor AUX BRAKE PRESSURE gauge. Tap wheelbrakes to seat priority valve if pressure is decreasing.

2. In-flight refueling PROBE switch — EXTD (in carrier environment).

3. Wing sweep — Set at 20°.

4. L INLET RAMP switch — STOW (less than 1.2 IMN).

WARNING

If WING SWEEP advisory light is illuminated, pulling L AICS (LF2) cb may cause unintentional wing sweep unless WING SWEEP DRIVE NO. 1 (LE1) and WG SWP DR NO. 2/MANUV FLAP (LE2) cbs are pulled.

5. L AICS (LF2) cb — Pull.

Note

Pulling the AICS cb while airborne may illuminate the FCS CAUTION and ARI DGR lights. Above about 600 KIAS, the PITCH SAS and ROLL DGR lights will also be illuminated. These should clear with a MASTER RESET following a programmer reset.

6. L INLET RAMP switch — AUTO.

7. DLC — Do Not Engage.

8. EMERG FLT HYD switch — HIGH (on final, committed to land).

9. Land as soon as possible.

CAUTION

- Loss of combined pressure may indicate impending fluid loss. Without fluid in the combined system return line, the inflight refueling probe will not extend with the handpump. Early extension of the refueling probe at the first indication of a combined system malfunction is recommended in a carrier environment.

- Monitor remaining hydraulic system pressure since the MASTER CAUTION and HYD PRESS lights will not illuminate if the remaining systems fail.

Note

To extend or retract the refueling probe using the hydraulic handpump requires the landing gear handle to be in the up position, combined system fluid in the system return line, and essential dc No. 2 electrical power. Extension of the in-flight refueling probe requires approximately 25 cycles of the pump handle.

14.11.2 Flight Pressure Approximately 2,400 to 2,600 Psi

WARNING

If hammering (cavitation) is experienced in the hydraulic system, component rupture is imminent. Turn the hydraulic transfer pump switch (BIDI) OFF.

1. Wing sweep — Set at 20°.

2. R INLET RAMP switch — STOW (less than 1.2 IMN).

3. R AICS (LG2) cb — Pull.

Note

Pulling the AICS cb while airborne may illuminate the FCS CAUTION and ARI DGR lights. Above about 600 KIAS, the PITCH SAS and ROLL DGR lights will also be illuminated. These should clear with a MASTER RESET following programmer reset.

4. R INLET RAMP switch — AUTO.

5. EMERG FLT HYD switch — HIGH (on final, committed to land).

CAUTION

Monitor remaining hydraulic system pressure since the MASTER CAUTION and HYD PRESS lights will not illuminate if the remaining system fails.

The following important equipment is inoperative:

a. Normal hook — Restored by weight on wheels. Hook handle restowed.

Note

Arrested landing will require emergency hook extension.

6. Land as soon as possible.

14.11.3 Combined Pressure Zero

1. HYD ISOL switch — FLT.

2. HYD TRANSFER PUMP switch — SHUTOFF.

3. In-flight refuel probe — EXTEND (in carrier environment).

4. Wing sweep — Set at 20°.

5. EMERG FLT HYD switch — LOW.

WARNING

- If the INLET RAMPS switch is not placed in STOW prior to the pressure reaching zero, do not place it in stow after complete loss of pressure. Trapped fluid may be the only thing holding the affected ramp in position.

- An outboard spoiler module failure with flaps extended below 180 KIAS, and with a combined failure rendering the inboard spoilers inoperative can result in asymmetric spoiler float such that the aircraft may not be flyable at normal approach airspeeds. A small amount of spoiler float can significantly increase approach speeds.

- Do not return to AUTO (low) mode once module is selected on (high or low) with operating flight hydraulic system. When operated in conjunction with zero combined pressure, some backup module fluid will be expelled by thermal expansion. The module will remain fully serviced and will operate normally as long as elevated temperatures are maintained. Once operating, the module should not be turned off in flight without combined system pressure available to reservice it. Doing so would result in fluid contraction and an underserviced condition that could prevent subsequent pump operation.

CAUTION

- Loss of combined pressure with landing flaps down may allow the auxiliary flaps to cycle causing moderate pitch oscillations.

- Monitor remaining hydraulic system pressure since the MASTER CAUTION and HYD PRESS lights will not illuminate if the remaining systems fail.

Note

Complete loss of combined hydraulic pressure will result in the following caution lights due to the loss of a single channel SAS actuator function: PITCH SAS, ROLL DGR, YAW DGR, ARI DGR, and SPOILER lights.

The following important equipment is inoperative.

a. One-half authority of SAS/ARI actuators in pitch, roll and yaw.

b. L AICS.

c. Inboard spoilers.

d. Emergency generator.

e. DLC.

f. Speedbrakes.

g. Normal hook.

h. Hook extend (emergency actuation available).

i. Flaps and slats (emergency actuation available).

j. Landing gear (emergency actuation available).

k. Wheelbrakes (emergency actuation available).

l. Refuel probe (emergency actuation available if system fluid remains in return line).

m. Auxiliary flaps.

n. Nosewheel steering.

o. Gun drive.

6. LDG GEAR handle — EMERG LOWER.

7. HOOK — EMERG DN.

8. AUX FLAP/FLAP CONTR cb — Pull (7G3).

9. Flaps (no auxiliary flaps available) — DN.

10. Brake accumulator (handpump) — Check.

11. ANTI SKID SPOILER BK switch — SPOILER BK (OFF for CV).

12. EMERG FLT HYD switch — HIGH (on final, committed to land).

13. Make arrested landing as soon as possible.

After landing:

14. Do not taxi out of arresting gear.

15. Engines — OFF.

14.11.4 Flight Pressure Zero

1. HYD TRANSFER PUMP switch — SHUTOFF.

2. Wing Sweep — Set at 20°.

3. EMERG FLT HYD switch — LOW.

WARNING

If the INLET RAMPS switch was not placed in STOW prior to pressure reaching zero, do not place it in stow after complete loss of pressure. Trapped fluid may be the only thing holding the affected ramp in position.

CAUTION

Monitor remaining hydraulic system pressure since the MASTER CAUTION and HYD PRESS lights will not illuminate if the remaining system fails.

Note

Complete loss of combined hydraulic pressure will result in the following caution lights due to the loss of a single channel SAS actuator function: PITCH SAS, ROLL DGR, YAW DGR, and ARI DGR lights.

The following important equipment is inoperative.

a. One-half authority of SAS/ARI actuators in Pitch, Roll and Yaw.

b. ACLS.

c. R AICS.

d. Normal hook — Restored by weight-on-wheels. Hook handle restowed.

4. EMERG FLT HYD switch — HIGH (on final, committed to land).

5. Land as soon as possible.

Note

Arrested landing will require emergency hook extension.

14.11.5 Both Combined and Flight Pressure Zero

1. EMERG FLT HYD switch — LOW.

2. DO NOT attempt CV recovery. Divert if possible.

WARNING

- If any undesirable motions or oscillations occur, immediately release the stick and permit the motions to dampen before resuming active control.

- Do not attempt IMC or close night formation while in the LOW mode.

- Operations of more than 8 minutes total in HIGH mode may fail the BFCM motor. The LOW mode should be selected as soon as practicable following a waveoff or bolter, and the HIGH mode reselected on the subsequent approach.

- Inboard spoilers can be expected to float, causing uncomfortable lateral stick requirements for level flight. Do not trim out lateral forces.

3. Reduce airspeed to below 250 KIAS if practicable.

Note

Airspeeds less than 250 KIAS while in the LOW mode will reduce the susceptibility of exceeding maximum stabilizer deflection rate.

The following important equipment is operative in flight:

a. Horizontal stabilizers (significantly reduced rate, no SAS/ARI).

b. Rudders (slightly reduced rate, no SAS/ARI).

c. Main flaps and slats (reduced rate via thumbwheel or flap handle).

d. Outboard spoilers.

e. Hydraulic handpump.

f. Landing gear (emergency actuation available).

g. Hook extend (emergency actuation available).

h. Refuel probe (emergency actuation available if system fluid remains in return line).

i. Wheelbrakes (emergency actuation available.

If in-flight refueling is required:

4. Decelerate with tanker to 180 KIAS

5. Maneuver flaps — Extend.

6. EMERG FLT HYD switch — HIGH (prior to moving to precontact).

7. Avoid abrupt control inputs during contact.

WARNING

Any abrupt control input to effect engagement can rate limit the stabilizers and result in loss of control. The pilot must resist spotting the basket and rely on RIO commentary to perform engagement.

WARNING

- Extended LOW mode operation (>30 minutes) after in-flight refueling will permit several additional minutes in HIGH mode for subsequent landing.

- Tanking from large-body tankers (KC-130, KC-10, and KC-135) is hazardous and should not be attempted.

Note

Once engaged, the airspeed can safely be increased to 200 KIAS to improve the transfer rate.

8. EMERG FLT HYD switch — LOW (immediately once clear of tanker).

9. Maneuver flaps — Retract.

Field recovery:

10. Landing gear — EMERG DN.

11. Maneuver flaps — Extend With Thumbwheel.

12. MANEUVER FLAP (LE2) cb — Pull.

13. Hook — EMERG DN.

14. Brake accumulator — Check.

Established on final, committed to land:

15. EMERG FLT HYD switch — HIGH.

WARNING

- Aggressive nose movement in close can rate limit the stabilizers, resulting in low altitude loss of control. Do not use APCS.

- Inboard spoilers can be expected to float, causing uncomfortable lateral stick requirements for level flight. Do not trim out lateral forces.

CAUTION

- Waveoff performance from low power settings is very poor. Carrying extra speed during IMC approach will improve waveoff performance by permitting smooth rotation to 15 units AOA to break the rate of descent while the engines are accelerating.

- Prolonged operation of the BFCM in the HIGH mode may cause failure of the module. The LOW mode should be selected as soon as practicable following a waveoff or bolter and the HIGH mode reselected on the subsequent approach.

16. If wings are 20°, fly straight-in approach between 15 units AOA and 180 KIAS.

17. If wings are greater than 20°, fly straight-in approach at 15 units.

Note

Control in LOW mode is satisfactory for performing transition to dirty configuration. Pitching moment caused by flap transition is easily countered with electrical trim because of very slow extension rate.

18. Make arrested landing as soon as possible.

After landing:

19. Do not taxi out of arresting gear.

20. Throttles — OFF.

14.11.6 Backup Flight Module Malfunction

CAUTION

Prolonged use of the backup flight control module in the high mode may result in a failure of the module.

1. FLT HYD BACKUP PH A, B, and C (2A1, 2C1, 2E1) cbs — In.

2. Land as soon as possible.

14.11.7 Low Brake Accumulator Pressure. In flight:

1. HYD ISOL switch — T.O./LDG.

If pressure does not recover:

2. LDG GEAR handle — DN.
3. HYD HANDPUMP — Recharge Accumulator.

Note

Monitor AUX BRAKE PRESSURE gauge. Tap wheelbrakes to seat priority valve if pressure is decreasing.

If accumulator cannot be recharged:

4. Make arrested landing as soon as practicable.
5. Parking brake — Pull (to lock wheels).

14.12 FLIGHT CONTROL FAILURES OR MALFUNCTIONS

There are a myriad of possible causes to binding flight controls. Unfortunately, unless the cause is a foreign object jammed in the cockpit controls and visible to the pilot, it may be impossible for the aircrew to determine the true cause. If the aircraft is in a controllable state, execute the Controllability Checklist. If the aircraft is uncontrollable, an attempt should be made to release pressure on the flight controls so that any potential foreign objects may be disloged. If the controls are still inhibited, apply negative g, flight conditions permitting, to forcefully dislodge the object. In the low altitude environment, applying negative g may not be possible. As always, the aircrew must decide if such an action will further jeopardize the aircraft. Finally, the pilot should use whatever force necessary in the direction of the bind in order to break any jamming foreign object. If unsuccessful, the aircrew should conduct a controllability check using alternative means to maneuver the aircraft to determine suitability for a safe landing. Consider using different axes to coordinate aircraft movement. Yaw through rudder displacement or asymmetric thrust can be substituted for roll commands via lateral stick and vice versa. Aircraft configuration (flap setting, wing sweep), airspeed/thrust, or sideslip may assist in inducing pitch commands in the event of inhibited control stick. The aircrew should thoroughly investigate all possible alternative control methods at a sufficient altitude to allow safe ejection should the aircraft depart controlled flight. Do not delay eject decision if approaching edge of the ejection envelope. If the aircraft is suitable for landing with restricted rudder pedal authority, consider an arrested landing.

14.12.1 Controllability Check. There are several malfunctions may significantly affect the handling characteristics in the cruise and landing configurations. For example, these include, but are not limited to:

1. Spoiler malfunction*
2. Flap/slat asymmetry*
3. Structural damage
4. Uncommanded SAS inputs*
5. Rudder malfunction (hardover)*
6. Wing-sweep asymmetry*
7. Jammed flight controls
8. ARI failure*.

*These malfunctions, which have unique NATOPS procedures specific to a particular failure mode, should be performed before beginning a controllability check.

NATOPS procedures cannot account for every potential malfunction. It is absolutely imperative that the aircrew thoroughly and safely evaluate the degraded handling characteristics of the damaged or malfunctioning aircraft prior to continued flight and landing. These guidelines do not take priority over existing emergency procedures.

Upon encountering a problem that alters the handling qualities of the aircraft, the aircrew should realize that the aircraft may no longer be a stable airframe, especially in the landing configuration. In addition, the flight characteristics may rapidly degrade or even become uncontrollable when normal configuration changes are introduced or during airspeed changes. Increased awareness of flight parameters should prevail following a malfunction until the aircraft is safely on deck.

Even though the aircraft may possess significantly different or even hazardous flying qualities, the pilot and RIO have numerous cues available to them to warn of potential problems. Some of these cues include:

1. Turn needle and ball position
2. AOA
3. Buffet
4. Yaw string position
5. Flight control positions
6. Trim settings
7. Roll-off
8. Rate of descent.

All cues should be very closely monitored, since they tell the pilot what the aircraft is doing or is about to do.

Stall/departure recovery procedures should be discussed prior to any controllability check. In the event of a stall, NATOPS procedures should be applied immediately. Flaps should be left down if already there. A rapid increase in airspeed can be attained through judicial use of forward stick and military power.

After a thorough controllability check, the aircrew must make the decision as to whether the aircraft can be safely landed aboard the carrier or should be diverted.

WARNING

- If aircraft stalls or departs in dirty configuration, immediately unload and place throttles at military. Do not raise flaps until recovered. (If during flap/slat transition, follow uncommanded roll/yaw procedures.)

- A controllability check requires the total attention and awareness of the aircrew. The aircrew must be prepared to encounter unusual handling characteristics since the aerodynamic properties of the aircraft may be significantly changed. Stall speed and characteristics may be drastically different from normal.

Note

If flight control malfunction is due to uncommanded STAB AUG transients, spoiler malfunction, flap/slat asymmetry, rudder malfunction (hardover), and/or wing-sweep malfunctions; perform applicable emergency procedure(s) as necessary before beginning a controllability check.

1. Climb to 10,000 feet AGL minimum.
2. Obtain visual check if possible.
3. Decelerate gradually to 200 KIAS if feasible.
4. Dirty aircraft, one configuration change at a time, while flying straight and level

Note

Landing gear should be lowered before flaps. Do not lower arresting hook until landing gear is confirmed down and locked.

5. If flaps are lowered, do so incrementally and be alert for flap/slat asymmetry.
6. If maneuver flaps are used for landing approach: WG SWP DR NO. 1 and WG SWP DR NO. 2/MANUV FLAP cbs — PULL (LE1 and LE2) .

Note

- Failure to pull wing sweep drive circuit breakers (LE1 and LE2) could result in inadvertent maneuver device retraction or wingsweep during approach.

- WINGSWEEP WARNING, WINGSWEEP ADVISORY and FLAP CAUTION lights will illuminate with both wingsweep drive circuit breakers pulled (LE1 and LE2).

7. Use differential thrust, if required, to achieve acceptable flight characteristics.
8. Slow-fly aircraft to determine approach handling characteristics, including turns.
9. Fly simulated approach to evaluate lineup corrections, power changes, and waveoff/bolter performance, and flight characteristics.
10. For landing, use minimum safe control speed, but no slower than optimum AOA.
11. If performance and flight characteristics dictate that a CV landing is not possible — DIVERT

12. If diverting with a flight control malfunction, make arrested landing, if possible.

Note

If normal landing rollout is attempted, flap handle should be checked DOWN on deck with SPL BK selected to enable full ground roll braking authority.

13. If directional controllability is in question:

    a. A shorebased arrested landing should be flown to touchdown at or just prior to the arresting gear.

    b. Use a Landing Signal Officer if possible.

    c. If arresting gear not engaged and performance and flight characteristics permit, execute waveoff/touch-and-go, if possible.

    d. Expect directional excursions during waveoff/bolter, arrested landing, or landing rollout.

    e. Nosewheel steering should not be engaged if rudder pedal authority is restricted.

    f. Use rudder, lateral stick and/or differential braking to oppose any directional excursions during normal landing rollout.

    g. Brief runway departure prior to landing and identify any obstructions in close proximity to the runway.

14.12.2 Uncommanded Roll and/or Yaw

Note

- If Uncommanded roll and/or yaw occurs during high-AOA maneuvering (above 15 units), assume departure from controlled flight and apply appropriate departure and/or spin recovery procedures.

- Failures that may cause uncommanded roll and/or yaw include but are not limited to:

    a. Engine failure.

    b. Stuck up spoiler.

    c. Asymmetric flaps and/or slats.

    d. Uncommanded differential stabilizer and/or rudder automatic flight control system inputs caused by abnormal power transients.

    e. Rudder hardover.

*1. If flap transition:
FLAP handle — Previous Position.

*2. Rudder and stick — Opposite Roll/Yaw.

Note

For spoiler malfunction, use lateral stick as primary lateral control and rudder only as needed to maintain balanced flight.

*3. AOA — Below 12 Units.

*4. Downwing engine — MAX THRUST (if required)

*5. MASTER RESET pushbutton — Depress

Note

DFCS synchronization can take up to 2 seconds following a power interrupt. If the MASTER RESET pushbutton is depressed during the synchronization time, an additional depression of the MASTER RESET pushbutton will be required to restore spoiler functionality.

6. Roll SAS — ON.

7. Roll trim — Opposite Stick (if required).

8. Out of control below 10,000 feet — Eject.

9. Control regained — Climb and Investigate for the following:

    a. Flap and slat asymmetry

    b. SAS malfunction

    Note

    SAS failure may cause uncommanded roll and/or yaw, even without illumination of the associated lights.

    c. Spoiler malfunction

    d. Hardover rudder

    e. Structural damage.

10. Slow-fly aircraft to determine controllability at 10,000 feet AGL minimum.

14.12.3 DFCS Flight Control Failures or Malfunctions. DFCS caution lights:

PITCH SAS	ROLL DGR	YAW DGR
FCS CAUTION	ARI DGR	ARI/SAS OUT

DFCS caution lights fall into three levels of severity.

Loss of redundancy — The FCS CAUTION light indicates some loss of DFCS redundancy. If FCS CAUTION is on alone, then no DFCS authority or function has been lost. It indicates that some sensor or function has been determined faulty but that other sensors or functions are redundantly providing all the input necessary to enable the DFCS to use full authority to provide all designed functions. The AFC acronyms in continuous monitoring (CM) will also give some indication of which axis or sensor has been declared invalid. Emergency procedures recommend limited supersonic operations and adhering to degraded DFCS high angle of attack maneuvering limitations (Figures 4-6 and 4-7 based on legacy SAS) because a subsequent sensor failure may abruptly restrict DFCS authority at a point that it is needed for departure resistance or supersonic stability.

Loss of some authority — The failure of certain sensors or control surface actuators will cause some loss of authority in part of the DFCS. If enough sensors or actuators become faulty, then a light in addition to the FCS CAUTION light will illuminate. The light will indicate which axis or function has become degraded. Loss of some authority will illuminate one of the caution lights in the top row or the ARI DRG light. The basic SAS and primary features of the system are operating with some loss of authority. Some failures may not be readily apparent to the aircrew until particular parts of the envelope are reached. Check of acronyms in CM can help to define the exact nature of the degrade. For degraded authority in roll, yaw or ARI, aggressive maneuvering should be terminated and speed reduced to subsonic if the lights do not clear with MASTER RESET.

Complete loss of SAS in an axis or ARI — A complete loss of authority in the roll or yaw axis or in the ARI will be accompanied by the ARI/SAS OUT light. Determination of which axis or function is lost depends upon what additional lights are illuminated. For example, complete loss of ARI function is indicated by illumination of both ARI lights (the ARI DGR and ARI/SAS OUT). Selecting roll or yaw STAB AUG switches off will disable all ARI but will illuminate only the ARI/SAS OUT light. Adhere to SAS off limits.

Similarly in roll and yaw axis, illumination of both lights in an axis (i.e., ROLL DGR and ARI/SAS OUT) indicates complete loss of authority in the associated axis (Roll axis). With the complete loss of roll or yaw SAS or ARI, aggressive maneuvering should be terminated. Departure resistance and landing characteristics may be significantly degraded. Refer to Ch 11 for high AOA flight characteristics. Consideration should be given to performing a straight in approach to a landing.

In the pitch axis, it is not always possible to resolve whether the loss is partial or total. Regardless, the difference in flying qualities is small and no flight restriction is applied due to pitch SAS degrades.

14.12.3.1 FCS CAUTION Light

Note

Verify maintenance file fault reporting acronyms (RIO) to troubleshoot system for maintenance debrief.

1. MASTER RESET pushbutton — Depress.

If light remains illuminated:

2. Airspeed — Remain below 600 KIAS or 1.3 IMN and adhere to the following limitation.

   a. Above 0.5 IMN, no cross control inputs permitted above 10 units AOA.

   b. With maneuvering devices retracted, coordinate all lateral stick inputs above 0.6 IMN and 15 units AOA.

Note

- The DFCS has lost redundancy, but has not lost any authority.
- The DFCS is potentially one failure away from losing authority and may degrade to ROLL SAS OFF or YAW SAS OFF characteristics with a subsequent failure.

14.12.3.2 PITCH SAS Degrade. Pitch SAS failures do not significantly degrade performance in the longitudinal axis, and incur no flight envelope restrictions. It is possible that the spoilers may be inoperative with a complete failure of the pitch axis.

14.12.3.3 PITCH SAS Light

1. MASTER RESET pushbutton — Depress.

2. If light remains illuminated — No limitations.

CAUTION

- The spoilers may be inoperative (ground roll braking) with a complete failure of the pitch computer.

- If spoilers are inoperative the degradation in the roll axis may be severe and a careful slow flight should be conducted to determine whether a CV approach should be attempted. Refer to spoiler failure procedure.

Note

- The PITCH SAS light will illuminate with any degrade to authority. Additional failures or a complete loss of SAS functions in the pitch axis may not provide any further warning.

- The autopilot will not be operational with a complete pitch SAS failure.

14.12.3.4 ROLL SAS, YAW SAS, or ARI Degrade. When the roll or yaw axes become degraded, the affected axis and ARI will operate with reduced authority. Single series actuator failure or any other degrade to authority is indicated by the ROLL DGR or YAW DGR light in conjunction with the ARI DGR light. This indicates that affected axis and ARI has less than normal authority. This may not be readily apparent to the pilot at all flight conditions. However, since the control system has malfunctioned and lost authority, departure resistance may be significantly reduced. Certain air data failures can cause the ARI to degrade without loss of authority in either the roll or yaw axis. For all Roll, Yaw and ARI degrades, supersonic flight and aggressive maneuvering should be terminated. Precautionary flight restrictions are imposed as listed below.

14.12.3.5 ROLL DGR Light, YAW DGR Light and/or ARI DGR Light

1. MASTER RESET pushbutton — Depress.
2. If light remains illuminated, aggressive maneuvering should be terminated.
3. Remain below 0.93 IMN.

Note

Rudder pedal shakers inop if YAW B fail.

14.12.3.6 ROLL SAS, YAW SAS, or ARI Failure. More serious failures that shut down all inputs in the roll or yaw axis will light the ARI/SAS OUT light along with the ROLL DGR or YAW DGR light. If all ARI functions are lost then both ARI DGR and the ARI/SAS OUT light will illuminate. Failure of both roll or yaw series actuators will also illuminate the ARI/SAS OUT light.

Complete Roll SAS failures are a very significant loss of the DFCS capabilities. CV landings with ROLL SAS failures can be accomplished with moderate effort, provided all spoilers are operating. If spoilers are inoperative the degradation in the roll axis may be severe, and a careful slow flight should be conducted to determine whether a CV approach should be attempted. Refer to Spoiler Malfunction procedures, paragraph 14.12.7.

A second yaw series failure or a complete loss of yaw axis authority is indicated when the ARI/SAS OUT light illuminates in addition to the YAW DGR light. The YAW STAB switch is not automatically positioned to OFF. CV landings with total YAW SAS failure require increased attention to control of directional oscillations especially in turbulence and/or during lineup corrections. Severely decreased yaw damping will be evident throughout the envelope.

14.12.3.7 ARI/SAS OUT Light (with ROLL DGR, YAW DGR or ARI DGR Light)

1. Ensure ROLL and YAW STAB AUG switches — ON.

2. MASTER RESET pushbutton — Depress.

If lights remain illuminated:

3. Leave STAB AUG switches — ON. (to take advantage of any remaining capability that the

DFCS may be able to provide). Terminate aggressive maneuvering and remain below 0.93 IMN.

WARNING

Maneuvering with YAW SAS OFF or inoperative shall not be conducted above 15 units AOA with landing gear retracted.

4. Perform Controllability Check procedure.

CAUTION

- If spoilers are inoperative the degradation in the roll axis may be severe and a careful slow flight should be conducted to determine whether a CV approach should be attempted. Refer to spoiler failure procedure.
- CV landings with total yaw SAS failure require increased attention to control of directional oscillations especially in turbulence and/or during lineup corrections.
- Rudder pedal shakers inop if YAW B fail.

Note

ROLL DGR and ARI/SAS OUT lights may automatically extinguish upon selection of gear handle down. This is indicative of a DFCS dual air data failure (AOA or Mach sensor inputs). These failures inhibit roll SAS and ARI functions in cruise configuration, but not in the landing configuration.

14.12.3.8 STAB AUG Transients

Note

Paddle switch disengages autopilot and ACLS but does not disengage any STAB AUG switches.

1. MASTER RESET pushbutton — Depress
2. Airspeed — Decelerate below 400 KIAS or 0.93 IMN.
3. STAB AUG switches — All OFF.

Note

With ROLL or YAW STAB AUG OFF, the ARI/SAS OUT light will be illuminated.

4. STAB AUG switches — Reset (reset individually to isolate failure).
5. Perform Controllability Check procedure.

14.12.4 Rudder Authority Failure. Scheduling of allowable rudder deflection is computed in the CADC as a function of dynamic pressure. If the command signals and position feedback do not agree, power is removed, stopping further movement and the RUDDER AUTH light illuminates. Directional authority is never limited to less than 9.5° of rudder.

14.12.4.1 RUDDER AUTH Light

1. MASTER RESET pushbutton — Depress (10 seconds).
2. If light remains illuminated — Above 250 KIAS, restrict rudder inputs to less than 10°.

CAUTION

- With rudder authority stops failed open, excess rudder authority is available and could result in structural damage above 250 KIAS.
- After landing, nosewheel steering authority may be restricted to 10° (with neutral directional trim) and differential braking is required coming out of the arresting gear.

14.12.5 Runaway Stabilizer Trim. A runaway trim failure is sensed by the pilot by both uncommanded stick motion and by changes in aircraft pitch and normal acceleration. This failure state causes the horizontal tall to move along the normal stick-to-tail gearing curve for the hands-off condition. Aircraft response to a runaway stabilizer trim, even in the high-speed configuration, is slow enough (about 1 per second stabilizer change,) to be recovered from safely.

The most critical steady-state trim conditions are those for which the greatest stick force is required. A field or carrier landing with either a full noseup or nosedown runaway stabilizer trim requires an average stick force of 14 to 19 pounds to maintain longitudinal control. If pilot fatigue becomes a factor full noseup trim, stick forces may be significantly reduced by placing the wings aft of 21 and lowering the FLAP handle causing the main flaps to extend while tile auxiliary flaps remain retracted. This overrides the wing sweep 210 interlock and the FLAP light will be illuminated. This configuration is not recommended for landing. At approach speed, the nosedown trim condition requires a maximum stick pull of 27 pounds without DLC engaged and approximately 24 pounds with DLC engaged. A full noseup runaway trim, requires a maximum of 17 pounds stick push without DLC engaged and 23 pounds with DLC engaged.

Note

With abnormal stabilizer trim response, continuing to trim may preclude ability to retrim to a neutral position.

1. SPD BK/P-ROLL TRIM ENABLE (RA2) cb — Pull.
2. Decelerate to below 300 KIAS.
3. Use Autopilot, if available, in the cruise configuration to reduce pilot workload.
4. Minimum stick forces are achieved under the following conditions:
   a. Runaway nose down — Flaps up.
   b. Runaway nose up — Flaps down.
5. Straight-in approach.

Note

Force required (push or pull) may be as much as 30 lbs.

14.12.6 Horizontal Tail Authority Failure. Lateral stick inputs are limited by control authority stops scheduled by the CADC as a function of dynamic pressure. Failure of the lateral stick stops is indicated by the HZ TAIL AUTH caution light. Failure of the stops in the fully closed position does limit low-speed rolling performance but ample roll control is available for all landing conditions and configurations. Failure in the open condition with SAS on requires the pilot to manually limit stick deflection to prevent exceeding fuselage torsional load limits.

14.12.6.1 HZ TAIL AUTH Light

1. MASTER RESET pushbutton — Depress (10 seconds).

If light remains illuminated:

2. ROLL STAB AUG switch — OFF.

Note

ARI/SAS OUT light will illuminate.

3. Restrict lateral control inputs above 400 KIAS or 0.9 IMN to one-quarter throw.
4. ROLL STAB AUG switch — ON (for landing).

Note

At low airspeeds, lateral control effectiveness may be reduced.

5. Do not select OV SW after landing.

14.12.7 Spoiler Malfunction. Spoiler monitoring and fault isolation is internal to the DFCS. DFCS should recognize and disable any malfunctioning spoiler and permit other spoilers to operate normally, automatically maintaining greater control authority in event of a spoiler malfunction.

For malfunctions where failed spoilers are successfully commanded to trail, straight-in full flap CV approaches can be accomplished with minor degradation in handling qualities. The control capability remaining with a failed up spoiler is influenced by flap position, SAS operation, and availability of the remaining spoilers.

14.12.7.1 SPOILERS Caution Light/Spoiler Malfunction/Spoiler Stuck Up

CAUTION

If the current configuration is acceptable for landing, careful consideration should be given before depressing MASTER RESET when a spoiler actuator mechanical malfunction is suspected. A deployed spoiler that resulted from DFCS computers dropping off line is not considered a mechanical failure.

Note

- Use lateral stick as primary control and rudder only as needed to maintain balanced flight.
- Subsequent depression of the MASTER RESET pushbutton may clear failure until spoiler is commanded to move again.

1. MASTER RESET pushbutton — Depress.

Note

DFCS synchronization can take up to 2 seconds following a power interrupt. If the MASTER RESET pushbutton is depressed during the synchronization time, an additional depression of the MASTER RESET pushbutton will be required to restore spoiler functionality.

If failure remains/reoccurs:

2. Avoid abrupt lateral control movements and high roll rates.

CAUTION

With wings forward of 62°, excessive horizontal tail differential may cause severe structural damage.

If spoiler(s) fail down:

3. Perform Controllability Check procedure, paragraph 14.12.1.

If spoiler(s) remain up or floating, or if control unsatisfactory with flaps down:

Note

Any single, fully deflected, failed-up spoiler is controllable even with flaps down if the remaining spoilers are operating. With multiple failures, aircraft configuration is the critical factor. With flaps down, roll control using lateral stick alone may be impossible. However, with flaps up, adequate roll control to regain wings level flight is available with use of lateral stick alone. Choice of flap position for landing and CV recovery/divert decision should be made following a controllability check.

4. Perform Controllability Check procedure, paragraph 14.12.1, using maneuvering flap/slat (preferred) or no flap configuration only.

Note

If controllability is unsuitable for landing approach due to a complete loss of spoilers, consideration may be given to attempting a flight control computer Power On Reset in an attempt to regain at least one spoiler set. See DFCS POR procedures, paragraph 14.12.9.

If controllability satisfactory:

5. Perform maneuver flap/slat or no flap straight-in approach at or above minimum control airspeed.

If controllability still unsatisfactory:

WARNING

With both INBD and OUTBD spoiler control cbs pulled, all opposing spoiler control will be lost.

CAUTION

Marginal control or loss of control may be experienced due to removal of a spoiler set with multiple failures present.

Note

If multiple failed-up spoiler panels result in unsatisfactory handling qualities regardless of flap position, an attempt may be made to fail the panels down by removing power via the corresponding spoiler control cbs. This may take as long as 60 seconds, and result in a marginal control or loss of control situation because power to the other spoilers has been removed. Therefore, it should be considered only as a last resort.

5. SPOILER CONTR cb for affected pair — Pull (7G9 for INBD, 8C5 for OUTBD).

If uncontrollable roll, or no improvement in controllability:

6. SPOILER CONTR cb (affected spoiler) — Reset

7. MASTER RESET pushbutton — Depress.

   Functionality lost from cycling spoiler control cb will not be regained until the MASTER RESET pushbutton is depressed.

8. If unsuitable for landing, perform controlled ejection.

If controllability improves:

9. Perform straight-in approach in best configuration with cb(s) out.

Note

- Outboard spoiler position indicators will indicate down with cb 8C5 pulled.
- With cbs 7G9 and 8C5 pulled, ground roll braking is not available. Reset on landing rollout if desired.

14.12.8 Outboard Spoiler Module Malfunction

WARNING

An outboard spoiler module failure with flaps extended, below 180 KIAS, and with a combined hydraulic failure rendering the inboard spoilers inoperative can result in asymmetric spoiler float such that the aircraft may not be flyable at normal approach speeds.

CAUTION

If outboard spoilers fail with airspeed greater than 225 KIAS and wing sweep less than 62°, limit lateral stick to one-half pilot authority.

1. OUTBD SPOILER PUMP (2B2) cb — Check.

   a. If OUT — Attempt Reset.

   b. If IN and outboard spoiler module flag indicates OFF — Pull (2B2).

   The following important equipment is inoperative:

   (1) Outboard spoilers

   (2) Flap and slat backup

   (3) ACL.

2. Evaluate flaps-down lateral control characteristics at safe altitude.

If unacceptable:

3. Make flaps-up landing (No Flaps and No Slats Landing Procedure, paragraph 15.6.1).

14.12.9 DFCS Power On Reset (POR). If controllability is unsuitable for landing approach due to complete loss of spoilers or other major flight control malfunction, consideration may be given to attempting a flight control computer reset in an attempt to regain adequate controllability for landing. A POR will re-initialize DFCS computers, interpreting the current sensor information as valid. This can create a potentially hazardous situation under conditions where a dual sensor failure occurred prior to restoring power. When the DFCS re-initializes, it is possible for the failed signals to be interpreted as valid and the remaining good signal to be interpreted as invalid. Therefore, careful consideration should be given before executing a POR airborne, since it can result in erroneous DFCS commanded control deflections. Aircrew must be alert for erroneous uncommanded SAS and/or spoiler control inputs following an airborne POR.

WARNING

If a dual failure has been declared that will not clear with a MASTER RESET, performing a power on reset (POR) to clear the failure can result in erroneous uncommanded SAS and/or spoiler control inputs.

Note

As with any controllability check, a POR should be performed above 10,000 ft AGL and in the cruise configuration between 250 and 300 KIAS if possible to minimize the potential effects of transient series servo actuator inputs.

1. BOTH SPOILER CONTR cbs — Pull (7G9, INBD and 8C5, OUTBD).

2. PITCH, ROLL, and YAW STAB AUG switches — OFF.

3. ROLL A, YAW B, and YAW A cbs (7B4, 7B5, and 7B6) — Cycle (RIO). Observe PITCH SAS, ROLL DGR, YAW DGR, FCS CAUTION, ARI DGR, ARI/SAS OUT, SPOILERS, HZ TAIL AUTH, RUDDER AUTH, and AUTOPILOT caution lights illuminated.

Note

Attempt to reset cbs 7B4, 7B5, and 7B6 simultaneously to optimize DFCS power-up sequence.

4. MASTER RESET pushbutton — Depress. Observe all lights extinguished with the exception of ARI/SAS OUT light due to ROLL and YAW STAB switches OFF.

WARNING

- If the system continues to display any DFCS related caution lights following MASTER RESET, this could be indicative of a recurring flight control malfunction.

- If a SPOILERS caution light will not extinguish following the execution of a POR, selection of ROLL STAB AUG switch ON can result in erroneous uncommanded SAS control inputs.

- When attempting to individually reset PITCH, ROLL, and YAW STAB AUG switches, be prepared to isolate the affected STAB AUG switch OFF if any uncommanded SAS inputs are observed.

Note

- Minimize control stick inputs during or following MASTER RESET as this can result in the SPOILERS caution light with SPOILER CONTR cbs pulled.

- More than one MASTER RESET may be required to extinguish all caution lights.

5. Individually select PITCH, ROLL, and YAW STAB AUG switches — ON.

If any Uncommanded SAS control inputs:

6. Affected STAB AUG switch — OFF.

WARNING

If Uncommanded roll SAS inputs are observed following a POR, reselection of the SPOILER CONTR cbs can result in full spoiler deflection and an out of control aircraft.

7. If Uncommanded roll SAS control inputs, DO NOT reset SPOILER CONTR cbs.

8. Perform Controllability Check procedure.

If no Uncommanded roll SAS control inputs:

6. Reset SPOILER CONTR cbs.

7. Perform Controllability Check procedure.

14.12.10 Rudder Hardover. A rudder hardover will result in a single fully deflected (over 30°, pegged on cockpit indicator) inboard or outboard rudder with possible restricted opposing “good” rudder authority and a flight hydraulic failure. Rudder trim and rudder pedal authority may also be restricted.

This procedure only applies to a true rudder hardover failure, not a Yaw SAS hardover failure which will be manifested by both rudders being deflected up to 9.5° with mechanical rudder authority still available. A Yaw SAS hardover should be easily controlled with rudder trim and the available mechanical rudder.

In cruise configuration above 15 units angle of attack, a departure from controlled flight may occur with a rudder hardover. Upright departure/spin recovery procedures may not fully recover the airplane, and it may be necessary to perform uncommanded roll/yaw procedures.

WARNING

With zero flight hydraulic pressure, ensure hydraulic transfer pump switch is secured as soon as possible. In the event of hydraulic malfunction, refer to appropriate hydraulic emergency procedure and execute appropriate steps in parallel as required.

After completion of uncommanded roll/yaw procedures:

1. Confirm rudder hardover via cockpit indicator and/or RIO/wingman visual inspection.

Note

Restriction of authority, if any, of opposing "good" rudder may be determined by reference to the cockpit indicator.

2. If carrier based, divert to an airfield with short field arresting gear.

3. Perform Controllability Check procedure.

Note

- Expect roll and yaw oscillations during throttle and control movements. Undesirable airspeed increase may occur due to differential thrust. Airspeed control may also be influenced by flap position and pilot workload. Specifically, evaluate the effects of any required differential thrust on lineup corrections, waveoff/bolter performance, and flight characteristics.

- Simulation has indicated that full flap setting combined with severely restricted opposing rudder results in more pronounced roll and yaw oscillations.

4. During cruise, use differential thrust, rudder, lateral stick, and rudder trim to relieve pilot workload and control forces. Use lateral trim as necessary.

WARNING

If jettison is required, consideration should be given to keeping the wing stations symmetric and avoiding aft c.g. conditions.

Note

It is unknown what the fuel consumption will be in this configuration. Therefore, fuel quantity must be closely monitored. Recommend using gear up, flaps down, single engine BINGO charts. Fuel imbalance may occur during prolonged flight with higher demands on one engine. Use feed switch to minimize fuel split.

5. If no suitable divert available and aircraft sufficiently controllable for a CV approach, attempt CV arrested landing.

Note

Recommend practice approach to CV, fuel permitting.

6. If no suitable divert available and controlled CV approach in question, perform a controlled ejection.

Prior to landing:

WARNING

Controllability of a rudder hardover airborne is no indication of the ability to maintain directional control on deck. Upon touchdown, expect the aircraft to experience uncontrollable directional excursions potentially departing the landing area/runway.

Note

- Ensure familiarity with landing considerations of controllability check procedures.

- Simulation indicated that bank angle control was enhanced by leading lateral stick inputs with differential thrust.

7. Lateral trim — Neutralize

Note

The use of lateral trim to reduce stick forces during actual approach and landing should be avoided as this reduces the spoiler deflection available for roll control.

8. Asym Thrust Limiter System switch — Off (if reqd.).

WARNING

Asymmetric thrust limiter should only be disabled if required to assist/maintain control.

9. Perform arrested landing.

WARNING

Use only opposing throttle for waveoff/bolter.

CAUTION

If rudder pedal authority is restricted, nosewheel steering should not be engaged upon landing rollout.

14.12.11 FLAP Light

14.12.11.1 Not After Landing/Takeoff Flap Transition

1. Airspeed — Below 225 KIAS.
2. FLAP handle — Ensure Full Up.
3. MASTER RESET pushbutton — Depress.

While holding MASTER RESET pushbutton depressed:

4. Maneuver flap thumbwheel — Full Forward.
5. Check FLAP light out. (Light can take up to 10 seconds to reilluminate.)

14.12.11.2 After Landing/Takeoff Flap Transition or Reillumination After Above Procedures

1. MASTER RESET pushbutton — Depress.
2. If light still illuminated, check FLAP handle and indicator position, then proceed with appropriate steps below.

14.12.11.3 FLAP Handle Up and Flaps Not Fully Retracted

1. FLAP handle — EMER UP.

If FLAP handle or flaps will not respond or FLAP light remains illuminated, refer to Flap and Slat Asymmetry procedures, paragraph 14.12.12.

14.12.11.4 FLAP Handle Up and Flaps Indicating Full Up

1. Flaps — Cycle.

If FLAP handle or flaps will not respond or FLAP light remains illuminated, refer to Flap and Slat Asymmetry procedures, paragraph 14.12.12.

14.12.11.5 FLAP Handle Down and Flaps Not Fully Extended

1. Wing sweep — Ensure at 20°.

Flaps will not respond or FLAP light remains illuminated. Refer to Flap and Slat Asymmetry procedures, paragraph 14.12.12.

14.12.11.6 FLAP Handle Down and Flaps Down

1. Wing sweep — Ensure at 20°.

2. MASTER RESET pushbutton — Depress (allow 10 seconds for auxiliary flaps to extend).

Note

If FLAP handle or flaps will not respond or FLAP light remains illuminated, refer to Flap and Slat Asymmetry procedures, paragraph 14.12.12.

14.12.12 Flap and Slat Asymmetry. Actuator flap and slat asymmetry can occur with failure of an asymmetry sensor and subsequent failure of the flap and slat drive mechanism for one wing. The pilot's only indication will be an uncommanded roll followed by a FLAP light approximately 10 seconds later. The flap indicator does not indicate actual flap position, but the position to which the flap and slat control box has been driven. The slat indicator shows up, down, or transition (barberpole) for the starboard slat only. The port slat position is not monitored. Asymmetric flaps cause an immediate roll. Asymmetric slats may not be apparent until just before wing stall. Asymmetric slats can cause rapid rolloff above 15 units AOA. Slat position must be monitored by the RIO during transition.

WARNING

The use of lateral trim to reduce stick force will reduce spoiler control significantly. An uncontrollable situation can develop if lateral trim is out of neutral before flap and slat asymmetry or if the pilot trims laterally in the neutral direction (opposite the roll) during flap and slat transition. This situation will be aggravated and recovery may not be possible with roll SAS off because of reduced differential tail authority. Once asymmetry occurs, do not trim out stick forces. If lateral control is marginal, trim opposite to the natural direction until full spoiler deflection is available. For example, stick to the right, trim left.

If a roll is encountered during flap and slat transition or if RIO notes asymmetric slat extension or retraction:

Note

Uncommanded roll/yaw procedures take precedence if appropriate. Otherwise, perform the procedures below.

1. FLAP/SLAT CONTR SHUT-OFF cb — Check IN (RE2)

WARNING

Lack of asymmetry protection (RE2 circuit breaker out) may cause uncommanded roll and/or yaw during flap or landing gear handle movement.

2. Flaps — Match Handle With FLAPS Position.
3. Obtain a visual check if possible to ascertain position of all flap and slat surfaces.
4. Slow fly aircraft in approach configuration at or above 10,000 feet AGL to determine approach characteristics, conditions permitting.
5. Land as soon as practicable if aircraft is controllable and minimum approach airspeed is within shipboard arresting gear limits.

If asymmetry is so large as to make landing impossible or minimum safe approach speed is above shipboard arresting gear limits with no possible divert field available:

6. Climb above 10,000 feet AGL.
7. AUX FLAP/FLAP CONTR (7G3) cb — Pull.

WARNING

- Failure to complete step 7 before the subsequent steps can result in large uncommanded pitch trim changes because of auxiliary flap movement.
- Pulling circuit breaker RE2 removes flap/slat asymmetry protection, which could result in an uncontrollable aircraft, and flap/slat overtravel protection, which could result in structural damage.

8. FLAP/SLAT CONTR SHUT-OFF (RE2) cb — Pull.
9. Slowly move FLAP handle in direction to minimize asymmetry and/or lateral control requirements.

10. Stop flap and slat travel before reaching full up or down.

11. FLAP/SLAT CONTR SHUT-OFF (RE2) cb — Reset.

WARNING

Asymmetric slats may not be apparent until just before wing stall. Asymmetric slats can cause rapid roll-off above 15 units AOA.

12. If asymmetry has been corrected, land using 15 units AOA.

13. If asymmetry has not been corrected, flaps and slats did not respond to above procedure, or lateral control problems exist, land using a minimum safe speed AOA if landing is elected.

14.12.13 Wing-Sweep Lights

14.12.13.1 Advisory Light Only — No Loss of Normal Control

1. MASTER RESET pushbutton — Depress.

14.12.13.2 Advisory and Warning Lights — No Automatic or Manual Control

1. Airspeed — Decelerate to 0.9 IMN or Less.

2. Check spider detent engaged.

3. MASTER RESET pushbutton — Depress (wait 15 seconds to determine system status).

If advisory and warning lights illuminate again:

4. WING SWEEP DRIVE NO. 1 and WG SWP DR NO. 2/MANUV FLAP (LE1, LE2) cbs — Pull.

5. Emergency WING SWEEP handle — Comply With Below Schedule:

   a. ≤ 0.4 IMN — 20°

   b. ≤ 0.7 IMN — 25°

   c. ≤ 0.8 IMN — 50°

   d. ≤ 0.9 IMN — 60°

   e. >0.9 IMN — 68°.

CAUTION

Avoid ACM and aerobatics.

14.12.13.3 Unscheduled Wing Sweep

1. Emergency WING SWEEP handle — Raise and Hold.

CAUTION

Unscheduled wing sweep at supersonic speed may cause structural damage.

2. Airspeed — Decelerate to 0.6 IMN or Less in 1g Nonmaneuvering Flight.

3. Emergency WING SWEEP handle — Full Forward.

If wings do not move full forward:

4. Emergency WING SWEEP handle — Match With Actual Wing Position.

5. WING SWEEP DRIVE NO. 1 and WG SWP DR NO. 2/MANUV FLAP (LE1, LE2) cbs — Pull (refer to Aft Wing-Sweep Landing in paragraph 15.8.1).

6. Land as soon as practicable.

Note

- After a wing-sweep malfunction, the WING SWEEP warning light may take 15 seconds to illuminate.
- FLAP light will be illuminated with cb LE2 pulled.

14.12.14 CADC Light

1. MASTER RESET pushbutton — Depress.

2. CADC (LA2, LB2, LC2, LH2) cbs — Cycle.

3. MASTER RESET pushbutton — Depress.

If light remains illuminated:

4. Remain below 1.5 IMN.

One or more of the following systems may be affected by CADC malfunction that illuminates CADC light only:

a. Maximum safe Mach

b. Autopilot

c. Idle lockup of AFTC

d. Wing-sweep indicator

e. Cockpit cooling less than Mach 0.25

f. HUD display (takeoff and landing)

g. Servo altimeter.

Note

- Erroneous Mach inputs to the AFTC may cause uncommanded acceleration of both engines to near-military values in the PRI engine mode.

- If illumination of the CADC light is accompanied by other caution or advisory light(s), refer to the appropriate procedure that will dictate the most restrictive limitation.

14.12.15 Autopilot Light

1. MASTER RESET pushbutton — Depress.

14.12.16 Weight On-Off Wheels Switch Malfunction. For most systems, failure of both the left and right weight-on-wheels switches is required to cause the systems to revert to the on-deck mode. Should such failures occur, the following anomalies can result:

Indications:

1. Approach indexers are inoperative.

2. APC will not engage.

3. Outboard spoiler module inoperative (flaps up).

4. Nozzles full open (gear down, throttles IDLE).

5. Ground-roll spoiler braking (throttles IDLE).

6. Radar will not scan.

7. Autopilot cannot be engaged.

8. BOL chaff will not dispense.

9. At high altitude, ground cooling fans may overspeed and shut down, causing smoke in cockpit.

10. RATS will be enabled airborne with the hook handle down or the hook out of the stowed position.

WARNING

With RATS enabled airborne, military power provides 20 to 25 percent less thrust than normal, resulting in less than optimum waveoff and bolter performance.

If two or more of the above anomalies are detected, the following action should be taken.

14.12.16.1 In Flight — Pilot

1. Throttles — Any Position Except IDLE.

WARNING

Do not move both throttles to IDLE unless ANTI SKID SPOILER BK switch is set to OFF if weight on-off wheels switch is suspected because of loss of lift caused by spoilers deploying.

2. ANTI SKID SPOILER BK switch — OFF.

3. Land as soon as practicable.

CAUTION

If weight on/off wheels switch failure is suspected, cocked-up, high-sink-rate landing with throttles at idle can result in damage to the afterburner.

14.12.16.2 In Flight — RIO

1. MLG SAFETY REL NO. 1 and REL NO. 2 cbs — Pull (6F5, 6F4).

Note

- Circuit breakers can be reset after touchdown to enable ground roll braking, antiskid, nozzles open at idle, and nosewheel steering.
- Circuit breakers must be reset simultaneously (within 0.1 sec) once on deck or a secondary fault may be declared which will inhibit ground roll braking.

14.13 DEPARTURE/SPIN

Successful recovery from out-of-control flight requires correct situation analysis, timely and correct application of procedures, crew coordination, and recognition of recovery. Departure from controlled flight should be recognized and the appropriate recovery procedures initiated as soon as the aircraft begins uncommanded motion. If an engine stall is indicated by the warning lights/tone, throttles should be reduced to IDLE to prevent thrust asymmetry from delaying recovery. If recovery is not immediately apparent, instrument cues must be cross-checked. Full departures/ spins are indicated by pegged AOA (30 units for upright, 0 units for inverted), low airspeed (less than 150 KIAS), and sustained yaw rate as indicated by the turn needle and/or spin arrow. The spin arrow is the best indicator of yaw direction if it is available. If the above indications are not present, neutralize the controls and fly the aircraft as airspeed increases. Recovery q controls should be applied and maintained until recovery is indicated, minimum altitude is reached, or an increase in eyeball-out g threatens aircrew incapacitation. The most positive indication of recovery is a break in AOA as yaw rate is reduced, followed by an increase in airspeed and g load in the direction commanded by longitudinal stick. To minimize altitude loss for recovery, pull out at 17 units AOA.

Crew coordination is essential. The RIO must be able to analyze the situation and provide timely and accurate information and procedural backup to the pilot without excess communication. The RIO should use airspeed, altitude remaining, and spin arrow (that may not be visible to the pilot) as cues. Lateral stick application can be confirmed by observing spoilers deflected up on the wing pointed to by the spin arrow. Ejection in an out-of-control flight situation can best be accomplished by the RIO after consultation with the pilot. A thorough understanding of Chapter 11 is required of the aircrew when dealing with these high-task emergencies.

14.13.1 Vertical Recovery

1. Above 100 KIAS, use longitudinal stick to pitch the nose down. At extreme nose-high attitudes, aft stick facilitates recovery time and will avoid prolonged engine operation with zero oil pressure.
2. Below 100 KIAS, release controls and wait for aircraft to pitch nose down. This prevents depletion of hydraulic pressure in the event both engines are lost and provides quickest recovery.
3. If roll and/or yaw develop, wait until aircraft is in a nosedown attitude and accelerating before correcting with rudder or lateral stick.
4. Use longitudinal control as necessary to keep nose down and accelerating.
5. Above 100 KIAS, pull out using 17 units AOA.
6. Recovery to level flight from point of pitchover can normally be completed in less than 10,000 feet.

14.13.2 Upright Departure/Flat Spin

*1. Stick — Forward/Neutral Lateral, Harness Lock.

*2. Throttles — Both IDLE.

*3. Rudder — Opposite Turn Needle/Yaw.

If no recovery:

*4. Stick — Into Turn Needle.

If yaw rate steady/increasing or spin arrow flashing or eyeball-out g sensed:

*5. Roll SAS — ON, Stick — Full into turn needle and aft.

If recovery indicated:

*6. Controls — Neutralize.

*7. Recover at 17 units AOA, thrust as required.

If flat spin verified by flat attitude, increasing yaw rate, increasing eyeball-out g, and lack of pitch and roll rates:

*8. Canopy — Jettison.

*9. Eject (RIO command eject).

WARNING

Ejection guidelines are not meant to prohibit earlier canopy jettison and/or ejection. If insufficient altitude exists to recover from departed flight, the flightcrew should not hesitate to eject.

Note

At high yaw rates where eyeball-out g is sensed, aft stick and full lateral stick into the turn needle may arrest the yaw rate and increase the possibility of recovery. At these yaw rates, the additional differential tail provided by roll SAS on will also increase the possibility of recovery. It may be necessary to momentarily center stick laterally to engage roll SAS.

14.13.3 Inverted Departure/Spin

*1. Stick — Full Aft/Neutral Lateral, Harness — Lock.

*2. Throttles — Both IDLE.

*3. Rudder — Opposite Turn Needle/Yaw.

If recovery is indicated:

*4. Controls — Neutralize.

*5. Recover at 17 units AOA, thrust as required.

If spinning below 10,000 feet AGL:

*6. Eject (RIO command eject).

CAUTION

Dual compressor stalls/overtemperatures should be expected in an inverted spin.

Note

If pedal adjustment and/or pilot positioning (because of negative-g forces) is such that full rudder pedal travel cannot be obtained, full lateral control opposite the turn needle/ yaw may provide an alternate recovery method. Aft longitudinal stick should be relaxed enough to allow full lateral stick application.

CHAPTER 15

Landing Emergencies

15.1 DUAL-ENGINE LANDING, ONE OR BOTH ENGINES IN SECONDARY MODE

With either one engine in secondary mode (the other engine in primary) or both engines in secondary mode, a straight-in approach should be conducted with slats and flaps fully extended, 15 units AOA, DLC engaged, and speedbrakes extended. Approaches can be accomplished safely up to the normal gross weight limits of the aircraft. Throttle position in secondary mode will be 5° to 10° higher than in primary mode for the same amount of thrust. Thrust response in secondary mode is nonlinear and very sluggish. Engine acceleration time can be as much as three times longer than in primary mode. Secondary mode MIL power thrust levels can vary from as little as 65 percent to as much as 116 percent of primary mode MIL thrust.

CAUTION

For shipboard landing, the LSO and tower must be informed if the landing is to be made with both engines in secondary mode to ensure wind-over-deck requirements are met as RATS is not operative in secondary mode.

During flight tests with one engine in secondary mode, optimum results were obtained by matching engine rpms prior to commencing final approach and maintaining the throttle split when making power corrections. Use of DLC to make small glideslope changes will improve lineup control by reducing throttle activity and the associated yaw excursions. Waveoff and bolter performance is essentially the same as in dual-engine primary mode except for a slight yaw into the secondary mode engine.

With both engines in secondary mode, expect very sluggish power response and throttle positions 5° to 10° more forward than in primary mode. Extreme care should be taken to avoid an underpowered condition as this will significantly degrade waveoff performance. The LSO should move the waveoff window such that only minor glideslope/lineup corrections are required from the middle position.

WARNING

Waveoff performance with both engines in SEC mode may be severely degraded. Extreme care should be used to avoid an underpowered, high-rate-of descent situation.

15.2 SINGLE-ENGINE LANDING PRIMARY MODE

Perform a straight-in approach with flaps and slats extended and speedbrakes retracted (to reduce thrust required). External tanks have a negligible effect on thrust required and need to be dropped only if necessary for gross weight considerations. If operating on the left engine, DLC is available and is recommended. DLC can be used to aid in the control of glideslope, thereby minimizing required power changes and the resultant lateral/directional deviations. The 8-knot increase in airspeed with DLC engaged results in more control authority and improved waveoff and bolter performance. Flight in the power approach configuration is critical. Turns should be made away from the failed engine using bank angles that do not exceed 20°. Remain below 12 units AOA until established on final approach. Final approach should be conducted at 15 units AOA with DLC engaged/14 units with DLC stowed (DLC is not available when combined hydraulic system is pressurized by the BI-DI pump). Small rudder inputs should be made in conjunction with power changes to reduce the amount of yaw.

Waveoff and bolter (with RATS) may be accomplished up to normal gross weight limits of the aircraft. Test results have shown that MIL power provides satisfactory waveoff performance. Minimum AB (ATLS on) reduces altitude loss when waveoff occurs from a high rate of descent. The use of maximum AB is prohibited. No significant difference in altitude loss during waveoff was noted between minimum AB and maximum AB. The aircraft is extremely difficult to control in maximum AB and large bank angles into the operating engine are required to maintain centerline. Late or inadequate control inputs during a maximum AB waveoff can result in large lateral flightpath deviations. Waveoff technique is to select MIL or minimum AB (ATLS on), maintain approach AOA until a positive rate of climb is established, then accelerate and climb out at the airspeed indicated in Climb Performance After Takeoff (Single Engine) charts in NAVAIR 01-F14AAP-1.1.

The bolter maneuver is effected by selecting MIL or minimum AB (ATLS on) and slight aft control stick until the desired flyaway attitude is established. During a bolter following a DLC-stowed approach, nose rotation will be more sluggish than normal (because of the slower approach speed), requiring a slightly more aggressive aft control stick input.

CAUTION

The use of excessive backstick on a bolter may cause the tail surface to stall, delaying aircraft rotation and causing the aircraft to settle off the angle deck.

As power is advanced during a waveoff or bolter, simultaneously apply rudder (approximately two-thirds to three-quarters of full deflection) to counter the asymmetric thrust and prevent lateral drift. Rudder may be supplemented with small lateral stick inputs. If yaw rate develops into the dead engine, immediately apply full opposite rudder to arrest the yaw rate and then reduce the rudder as required to track centerline. If unable to control yaw rate during AB waveoff (possible ATLS failure), immediately reduce power to MIL.

During single-engine operations at fuel states above 4,000 pounds, a fuel split will develop between the aft/left and forward/right sides. When either cell No. 2 or No. 5 thermistor is uncovered (at approximately 2,000 pounds on either tape), or when FWD or AFT is selected on the FEED switch, the motive flow isolation and sump tank interconnect valves open, making wing and fuselage fuel on both sides available to the operating engine. However, if the sump tank interconnect valve fails to open, fuel will migrate to the wing and fuselage tanks on inoperative engine side and will not be available to the operating engine. Under these conditions, the maximum migration rate could reach 300 ppm. If the FUEL SHUT-OFF handle on the inoperative engine is not pulled, an additional migration path could exist through the engine crossfeed valve. During single-engine operation, the following procedures will minimize fuel migration if the sump tank interconnect valve fails to open.

1. FUEL SHUT OFF handle (inoperative engine) — PULL.

If not on final approach:

2. Refer to Single-Engine Cruise Operations, paragraph 14.5.3.3.

If after commencing final approach or in landing pattern:

2. ATLS — Check ON.

WARNING

Use of maximum AB during waveoff or bolter is prohibited and provides little or no improvement over minimum AB. If unable to control yaw rate (possible ATLS failure), immediately reduce power to minimum AB or MIL.

Note

Altitude loss during waveoff is minimized by maintaining approach AOA until positive rate of climb is established. Avoid overrotating in close as this will increase the chance of an in-flight engagement. Minimum AB (ATLS on) will improve waveoff performance (minimize altitude loss) from high sink rates.

3. Afterburner operation (airspeed >170 KIAS, fuel permitting, and full rudder authority (RUDDER AUTH light out)) — Stage To Verify Proper Operation of ATLS.

4. Wing sweep — Set at 20° (EMER).

WARNING

If hammering (cavitation) is experienced in the hydraulic system, component rupture is imminent. Turn the HYD TRANSFER PUMP switch (BIDI) OFF.

5. Reduce gross weight/minimize lateral asymmetry into the inoperative-engine side — as required.

6. Speedbrakes — RET (on final approach).

7. LDG GEAR handle — DN (if combined pressure zero — EMERG DN.)

8. HOOK — As Required.

9. Check SAS — ON.

10. If combined pressure zero — Pull AUX FLAP/FLAP CONTR cb (7G3)

11. Flaps — DN.

12. DLC (if operating on right engine) — Do Not Engage. (If operating on left engine and 3,000 psi combined pressure — Engage on Final.)

13. EMERG FLT HYD switch — HIGH (on final, committed to land).

WARNING

If combined pressure is zero, do not return to AUTO (LOW) mode once module is selected on. If module is shut off after operation commences, it may not restart.

14. For landing pattern, use 12 units AOA for pattern airspeed and do not attempt turns greater than 20° angle of bank.

WARNING

Extreme caution must be exercised when performing turns into a dead engine. Decaying airspeed/increasing AOA can rapidly result in a situation where there is not enough rudder authority to return the aircraft to level flight and insufficient altitude to effect a recovery.

15. Final approach airspeed:

    a. DLC engaged — 15 Units AOA.

    b. DLC stowed — 14 Units AOA.

WARNING

Military power climb performance during heavy waveoffs may not adequately arrest high-sink rate conditions. Use of minimum AB provides an increase in climb performance. Up to full rudder may be required to counter AB asymmetric thrust yawing moment during waveoff or bolter. Do not exceed 14 units AOA during waveoff or bolter.

15.3 SINGLE-ENGINE LANDING SECONDARY MODE

Approaches in single-engine secondary (SEC) mode are considered extremely hazardous. Engine military (MIL) power thrust levels can vary from as little as 65 percent to as much as 116 percent of primary mode MIL thrust. Although the majority of engines produce greater than 90 percent of primary mode thrust (at MIL power), the possibility exists that in the full flap configuration, a low thrust engine will not provide enough thrust for level flight. Engine acceleration times also vary and can be as much as three times longer than in primary mode. Aircraft in this configuration should recover shore based. Shipboard landings should be attempted only as a last resort and only if performance is adequate. For example, 72 percent of primary mode MIL thrust is considered the minimum required for a safe CV approach with a 48,000-pound aircraft with no stores.

To accomplish the performance check, configure the aircraft at 2,000 feet AGL or greater and 10 units AOA with the maneuvering flaps down (if available) and leave the landing gear up. With the engine at MIL thrust, establish a constant airspeed climb (±5 knots) at the airspeed corresponding to 10 units AOA. The minimum change in altitude required in 30 seconds is as follows:

	CHANGE IN ALTITUDE — FEET	
	MANEUVER FLAPS DN	MANEUVER FLAPS UP
2,000 feet	950 feet	900 feet
4,000 feet	800 feet	750 feet
6,000 feet	700 feet	650 feet

Note

Climb performance will improve by 20 feet in a 30-second climb for every 1,000-pound gross weight reduction.

If the test is passed based on predicted gross weight, do not lower the landing gear and flaps until the predicted gross weight is reached. If the performance test is passed and divert is not possible, a CV approach may be attempted. The minimum performance is required for optimum conditions (day, VMC, steady deck, experienced aircrew, normal wind over deck, etc.). For degraded conditions, the minimum performance should be increased based on judgment. If the minimum performance test is not passed, and all other options are exhausted (stores jettisoned, gross weight minimized, divert not possible), eject under controlled conditions.

For shore-based landings, conduct a straight-in approach with flaps up and speedbrakes retracted. If conditions warrant a full-flap landing, conduct a performance test and proceed as in the case of a shipboard landing. Gross weight should be reduced as much as practicable to improve flyaway performance. Maintain 10 units AOA in the pattern, slowing to 15 units AOA at touchdown when a safe landing is assured. Use extreme caution when working off a high and/or fast situation, avoiding any large power reductions. The natural tendency will be to underestimate the sluggish power response resulting in an underpowered condition. Waveoff capability is dependent on engine thrust/thrust response, aircraft rate of descent, and power setting at waveoff initiation. Waveoffs should be conducted by rotating toward 14 units (maximum) AOA until a positive rate of climb is attained, then slowly reducing AOA to 10 units AOA to achieve maximum rate of climb. Bolters should be conducted by rotating to 10° pitch attitude not to exceed 14 units AOA. Avoid increasing AOA, as performance will degrade and wing drop will occur at 16.5 to 17.5 units AOA.

Shipboard landings in single-engine SEC mode are not recommended and should be attempted as a last resort (divert not available) and if the performance check is successful. Jettison all external stores and reduce fuel weight as much as practicable to reduce gross weight and drag. Configure the aircraft for landing no lower than 2,000 feet AGL. Approaches should be conducted with the flaps and slats fully extended, speedbrake retracted, and DLC stowed.

Conduct a straight-in approach. Any turns should be made away from the dead engine using bank angles that do not exceed 20°. Maintain 10 units AOA until established on final, at which time the aircraft should be slowed to 13 units (maximum) AOA. Extreme care should be used when working off a high and/or fast condition, as any large power reductions could result in an underpowered situation. A high and/or fast condition should be corrected using only small power reductions. Upon detection of a deceleration or settle, immediate selection of MIL power may be required to correct the situation in a timely manner. To minimize the chance of a hook-skip bolter, it is important to maintain aft stick pressure on touchdown. Waveoffs should be conducted by rotating the aircraft to 14 units (maximum) AOA until a positive rate of climb is attained, then slowly reducing AOA to 11 to 12 units to achieve a maximum rate of climb. Bolters should be conducted by rotating to 10° pitch attitude not to exceed 14 units AOA.

15.3.1 Single-Engine Landing — SEC Mode

1. FUEL SHUTOFF handle (inoperative engine) — Pull.

2. In CV environment — Divert.

3. Refer to Single-Engine Cruise Operations, paragraph 14.5.3.3, and engine transfer to SEC mode procedures.

If not preparing for CV approach, see step 6.

If divert is not possible:

WARNING

Engine thrust and thrust response can be severely degraded such that level flight cannot be maintained in the full-flap landing configuration. DO NOT configure for landing until the performance test has been accomplished.

If not configured for landing:

4. Perform constant airspeed climb (+5 knots) at 10 units AOA, landing gear up, maneuvering flaps down (if possible), above 2,000 feet. Minimum climb required in 30 seconds is as follows:

	CHANGE IN ALTITUDE — FEET	
	MANEUVER FLAPS DN	MANEUVER FLAPS UP
2,000 feet	950 feet	900 feet
4,000 feet	800 feet	750 feet
6,000 feet	700 feet	650 feet

CAUTION

If minimum performance test is passed based on predicted gross weight, do not lower landing gear and flaps until predicted gross weight is reached.

Note

Climb performance will improve by 20 feet in a 30-second climb for every 1,000-pound gross weight reduction. Minimum performance criteria is based on optimum conditions (day, VMC, steady deck, experienced aircrew, normal wind over deck, etc.) and should be increased for degraded conditions based on judgment.

5. If minimum performance criteria are not passed and all options are exhausted (stores jettisoned, minimum gross weight, and divert not possible), eject under controlled conditions.

If configured for landing:

4. Throttle — MIL.

5. Ensure a minimum of 500-fpm rate of climb at 14 units AOA available for CV approach.

When preparing for landing:

WARNING

Shipboard recovery in single-engine SEC mode is considered extremely hazardous and should be conducted only as a last resort and if the performance check is successful.

6. RUDDER AUTH light — Check out.

7. Wing sweep — Set at 20°.

WARNING

If hammering (cavitation) is experienced in the hydraulic system, component rupture is imminent. Turn the HYD TRANSFER PUMP switch (BIDI) OFF.

8. External stores — Jettison for Shipboard Recovery.

9. Fuel — Dump or Burn.

10. Speedbrakes — RET (on final approach).

11. LDG GEAR handle — DN (if combined pressure zero — EMERG DN).

12. HOOK — As Required.

13. Check SAS — ON.

WARNING

Shore-based landings should be conducted with flaps up. If conditions warrant a full-flap landing, conduct a performance test and proceed as in the case of a shipboard landing.

14. If combined pressure zero — Pull AUX FLAP/ FLAP CONTR cb (7G3).
15. Flaps — DN (shipboard recovery), As Required (field landing).
16. DLC — Do Not Engage.
17. EMERG FT HYD switch — HIGH (on final, committed to land).

WARNING

If combined pressure is zero, do not return to AUTO (LOW) mode once module is selected on. If module is shut off after operation commences, it may not restart.

18. For landing pattern, use 10 units AOA for pattern airspeed and do not attempt turns greater than 20° angle of bank.

WARNING

Extreme caution must be exercised when performing turns into a dead engine. Decaying airspeed/increasing AOA can rapidly result in a situation where there is not enough rudder authority to return the aircraft to level flight and insufficient altitude to effect a recovery.

19. Final approach airspeed — 13 Units (CV), (field landing slow to 15 units, no flaps at touchdown).

WARNING

Waveoff performance from high rates of descent in SEC mode may be severely degraded. Extreme care should be used to avoid an underpowered, high-rate-of-descent situation.

Note

- Waveoff should be conducted by rotating to 14 units (maximum) AOA until a positive rate of climb is attained.
- Bolters should be conducted by rotating to 10° pitch attitude not to exceed 14 units AOA.

15.4 LANDING GEAR EMERGENCIES

15.4.1 Landing Gear Emergency Lowering. Use emergency lowering of the landing gear only as a last resort. Once this system is used, the gear cannot be retracted; therefore, the landing must be made in whatever configuration you have at that time. If a long flight is necessary to make a field landing, it will have to be made with the gear down (see Figure 15-1).

1. Airspeed — Less Than 280 KIAS.
2. LDG GEAR handle — DN.

CAUTION

The LDG GEAR handle should be pulled with a rapid and continuous 55-pound force until the handle is loose (fore and aft) in its housing as an indication of complete extension of the handle.

3. Push LDG GEAR handle in hard, turn it 90° clockwise, pull, and hold.
4. Gear position indication — Check (12 seconds).
5. Make arrested landing if available.

FINAL CONFIGURATION	CARRIER LANDINGS		FIELD LANDING			
			ARRESTING GEAR AVAILABLE		NO ARRESTING GEAR AVAILABLE	
		NOTES		NOTES		NOTES
Cocked Nose Gear	Land	1, 8,11	Arrested Landing	6, 8, 9, 11, 12,13	Land	6, 9, 11, 13
Side-Brace Not In Place	Land	1, 2, 8,11	No Arrested Landing	3, 6, 7, 8, 11	Land	3, 6, 7, 8, 11
Nose Gear Up/ Unsafe Down	Land	1, 2, 4, 8, 11	No Arrested Landing	4, 6, 8, 9, 10, 11	Land	6, 8, 9, 10, 11
Stub Nose Gear	Land	1, 2, 4, 8, 11	No Arrested Landing	4, 6, 8, 9, 10, 11	Land	6, 8, 9, 10, 11
Nose Gear Up, One Main Up	Eject Pilot Option To Land If Tanks Installed	1, 2, 4, 8, 11	Pilot Option Eject or Arrest	6, 8, 10, 11, 12	Eject	—
One Main Up/ Unsafe Down	Land	1, 2, 8, 11	Arrested Landing	6, 8, 10, 11, 12, 13	Pilot Option Eject or Land	5, 6, 8, 10, 11, 13
Both Main Up/ Unsafe Down	Eject Pilot Option to Land if Tanks Installed	1, 2, 8, 11	Pilot Option Eject or Arrest	6, 8, 10, 11, 12	Pilot Option Eject or Land	
Mains One Or Both Stub/Mount/ Hyperextended/ Wheel Cocked	Land	1, 2, 4, 8, 11	No Arrested Landing	4, 5, 6, 8, 11	Land	5, 6, 8, 11
All Gear Up	Eject Pilot Option to Land if Tanks Installed	1, 2, 8, 11	Pilot Option Eject or Land	4, 6, 8, 10, 11	Pilot Option Eject or Land	6, 8, 10, 11

1. Divert if possible.
2. Hook down barricade engagement.
3. Minimize skid and drift rollout.
4. Remove all arresting gear.
5. Land off center to gear down side.
6. Minimum rate of descent landing (480 fpm max).
7. Gradual symmetrical braking.
8. Retain empty drop tanks.
9. Lower nose gently prior to fall through.
10. Secure engines at airframe contact.
11. External ordnance — SEL JETT if required. Activate emerg landing gear lowering to enable raising gear handle for SEL or ACM JETT.
12. Hold damaged gear off deck until pendant engagement.
13. Engage NWS if operable, use as required.

Figure 15-1. Landing Gear Malfunction Emergency Landing Guide

Note

- The nosegear cannot be confirmed as locked by visual observation. If both the indicator and transition light indicate unsafe, assume that the downlock is not in place.
- If there is disagreement between the indicator and light and the gear appears down, the malfunction may be caused by a faulty contact on the nosegear downlock microswitch.
- Use of emergency gear extension results in loss of nosewheel steering.
- To facilitate in-flight refueling probe extension when the gear has been blown down, raise the LDG GEAR handle to give priority to the refueling probe system.

If any gear does not come down:

6. Increase airspeed. Do not exceed 280 KIAS.

7. Apply positive and negative g to force gear down.

8. Obtain visual in-flight check if possible.

If still unsafe and visually confirmed unsafe, or gear position cannot be confirmed:

9. Refer to Landing Gear Malfunction Emergency Landing Guide, Figure 15-1.

15.4.2 Landing Gear Malfunctions

1. Remain below 280 KIAS.

2. Combined hydraulic pressure — Check.

3. If less than 3,000 psi, refer to combined hydraulic failure procedures.

15.4.2.1 Landing Gear Indicates Unsafe Gear Up or Transition Light Illuminated

1. LDG GEAR handle — Down.

If safe gear down indication is obtained and transition light is out:

2. Landing gear — Leave Down.

3. Obtain visual check of gear condition.

WARNING

A hyperextended main strut, whether because of a broken piston or overextended piston barrel and/or main strut with a cocked wheel, will likely result in a combined hydraulic system failure while airborne and a sheared strut upon touchdown. A hyperextended main strut is evident to a wingman by full vertical extension of the scissors and broken brake lines; to the tower or LSO by one main gear hanging noticeably lower than the other. When either of these situations occurs, landing procedures for a stub (MLG) mount must be followed.

4. Land as soon as practicable.

CAUTION

If landing gear indicates unsafe after retraction and a down-and-locked indication can be obtained, the brake pedals should be depressed for 60 seconds to ascertain whether brake hydraulic lines are severed and a combined hydraulic failure occurs, refer to combined hydraulic system failure procedures (Chapter 14).

15.4.2.2 Landing Gear Indicates Unsafe Gear Down, Transition Light Out.

This indication means a failure in one of the dual-pole downlock microswitches.

1. Transition light bulb — Check (LTS TEST).

CAUTION

If associated with launch bar light, leave gear down and obtain visual check.

2. Landing gear — Cycle.

If condition still exists:

3. Obtain visual check if possible.

4. Make normal landing.

15.4.2.3 Landing Gear Indicates Unsafe, Gear Down, Transition Light Illuminated. Nosegear By unsafe indicates that the downlock pin through the drag brace is not in place. Visual determination of nosegear unlocked status is assisted by a red band painted on the landing nosegear brace oleo. However, a positive check for locked nosegear is not possible visually. Main gear unsafe should be verified by visual inspection. If the drag brace is fully extended, the main gear should be down and locked.

1. Obtain visual check if possible.

CAUTION

- Visual determination of nose landing gear unlocked status is assisted by a red band painted on the nose landing gear drag brace oleo. If red is visible, the nosegear is not locked.
- During an airborne visual inspection of the main landing gear (even if the paint stripe across the drag brace knee pin appears to be straight), the possibility exists that the downlock actuator has failed and the gear may not be locked in the down position.

2. LDG GEAR handle — Cycle.

If still unsafe:

3. Increase airspeed to 280 KIAS, pull positive g's and yaw aircraft.

If main landing gear still unsafe, go to step 5.

If nose landing gear indicates unsafe, transition light illuminated, continue with step 4:

4. LDG GEAR handle — Cycle UP Then DOWN in Less Than 2 Seconds.

WARNING

Failure to place the landing gear handle to DN immediately after selecting UP may allow the main landing gear doors to receive the signal to close with main gear struts extended, causing damage to the doors and inducing a possible combined hydraulic or brake system failure. Do not reselect UP with the landing gear handle after the doors attempt to close, as indicated by an unsafe main mount or visual inspection.

Note

Use of the above procedure should be done at the intended point of landing or within range of an acceptable divert field exercising a gear-down bingo profile.

5. LDG GEAR handle — EMERG DN (refer to landing gear emergency lowering).

Note

Use of the emergency gear lowering procedure will result in loss of nosewheel steering.

If still unsafe and visually confirmed unsafe or gear position cannot be confirmed:

6. Refer to landing gear malfunctions emergency landing guide (Figure 15-1).

CAUTION

- When landing with nosegear unsafe-down indication, anticipate possible nose landing gear collapse.
- Do not attempt to tow aircraft by nosegear until gear is secured in down position.
- Nose landing gear ground safety pin installation will not prevent nosegear collapse. The nose landing gear strut must be restrained against forward rotation.

15.4.2.4 Landing Gear Indicates Safe Gear Down, Transition Light Illuminated. This indication can be caused by a malfunction of the following:

- Half of the dual-pole micro in the nose-gear downlock.
- Half of the dual-pole micros in either of the main gear downlocks.
- The proximity micros in the side braces.
- Failure of the LDG GEAR handle position micro.
- If a visual check confirms the gear extended and both side braces in place, a malfunction of one of the transition light micros is indicated.

CAUTION

If associated with launch bar light, leave gear down and obtain visual check.

1. LDG GEAR handle — Cycle.

If transition light remains on:

2. Obtain visual check.
3. Gear/side braces appear in place — Normal Landing.

Side braces are confirmed not in place:

4. Refer to Figure 15-1.

15.4.3 Launch Bar Light

1. Landing gear — Leave Down.
2. Obtain visual inspection.

If nose gear is cocked, see Figure 15-1.

If launch bar is down and visual inspection is not available:

3. Remove arresting cables for field landing.
4. Remove crossdeck pendant Nos. 1 and 4 for CV landing.

15.5 BLOWN-TIRE LANDING

Blown-tire landings should be performed into arresting gear whenever possible. Rollout is extremely rough on blown tires. Do not apply full aft stick in attempt to rotate the aircraft before reaching flying speed. The drag from full-up deflection of the stabilizers is large and significantly delays acceleration. Blown-tire landings will frequently result in damaged main landing gear hydraulic lines. Anticipate possible combined hydraulic system failure and attendant committal to gear-down bingo following blown tire.

CAUTION

- Engine should not be secured until crash crew is in position to extinguish a possible fire from drain fuel contacting hot wheel assembly.
- Blown tire(s) can cause engine FOD and/or structural damage. Leave flaps and slats as set. Aircraft should have ground locks installed and engines secured before moving aircraft.
- Do not allow the aircraft to roll backward after the arrestment. The downlock actuator may have been damaged by tire failure and rearward movement of the aircraft could cause the gear to collapse.

1. Obtain in-flight visual check if possible.
2. ANTI SKID SPOILER BK switch — SPOILER BK (OFF for CV).
3. HOOK — DN.
4. Make carrier or short-field fly-in, arrested landing as soon as practicable.
5. HYD ISOLATE switch — T.O./LAND (on final).

If arresting gear is not available:

6. Land on centerline.
7. Nosewheel steering — ENGAGED.

CAUTION

Do not delay engaging nosewheel steering in order to center rudder pedals.

Note

Antiskid will sense a constant release on a dragging blown tire.

15.6 FLAP AND SLAT LANDING EMERGENCIES

15.6.1 No Flaps and No Slats Landing. A no-flaps and no-slats landing is basically the same as a normal landing except that the pattern is extended and the approach speed is slightly higher than normal. Field arresting gear should be used if necessary. CV arrestments are permitted. Consult applicable recovery bulletins for WOD requirements.

CAUTION

Aircrew should expect hot brakes following high speed landings. Application of the parking brake could cause the brake assembly to fail and result in a brake fire.

1. Gross weight — Reduce (weight consistent with existing runway length and conditions).
2. Flaps — UP.

Note

If outboard spoilers are needed for groundroll braking, FLAP handle must be set to DN.

3. Fly landing pattern slightly wider than normal or make straight-in approach at 15 units AOA.

CAUTION

Maximum airspeed for wheelbrake application is 165 KIAS at a gross weight of 46,000 pounds and 145 KIAS at 51,000 pounds.

4. Use normal braking technique.

CAUTION

- Use of full aft stick during landing in this configuration can result in tailpipe ground contact.
- Avoid slow approaches. Wing drop and increased sink rate may occur at 16.5 to 17.5 units AOA.

15.6.2 Auxiliary Flap Failure. A no-auxiliary-flaps landing is basically the same as a normal landing except that the approach speed is slightly higher than normal and the longitudinal stick position during the approach is more aft than normal. CV arrestments are permitted; consult applicable recovery bulletin for WOD requirements.

1. Wing sweep — Ensure at 20°.
2. AUX FLAP/FLAP CONTR cb (7G3) — Pull.
3. Approach — 15 Units AOA.

Note

With AUX FLAP/FLAP CONTR cb (7G3) pulled, wings will not sweep aft.

15.7 WING-SWEEP EMERGENCIES

15.7.1 Aft Wing-Sweep Landings. CV arrestments are permitted with up to 40° of wing sweep; emergency barricade engagements are permitted with up to 35° of wing sweep. Shipboard aft wing-sweep landings should be conducted at 15 units AOA. Field aft wingsweep landings may be conducted at AOAs up to 17 units when wings are stuck aft of 50° to minimize approach airspeed for normal landings or to remain within published field arresting gear limitations for short-field arrested landings. Main flaps and slats should be utilized to reduce approach speed with aft wing sweeps up to 50°. Maneuver flaps maybe utilized if main flaps and slats fail to extend. If wings are determined to be stuck aft of 20° position:

1. Emergency WING SWEEP handle — Match Captain Bars With Actual Wing Sweep Position Tape.

CAUTION

Closely monitor wing sweep movement when attempting to match handle with wing sweep position. If abnormal movement is noticed, immediately return handle to previous position.

2. Gross weight — Reduce as Required.

If wings equal or less than 50°;

3. Main flaps — Full Down.

Note

Main flap/slat extension with the wings aft of 20° will result in a large nosedown pitch transient.

If main flaps fail to extend:

4. Maneuvering flaps — Extend.

WARNING

If maneuvering flaps are used, ensure that maneuver flap thumbwheel is not actuated during the approach.

5. DLC and APC — Do Not Engage.

6. Slow-fly aircraft at a safe altitude to determine approach airspeed (up to 17 units AOA for field landings with wings aft to 50°) and to evaluate handling/stall characteristics and waveoff performance.

Note

- Refer to Emergency Field Arrestment Guide for maximum engagement speed if field arrestment is desired.
- Refer to landing approach airspeed table (Figure 11-9) for approach speed.

7. Fly straight-in approach at 15 units AOA (up to 17 units for field landings with wings aft of 50°).

CAUTION

Ventral fin clearance is reduced at elevated approach AOA. Ensure that a maximum of 17 units is maintained at touchdown.

Note

Maximum airspeed for wheelbrake application is 165 KIAS at gross weight of 46,000 pounds and 145 KIAS at 51,000 pounds.

15.7.2 Asymmetric Wing Sweep. Refer to Chapter 11 for asymmetric wing-sweep design limitations and flight characteristics.

With asymmetric wing-sweep emergency condition, divert field landing is preferable to CV landing attempt. Aircrew must fully consider approach speed and aircraft controllability characteristics prior to attempting CV arrestment. See Figure 15-2 for recommended approach airspeed for 14 or 15 units AOA with asymmetric wing configurations.

CAUTION

To preclude potential damage to aircraft, avoid all wing-sweep commands prior to performing steps 1 through 9. Limit maneuvering envelope to 350 KIAS and 1.5g's.

1. Leave wings and flaps as set.
2. Altitude — Climb/Remain Above 10,000 Feet AGL.
3. Airspeed — 250 Knots/Do Not Exceed 12 Units AOA.
4. Maneuver devices — Thumbwheel Manual Retract.
5. WING SWEEP DRIVE NO. 1 (LE1) and WG SWP DR. NO. 2/MANUV FLAP (LE2) cbs — Pull.
6. ALPHA COMP/PEDAL SHAKER cb (7C8) — Pull.
7. All SASs — On.

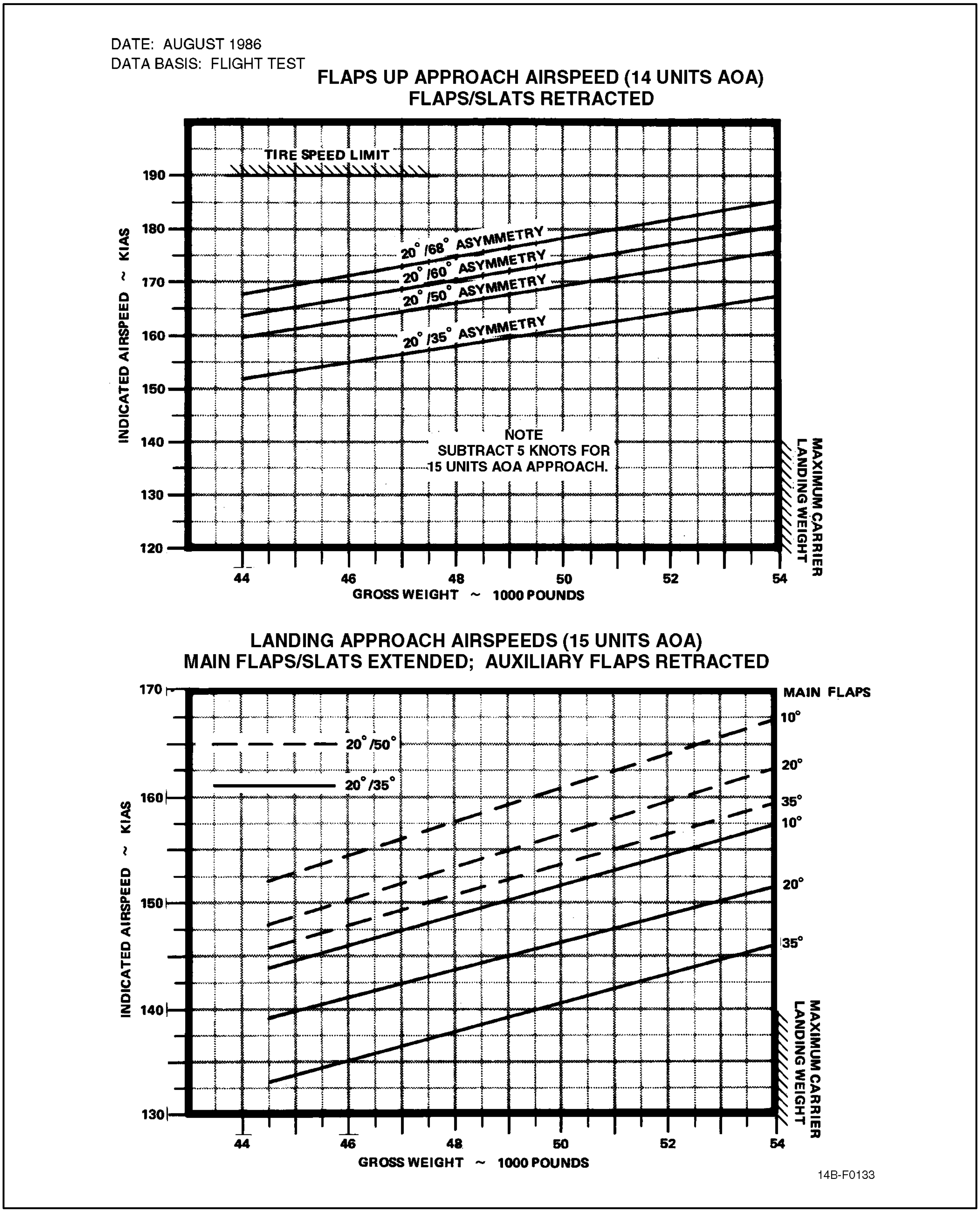


Figure 15-2. Asymmetric Wing-Sweep Landing Approach Airspeed

Note

If roll SAS will not engage, accelerate and attempt to reset at 20-knot intervals. Stick may have to be released laterally in order to engage roll SAS.

8. Confirm left and right wing positions.

Note

Wing-sweep tape indicates actual rightwing position. All other cockpit wing position indications may be unreliable, including WING SWEEP handle position. Visually verify left-wing position.

If left wing is aft of 62° spoiler cutout and right wing is at 20°, perform Asymmetric Wing Sweep Unacceptable for Landing procedure, paragraph 15.7.2.2.

9. Perform preliminary controllability check as follows:

   a. Trim away from forward wing (opposite stick force) to ensure that maximum spoiler deflection is available.

   b. Assess spoiler function by controlled left- and right-stick inputs.

WARNING

Aircraft controllability in approach configuration with spoilers inoperative and a large wing-sweep asymmetry will range from difficult to impossible depending on split.

   c. Landing Gear — Down.

   d. Leave flaps as set until further determinations are complete.

   e. Increase AOA to more than 15 units (attempt to maintain 0° sideslip).

   f. Make small lateral stick inputs to simulate line-up corrections.

If aircraft controllability is questionable for safe landing, perform Asymmetric Wing Sweep Unacceptable for Landing procedure, paragraph 15.7.2.2.

If aircraft controllability is safe for landing, perform Asymmetric Wing Sweep Acceptable for Landing procedure, paragraph 15.7.2.1.

15.7.2.1 Asymmetric Wing Sweep Acceptable for Landing. Establish final landing configuration as follows:

1. AUX FLAP/FLAP CONTR cb (7G3) — Pull.

Note

Pulling the AUX FLAP/FLAP CONTR cb (7G3) with the emergency WING SWEEP handle at the 20° position disables wing-sweep commands.

If both wings are forward of 50°:

   a. Airspeed — Below 225 KIAS.

CAUTION

Extending the main flaps with either wing aft of 50° could result in damage to both the flaps and the aft fuselage.

   b. Flaps — Lower incrementally to 20° to 25°.

CAUTION

When flaps are set to greater than 25°, lateral pilot-induced oscillations are likely and may result in wingtip damage at touchdown and/or hard landings.

Note

The 25° flap position can established by first noting when the spoiler position indicators switch to the dropped position during flap extension. An uncommanded, but controllable, roll transient caused by spoiler gearing change will also occur. Upon observing either event, retract the flaps to just less than 25°. The roll transient will occur in the opposite direction as the flaps pass through 25°. Main flap extension without auxiliary flaps will require greater than normal aft stick trim.

c. Approach airspeed — 15 Units AOA.

Note

Indicated AOA is subject to a 1- to 2-unit sideslip-induced error. Verify proper AOA at zero sideslip.

If either wing is aft of 50°:

d. Flaps — UP.

e. Approach airspeed — 14 units AOA.

CAUTION

Wing rock and wing stall may occur at 16 to 16-1/2 units AOA during flaps-up approaches. Rapid lateral stick inputs will result in pitch coupling. Excessive descent rates may develop and/or wingtip damage at touchdown may occur. Precise AOA control and smooth lateral control inputs are required.

Note

Indicated AOA is subject to a 1- to 2-unit sideslip-induced error. Verify proper AOA at zero sideslip.

2. Emergency WINGSWEEP handle — Leave in Position That Established Satisfactory Controllability.

3. Gross weight — Reduce as Required.

4. DLC — Stowed.

5. Autothrottles (APC) — Do Not Engage.

6. Confirm flight characteristics by flying a simulated landing approach at safe altitude to include lineup corrections, power changes, and waveoff.

CAUTION

Full spoiler authority will be required for landing with large wing-sweep asymmetry. Before attempting actual approach, trim away from the forward wing (opposite stick forces) to ensure that maximum spoiler deflection is available.

7. Fly straight-in approach to arrested or normal landing.

CAUTION

Avoid rapid lateral stick inputs as significant pitch-roll coupling may result in roll ratcheting, pitching motion, and lateral PIO tendency; an excessive descent rate may develop, and/or wingtip damage at touchdown may occur.

Note

- Maximum airspeed for wheelbrake application is 165 KIAS at gross weight of 46,000 pounds and 145 KIAS at 51,000 pounds.

- A crosswind from the swept-wing side is favorable while a crosswind from the forwardwing side is unfavorable.

- To reduce lateral stick force, the landing approach can be flown with rudder trim into the forward wing, allowing aircraft to yaw into the forward wing. Sideslip should be reduced with rudder just prior to touchdown.

- If desired, sideslip can be reduced to zero with rudder at the beginning of the approach and held to touchdown. Lateral stick force increases as sideslip is reduced. Method of approach is at pilot's option.

- In event of bolter or go-around, as airspeed increases, the aircraft will roll toward the swept wing and yaw toward the forward wing.

15.7.2.2 Asymmetric Wing Sweep Unacceptable for Landing

WARNING

Efforts to improve controllability by attempting to minimize or eliminate wing-sweep mismatch could result in an acceptable condition becoming unacceptable.

Note

Once spoiler operation is assessed, stick forces may be trimmed to reduce pilot workload during transit to field or CV. The use of lateral trim to reduce stick forces during actual approach and landing should be avoided as this reduces the spoiler deflection available for roll control.

1. Flaps — UP.

2. AUX FLAP/FLAP CONTR cb (7G3) — In.

Note

- At any point during the following procedures, if wing-sweep symmetry is regained at aft wing-sweep position and runway length/approach speed permit, aircrew may elect to perform Aft Wing Sweep Landing emergency procedure, paragraph 15.7.1.

- If left wing is jammed, wing-sweep command can result in right wing driving to either 19° (forward command) or 69° (aft command) actuator overtravel stop. Subsequent wing-sweep commands may not move the right wing.

If spoilers are operational:

a. Emergency WING SWEEP handle — Input a Small Forward Command.

If spoilers are not operational:

a. Emergency WING SWEEP handle — Input a Small Aft Command.

3. Note movement of left and right wings and attempt to regain wing-sweep asymmetry by using the following wing-sweep commands.

If both wings are movable and left wing is forward of right wing:

a. Airspeed — 300 KIAS.

b. Emergency WING SWEEP handle — 68°.

c. Emergency WING SWEEP handle — 20°.

d. AUX FLAP/FLAP CONTR cb (7G3) — Pull.

e. Repeat preliminary landing controllability check (step 9 of paragraph 15.7.2)

If both wings are movable and right wing is forward of left wing:

a. Emergency WING SWEEP handle — 20°.

b. AUX FLAP/FLAP CONTR cb (7G3) — Pull.

c. Repeat preliminary landing controllability check (step 9 of paragraph 15.7.2)

If right wing is jammed and left wing is movable:

a. Airspeed — 300 KIAS.

Note

If right wing is jammed aft of spoiler cutout angle, matching left wing will result in loss of spoiler control. If this reduced lateral control is undesirable, left wing should be commanded to just forward of spoiler cutout to regain spoiler control. If this reduce lateral control is undesirable, left wing should be commanded to just forward of spoiler cutout to regain spoiler control.

b. Emergency WING SWEEP handle — Match Left Wing to Right-Wing Position.

c. AUX FLAP/FLAP CONTR cb (7G3) — Pull.

d. Repeat preliminary landing controllability check (step 9 of paragraph 15.7.2)

If left wing is jammed and spoilers are operational:

a. Emergency WING SWEEP handle — 20°.

b. AUX FLAP/FLAP CONTR cb (7G3) — Pull.

c. Repeat preliminary landing controllability check (step 9 of paragraph 15.7.2)

If left wing is jammed aft of spoiler cutout wing-sweep angle and spoilers inoperative:

a. Airspeed — 300 KIAS.

b. Emergency WING SWEEP handle — 68°.

c. AUX FLAP/FLAP CONTR cb (7G3) — Pull.

d. Repeat preliminary landing controllability check (step 9 of paragraph 15.7.2)

If final wing configuration is unsafe for landing:

a. Prepare for and execute controlled ejection.

15.8 AFT HUNG-ORDNANCE LANDINGS

The normal NATOPS cg zero fuel gross weight limit for tunnel-mounted stores is 17.0 percent. On a typical fleet aircraft, one Mk 84 2,000-pound bomb placed on station No. 4 or 5 results in a ZFGW cg aft of 17.0-percent MAC, possibly as far aft as 18.5- to 19.0-percent MAC. Two aft hung Mk 84s can produce a ZFGW cg of up to 22-percent MAC. These aft cg locations reduce the normal static stability of the F-14, producing a marked degradation in landing flying qualities. Aft wing sweep can be used to restore the normal static longitudinal stability margin, regaining normal flying qualities even with extremely aft cg locations.

Aircrew may have difficulty detecting aft hung ordnance following bomb release. The only cockpit indication of an unsuccessful release will be a hot trigger light that remains illuminated following the intended release of all selected stations. With MASTER ARM on, individually selecting stations will illuminate the hot trigger light when the hung station is selected. Obtain a visual check if possible to validate this check as failures of the stores-aboard switch regularly occurred during flight test and will indicate hung stores when none actually exist.

In-flight actual cg location varies as fuel is burned but remains relatively constant at its most-forward position between 5,000 to 10,000 pounds. Below 5,000 pounds, the cg moves aft toward the ZFGW position. Landing should be accomplished at 5,000 pounds of fuel or more if possible. Wing-mounted AIM-7/9s move the cg location slightly forward and have no adverse effects on flying qualities. External tanks produce no change to the cg location and also have no adverse effects. Combinations of forward and aft stores will produce a cg change slightly less than considering the difference as hung on the aft stations alone (i.e., the cg location with 2,000 pounds forward and 4,000 pounds all will be slightly more forward than 2,000 pounds all alone).

Flying qualities at aft cg locations with gear and flaps up are only slightly degraded. This degradation will probably not be apparent to the pilot. Stick force per g remains relatively nominal even with 4,000 pounds of aft hung bombs. No change in flying qualities is noted during dive recoveries between 400 and 500 KIAS. At 20° of wing sweep with the gear and flaps down and an aft cg, the aircraft is extremely susceptible to pilot-induced oscillations during closely controlled tasks such as flying the ball. Loss of control is likely.

The transition to landing configuration should be performed in straight-and-level flight to allow handling qualities to be evaluated in benign conditions. Wings should be swept to the desired position before the gear and flaps are lowered. The AUX FLAP/FLAP CONTR (7G3) cb should be pulled in case of a wing/flap interlock failure and also to prevent the auxiliary flaps from deploying if 20° of wing sweep is inadvertently selected. Sweeping the wings with auxiliary flaps retracted results in significant pitch trim changes. A straight-in approach should be flown as power requirements with aft wing sweep in a turn are significantly different than normal and could produce a severely underpowered approach. Once established in the optimum wing-sweep configuration appropriate for the amount of ordnance hung on the aft stations, normal approach techniques can be used. No abnormalities in aircraft response or performance are apparent during landing approaches at 15 units, even with 4,000 pounds of all hung ordnance. APC is not optimized for aft wingsweep landings and should not be used. DLC should not be used as it adds 8 knots to recovery WOD requirements and has improper pitch trim response at aft wing sweep. Expect onspeed airspeed for 25° of wing-sweep to increase 6 knots over the normal DLC on

20° of wing-sweep approach speed, and a 12-knot increase if wings are at 30°. For CV arrestments, the appropriate recovery bulletin should be consulted. Ashore, with greater than 2,000 pounds of aft hung ordnance, a field arrestment is recommended with spoiler brakes dearmed because of the large noseup pitch occurring at spoiler deployment. If a field arrestment is not possible, expect to use full forward stick to counter the noseup pitching moment and to maintain forward stick until below 80 KIAS with a resultant longer rollout.

15.8.1 Landing With Aft Hung Ordnance

1. Determine location of hung stores. Obtain visual check if possible.

If aft hung ordnance exceeds 1,000 pounds:

2. Wing sweep — Set At 25° for 1,000 to 2,000, Pounds Hung Aft; Set at 30° if > 2,000 Pounds Hung Aft.
3. Perform transition to gear-down configuration in straight-and-level flight.
4. AUX FLAP/FLAP CONTR (7G3) cb — Pull.
5. Flaps — Full DN.
6. Fly straight-in approach at 15 units AOA. Do not engage APC or DLC.

CV approach:

7. Perform CV arrestment in accordance with applicable recovery bulletin.

Field Approach:

8. Spoiler brake — OFF.
9. Perform field arrestment.

Note

Refer to Figure 15-3 for maximum engagement speed.

If arresting gear is not available:

10. If field arrestment is not available, spoiler brake — BOTH.

WARNING

Expect a significant nose pitchup during landing rollout as spoilers deploy. Full forward stick may be required to avoid a tail strike.

15.9 FIELD ARRESTMENTS

15.9.1 Field Arresting Gear. The types of field arresting gear in use include the anchor chain cable, water squeezer, and Morest-type equipment. All require engagement of the arresting hook in a cable pendant rigged across the runway. Location of the pendant in relation to the runway will classify the gear as follows:

1. Shortfield gear — Located 1,500 to 2,000 feet past approach end of runway. Usually requires prior notification in order to rig for arrestment.
2. Midfield gear — Located near the halfway point of the runway. Usually requires prior notification in order to rig for arrestment in the direction desired.
3. Abort gear — Located 1,500 to 2,500 feet short of the upwind end of the duty runway and usually rigged for immediate use.
4. Overrun gear — Located shortly past the upwind end of the duty runway. Usually rigged for immediate use.

Some fields will have all types of gear, others none. For this reason, it is imperative that all pilots be aware of the type, location, and compatibility of gear in use with the aircraft and the policy of the local air station with regard to which gear is rigged for use and when.

As various modifications to the basic types of arresting gear are made, exact speeds will vary accordingly. Certain aircraft service changes may also affect engaging speed and weight limitations.

CAUTION

An engagement in the wrong direction into chain gear can severely damage the aircraft.

EMERGENCY FIELD ARRESTMENT DATA F-14B

TYPE OF ARRESTING GEAR	MAXIMUM ENGAGING SPEED (KNOTS) (d)											MAXIMUM OFF-CENTER ENGAGEMENT (FT)
	GROSS WEIGHT X 1,000 POUNDS											
	SHORT-FIELD LANDING (j) (k)					LONG-FIELD LANDING (l)		ABORTED TAKEOFF (a)				
	40	44	48	51.8	54	57	60	64	68	69.8	72	
E-28	176 (b)	180	179	178	177	176	175	174	172	172	171	40
E-28 (g)	176 (b)	176	160	160	160	160	156	145	145	145	145	40
M-21	130	130	130	130	125	125	120	115	115	115	113	10
BAK-9	160	160	160	155	150	144	138	131	124	122	118	30
BAK-12 (h)	160	160	159	146	137	118	(i)	(i)	(i)	(i)	(i)	50
DUAL BAK-12 (c)	160	160	160	160	160	160	160	160	160	160	160	30
BAK-13	160	160	160	160	160	160	160	160	160	160	160	40

NOTES:

a. Data provided in aborted takeoff column may be used for emergency high gross weight arrestment.

b. Maximum engaging speed limited by aircraft limit horizontal-drag load factor (mass item limit “G”).

c. Dual BAK-12 limits are based on 150 to 300 foot span, 1-1/4 inch cross deck pendant, 50,000 pound weight setting, and 1,200 foot runout. No information available regarding applicability to other configurations.

d. Maximum engaging speed limited by arresting gear capacity, except as noted.

e. Off-center engagement may not exceed 25 percent of the runway span.

f. Before making an arrestment, the pilot must check with the air station to confirm the maximum engaging speed because of a possible installation with less than minimum required rated chain length.

g. Only for the E-28 systems at Keflavik and Bermuda with 920 foot tapes.

h. Standard BAK-12 limits are based on 150 foot span, 1 inch crossdeck pendant, 40,000 pound weight setting, and 950 foot runout. No information available regarding applicability to other configurations.

i. Engaging speed limit is 96 knots at 59,000 pounds. Due to runout limitations it is recommended this gear not be engaged at weights greater than 59,000 pounds.

j. Maximum of 3.0° glideslope.

k. Consult appropriate section for recommended approach speed.

l. Flared or minimum rate of descent landing.

Figure 15-3. Emergency Field Arrestment Guide (Sheet 1 of 2)

AIRCRAFT ENGAGING SPEED LIMITS
FOR E-5 EMERGENCY ARRESTING GEAR

AIRCRAFT: F-14B

ARRESTING GEAR RATING	SHORT FIELD LANDING UP TO 54,000 POUNDS				LONG FIELD LANDING UP TO 60,000 POUNDS				ABORTED TAKEOFF 60,100 TO 72 000 POUNDS			
	STANDARD CHAIN		HEAVY CHAIN		STANDARD CHAIN		HEAVY CHAIN		STANDARD CHAIN		HEAVY CHAIN	
	E-5 E-5-2	E-5-1 E-5-3	E-5 E-5-2	E-5-1 E-5-3	E-5 E-5-2	E-5-1 E-5-3	E-5 E-5-2	E-5-1 E-5-3	E-5 E-5-2	E-5-1 E-5-3	E-5 E-5-2	E-5-1 E-5-3
COL. 1	COL. 2	COL. 3	COL. 4	COL. 5	COL. 6	COL. 7	COL. 8	COL. 9	COL. 10	COL. 11	COL. 12	COL. 13
300 to 349	39(D)	39(D)	40(D)	40(D)	37(D)	37(D)	38(D)	38(D)	33(D)	33(D)	34(D)	34(D)
350 to 399	45(D)	45(D)	47(D)	47(D)	43(D)	43(D)	44(D)	44(D)	39(D)	39(D)	40(D)	40(D)
400 to 449	51(D)	51(D)	54(D)	54(D)	48(D)	48(D)	51(D)	51(D)	44(D)	44(D)	47(D)	47(D)
450 to 499	57(D)	57(D)	61(D)	61(D)	54(D)	54(D)	58(D)	58(D)	49(D)	49(D)	53(D)	53(D)
500 to 549	63(D)	63(D)	68(D)	68(D)	60(D)	60(D)	65(D)	65(D)	55(D)	55(D)	59(D)	59(D)
550 to 599	69(D)	69(D)	76(D)	76(D)	65(D)	65(D)	72(D)	72(D)	60(D)	60(D)	66(D)	66(D)
600 to 649	75(D)	75(D)	84(D)	84(D)	71(D)	71(D)	79(D)	79(D)	65(D)	65(D)	73(D)	73(D)
650 to 699	81(D)	81(D)	91(D)	91(D)	77(D)	77(D)	87(D)	87(D)	71(D)	71(D)	79(D)	79(D)
700 to 749	87(D)	87(D)	99(D)	99(D)	83(D)	83(D)	94(D)	94(D)	76(D)	76(D)	86(D)	86(D)
750 to 799	93(D)	93(D)	107(D)	107(D)	89(D)	89(D)	102(D)	102(D)	82(D)	82(D)	93(D)	93(D)
800 to 849	99(D)	99(D)	115(D)	115(D)	94(D)	94(D)	109(D)	109(D)	87(D)	87(D)	100(D)	100(D)
850 to 899	105(D)	105(D)	123(D)	123(D)	100(D)	12(D)	117(D)	117(D)	93(D)	93(D)	107(D)	107(D)
900 to 949	111(D)	111(D)	131(D)	131(D)	106(D)	106(D)	125(D)	125(D)	98(D)	98(D)	114(D)	114(D)
950 to 999	117(D)	117(D)	140(D)	140(D)	112(D)	112(D)	133(D)	133(D)	104(D)	104(D)	121(D)	121(D)
1,000 to 1,049	123(D)	123(D)	148(D)	148(D)	118(D)	118(D)	140(D)	140(D)	109(D)	109(D)	129(D)	129(D)
1,050 to 1,099	129(D)	129(D)	150(D)	156(D)	123(D)	123(D)	148(D)	148(D)	115(D)	115(D)	136(D)	136(D)
1,100	135(D)	135(D)	150(D)	165(D)	129(D)	129(D)	150(D)	156(D)	120(D)	120(D)	143(D)	143(D)

Figure 15-3. Emergency Field Arrestment Guide (Sheet 2)

In general, arresting gear is engaged on the centerline at as slow a speed as possible. Burn or dump down to an acceptable landing weight. While burning down, make practice passes to accurately locate the arresting gear. Engagement should be made with feet off the brakes, shoulder harness locked, and with the aircraft in a three-point attitude. After engaging the gear, good common sense and existing conditions dictate whether to keep the engines running or to shut down and abandon the aircraft.

In an emergency situation, first determine the extent of the emergency by whatever means are available (instruments, other aircraft, LSO, RDO, tower, or other ground personnel). Next, determine the most advantageous arresting gear available and the type of arrestment to be made under the conditions. Whenever deliberate field arrestment is intended, notify control tower personnel as much in advance as possible and state estimated landing time in minutes.

If gear is not rigged, it will probably require 10 to 20 minutes to prepare. If foaming of the runway or area of arrestment is required or desired, it should be requested by the pilot at this time.

If fuel is streaming from the bottom of the aircraft, a field-arrested landing is not recommended because of the high probability of sparks and heat from the arresting hook igniting the streaming fuel and air mixture. If an arrested landing is mandated because of the lack of adequate braking or runway conditions, an effort should be made to foam the runway in the runout area of the arresting gear.

15.9.2 Short-Field Arrestment. If at any time before landing a directional control problem exists or a minimum rollout is desired, a short-field arrestment should be made and the assistance of an LSO requested. He should be stationed near the touchdown point and equipped with a radio. Inform the LSO of the desired touchdown point. A constant glideslope approach to touchdown is permitted (mirror or Fresnel lens landing aid) with touchdown on centerline at or just before the arresting wire with the hook extended. The hook should be lowered while airborne and a positive hook-down check should be made. Use midfield gear or Morest-type, whenever available. If neither is available, use abort gear. Use an approach speed commensurate with the emergency experienced. Landing approach power will be maintained until arrestment is assured or a waveoff is taken. Be prepared for a waveoff if the gear is missed. After engaging the gear, retard the throttles to IDLE or secure engines and abandon aircraft, depending on existing conditions.

15.9.3 Long-Field Arrestment. The long-field arrestment is used when a stopping problem exists with insufficient runway remaining (e.g., aborted takeoffs, icy or wet runways, loss of brakes after touchdown, etc.). Lower the hook, allowing sufficient time for it to extend fully before engagement (normally 1,000 feet before reaching the arresting gear). Do not lower the hook too early and weaken the hook point. Line up the aircraft on the runway centerline. Inform the control tower of your intentions to engage the arresting gear, so that aircraft landing behind you may be waved off. If leaving the runway is inevitable, secure the engines.

15.9.4 Engaging Speeds. The maximum permissible engaging speed, gross weight, and off-center engagement distance for field arrestment are listed in Figure 15-3. The data in the long-field landing columns may be used for lightweight aborted takeoff where applicable; data in the aborted takeoff columns may be used for heavy gross-weight landings.

As various modifications to the basic types of arresting gear are incorporated, engaging speeds or gross-weight limitations may change. For this reason and for more detailed information, the applicable aircraft recovery bulletin should be consulted.

15.10 BARRICADE ARRESTMENT

1. External stores — Jettison (except AIM-7 or AIM-54 on fuselage stations if wing is at full forward sweep).
2. External tanks — Jettison (empty tanks retained only for landing gear malfunction).
3. Fuel — Dump or Burn (reduce to 2,000 pounds).
4. HOOK — DN (lower to permit engagement of across-deck pendant, which will minimize barricade engagement speed and damage to aircraft).
5. Fly normal pattern and approach, on-speed, angle of attack, centerline, and meatball.

Note

Anticipate loss of meatball for a short period of time during the approach. Barricade stanchions may obscure the meatball.

Upon engaging the barricade:

6. Throttles — OFF.
7. Evacuate aircraft as soon as practicable.

WARNING

Weight limits for barricade engagement are:

a. Wing sweep 20° — 51,800 pounds (maximum).

b. Wing sweep >20° to <35° — 46,000 pounds (maximum).

c. Wing sweep >35° — Not permitted.

15.11 ARRESTING HOOK EMERGENCY DOWN

1. HOOK handle — DN.
2. HOOK handle — Pull, Then Rotate.

Note

Pull handle aft approximately 4 inches and turn counterclockwise. This will mechanically release the uplatch mechanism and allow hook to extend.

3. Hook transition light — Check OFF.

If light illuminated and hook visually checked up:

4. HOOK handle — Restow In Down Position.

5. HYD VALVE CONTR cb (7E5) — Pull and Reset After 5 Seconds.

If light illuminated and hook visually checked down:

4. WSHLD AIR/ANTI-ICE HOOK CONT cb (7C2) — Pull.

Note

Cb 7C2 also controls windshield air and anti-ice.

15.12 FORCED LANDING

Landing the aircraft on unprepared surfaces is not recommended. If it is necessary to do so, landing with the landing gear down, regardless of the terrain, will assist in absorbing the shock of ground impact and reduce possibility of flightcrew injuries. External stores should be jettisoned in a safe area prior to touchdown. External tanks should be jettisoned if they contain fuel, but retained to absorb landing shock if they are empty. If time permits, dump fuel to allow touchdown at the slowest possible speed with full flaps.

15.13 GROUND ROLL BRAKING FAILURE

*1. ANTISKID SPOLIER BK switch — Check.

*2. MASTER RESET pushbutton — Depress

CAUTION

For DFCS, ground roll braking may fail to extend spoilers on touchdown due to a momentary miscompare of the weight-on-wheels switches. MASTER RESET should restore normal ground roll braking operation.

CHAPTER 16

Ejection and Bailout

16.1 EJECTION

Responsibility for the decision to eject shall be determined and briefed before flight. Thereafter the decision to abandon the aircraft shall rest with the crewmember assigned responsibility for that particular situation. The decision should be made before sink rate and altitude conditions jeopardize safe ejections for both occupants. The aircraft should be abandoned by means of the ejection seats, and manual bailout should be attempted only as a last resort. Prior to ejection from a flyable or controllable aircraft, it is the pilot's responsibility to do everything reasonable to ensure that the abandoned aircraft will inflict the least possible damage on impact.

Ejection may be necessary as a result of fire, engine failure, structural failure, midair collision, or when the aircraft becomes uncontrollable. In each case, the pilot must decide when to eject, using the following as a guide:

1. Ejection is mandatory under following conditions:

   a. Serious, uncontrolled fire.

   b. If aircraft is in uncontrolled flight at 10,000 feet AGL or below.

   c. When dual engine flameout occurs below 1,500 feet AGL and 250 KIAS.

   d. If repeated relight attempts are not successful between 30,000 and 10,000 feet, eject by 10,000 feet AGL.

   e. If still on first or second relight attempt when passing through 10,000 feet AGL and it appears that a relight is likely, airstart attempt may be continued to a minimum of 2,000 feet AGL.

2. If dual engine flameout occurs below 10,000 feet, zoom to convert excess airspeed to altitude. Attempt airstart as time permits. If peak altitude is above 5,000 feet AGL and airstart attempt is not successful, eject no lower than 5,000 feet AGL. If peak altitude is below 5,000 feet AGL and airstart attempt is made during zoom and there is no evidence of a relight, eject at peak altitude. If no airstart attempt is made, eject at peak altitude.

3. If a decision to abandon aircraft is made at high altitude, the recommended minimum altitude for ejection is 10,000 feet AGL, or higher, if conditions so indicate. Under any circumstances and if at all possible, ejection should be accomplished prior to descending below 2,000 feet AGL.

16.1.1 Ejection Envelope. The ejection seat limitations shown in Figure 16-1 represent the ejection seat capability with respect to airspeed limitations and minimum altitudes. For all ejections, it is recommended that airspeed be reduced as slow as practicable; however, in uncontrolled situations, do not delay ejection because the aircraft is not within the published safe escape envelope. For ejection at low altitude, it is recommended that a climb be initiated to convert excess airspeed into altitude. Although the escape system is capable of zero-zero ejection, it should be borne in mind that a combination of low airspeed and high rate of descent at low altitude can present a condition more severe than zero-zero. For zero-zero ejection limitations, see paragraph 16.1.1.1. For details of ejection seat mechanical operation, refer to Chapter 2. Ejection sequences are shown in FO–16.

The escape system will function up to 0.9 IMN or 600 KIAS, whichever is greater; however, human limitations are more restrictive as indicated below:

WARNING

Regardless of the GRU-7A ejection seat limitations, any person whose nude body weight is below 136 pounds or above 213 pounds is subject to increased injury from ejection.

1. 0 to 250 KIAS — Safe ejection (injury improbable).

2. 250 to 600 KIAS — Hazardous ejection (appreciable forces are exerted on the body, making injury probable).

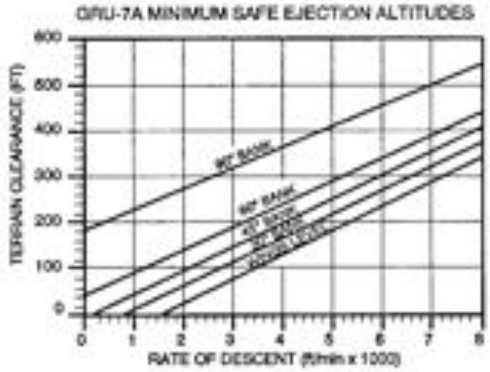
3. Above 600 KIAS — Extremely hazardous ejection (excessive forces are exerted on the body, making serious injury or death highly probable).

COMMAND DUAL EJECTION
GRU-7A Ejection Seats

NOTE

THESE CURVES REPRESENT THE EJECTION SEAT CAPABILITY AND ARE ABSOLUTE MINIMUM ALTITUDES AT WHICH EJECTION MUST HAVE BEEN INITIATED.

GRU-7A MINIMUM SAFE EJECTION ALTITUDES

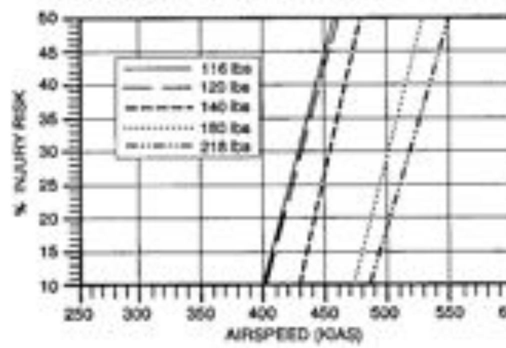


140 TO 204 LB AIRCREW, 200 KEAS EJECTIONS, 0 PITCH, 0 YAW

0 REACTION TIME, 0.4s DELAY FOR CANOPY JETTISON,

0.4s DELAY FOR CANOPY JETTISON

EJECTION SEAT - HUMAN FACTOR LIMITATIONS

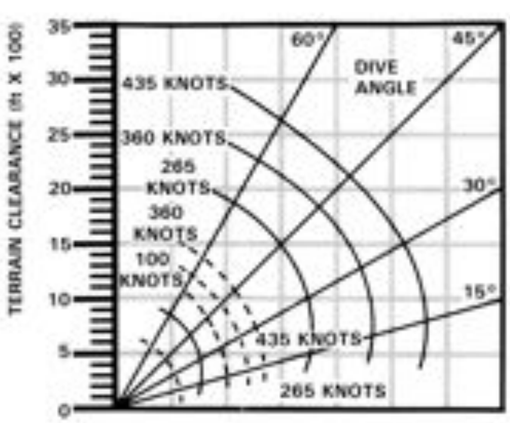


- THIS INFORMATION WAS EXTRAPOLATED USING THE GRU-7A QUALIFICATION WEIGHTS.
- THE GRU-7A WAS QUALIFIED FOR USE BY MALE AVIATORS WITH NUDE WEIGHTS FROM 136 TO 213 POUNDS.
- THE HUMAN FACTOR LIMITATIONS ARE FOR HIGH SPEED AERODYNAMIC LOADS ONLY.

NOTE

FOR INVERTED FLIGHT ADD 400 ft TO TERRAIN CLEARANCE REQUIRED FOR WINGS LEVEL.

VELOCITY vs DIVE ANGLE



TERRAIN CLEARANCE vs AIRCRAFT SPEED

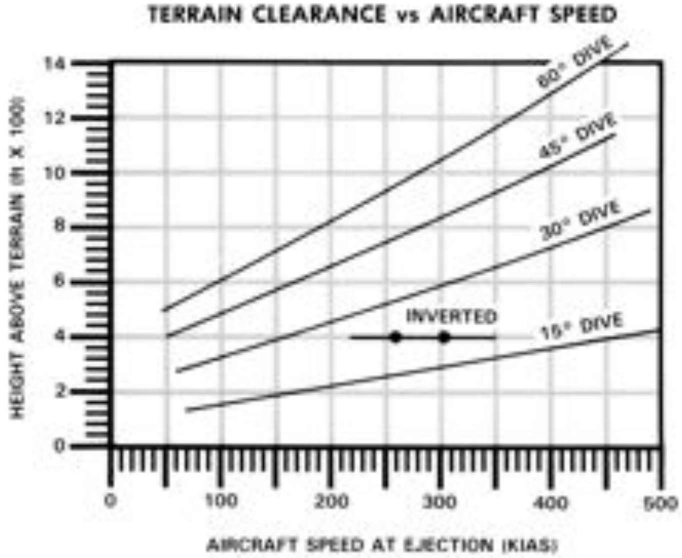
NOTE

- CURVES ARE BASED ON WINGS LEVEL, BANK ATTITUDES, AND APPROPRIATE ANGLE OF ATTACK

——— 2 SECONDS PILOT REACTION TIME
— — — — 0 SECONDS PILOT REACTION TIME

- 600 KNOTS DATA NOT AVAILABLE AT TIME OF CHARTS.

TERRAIN CLEARANCE vs AIRCRAFT SPEED



NOTE

- INVERTED AND BANK PLOTS AIRCRAFT AT CONSTANT ALTITUDE
- THESE CURVES DO NOT INCLUDE REACTION TIME

14B-F0134

Figure 16-1. Ejection Seat Limitations

Usually, the pilot will have enough time to do several things to prepare for a successful ejection prior to pulling the face curtain. However, when the emergency condition requiring ejection is such that ejection must be made without hesitation, simply grasp the face curtain handle or lower ejection handle and pull forcibly to the fullest extent until seat ejects.

16.1.1.1 Ejection at Ground Level/On Deck. The GRU-7A ejection seat is designed for zero-zero ejection capability for a maximum nude crewmember weight of 213 pounds. Aircrew above 213 pounds nude weight have an increased risk of injury due to an inadequate parachute recovery time. At the maximum nude weight of 213 pounds, the margin of safety is very narrow below 50 KTAS. Tailwind and aircraft deceleration also contribute to increased injury risk.

For aircrew below 136 pounds, the zero-zero ejection parachute recovery altitude is increased. However, lightweight aircrew occupants below 136 pounds nude weight are subjected to higher loads as airspeed increases, especially at airspeeds greater than 450 KIAS. The ejection seat becomes less stable and deceleration forces during drogue chute deployment become more severe. Analysis has shown that lowering the seat prior to ejecting increases seat stability during a high speed ejection.

For all ejections, the two most critical factors affecting potential for aircrew injury are airspeed and body position during ejection. Airborne ejections should occur at the minimum practical airspeed. As the last and most aircrew-controllable factor affecting injury risk, aircrew should strive to be in the proper body position at ejection initiation.

WARNING

The margin of safety for ground-level ejections is very narrow. Do not eject below 50 knots forward speed unless it is the only available option. When possible, the aircraft should be positioned with surface winds forward of the wing line when arming, refueling, or holding short of the runway. Ground-level ejection in the presence of tailwinds or deceleration forces could result in serious injury or death.

16.1.2 Lower Ejection Handle Selection. Because of its greater accessibility and shorter travel when compared to the face curtain, the lower ejection handle should be used during situations requiring an expeditious ejection. Some of these situations are insufficient flying speed from catapult, ramp strike, parting of cross-deck pendant during carrier arrestment, low-altitude uncontrolled flight, and under high g forces during spin or other maneuvers.

16.1.3 Ejection Preparation

WARNING

Do not secure engines. Unsuccessful seat activation may require continued flight to allow alternate egress method.

Note

Prior to ejection from controllable aircraft, ensure that abandoned aircraft inflicts least possible damage on impact.

Time permitting, perform all or as much as possible of the following:

1. Place aircraft in safe envelope and attitude for ejection.

WARNING

Minimum ejection attitudes are dependent upon dive angle, airspeed, and angle of bank.

2. Warn other crewmember.

3. EJECT CMD lever — Select (RIO).

4. IFF/SIF — EMERG/7700 (RIO).

5. Position report — Transmit.

6. Check altimeter.

WARNING

- Positioning the legs aft prior to ejection will cause the spine to flex and will increase the possibility of spinal injury and will also increase likelihood of seat/thigh slap with attendant leg injury.

- Proper body position is a critical factor in preventing ejection injuries.

7. Assume proper ejection position (see Figure 16-2).

   a. Head pressed back against headrest.

   b. Chin slightly elevated (10° up).

   c. Back straight.

   d. Hips against seat back.

   e. Thighs flat on seat survival kit.

   f. Elbows and arms pressed firmly against body.

   g. Feet on rudder pedals, heels on deck.

   h. Visor down, oxygen mask tightened, helmet secure.

16.1.4 Ejection Initiation. See Figure 16-3 for controlled ejection sequence. After the face curtain or lower handle is pulled:

1. The harness retraction unit retracts the shoulder harness, pulling the occupant to an upright position. The leg garters are retracted as the seat moves up the rail.

2. Ejection cannot be performed through the canopy; therefore, canopy is jettisoned as part of normal ejection sequence.

3. Seats eject individually and in opposite directions (left, right).

PROPER BODY POSITION

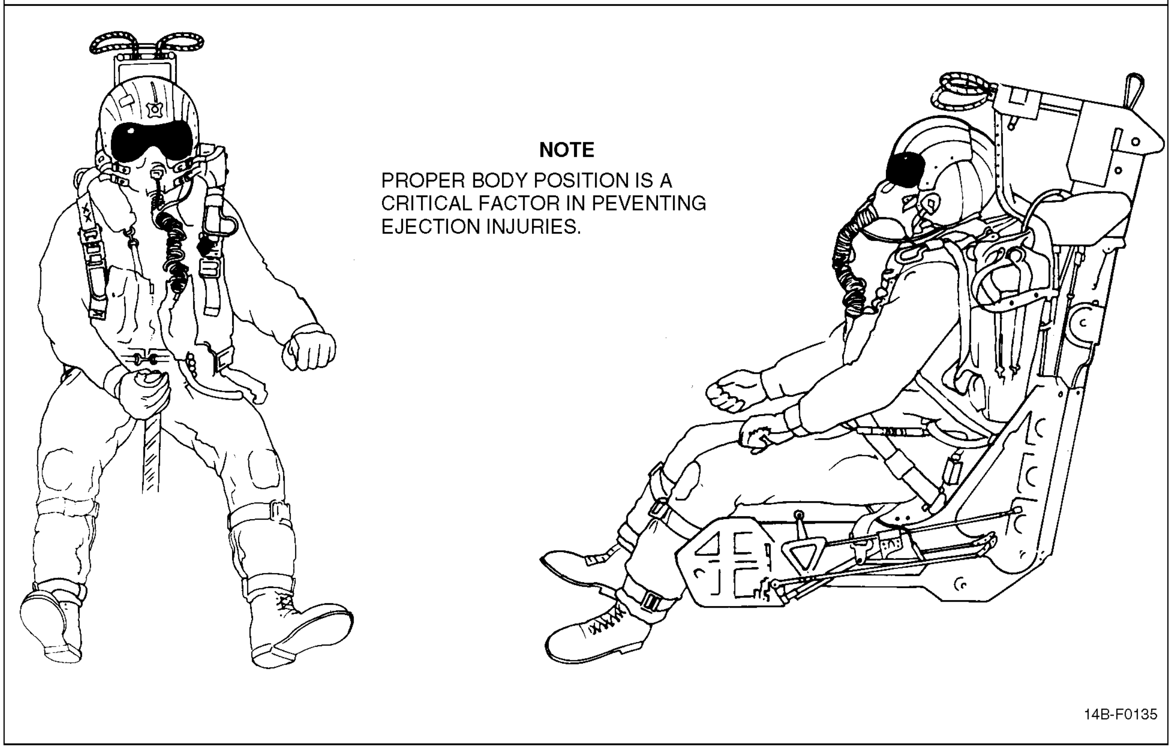
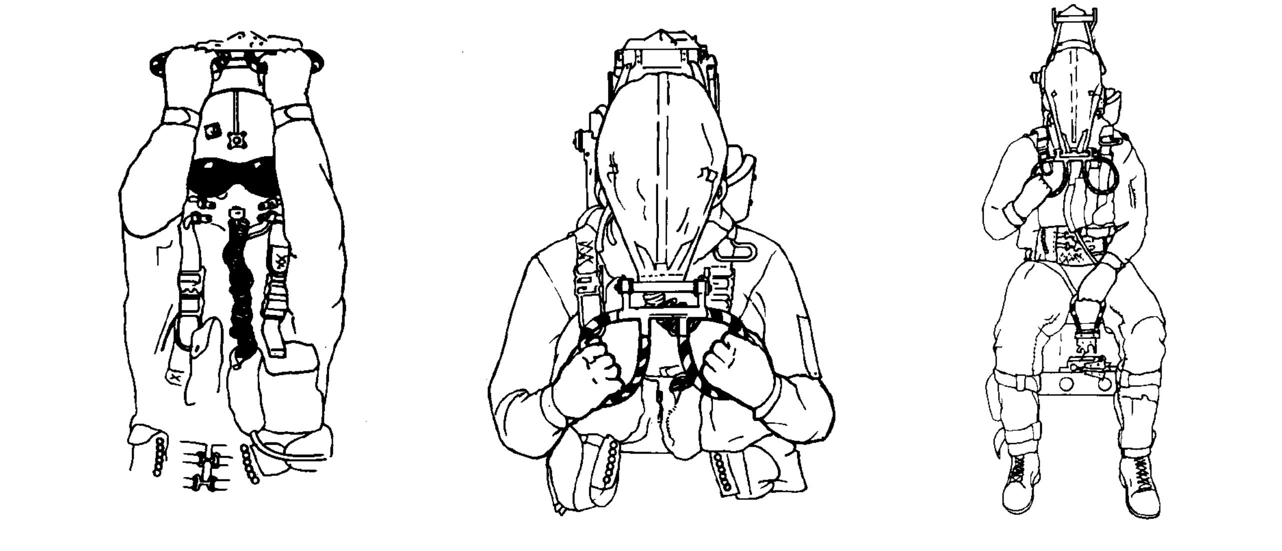


Figure 16-2. Proper Ejection Position

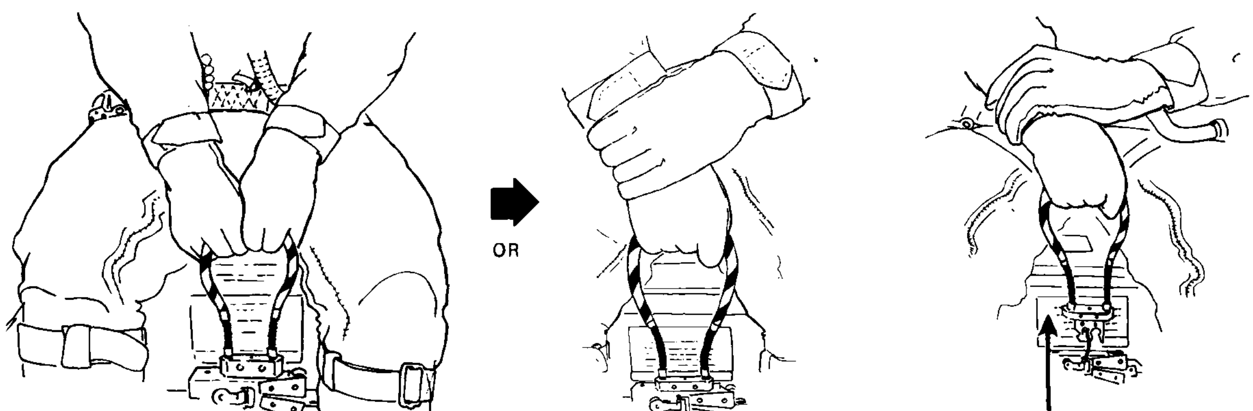
FACE CURTAIN EJECTION INITIATION



1. GRIP UPPER HANDLE, PALMS TOWARD BODY, USING THUMBS AROUND HANDLE GRIP. KEEP ELBOWS AS CLOSE TOGETHER AS POSSIBLE.
2. PULL CURTAIN SHARPLY OVER HEAD AND INTO CHEST. ENSURE PULLING HANDLE TO END OF TRAVEL. KEEP ELBOWS AS CLOSE TO TORSO AS POSSIBLE.
3. IF THE SEAT FAILS TO EJECT AFTER PULLING THE FACE CURTAIN HANDLE, CONTINUE TO HOLD FACE CURTAIN HANDLE WITH ONE HAND WHILE GRASPING THE LOWER EJECTION HANDLE WITH OTHER HAND AND PULL UP FIRMLY.

LOWER HANDLE EJECTION INITIATION

THERE ARE TWO ACCEPTABLE METHODS FOR EJECTION INITIATION USING THE LOWER HANDLE: THE TWO-HAND GRIP AND THE SINGLE HAND GRIP.



1. GRIP THE EJECTION HANDLE WITH THE THUMB AND AT LEAST TWO FINGERS OF EACH HAND, PALMS TOWARD BODY AND ELBOWS CLOSE TO BODY.

1. GRIP HANDLE WITH STRONG HAND, PALM INWARD. GRIP WRIST OF STRONG HAND WITH OTHER HAND, PALM TOWARD BODY AND ELBOWS CLOSE TO BODY.
2. PULL HANDLE SHARPLY UP AND TOWARD ABDOMEN, KEEPING ELBOWS IN. ENSURE HANDLE IS PULLED TO END OF TRAVEL.

NOTE

IN LOW-ALTITUDE, LOW-AIRSPEED SITUATIONS, A ONE-HANDED METHOD, USING ONE HAND TO INITIATE EJECTION VIA THE LOWER HANDLE AND USING THE OTHER TO MAINTAIN THE AIRCRAFT IN THE SAFE OPERATING ENVELOPE OF THE EJECTION SEAT, MAY BE REQUIRED. WHENEVER INITIATING EJECTION WITH THE LOWER HANDLE, UTILIZING ONE OF THE PREVIOUSLY DESCRIBED METHODS, PARTICULAR ATTENTION MUST BE PAID TO MAINTAINING PROPER HEAD, NECK, AND BODY POSITION.

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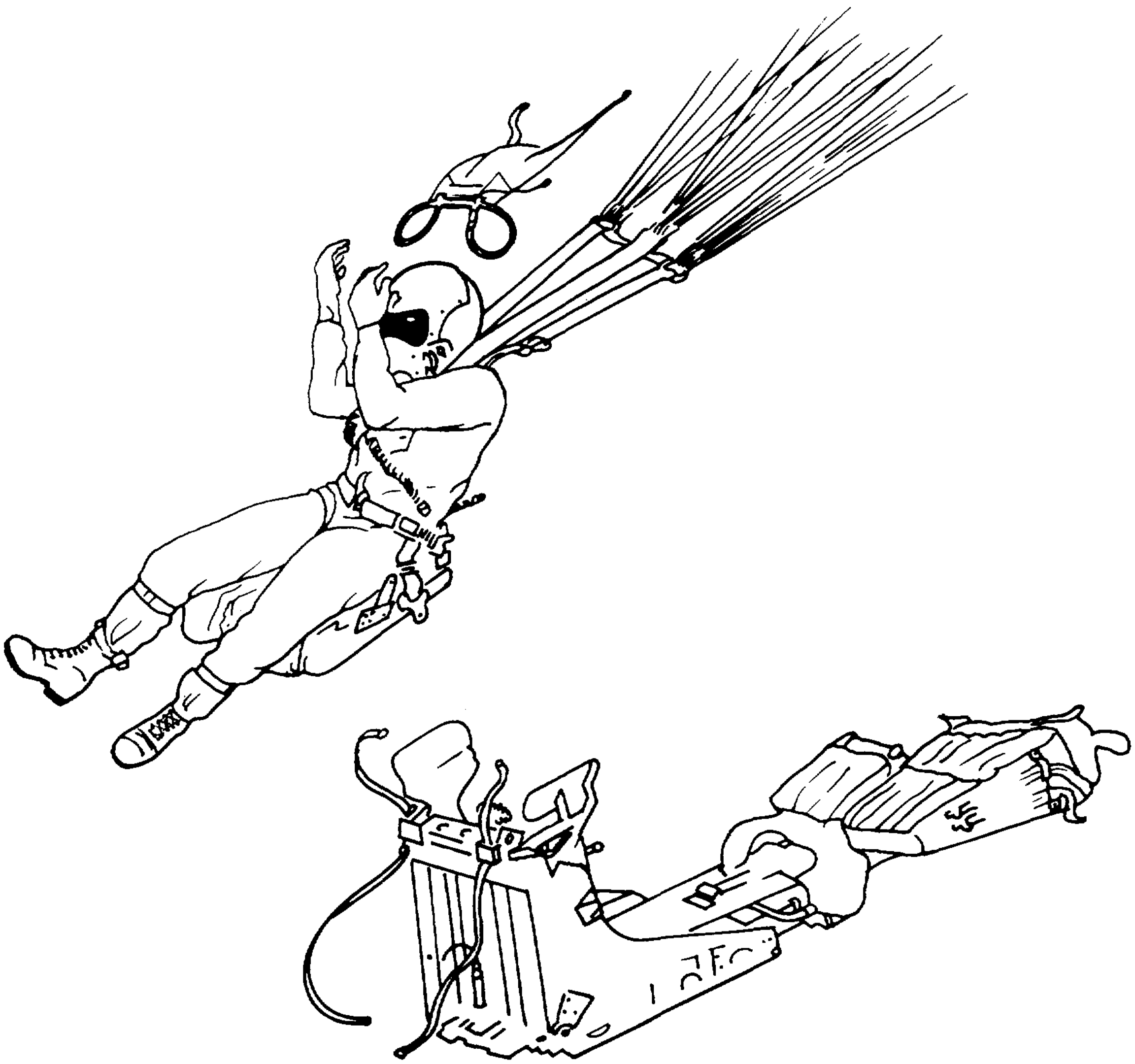
Figure 16-3. Controlled Ejection (Sheet 1 of 3)

AUTOMATIC SEAT/MAN SEPARATION

WHEN AUTOMATIC SEAT/MAN SEPARATION OCCURS (UPON DESCENT TO BETWEEN 14,500 TO 11,500 FEET OR 2 SECONDS AFTER EJECTION IF INITIALLY UNDER 11,500 FEET), THE SHOULDER HARNESS, LAP AND LEG RESTRAINTS, FACE CURTAIN AND SURVIVAL KIT ARE AUTOMATICALLY UNLOCKED FROM THE SEAT. THE OCCUPANT IS THEN FREE TO BE PULLED FROM THE SEAT STICKER CLIPS BY THE LINE STRETCH OF MAIN PARACHUTE AS THE SEAT ROTATES AWAY.



NOTE

IF AFTER PASSING THE BAROSTAT OPENING ALTITUDE, THE AUTOMATIC EJECTION SEQUENCE FAILS TO SEPARATE THE OCCUPANT FROM THE SEAT, MANUAL SEAT/MAN SEPARATION PROCEDURES MUST BE PERFORMED.

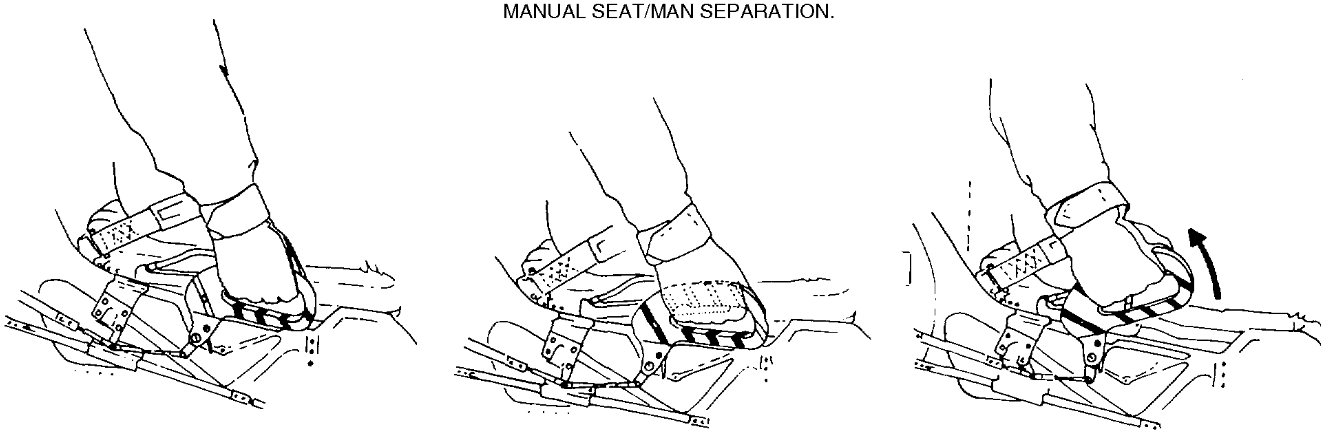
14B-F0137

Figure 16-3. Controlled Ejection (Sheet 2)

MANUAL SEAT/MAN SEPARATION

WARNING

IF THE AUTOMATIC SEPARATION SEQUENCE DOES NOT OCCUR, MANUAL SEAT/MAN SEPARATION MUST BE PERFORMED. A MINIMUM OF 5,000 FEET ALTITUDE IS REQUIRED TO PERFORM MANUAL SEAT/MAN SEPARATION.



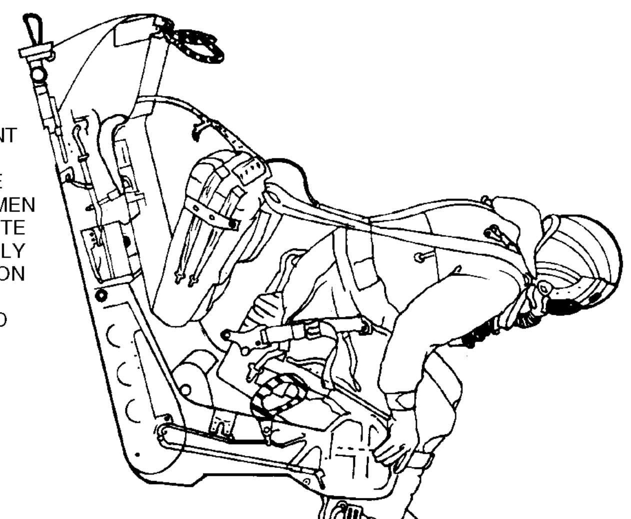
1. LOCATE EMERGENCY RESTRAINT RELEASE HANDLE (ERRH) ON RIGHT SIDE OF EJECTION SEAT.
2. SQUEEZE THE ERRH TRIGGER RELEASE MECHANISM.
3. ROTATE HANDLE UP AND AFT.

THE FOLLOWING OCCURS WHEN THE HANDLE IS ACTUATED:

- RESTRAINT HARNESS AND LEG RESTRAINT CORDS ARE RELEASED.
- A CARTRIDGE ACTUATED GUILLOTINE SEVERS THE LINK BETWEEN THE PERSONNEL PARACHUTE AND DROGUE PARACHUTE.

WARNING

WHEN THE EMERGENCY RESTRAINT RELEASE HANDLE IS PULLED, THE PERSONNEL PARACHUTE MUST BE DEPLOYED MANUALLY. AIRCREWMEN USING THIS METHOD OF PARACHUTE DEPLOYMENT SHOULD IMMEDIATELY CHECK FOR PARACHUTE ACTUATION AND BE PREPARED TO FORCIBLY DEPLOY THE PARACHUTE BY HAND AFTER D-RING ACTUATION.



4. PUSH FREE OF STICKER CLIPS AND CLEAR OF SEAT.

WARNING

ATTEMPTS TO "BEAT THE SEAT" (OVERRIDE THE AUTOMATIC EJECTION SEQUENCE) ARE ADVISABLE ONLY WHEN CERTAIN THAT THE BAROSTAT OPENING ALTITUDE HAS PASSED AND THE AUTOMATIC SEQUENCE HAS MALFUNCTIONED. AN AVERAGE ALTITUDE OF 5,000 FEET IS REQUIRED TO PERFORM MANUAL SEAT/MAN SEPARATION.

14B-F0138

Figure 16-3. Controlled Ejection (Sheet 3)

16.2 MANUAL BAILOUT

Manual bailout is extremely hazardous, even under the most favorable conditions (level flight, slow airspeed, and optimum altitude) and is considered only as a last chance method of escape. If the canopy has been jettisoned and the seat cannot be ejected, the following bailout procedures are suggested.

WARNING

Manual bailout below 2,000 feet AGL (minimum sink rate) may not allow sufficient altitude for parachute deployment.

1. Warn RIO.

2. Place aircraft in safe envelope.

3. Ensure canopy is jettisoned.

4. Pitch trim — Full Nose Down.

5. Emergency restraint release — Pull.

6. Ensure seat pan and leg restraints are disconnected from ejection seat.

7. Release stick.

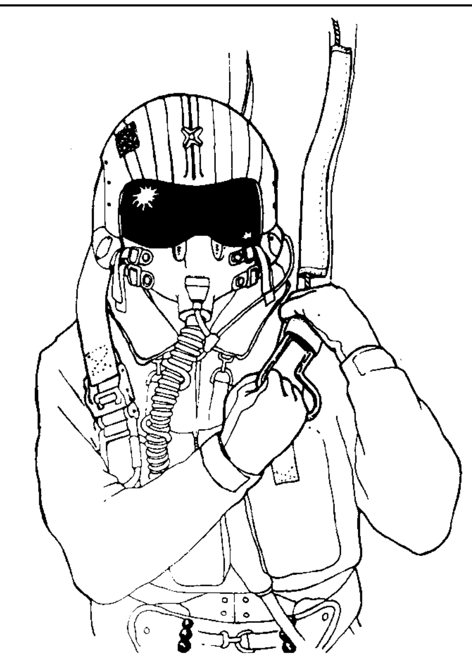
8. Roll forward and push free of aircraft.

Figure 16-4 shows the procedures for manual ripcord release.

16.3 CANOPY JETTISON

The canopy may be jettisoned by pulling the CANOPY JETTISON handle in either cockpit. The handle must be squeezed and held before and while pulling. On pulling, the handle disconnects from the

MANUAL RIPCORD RELEASE



1. LEFT HAND: GRASP LEFT RISER ABOVE PARACHUTE D-RING.

2. RIGHT HAND: GRIP PARACHUTE D-RING HANDLE AND PULL DOWNWARD AND TO RIGHT SIDE OF BODY. PULL HANDLE THE MAXIMUM LENGTH OF TRAVEL TO ENSURE COMPLETE RELEASE OF PINS FROM PARACHUTE PACK.

14B-F0139

Figure 16-4. Manual Bailout

instrument panel. Jettisoning the canopy before initiation of ejection sequence is not recommended because of the windblast on the RIO. If normal seat ejection sequence has been attempted but the canopy has not jettisoned, jettisoning the canopy could initiate ejection. If the face curtain has been pulled, it should be grasped and held before jettisoning to prevent drogue chute entanglement.

16.4 SURVIVAL/POSTEJECTION PROCEDURES

Figure 16-5, sheets 1 through 14, describes step-by-step procedures for inflation of the life preserver assembly configured with beaded handles, the 35-gram CO_2 cylinder, and using the SKU-2 (single handle) or RSSK-7 (dual handle) survival kit. The ejection situation is below-barostat, high-altitude, and over water in which seat/man separation and parachute deployment was accomplished automatically.

WARNING

Ejection at low altitude allows only a matter of seconds to prepare for landing. Over water, inflation of the LPA is the most important step to be accomplished. Release of the parachute quick-release fittings as the feet contact the water is the second most important step to prevent entanglement in the parachute shroud lines.

WARNING

- When ejection is in the immediate vicinity of the carrier, parachute entanglement combined with wake and associated turbulence can rapidly pull a survivor under. The deployed seat survival kit may contribute to shroud line entanglement. The survivor must be prepared to cut shroud lines that are dragging him down.

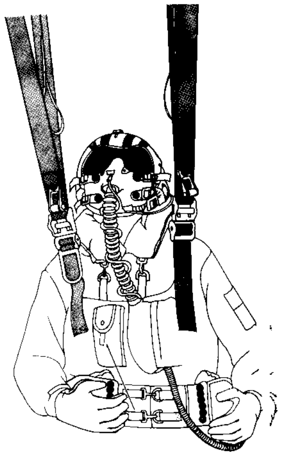
- The crashed aircraft may release large quantities of jet fuel and fumes that could hamper breathing and create a fire hazard if smoke or flare marker is present. The emergency oxygen system may be invaluable in this case and discarding the seat pan would terminate its use. However, totally discarding the seat pan may be appropriate after considering weather, sea conditions, and rescue potential.

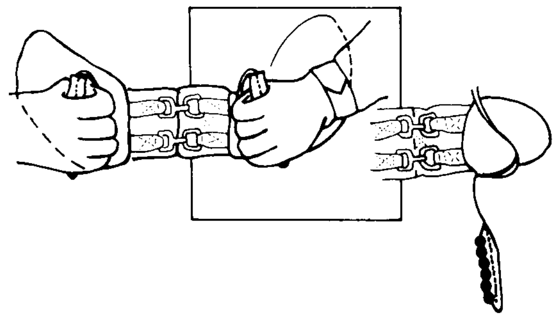
Note

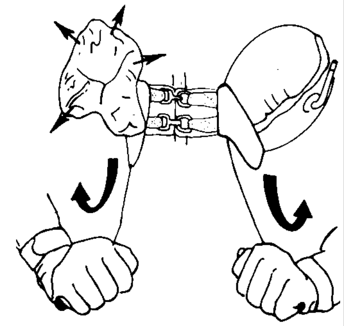
The variety and complexity of conditions encountered during the time-critical movements following a low-altitude overwater ejection make it impossible to formulate procedures to cover every contingency.

Figure 16-5, sheets 15 through 18, describes step-by-step procedures for pickup by rescue helicopter.

LPU INFLATION







2. LOCATE BEADED HANDLES ON LPA.

1. IMMEDIATELY FOLLOWING OPENING SHOCK, CHECK CONDITION OF PARACHUTE. IF THERE IS NO DAMAGE/ MALFUNCTION ....

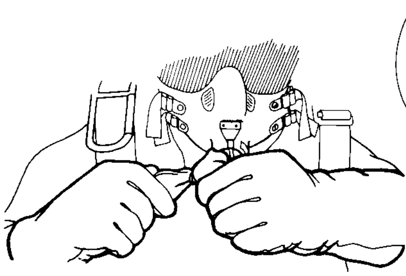
3. PULL BEADED HANDLES DOWN AND STRAIGHT OUT TO INFLATE.

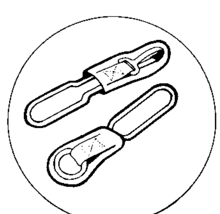
WARNING

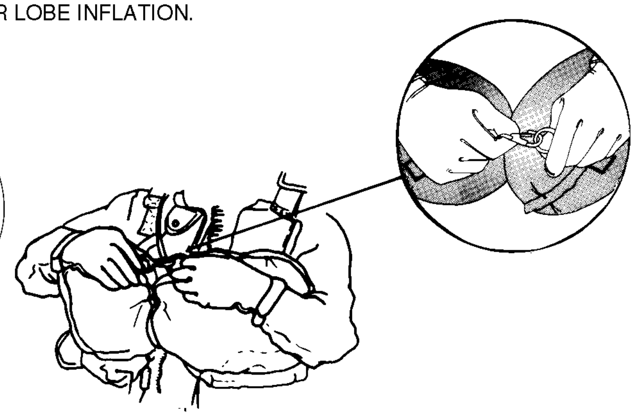
ALTHOUGH THE FLU-8 AUTOMATIC INFLATION DEVICE IS DESIGNED TO INFLATE THE LPA UPON WATER CONTACT, MANUAL INFLATION REMAINS THE PRIMARY MODE OF OPERATION. AUTOMATIC ACTUATION IS INTENDED FOR DISABLED OR UNCONSCIOUS SURVIVORS OR IF THERE IS INSUFFICIENT TIME TO MANUALLY ACTIVATE THE LPA.

SQUEEZE LPA WAIST LOBES TOGETHER TO HELP RELEASE VELCRO ON COLLAR LOBE OR MANUALLY RELEASE VELCRO ON COLLAR, IF NECESSARY, TO ACHIEVE COMPLETE COLLAR LOBE INFLATION.

OPTIONAL PROCEDURE







5. REMOVE CHAFFING MATERIAL (WHEN REQUIRED) FROM WAIST LOBE SNAPS.

6. SNAP WAIST LOBES TOGETHER.

WARNING

FAILURE TO SNAP WAIST LOBES BEFORE WATER ENTRY MAY RESULT IN FACE DOWN FLOTATION.

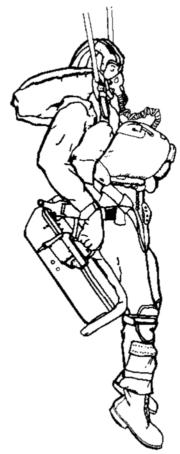
14B-F0140

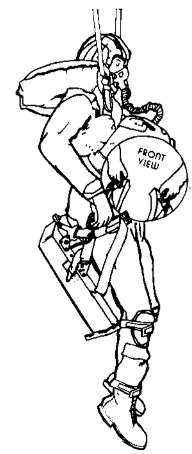
Figure 16-5. Survival/Postejection Procedures (Sheet 1 of 18)

SEAT KITS DEPLOYMENT

SKU-2 | **RSSK-7**

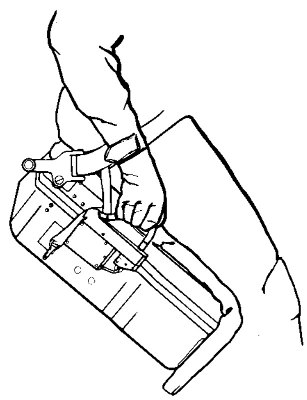
7. AFTER INFLATING LPA, PREPARE TO DEPLOY SEAT KIT.

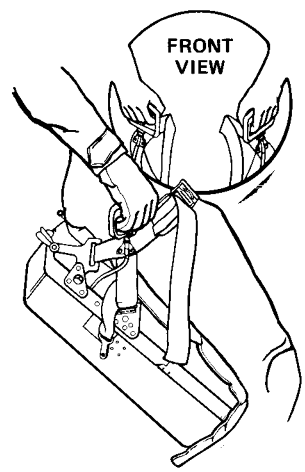




NOTE

DEPLOYMENT OF THE SEAT KIT IS NOT RECOMMENDED IN EJECTIONS OVER LAND.



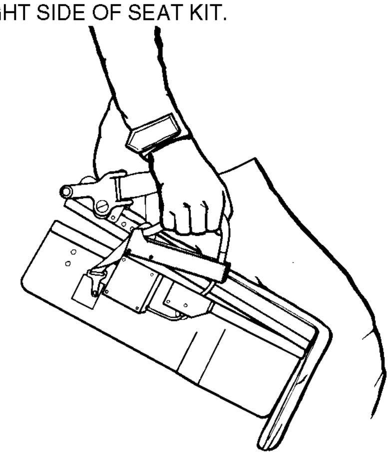


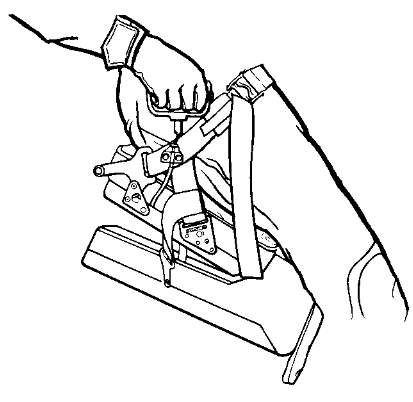
SKU-2:

8. WITH RIGHT HAND, LOCATE THE SINGLE KIT RELEASE HANDLE ON RIGHT SIDE OF SEAT KIT.

RSSK-7:

8. WITH EITHER HAND, LOCATE KIT RELEASE HANDLE ON EITHER SIDE OF SEAT KIT.





SKU-2:

9. FIRMLY PULL UP ON KIT RELEASE HANDLE UNTIL HANDLE IS FREE OF KIT AND LOWER HALF OF SEAT KIT FALLS AWAY.

RSSK-7:

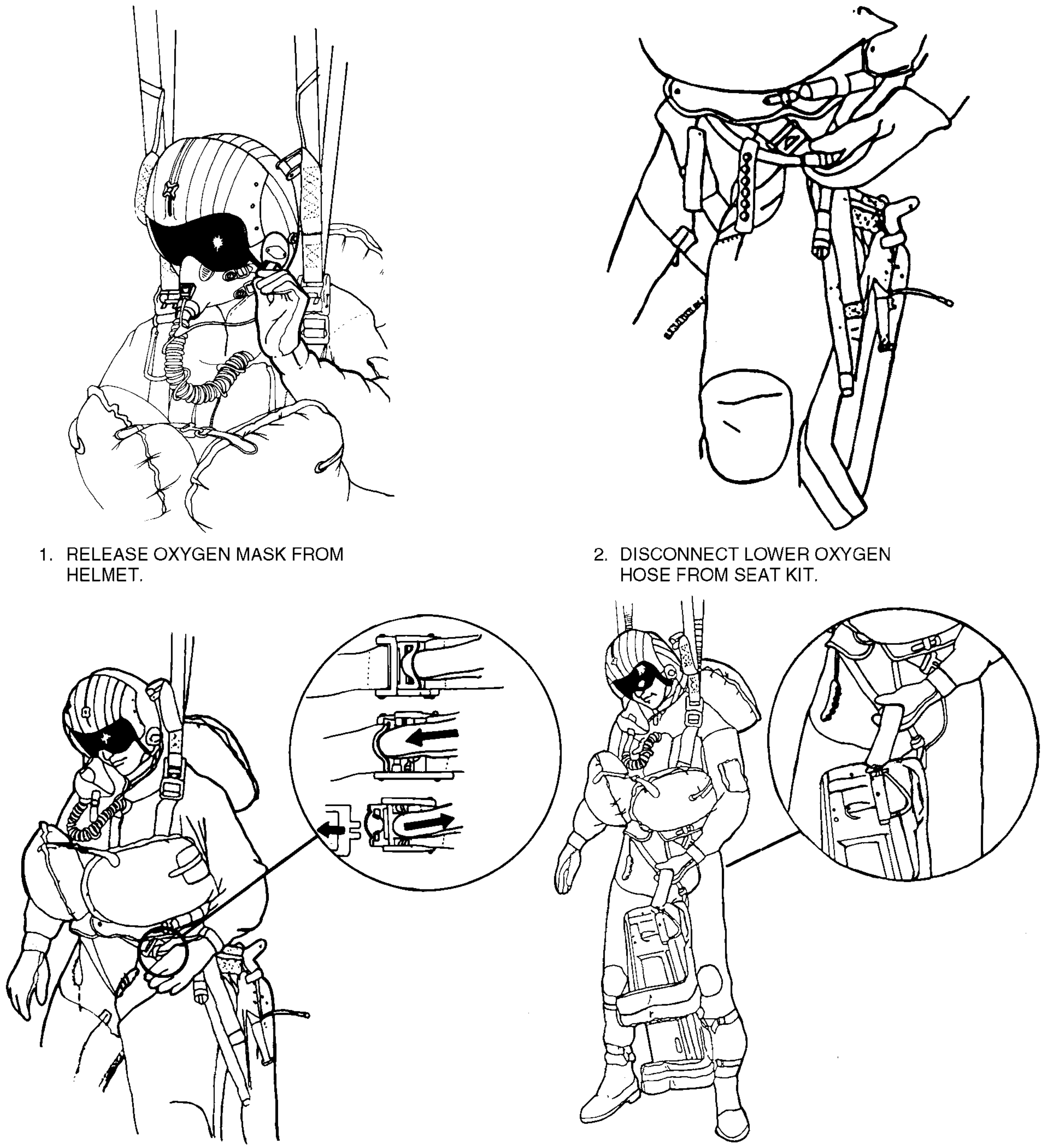
9. FIRMLY SQUEEZE AND PULL UP ON EITHER HANDLE UNTIL CABLE HAS TRAVELLED ITS FULL DISTANCE AND LOWER HALF OF SEAT KIT FALLS AWAY.

14B-F0141

Figure 16-5. Survival/Postejection Procedures (Sheet 2)

SEAT KITS DEPLOYMENT — INJURED ARM PROCEDURES

THE SKU-2 SURVIVAL KIT HAS ONLY ONE RELEASE HANDLE LOCATED ON THE RIGHT SIDE. IN THE EVENT OF AN INJURED RIGHT ARM AND SEAT KIT DEPLOYMENT IS DESIRED, THE FOLLOWING PROCEDURES MUST BE ACCOMPLISHED.



1. RELEASE OXYGEN MASK FROM HELMET.
2. DISCONNECT LOWER OXYGEN HOSE FROM SEAT KIT.
3. RELEASE LEFT SEAT KIT QUICK RELEASE FITTING.
4. USING LEFT HAND, ROTATE SEAT KIT UNTIL KIT RELEASE HANDLE CAN BE REACHED.

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Figure 16-5. Survival/Postejection Procedures (Sheet 3)

SEAT KITS DEPLOYMENT — INJURED ARM PROCEDURES (CONTINUED)

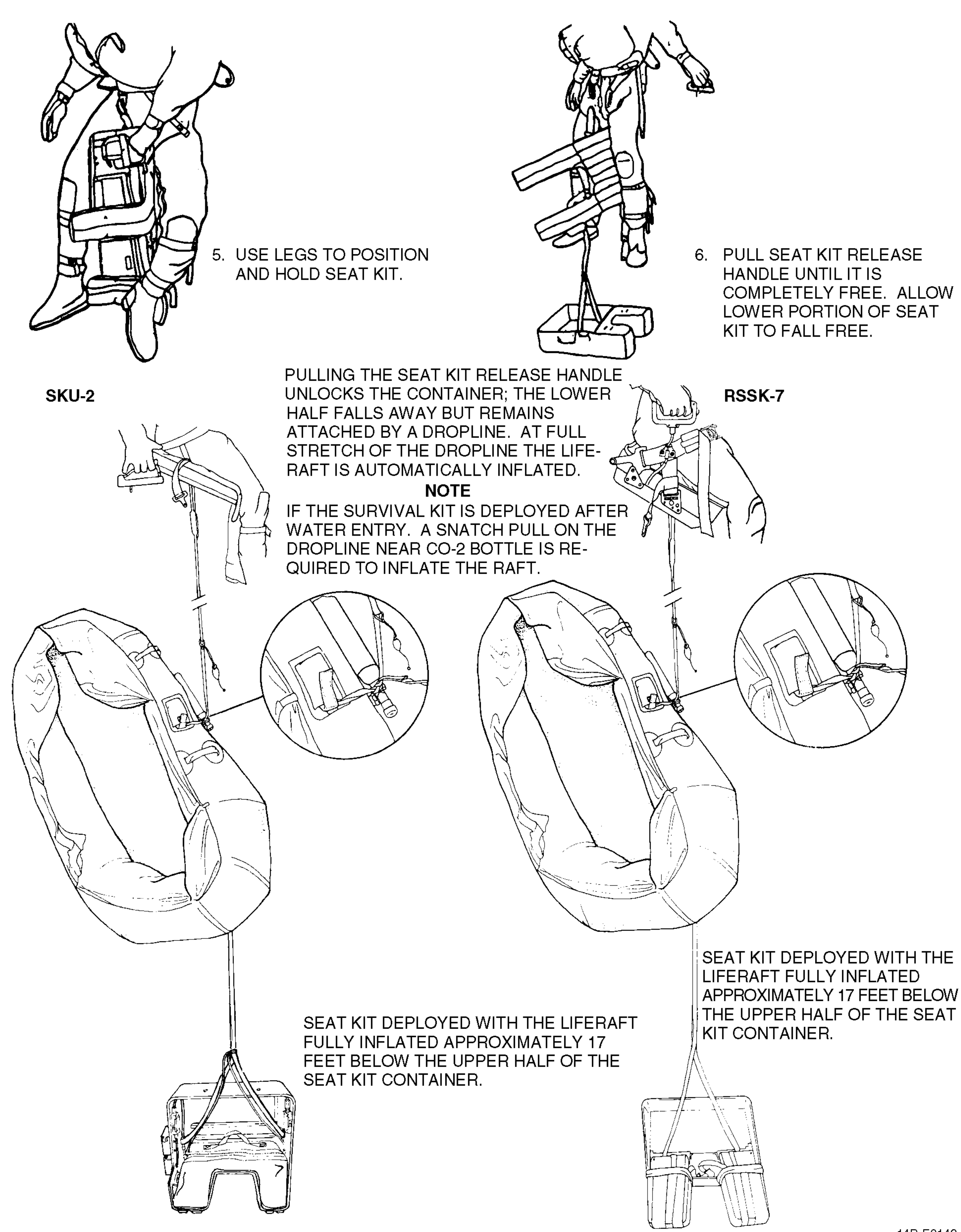


Figure 16-5. Survival/Postejection Procedures (Sheet 4)

OVER WATER OPTIONS

IF TIME AND ALTITUDE PERMIT OR RESCUE IS NOT IMMINENT, THE FOLLOWING OPTIONS FOR THE OXYGEN MASK, VISOR, GLOVES AND PARACHUTE 4 LINE RELEASE MAY BE CONSIDERED:

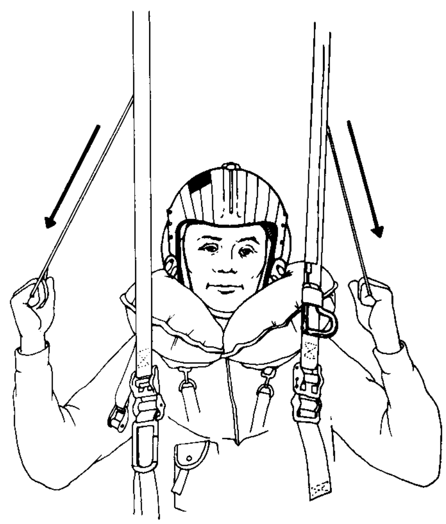
1. REMOVE OXYGEN MASK. OXYGEN MASK/HOSE ASSEMBLY MAY BE DISCONNECTED FROM SEAT KIT AND DISCARDED, IF DESIRED.

2. RAISE VISOR.

3. REMOVE GLOVES.

NOTE

STOW GLOVES IN A SECURE PLACE TO PREVENT LOSS. REMOVAL OF GLOVES MAY FACILITATE SUBSEQUENT RELEASE OF PARACHUTE RELEASE FITTINGS.



4. TO DEPLOY 4 LINE RELEASE, LOCATE PARACHUTE CONTROL LANYARDS ON INSIDE OF REAR RISERS AND PULL DOWN SHARPLY.

NOTE

APPROXIMATELY 20 POUNDS PULL FORCE IS NEEDED TO BREAK THE TACKINGS AND FREE THE DAISY CHAIN COUPLING.

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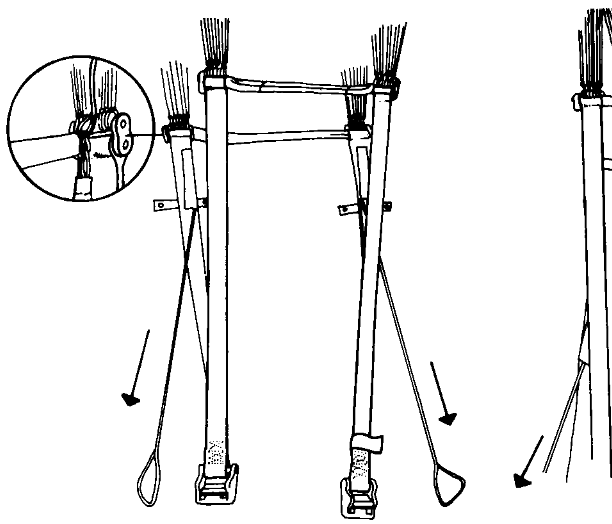
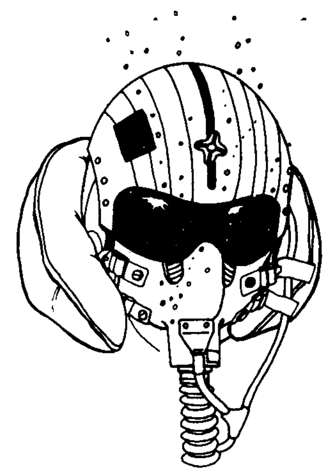
Figure 16-5. Survival/Postejection Procedures (Sheet 5)

OVER WATER OPTIONS (CONTINUED)



5. FOUR SUSPENSION LINES RELEASE FROM THEIR CONNECTOR LINKS AND A LOBE FORMS AT CENTER REAR OF PARACHUTE CREATING A CONTROLLED CHANNEL FOR AIR ESCAPE.

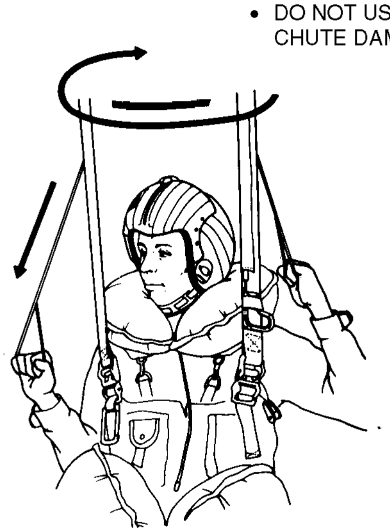


NOTE

THE A-13 OR MBU SERIES OXYGEN MASK AND MINIATURE REGULATOR PROVIDE UNDERWATER BREATHING CAPABILITY AND SHOULD BE RETAINED IN LOW-LEVEL OVERWATER EJECTION.

WARNING

- CAREFULLY INSPECT THE PARACHUTE AND SUSPENSION LINES PRIOR TO USING THE 4 LINE RELEASE SYSTEM. IF ANY PARACHUTE DAMAGE OR BROKEN SUSPENSION LINES ARE EVIDENT, DO NOT USE THE 4 LINE RELEASE.
- DO NOT USE THE 4 LINE RELEASE AT NIGHT BECAUSE PARACHUTE DAMAGE MAY BE DIFFICULT TO DETERMINE.



NOTE

IT IS SAFE TO ACTIVATE ONLY ONE SIDE OF THE FOUR-LINE RELEASE SYSTEM. THE PARACHUTE WILL TURN INTO THE DIRECTION OF THE SIDE ACTIVATED.

6. PULL DOWN ON RIGHT LANYARD TO STEER RIGHT

7. PULL DOWN ON LEFT LANYARD TO STEER LEFT.

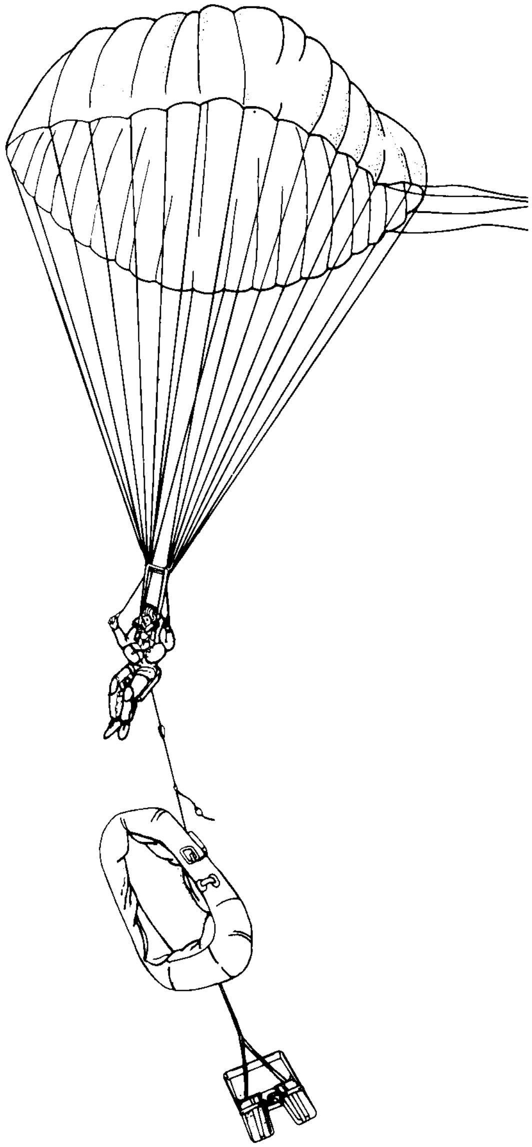
NOTE

A 180° TURN CAN BE ACCOMPLISHED IN ABOUT 20 SECONDS.

14B-F0145

Figure 16-5. Survival/Postejection Procedures (Sheet 6)

LANDING PREPARATION



TRY TO DETERMINE THE WIND DIRECTION AT THE SURFACE USING WHITE CAPS, SMOKE FROM THE WRECKAGE, OR KNOWN SURFACE WINDS IN THE VICINITY. WINDS AT THE SURFACE MAY BE QUITE DIFFERENT FROM THOSE ENCOUNTERED AT ALTITUDE. WHEN NEARING THE SURFACE, MANEUVER THE PARACHUTE SO THAT YOU ARE FACING INTO THE WIND, IF OVERLAND, AND WITH YOUR BACK TO THE WIND, IF OVER WATER. THEN ASSUME THE PROPER BODY POSITION FOR LANDING:

- FEET TOGETHER
- KNEES SLIGHTLY BENT
- TOES POINTED SLIGHTLY DOWNWARD
- EYES ON HORIZON
- FIRMLY GRASP PARACHUTE RELEASE FITTINGS
- TUCK ELBOWS IN PRIOR TO WATER ENTRY

OVER LAND

PERFORM THE SAME PROCEDURES AS FOR OVER WATER, BUT WITH THE FOLLOWING EXCEPTIONS:

- VISOR – DOWN.
- GLOVES – ON.
- DO NOT DEPLOY SEAT KIT.

14B-F0146

Figure 16-5. Survival/Postejection Procedures (Sheet 7)

PARACHUTE LANDING FALL (PLF) PROCEDURES

UPON TOES TOUCHING GROUND SURFACE:

1. ARCH SIDE OF BODY IN DIRECTION OF FALL.
2. CONTACT GROUND AT FIVE POINTS OF BODY CONTACT:

   a. BALLS OF FEET.

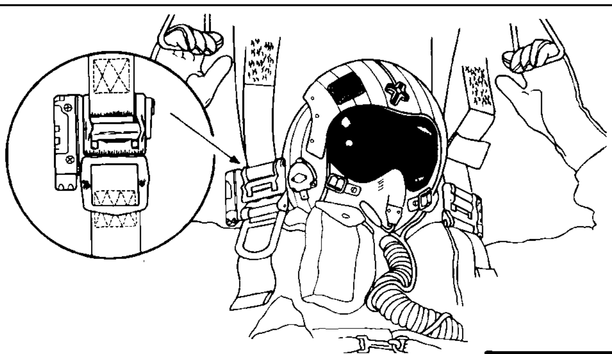
   b. CALF.

   c. THIGH.

   d. BUTTOCKS.

   e. UPPER BACK MUSCLE (TRAPEZIUS)
3. RELEASE PARACHUTE FITTINGS.

PARACHUTE FITTING RELEASE

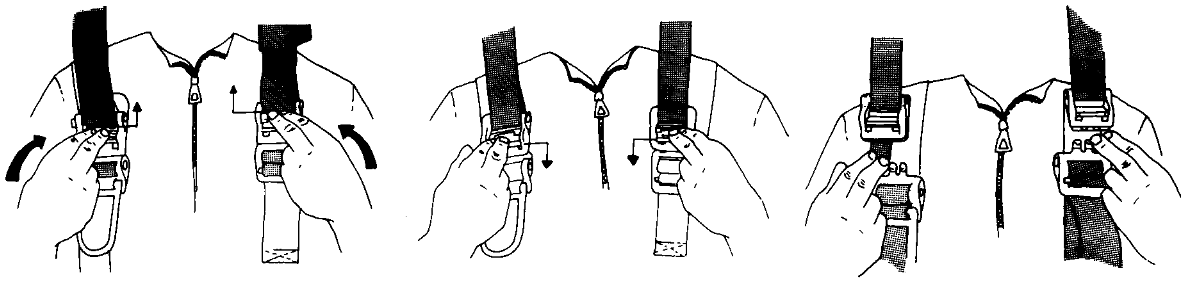


NOTE

SEAWATER ACTIVATED PARACHUTE RELEASE SYSTEM (SEAWARS). IF SEAWARS IS INSTALLED ON THE PARACHUTE RISERS IN THE AIRCRAFT, IT WILL AUTOMATICALLY RELEASE THE PARACHUTE FROM HARNESS UPON IMMERSION IN SEAWATER. THIS WILL HELP TO PREVENT ENTANGLEMENT AND/OR DRAGGING INJURED SURVIVOR. SEAWARS DOES NOT INTERFERE WITH THE MANUAL OPERATION OF PARACHUTE RELEASE FITTINGS. MANUAL OPERATION REMAINS THE PRIMARY MODE OF RELEASE WITH SEAWARS INTENDED AS A BACKUP SYSTEM.

WARNING

- IF A PARACHUTE LANDING IS MADE INTO THE WATER OR ON LAND WHEN A HIGH WIND PREVENTS NORMAL SPILLING OF THE PARACHUTE CANOPY, DISCONNECT BOTH QUICK-RELEASE FITTINGS THAT ATTACH RISERS TO TORSO-HARNESS SUIT, THUS JETTISONING THE PARACHUTE CANOPY.
- DO NOT DISCONNECT QUICK-RELEASE FITTINGS UNTIL AFTER CONTACT WITH GROUND OR WATER.



1. PUSH UP ON QUICK-RELEASE LOCKING LEVER COVER.
2. PULL DOWN ON QUICK-RELEASE LOCKING LEVER.
3. PARACHUTE RELEASED.

14B-F0147

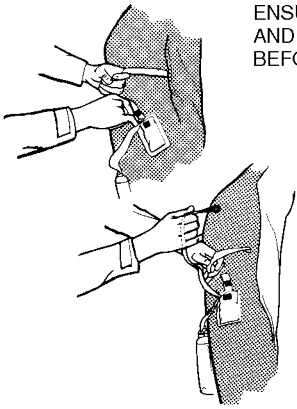
Figure 16-5. Survival/Postejection Procedures (Sheet 8)

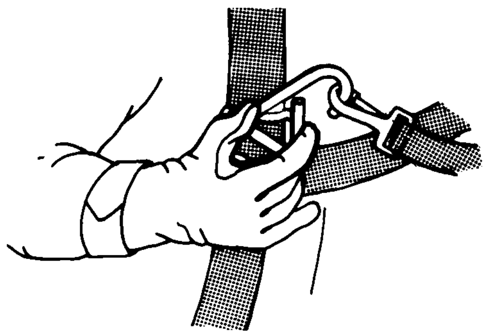
RAFT BOARDING

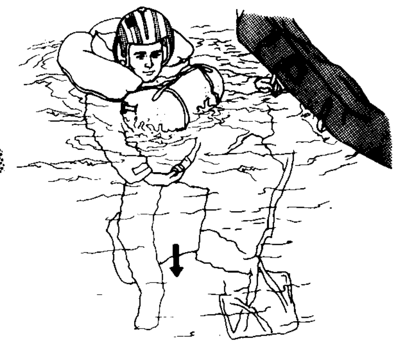
WHEN CLEAR OF THE PARACHUTE CANOPY, RETRIEVE THE LR-1 LIFE RAFT BY LOCATING THE DROPLINE AND PULLING THE RAFT TO YOU.

WARNING

ENSURE THAT RAFT RETAINING LANYARD IS SECURELY ATTACHED AND OXYGEN HOSE HAS BEEN DISCONNECTED FROM SEAT KIT BEFORE RELEASING UPPER HALF OF SEAT KIT.



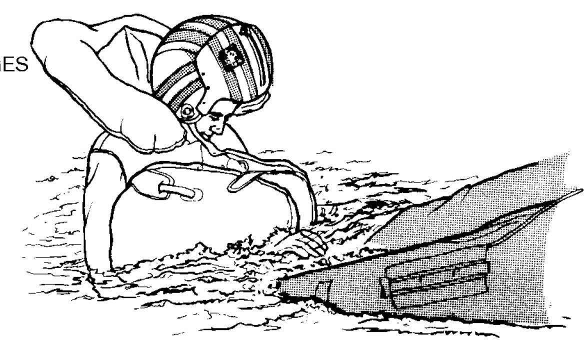




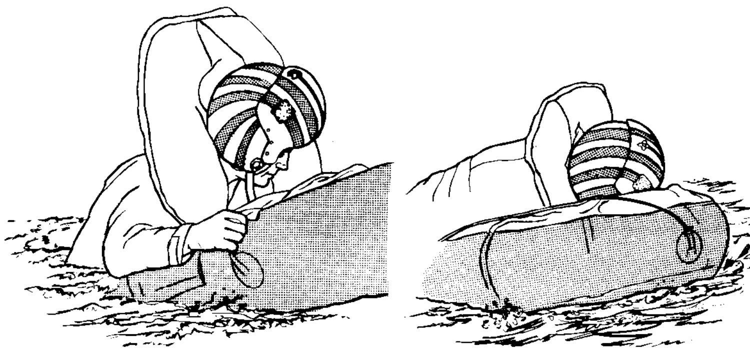
1. LOCATE AND REMOVE RAFT RETAINING LANYARD FROM ITS POCKET JUST ABOVE THE CO-2 CYLINDER.
2. ATTACH SNAPHOOK TO GATED HELO-HOIST LIFT RING.
3. LOCATE QUICK-RELEASE FITTING AND RELEASE UPPER HALF OF SEAT KIT.

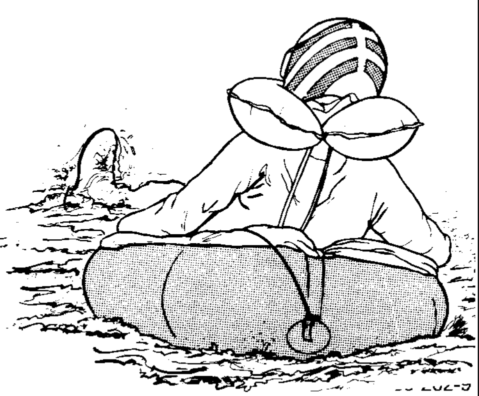
WARNING

ENSURE THAT NO SHARP EDGES CONTACT THE LIFERAFT.



4. BRING RAFT AROUND FOR ENTRY INTO SMALLER END (STERN).
5. GRASP STERN AND FORCIBLY PUSH RAFT UNDER LPA WAIST LOBES.



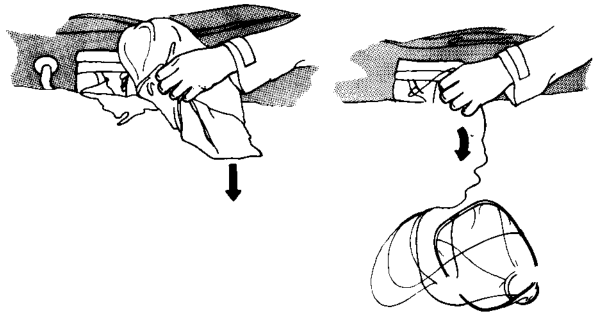


6. USING BOARDING HANDLES, PULL INTO RAFT AND TURN TOWARD A SEATED POSITION.
7. MOVE INTO COMFORTABLE AND WELL-BALANCED POSITION.

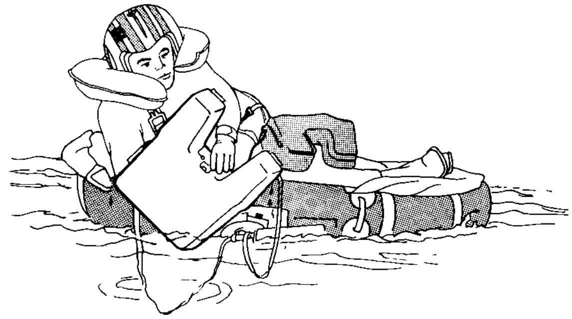
14B-F0148

Figure 16-5. Survival/Postejection Procedures (Sheet 9)

RAFT BOARDING (CONTINUED)

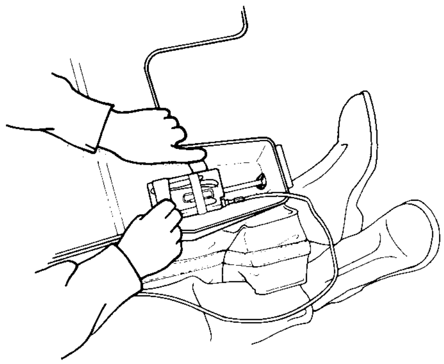


8. LOCATE SEA ANCHOR AND DEPLOY IT.

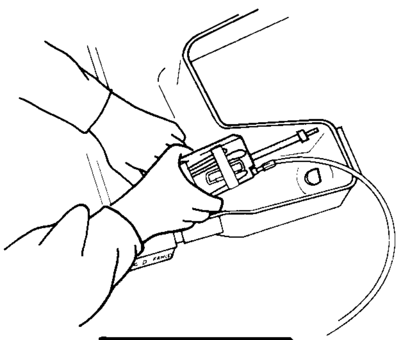


9. RETRIEVE LOWER HALF OF SEAT KIT.

SKU-2



10. LOCATE URT-33 (RIGHT LEG OF LOWER CONTAINER) AND RELEASE VELCRO STRAPS.

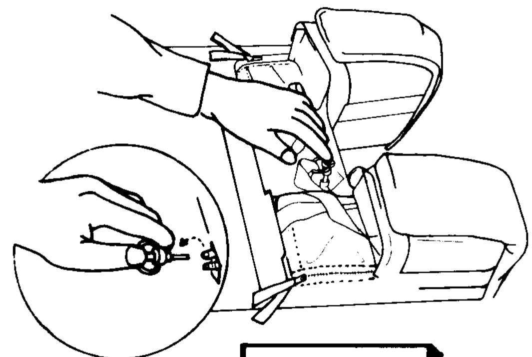


WARNING

URT-33 IS NOT TIED AND ONCE REMOVED FROM ITS BRACKET, CARE MUST BE TAKEN TO PREVENT ITS LOSS.

11. URT-33 HAS RETRIEVAL LANYARD SECURED TO RADIO WITH RUBBER BANDS. SECURE LANYARD TO SUITABLE PLACE ON SURVIVAL EQUIPMENT, THEN REMOVE URT-33 FROM ITS BRACKET.

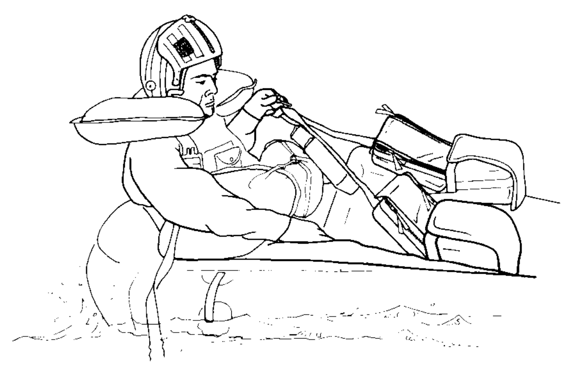
RSSK-7



WARNING

ONCE SAFETY PIN IS RELEASED, EQUIPMENT CONTAINERS WILL NO LONGER BE SECURED TO LOWER HALF OF SEAT PAN AND CARE MUST BE TAKEN TO PREVENT ITS LOSS.

10. LOCATE EQUIPMENT CONTAINER SAFETY PIN IN CENTER OF LOWER HALF OF SEAT PAN, DEPRESS BUTTON AND REMOVE PIN.



12. REMOVE EQUIPMENT CONTAINERS FROM LOWER HALF OF SEAT PAN.

14B-F0149

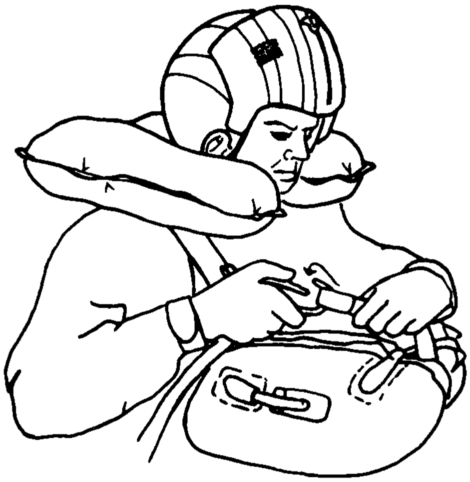
Figure 16-5. Survival/Postejection Procedures (Sheet 10)

RAFT BOARDING (CONTINUED)

SKU-2

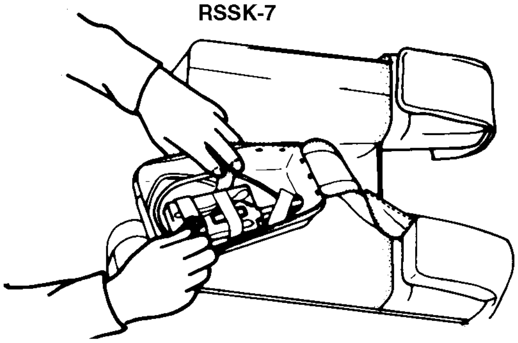
NOTE

URT-33 MUST BE TURNED OFF WHEN USING PRC-90 ON 243.0 MHz TO PREVENT INTERFERENCE FROM URT-33.



13. IMMEDIATELY SECURE EQUIPMENT CONTAINERS TO GATED HELO HOIST LIFT RING. THE SKU-2 EQUIPMENT CONTAINER CAN BE REMOVED FROM DROPLINE BY SLIPPING IT BACK THROUGH LARKSHEAD KNOT. THEN SECURE TO GATED HELO HOIST LIFT RING.

RSSK-7



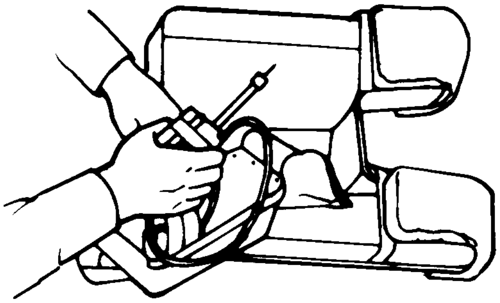
WARNING

ITEMS IN EQUIPMENT CONTAINERS ARE NOT TIED IN AND ONCE CONTAINERS ARE OPENED CARE MUST BE TAKEN TO AVOID THEIR LOSS.

13. LOCATE LARGE CONTAINER (WITH URT-33 AUTOMATIC ACTUATION ASSEMBLY PROTRUDING) NORMALLY STOWED IN RH LEG OF SEAT PAN, OPEN CONTAINER, RELEASE VELCRO TAPE. (ONE PACKET OF SRU-31P KIT WILL BE ON TOP OF URT-33).

WARNING

URT-33 IS NOT TIED AND ONCE REMOVED FROM ITS BRACKET CARE MUST BE TAKEN TO PREVENT ITS LOSS.



14. URT-33 HAS A RETRIEVAL LANYARD SECURED TO RADIO WITH RUBBER BANDS. SECURE LANYARD TO SUITABLE PLACE ON SURVIVAL EQUIPMENT. THEN REMOVE URT-33 FROM ITS BRACKET.

NOTE

- URT-33 MUST BE TURNED OFF WHEN USING PRC-90 ON 243.0 MHz TO PREVENT INTERFERENCE FROM URT-33.
- DEPENDING ON SEA STATE. DECIDE WHETHER TO RETAIN THE SEAT PAN OR DISCARD IT BY CUTTING DROP LINE NEAR THE CO-2 CYLINDER. ENSURE THAT THE EQUIPMENT CONTAINER(S) HAVE BEEN REMOVED FROM LOWER HALF OF THE SEAT PAN AND THAT THEY ARE SECURELY FASTENED TO GATED HELO HOIST LIFT RING.

14B-F0150

Figure 16-5. Survival/Postejection Procedures (Sheet 11)

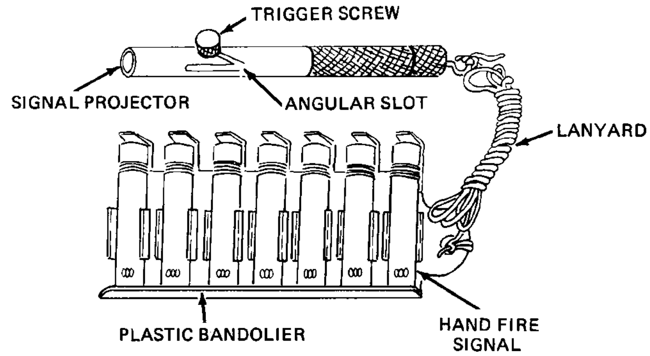
SIGNALING DEVICES

THE FOLLOWING INFORMATION DESCRIBES THE USE OF SIGNALING DEVICES WHILE IN LIFE RAFT AND IS NOT INTENDED TO PRESCRIBE ANY GIVEN ORDER OF PRIORITY WHICH WOULD BE DICTATED BY IMMEDIATE SITUATION OF SURVIVOR.

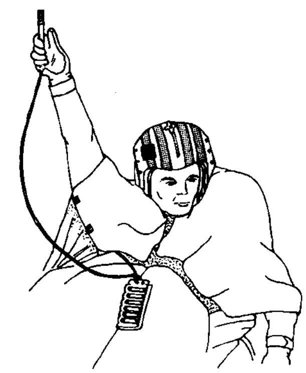
MK-79 MOD 0 ILLUMINATION SIGNAL KIT

WARNING

TO PREVENT PREMATURE LAUNCHING AND POSSIBLE SERIOUS INJURY, ENSURE THAT LAUNCHER IS IN COCKED POSITION PRIOR TO ATTACHING CARTRIDGE FLARE.



1. SCREW CARTRIDGE FLARE INTO LAUNCHER WHILE KEEPING FLARE POINTED IN A SAFE DIRECTION.

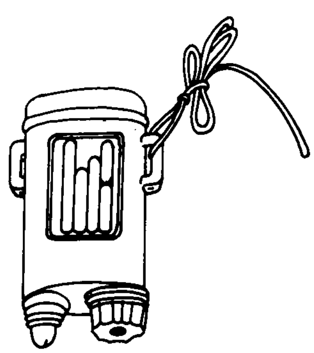


2. HOLD LAUNCHER DIRECTLY OVERHEAD. PULL BACK ON TRIGGER AND RELEASE. FLARE HAS A MINIMUM 4 1/2 SECOND DURATION AND CAN BE LAUNCHED TO ABOUT 200 FEET.

SDU-5/E DISTRESS MARKER LIGHT

NOTE

SDU-5/E IS ACTUATED BY PRESSING BUTTON ON BOTTOM OF LIGHT. EMITS 360° BEAM OF LIGHT THAT FLASHES ATA RATE OF 40 TO 60 FLASHES PER MINUTE FOR APPROXIMATELY 12 HOURS.



SDU-5/E DISTRESS MARKER LIGHT CAN BE ATTACHED TO THE HELMET BY MATING HOOK AND PILE (VELCRO) TAPE. THIS FREES THE HANDS FOR USING OTHER SIGNALING DEVICES WHILE ALLOWING LIGHT TO FLASH UP INTO THE SKY AND REFLECT OFF HELMET.

14B-F0151

Figure 16-5. Survival/Postejection Procedures (Sheet 12)

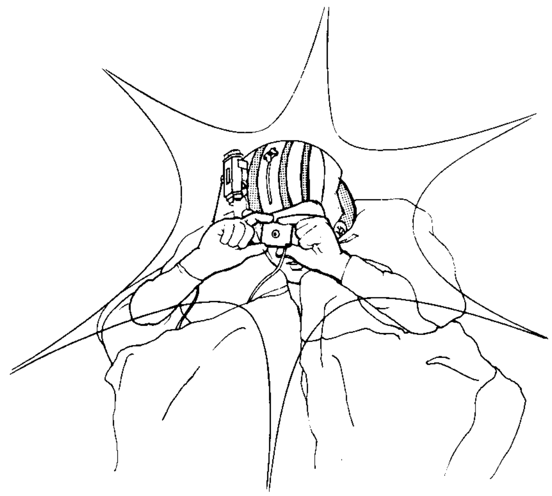
SIGNALING DEVICES (CONTINUED)

EMERGENCY SIGNALING MIRROR

NOTE

MIRROR FLASHES REFLECT LIGHT WITH A BRILLIANCY OF UP TO 8 MILLION CANDLE POWER, AND WITH A RANGE OF 45 TO 50 MILES WHEN SEARCH AIRCRAFT IS AT 5,000 FEET ON A CLEAR DAY.

1. REFLECT SUNLIGHT ONTO NEARBY SURFACE (RAFT, HAND, ETC.),
2. SLOWLY BRING MIRROR UP TO EYE LEVEL AND LOOK THROUGH SIGHTING HOLE. YOU WILL SEE A BRIGHT SPOT.
3. HOLD MIRROR CLOSE TO EYE, SLOWLY TURN AND MANIPULATE SO THAT BRIGHT SPOT IS ON TARGET.
4. EVEN IF NO AIRCRAFT OR SHIPS ARE IN SIGHT, CONTINUE TO SWEEP HORIZON. MIRROR FLASHES CAN BE SEEN FOR MANY MILES EVEN IN BAD WEATHER.



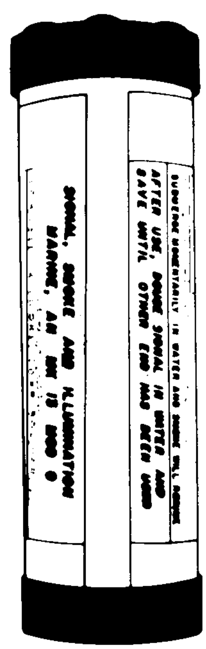
MK-13 MOD 0 MARINE SMOKE AND ILLUMINATION SIGNAL

WARNING

MK-13 MOD 0 SIGNAL MAY REACH A TEMPERATURE THAT IS UNCOMFORTABLE TO HANDLE AFTER IGNITION. USE OF GLOVES IS SUGGESTED.

NOTE

- THE MK-13 MOD 0 MARINE SMOKE AND ILLUMINATION SIGNAL IS USED TO ATTRACT ATTENTION AND TO GIVE WIND DRIFT DIRECTION.
- FLARE BURNS APPROXIMATELY 20 SECONDS WITH APPROXIMATELY 3,000 CANDLE POWER.



IDENTIFICATION:

NIGHT
- RED CAP
- PROTRUSIONS ON CAP.
- METAL WASHER ATTACHED TO LANYARD.

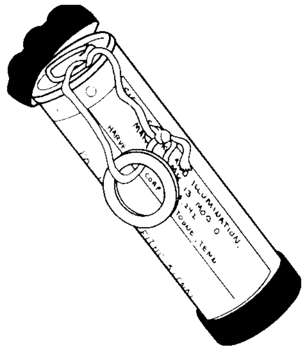
DAY
- ORANGE CAP.
- NO PROTRUSIONS ON CAP.

14B-F0152

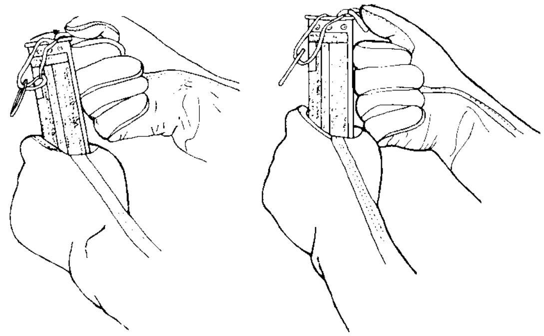
Figure 16-5. Survival/Postejection Procedures (Sheet 13)

SIGNALING DEVICES (CONTINUED)

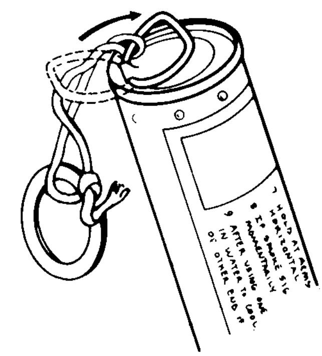
MK-13 MOD 0 MARINE SMOKE AND ILLUMINATION SIGNAL



1. TO USE MK-13 REMOVE CAP FROM DESIRED END.



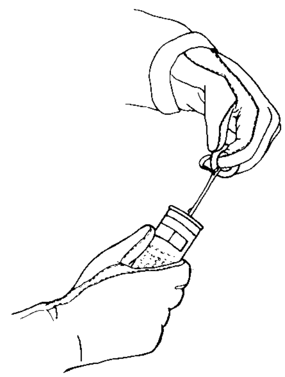
2. PULL FLIP RING OVER RIM TO BREAK LEAD SEAL. IF THE SEAL DOESN'T BREAK, PUSH RING UNTIL IT BENDS AGAINST CASE.



3. PULL BENT FLIP RING BACK TO ORIGINAL POSITION AND USE AS A LEVER TO BREAK SEAL.

NOTE

WHEN MANIPULATING THE FLIP RING, DO NOT USE UNDUE FORCE AS THIS MAY CAUSE THE RING TO SNAP OFF. IF SEAL DOESN'T BREAK, ROCK THE RING FROM SIDE TO SIDE.



4. WHILE HOLDING SIGNAL OVER SIDE OF LIFE RAFT, IGNITE SIGNAL BY A QUICK PULL ON RING.

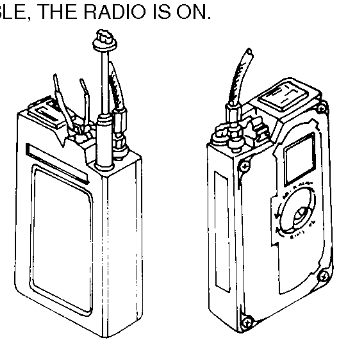
5. IGNITED MK-13 MOD 0 MUST BE HELD AT ARMS LENGTH, DOWN WIND, NO MORE THAN SHOULDER HIGH, AND OVER SIDE OF LIFE RAFT TO PREVENT DAMAGE TO RAFT FROM HOT RESIDUE.

SURVIVAL RADIOS

AN/URT-33A RADIO BEACON SET

NOTE

THE AN/URT-33A MUST BE TURNED OFF WHEN USING THE PRC-90 ON 243.0 MHz TO PREVENT INTERFERENCE. WHEN THE WORD "ON" IS VISIBLE, THE RADIO IS ON.

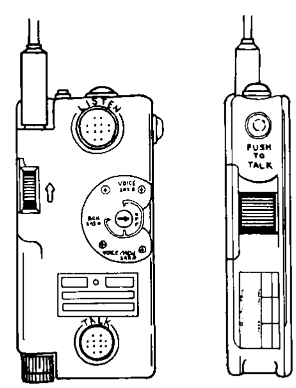


THE AN/URT-33A RADIO AUTOMATICALLY TRANSMITS A SWEPT TONE SIGNAL ON 243.0 MHz WHEN THE EJECTION SEAT LEAVES THE FLOOR OF AIRCRAFT.

NOTE

DUE TO A CONE OF SILENCE EFFECT, DO NOT POINT THE ANTENNA AT RECEIVING AIRCRAFT.

AN/PRC-90 RADIO SET



NOTE

RADIO IS EQUIPPED WITH EXTERNAL EARPHONE AND HELMET CONNECTOR TO ASSIST IN AVOIDING ENEMY DETECTION OR FOR USE IN THE EVENT OF AIRCRAFT RADIO FAILURE.

THE AN/PRC-90 RADIO SET IS A DUAL CHANNEL TRANSMITTER/RECEIVER RADIO. IT TRANSMITS (VOICE MODE) UP TO 60 NM (LINE OF SIGHT). IT OPERATES ON GUARD (243.0 MHz) OR SAR (282.8 MHz) WITH A MODE FOR SWEPT TONE SIGNAL ON 243.0 MHz ONLY. TRANSMISSION OF BEACON/CODE CAN BE UP TO 80 NMI.

14B-F0153

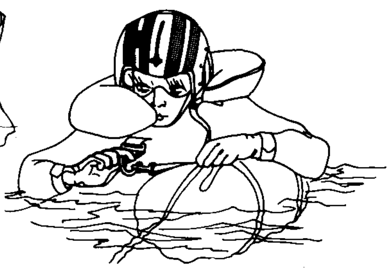
Figure 16-5. Survival/Postejection Procedures (Sheet 14)

RESCUE

IF SURVIVOR PICKUP IS TO BE EFFECTED BY RESCUE HELICOPTER, THE FOLLOWING PROCEDURES SHOULD BE FOLLOWED: (UNASSISTED RESCUE — NO SWIMMER DEPLOYED)

1. STOW OR DISCARD LOOSE GEAR, ROLL OUT OF RAFT ON RIGHT SIDE (SIDE WITH CO-2 CYLINDER).

2. SWIM AWAY FROM RAFT. ENSURE THAT HELMET VISOR HAS BEEN LOWERED.

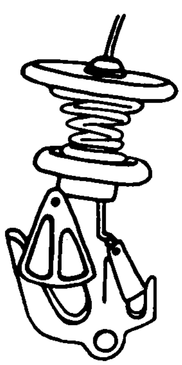


3. REMOVE RAFT RETENTION LANYARD AFTER RESCUE DEVICE HAS BEEN LOWERED.

WARNING

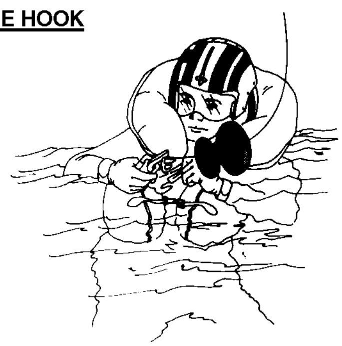
- TO ALLOW DISCHARGE OF STATIC ELECTRICITY AND PREVENT ELECTRICAL SHOCK, AVOID TOUCHING RESCUE DEVICE UNTIL IT HAS MADE CONTACT WITH WATER/GROUND.
- TO AVOID SEVERE INJURY, KEEP HANDS CLEAR OF HOOK AND RING ASSEMBLIES DURING HOISTING.
- DO NOT ATTEMPT TO ASSIST ENTRANCE INTO HELICOPTER OR MOVE FROM THE RESCUE DEVICE UNLESS DIRECTED BY HELICOPTER CREWMAN.

PROCEDURES FOR USE OF THE RESCUE HOOK

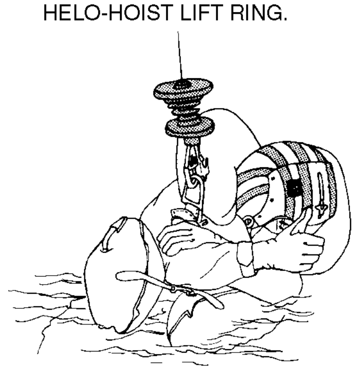


NOTE

THE HELO RESCUE HOOK HAS A SMALL AND A LARGE HOOK. THE LARGE HOOK IS THE PRIMARY HOOK FOR HOISTING PERSONNEL.



1. ATTACH LARGE HOOK TO GATED HELO-HOIST LIFT RING.



2. CROSS ARMS IN FRONT OF CHEST AND PLACE HEAD DOWN AND TO THE LEFT. GIVE THUMBS UP SIGNAL TO HELO-HOIST OPERATOR.

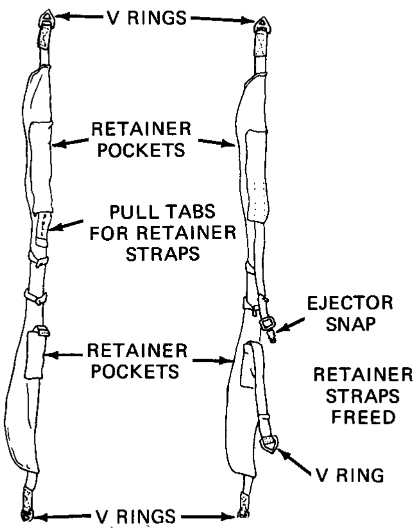
3. POSITION OF AIRCREWMAN DURING HELO-HOIST. UPON CLEARING GROUND/WATER, CROSS FEET.

14B-F0154

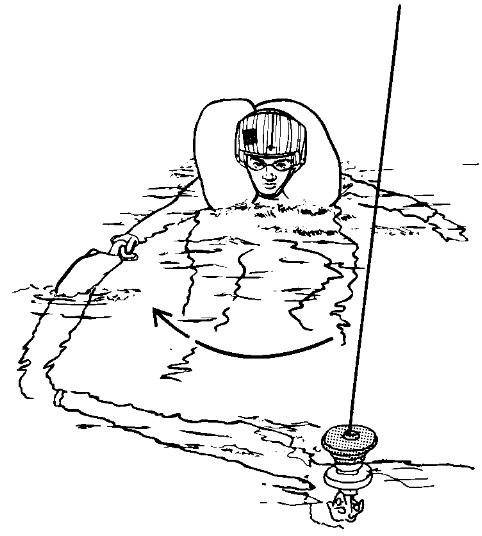
Figure 16-5. Survival/Postejection Procedures (Sheet 15)

RESCUE (CONTINUED)

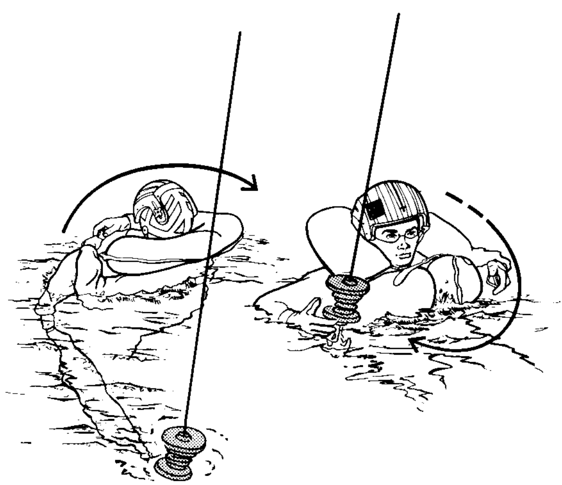
PROCEDURES FOR USE OF THE SURVIVOR'S RESCUE STRAP



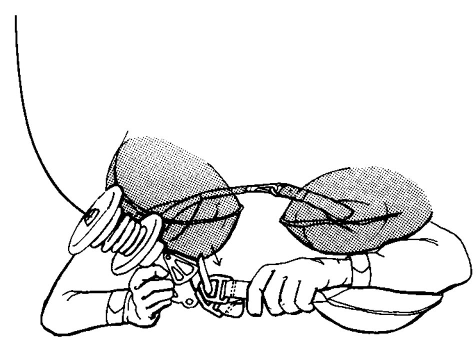
RESCUE STRAP (DESIGNED TO ACCOMMODATE ONE SURVIVOR AT A TIME).



1. GRASP FREE END OF RESCUE STRAP.



2. SWIM IN CIRCLE TOWARD RESCUE HOOK COMPLETELY ENCIRCLING BODY WITH RESCUE STRAP.

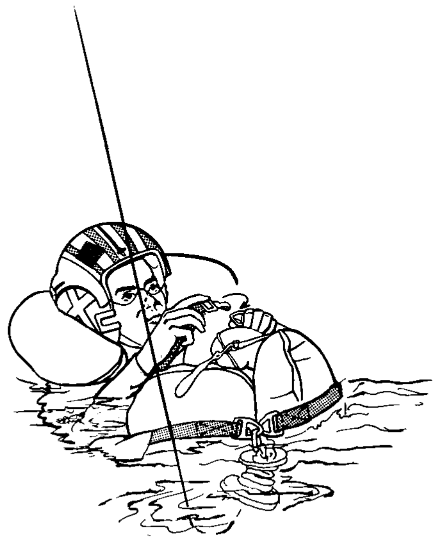


3. ATTACH FREE END OF STRAP TO LARGE HOOK.

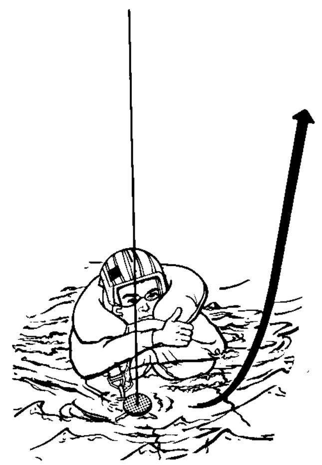
14B-F0155

Figure 16-5. Survival/Postejection Procedures (Sheet 16)

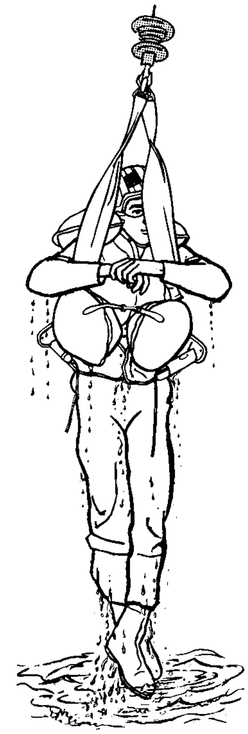
RESCUE (CONTINUED)



4. PULL BOTH RETAINER STRAPS FREE AND CONNECT EJECTOR SNAP TO V-RING OF OTHER RETAINER STRAP. PULL TIGHT.

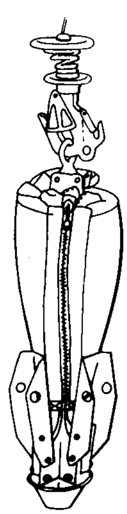


5. ENSURE THAT RESCUE STRAP IS ABOVE LPA WAIST LOBES AND HIGH ON BACK. WRAP ARMS AROUND STRAP AND PLACE HANDS IN ARMPITS. KEEP HEAD DOWN, AND GIVE THUMBS UP SIGNAL TO HELO-HOIST OPERATOR.

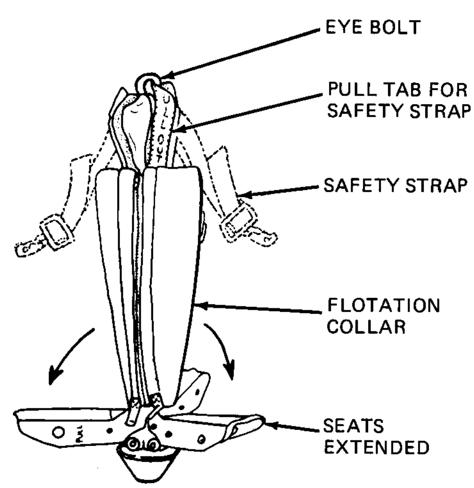


6. POSITION OF AIR-CREWMAN DURING HOIST. UPON CLEARING WATER, CROSS FEET.

PROCEDURES FOR USE OF THE FOREST PENETRATOR



FOREST PENETRATOR WITH FLOTATION COLLAR SHOWING SEATS RETRACTED (SAFETY STRAPS OMITTED TO SHOW CONNECTION OF RESCUE HOOK TO EYE-BOLT).



FOREST PENETRATOR WITH FLOTA-TION COLLAR SHOWING SEATS EXTENDED.

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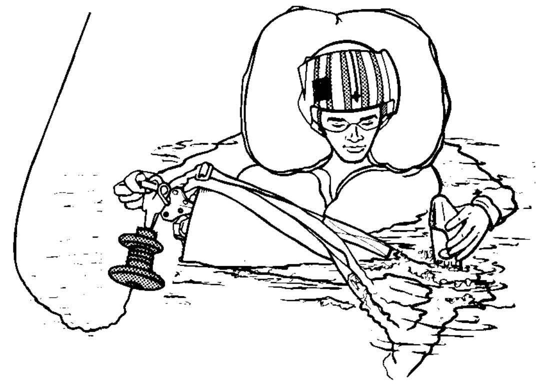
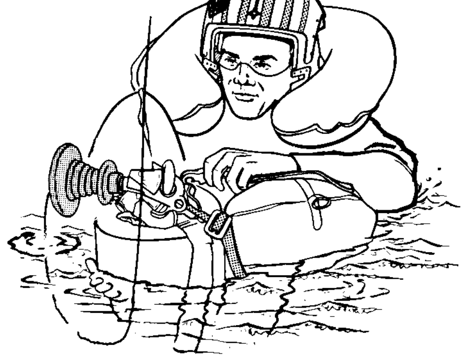
Figure 16-5. Survival/Postejection Procedures (Sheet 17)

RESCUE (CONTINUED)

1. UNSNAP LPA WAIST LOBES.



2. EXTEND ONLY ONE SEAT ON FOREST PENETRATOR.



3. SIT ON SEAT FACING FLOTATION COLLAR. USING ELBOWS, SEPARATE LPA WAIST LOBES AND PULL SHAFT OF PENETRATOR CLOSE TO CHEST.

4. PASS SAFETY STRAP UNDER ARM, AROUND BACK, AND UNDER OTHER ARM. CONNECT SAFETY STRAP AND TIGHTEN.

5. TURN HEAD DOWN AND TO THE LEFT. GIVE THUMBS UP SIGNAL TO HELO-HOIST OPERATOR.

6. UPON CLEARING WATER, CROSS FEET

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Figure 16-5. Survival/Postejection Procedures (Sheet 18)

ENGINE FIRE ON THE GROUND

*1. BOTH FUEL SHUTOFF HANDLES . . . . . . PULL

*2. BOTH THROTTLES . . . . OFF

UNCOMMANDED ENGINE ACCELERATION ON DECK

*1. PADDLE SWITCH . . . . . DEPRESS AND HOLD

*2. THROTTLE(S) . . . . AS DESIRED

*3. ENGINE MODE . . . . SEC

*4. THROTTLE MODE . . . . MAN

BRAKE FAILURE AT TAXI SPEED

*1. ANTI-SKID/SPOILER
BK SWITCH . . . . SPOILER BK OR OFF

ABORTED TAKEOFF

*1. THROTTLES . . . . IDLE

*2. SPEED BRAKES . . . . EXTEND

*3. STICK . . . . AFT

*4. HOOK . . . . DOWN (1,000 FEET
BEFORE WIRE)

*5. BRAKES . . . . AS REQUIRED

*6. RIGHT ENGINE . . . . OFF (IF REQUIRED)

SINGLE ENGINE FAILURE/WAVEOFF (TAKEOFF CONTINUED)

*1. SET 10° PITCH ATTITUDE (14 UNITS AOA MAXIMUM).

*2. RUDDER . . . . OPPOSITE ROLL/YAW
SUPPLEMENTED BY LATERAL STICK

*3. BOTH THROTTLES . . . . AS REQUIRED

*4. LANDING GEAR . . . . UP

*5. JETTISON . . . . IF REQUIRED

BLOWN TIRE DURING TAKEOFF/LANDING

TAKEOFF ABORTED OR AFTER LANDING TOUCHDOWN:

*1. NOSEWHEEL STEERING . . . . ENGAGED

*2. ANTI-SKID/SPOILER
BRAKE SWITCH . . . . SPOILER BK

TAKEOFF CONTINUED OR AFTER LANDING GO-AROUND

*1. BOTH THROTTLES . . . . AS REQUIRED

*2. GEAR/FLAPS . . . . LEAVE AS SET

FIRE WARNING LIGHT AND/OR FIRE IN FLIGHT

*1. THROTTLE (AFFECTED ENGINE) . . . . . . IDLE

*2. AIR SOURCE . . . . OFF

IF LIGHT GOES OUT AND NO SECONDARY INDICATIONS:

*3. MASTER TEST . . . . FIRE DET TEST

IF LIGHT IS ON, FIRE DET TEST FAILS, OR SECONDARY INDICATIONS:

*4. FUEL SHUTOFF HAND (AFFECTED
ENGINE) . . . . PULL

*5. THROTTLE (AFFECTED ENGINE) . . . . OFF

*6. CLIMB/DECELERATE.

*7. FIRE EXTINGUISHER . . . . DEPRESS

AICS MALFUNCTION

IF INLET AND/OR RAMPS LIGHT IS ILLUMINATED:

*1. AVOID ABRUPT THROTTLE MOVEMENTS.

*2. DECELERATE TO BELOW 1.2 IMN.

*3. AFFECTED INLET RAMP SWITCH . . . . . STOW

UPRIGHT DEPARTURE/FLAT SPIN

*1. STICK . . . . . . FORWARD/NEUTRAL LATERAL
HARNESS . . . . LOCK

*2. THROTTLES . . . . BOTH IDLE

*3. RUDDER . . . . OPP TURN NEEDLE/YAW

IF NO RECOVERY:

*4. STICK . . . . INTO TURN NEEDLE

IF YAW RATE STEADY/INCREASING OR SPIN ARROW FLASHING OR EYEBALL-OUT G SENSED:

*5. ROLL SAS — ON, STICK — FULL INTO TURN NEEDLE AND AFT.

IF RECOVERY INDICATED:

*6. CONTROLS . . . . NEUTRALIZE

*7. RECOVER AT 17 UNITS AOA, THRUST AS REQUIRED.

IF FLAT SPIN VERIFIED BY FLAT ATTITUDE, INCREASING YAW RATE, INCREASING EYEBALL-OUT G, AND LACK OF PITCH AND ROLL RATES:

*8. CANOPY . . . . JETTISON

*9. RIO . . . . COMMAND EJECT

INVERTED DEPARTURE/SPIN

*1. STICK . . . . FULL AFT/
NEUTRAL LATERAL HARNESS . . . . LOCK

*2. BOTH THROTTLES . . . . IDLE

*3. RUDDER . . . . OPP TURN NEEDLE/YAW

Figure 16-6. Emergency Procedures Checklist (Sheet 1 of 2)

IF RECOVERY INDICATED:

*4. CONTROLS .... NEUTRALIZE

*5. RECOVER AT 17 UNITS AOA, THRUST AS REQUIRED.

IF SPINNING BELOW 10,000 FT AGL:

*6. RIO .... COMMAND EJECT

COMPRESSOR STALL

*1. UNLOAD AIRCRAFT (0.5 TO 1.0 G)

IF GREATER THAN 1.1 IMN:

*2. BOTH THROTTLES .... MIL

WHEN 1.1 IMN OR LESS:

*3. BOTH THROTTLES .... SMOOTHLY TO IDLE

IF EGT ABOVE 935 °C AND/OR ENGINE RESPONSE ABNORMAL

*4. THROTTLE (AFFECTED ENGINE) .... OFF

ENGINE FLAMEOUT

*1. THROTTLE .... IDLE OR ABOVE

*2. BACKUP IGNITION .... ON

IF HUNG START OR NO START:

*3. THROTTLE .... CYCLE OFF THEN IDLE

IF STILL HUNG OR NO START:

*4. ENG MODE .... SEC

IF BOTH ENGINES FLAMED OUT/INOP OR CROSS-BLEED NOT POSSIBLE:

*5. AIRSPEED .... 450 KIAS (ALTITUDE PERMITTING)

ELECTRICAL FIRE

*1. L AND R GENERATORS .... OFF

IF UNCOMMANDED SAS OR SPOILER INPUTS PRESENT:

*2. PITCH, ROLL AND YAW STAB AUG SWITCHES .... OFF

ECS LEAK/ELIMINATION OF SMOKE AND FUMES

*1. AIRSOURCE PUSHBUTTON .... OFF

*2. IF SMOKE OR A FUMES PRESENT:

a. ALTITUDE .... BELOW 35,000 FT

b. CABIN PRESSURE SWITCH ..... DUMP

*3. RAM AIR SWITCH .... INCREASE

CANOPY LIGHT

*1. CANOPY HANDLE .... BOOST (CANOPY REMAINING)

*2. EJECT CMD LEVER .... PILOT

UNCOMMANDED ROLL/YAW

*1. IF FLAP TRANSITION:
FLAP HANDLE .... PREVIOUS POSITION

*2. RUDDER AND STICK .... OPPOSITE ROLL/YAW

*3. AOA .... BELOW 12 UNITS

*4. DOWNWING ENGINE .... MAX THRUST (IF REQUIRED)

*5. MASTER RESET .... DEPRESS

Figure 16-6. Emergency Procedures Checklist (Sheet 2)

PART VI

All-Weather Operations

CHAPTER 17

Instrument Procedures

17.1 AUTOMATIC CARRIER LANDING SYSTEM

ACLS approaches apply to properly configured aircraft utilizing carrier or shore-based AN/SPN-10, or AN/SPN-42 ACLS radar facilities. Three primary modes of operation and two submodes are available.

1. Mode I approach automatically controlled to touchdown.

2. Mode IA approach automatically controlled to a minimum of 200 feet and 0.5 mile; manual control remainder of approach.

3. Mode IIT approach manually controlled using AN/SPN-41 or AN/SPN-42 VDI and/or HUD presentation for glideslope and lineup information as well as information from the CCA controller.

4. Mode III approach manually controlled using only CCA-controller-supplied information.

17.1.1 Mode I. Mode I provides a fully automatic, hands-off landing capability, called automatic carrier landing or all-weather landing. The landing radar system (AN/SPN-42) tracks the aircraft and compares its position with the desired position. The aircraft position is corrected to fly the desired glidepath by commands from the Naval Tactical Data System using the radar computer. These commands are transmitted over the UHF data link to the aircraft where the automatic flight control system executes the pitch and bank commands. Additional ramp input commands tailored to each specific ship or field are applied at the proper time to assist the aircraft through the burble. In addition to control of the aircraft, discrete words and glideslope error signals are transmitted for cockpit displays to show the pilot where the aircraft is in relation to the desired glideslope. Independent glideslope error signals from the AN/SPN-41 instrument landing system may also be displayed. The pilot may take control at any time and continue the landing to mode II. An approach that is automatically controlled to a minimum of 200 feet and 0.5 mile, then manually controlled to a landing, is called a mode IA approach.

17.1.2 Mode II. The control of the aircraft remains with the pilot along the entire glideslope to touchdown. Glideslope error signals are transmitted to the aircraft for cockpit displays from the AN/SPN-41 or the AN/SPN-42. The pilot flies the aircraft to null the error and to keep the vertical and lateral crosshairs centered. During a mode IIT approach, the final controller provides a mode III type talk down to assist the pilot in flying the needles.

17.1.3 Mode III. The pilot flies the aircraft in response to voice radio commands from the final controller to keep the aircraft on the proper glideslope. From the radar azimuth and elevation displays, the final controller determines the aircraft position with respect to the desired glidepath and gives guidance to the pilot.

17.2 AIRCRAFT SUBSYSTEMS

Mode I (automatic) landings are possible only if the ACLS installation, including data link, DFCS, radar beacon and augmentor, INS, and ACLS displays (VDI and/or HUD) are all fully operational. The approach power compensator should be used during the coupled portion of the approach. Mode II (manual) landings can be made using displayed cross-pointer information from either the data link or the AN/ARA-63 receiver decoder, or both (providing dual displays).

17.2.1 Data Link. Data-link (link 4A) messages are received and transmitted by a UHF frequency-shift-key-modulated radio link. Data link receives control messages in serial form from the NTDS and processes each message as necessary. For ACL, the position error information is furnished to the VDI and/or HUD needles, discrete messages appear on the digital data indicator panel, and control information is provided for the DFCS.

Reply messages are transmitted to the NTDS with detailed information on aircraft heading, speed, altitude, fuel quantity, weapons, stores, and autopilot status.

The shipboard data link continuously transmits a UTM and a MCM. When in operation, the UTM or MCM is used by the aircraft as a self-test feature. The aircraft data-link system self-test is performed by selecting ACL on the VDI and/or HUD (declutter off) and AWL/PCD (precision course direction) steering on the pilot display control panel.

Selection of D/L RAD on the pilot MASTER TEST panel will initiate test with the MCM. See Figure 17-1 (sheets 1 and 2) for correct display indications.

17.2.2 Digital Flight Control System. The DFCS performs two functions: stability augmentation and autopilot.

Stability augmentation (STAB AUG) provides added stability to the aircraft and is, in general, necessary for effective aircraft control.

The autopilot ACL mode can be engaged only after engaging all STAB AUG axes and then by placing the AUTO PILOT ENGAGE switch in ON. Selection of ACL on the AFCS control panel arms the mode and illuminates the A/P REF light on the pilot DDI panel. A/P REF indicates that an DFCS pilot relief mode has been selected (in this case, ACL), but not engaged. The pilot engages ACL through the reference engage switch on the stick grip, at which time the A/P REF warning light goes out.

Note

If a pitch parallel-actuator force-link disconnect occurs prior to an ACLS approach, the A/P REF warning light may go out when coupling is attempted, but the aircraft will not respond to SPN-42 commands and the aircraft will uncouple when the first pitch commands are received.

Following ACL engagement, the pilot can take control of the aircraft by simply overriding the data-link commands with the control stick. This causes immediate disengagement, and the DFCS will again revert to STAB AUG. Refer to Chapter 2, Automatic Carrier Landing System, for further information on ACL.

17.2.3 AN/APN-154 Radar Beacon. The radar beacon enhances aircraft tracking (range and accuracy) by ship and/or ground-based I-band radars for precision vectoring. Pulsed (coded) I-band signals transmitted by the surface radar station are received by the beacon and decoded; if they match the mode (six available) selected by the RIO, the beacon responds with a return pulse to the radar site. The reply signal, considerably stronger than a normal radar echo, enhances the radar acquisition and tracking capability of the surface station.

17.2.4 ACLS Beacon Augmentor (R-1623). The beacon augmentor is a crossband receiver that extends the tracking capability of the AN/SPN-42 shipboard radar with the capability of operating with either or both channels of the AN/SPN42 without interference.

The beacon augmentor eliminates radar scintillation by providing a large source of reply energy from one point on the aircraft. The beacon augmentor receives interrogations from the AN/SPN-42 carrier-based radar in the kA-band at 33.0 to 33.4 GHz, processes them, and retransmits modulated I-band pulses at 8.8 to 9.5 GHz to the AN/SPN-42, which has an I-band receiving system mounted contiguous with the basic kA-band radar transmitting antenna. The unique feature of the augmentor is that it uses the AN/APN-154 beacon as its I-band transmitter. This is accomplished by coupling the output of the augmentor to the AN/APN-154 and triggering its modulator and transmitter. During the landing phase, it is necessary to manually place the radar beacon MODE switch to ACLS. In this mode the AN/APN-154 receiver is disabled to ensure that I-band signals in the area will not trigger the AN/APN-154 transmitter during landing.

17.2.4.1 Beacon Controls. The RADAR BEACON panel (Figure 17-2) is on the RIO right console. POWER or STBY can be used for radar beacon warm-up; to preclude response to a premature or unintentional interrogation, the STBY (ACLS not selected) position should be used.

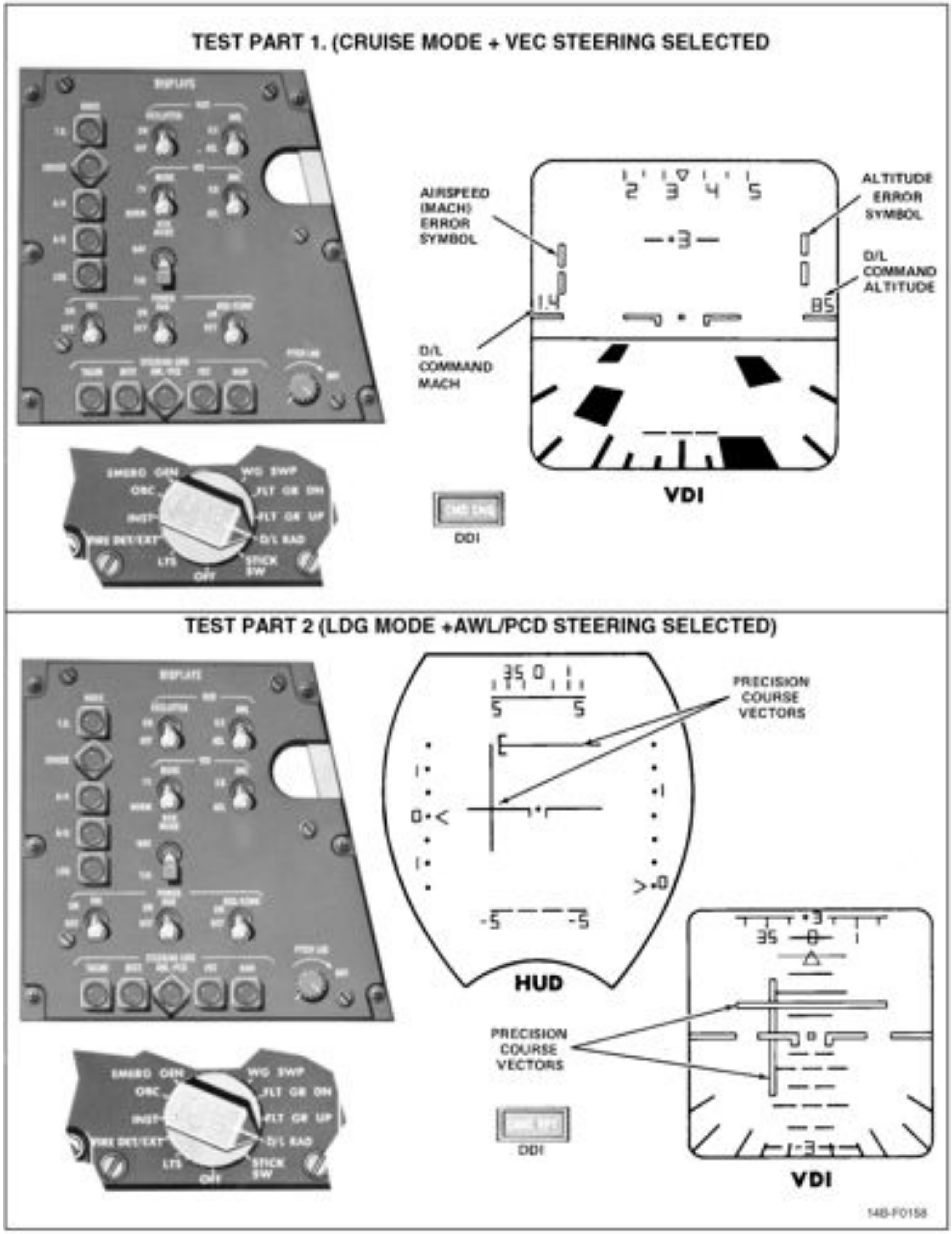


Figure 17-1. D/L Displays for D/L RAD (Sheet 1 of 2)

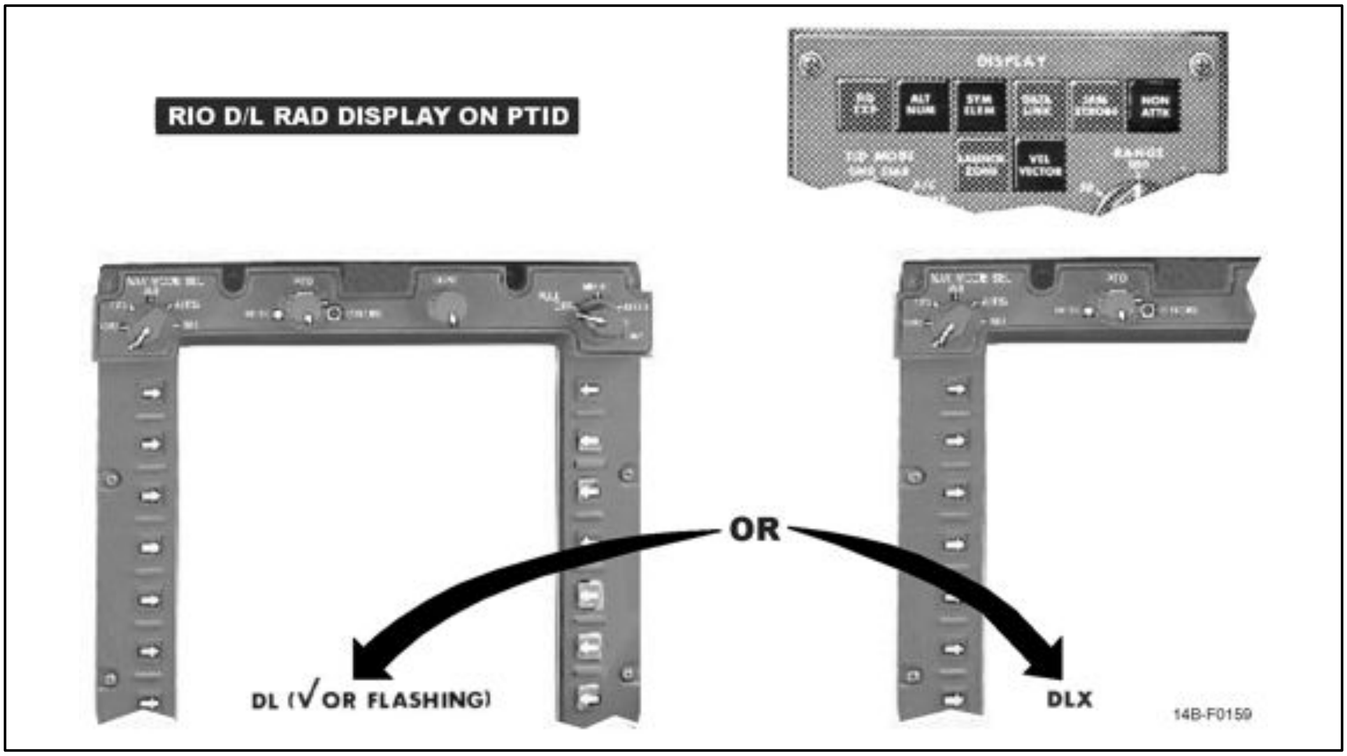


Figure 17-1. D/L Displays for D/L RAD (Sheet 2)

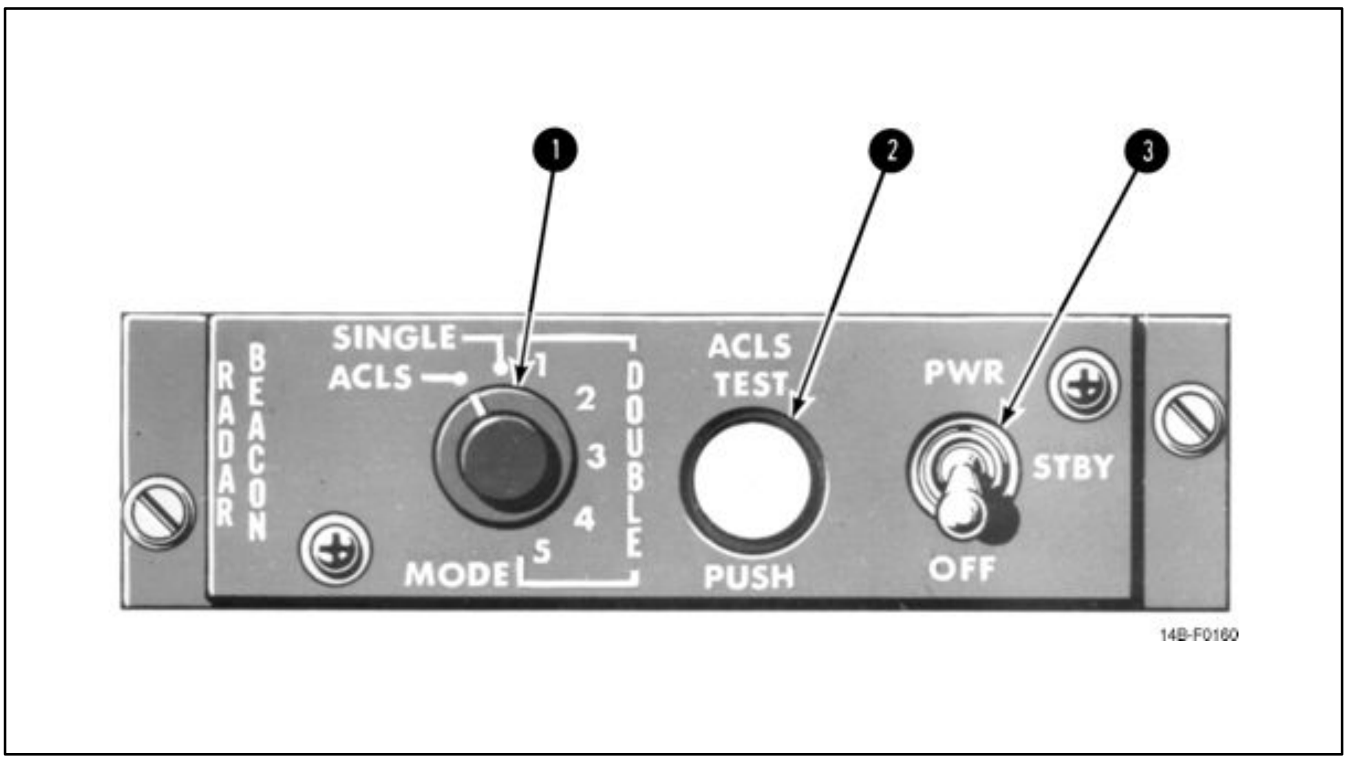


Figure 17-2. Radar Beacon Panel (Sheet 1 of 2)

NOMENCLATURE	FUNCTION
1 MODE switch	SINGLE — Limits beacon response to single pulse of any group received. DOUBLE — Beacon response to one of five double-pulse interrogations. ACLS — Enables augmentor operation. **WARNING** ACLS shall not be selected on the flight deck when the power switch is in STBY or PWR, or during the 5-minute beacon warm up period.
2 ACLS TEST light/ pushbutton	On (green) — Indicates a AN/SPN-42 lockon in ACLS mode; when pressed with radar beacon mode selector in ACLS, indicates a satisfactory self-test of ACLS mode only. Flashing — Indicates AN/SPN-42 is sweeping through aircraft but has not locked on. Intermittent — During self-test indicates a fault in the ACLS mode only. (or no light)
3 Power switch	PWR — With radar beacon mode selector in ACLS, enables I-band to Ka-band interrogations. STBY — With radar beacon MODE switch in ACLS, enables I-band replies to Ka-band interrogations; used for warmup with radar beacon MODE switch in SINGLE or DOUBLE. **NOTE** The beacon will warm up with the switch in either position STBY or PWR. To prohibit response to premature or unintentional interrogations, warm-up should be accomplished in STBY. For optimum performance allow 5-minute warm-up. OFF — Turns off all power to radar beacon.

Figure 17-2. Radar Beacon Panel (Sheet 2)

There are no cockpit displays for the beacon, although the ACLS TEST button will be illuminated if the beacon is responding during an ACLS approach. A selfcheck of the beacon ACLS mode is accomplished by depressing the ACLS TEST or performing an on-board check. Either of these two use the receiver video processing circuits of the augmentor in the same manner as a kA-band input from the AN/SPN-42. If operation of the receiver is normal, the ACLS TEST pushbutton light on the RADAR BEACON panel will illuminate. A BAG acronym will be displayed when performing an OBC and in the event of a beacon augmentor failure.

The radar beacon has a minimum warm-up time of 5 minutes. During this time, failure indications will be displayed and self-test results should be regarded as inconclusive. A NO GO light during OBC should be verified by depressing the ACLS TEST pushbutton. If the ACLS test light illuminates, the system is functioning regardless of the NO GO light indication.

WARNING

If the aircraft is parked on the flight deck aft of the island, the radar beacon should be in either OFF or STBY with ACLS not selected. With ACLS selected, stray energy can trigger beacon response and may seriously degrade performance or preclude lock on of aircraft attempting ACLS approaches. After shipboard arrestment and upon clearing the landing area, the radar beacon power switch should be turned to OFF to prevent possible beacon signal interference with other aircraft.

Note

Do not depress the ACLS TEST pushbutton after coupling on a mode I approach as it will cause the ground station to break lock.

17.2.5 APC Performance. For successful mode I and mode IA ACLS approaches, it is essential that the APC be functioning satisfactorily. Sluggish APC performance or its inability to maintain on-speed accurately during the approach will result in degraded control on the glideslope and unacceptable touchdown dispersion.

A properly functioning APC should hold the aircraft on-speed ±0.5 units throughout the majority of the approach. At tipover, the aircraft may accelerate to as much as 2 units fast but should correct to on-speed within 5 seconds. The APC should be checked for satisfactory operation prior to coupling. If the performance of the APC does not meet the above criteria, the approach should be downgraded to mode II.

17.2.6 ACLS Displays (VDI and HUD). ACLS and ILS steering information can be displayed on the VDI and the HUD (Figure 17-3). When the AWL/PCD pushbutton is depressed, final determination of the display submode is governed by the AWL switches on the pilot display control panel, which provides for separate ILS and ACLS selection for both the HUD and VDI.

This enables any mix of ILS (AN/SPN-41/AN/ARA-63) or ACL (AN/SPN-42/data link) displays at the pilot's option. Basically the two displays are the

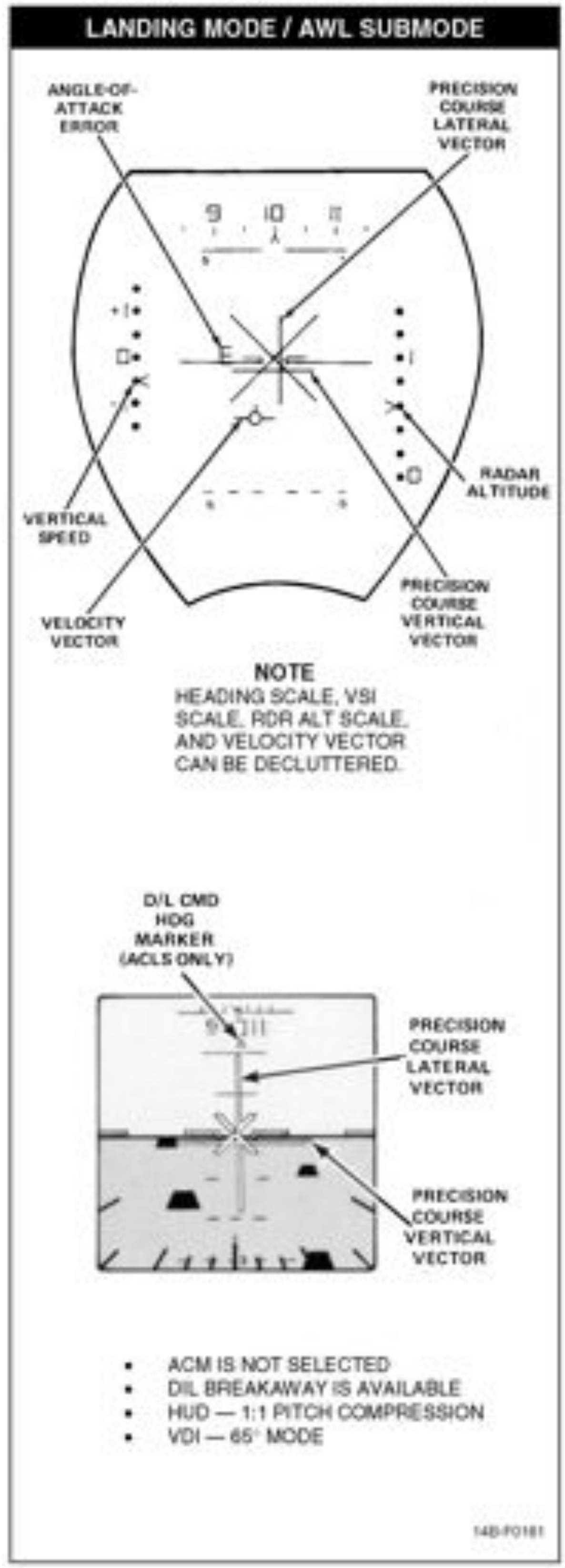


Figure 17-3. ACLS/ILS Mode Displays

same except for the driving source: ILS or ACL. The one difference is that in the ACL mode, the VDI displays a command heading marker. This marker, during AN/SPN42 approaches, indicates final bearing.

The ILS steering displays glideslope information in the form of precision course vectors. A vertical vector is used for a azimuth steering while the horizontal vector is for elevation. The pair form a crosspointer and are displayed on the HUD and VDI simultaneously. On the HUD, full-scale deflection will cause the vectors to deflect 2°. The vectors are limited to this deflection in order to ensure that the displayed symbol will always have an intersection. The VDI vector symbols have a 1.5-inch full scale deflection.

The ACL submode also uses the pair of precision course vectors but they are driven by the data link instead of the AN/ARA-63 receiver decoder. Normal operating procedure for mode selection is to select ILS display for the HUD and ACL display for the VDI.

Additionally, certain ACLS commands that are uplinked to aircraft via the data-link system are displayed to the RIO on the DDI and the pilot's repeater (Figure 17-4).

Note

For more detailed information on the DDI, refer to NAVAIR 01-F14AAA-1A.

17.2.7 AN/ARA-63 Instrument Landing System. The aircraft ILS uses the AN/ARA-63 receiver decoder to process AN/SPN-41 information. This system is used for manual instrument landing approaches or as an independent monitor during final approach with the ACLS. The AN/ARA-63 decoder panel (Figure 17-5) is located on the pilot right-side outboard console.

The aircraft system receives and decodes glideslope azimuth and elevation signals that are converted into command fly-to indications in the CSDC and displayed on the VDI and/or HUD in the landing mode (Figure 17-3). During ACL, the pilot normally displays ILS information on the HUD and selects ACL symbology on the VDI. If the ILS or ACL landing submodes selected on the pilot display control panel become invalid, the VDI will revert to a basic landing mode. The basic landing mode does not display the vertical and lateral cross-bars for glideslope error and does not provide a waveoff signal.

Note

The ILS has a minimum warmup time of 1 minute. During this time, a failure indication should be disregarded.

The ILS performs a self-test when the BIT pushbutton on AN/ARA-63 decoder panel is depressed and held. Response to the ILS self-test is displayed, providing the HUD and VDI MODE switches are set to ILS. The correct ILS landing mode display on the HUD and VDI during system checkout shows the vertical precision course vector symbol slowly oscillating on the right side of the display, then on the left side. The horizontal precision course vector symbol remains stationary in the center of the display.

17.2.8 PTID AOA, VV, ILS, and ACLS (AVIA) Displays. AOA, VV, ILS, and ACLS are displayed on the PTID when data-link (D/L) function button No. 4 on the computer address panel is selected.

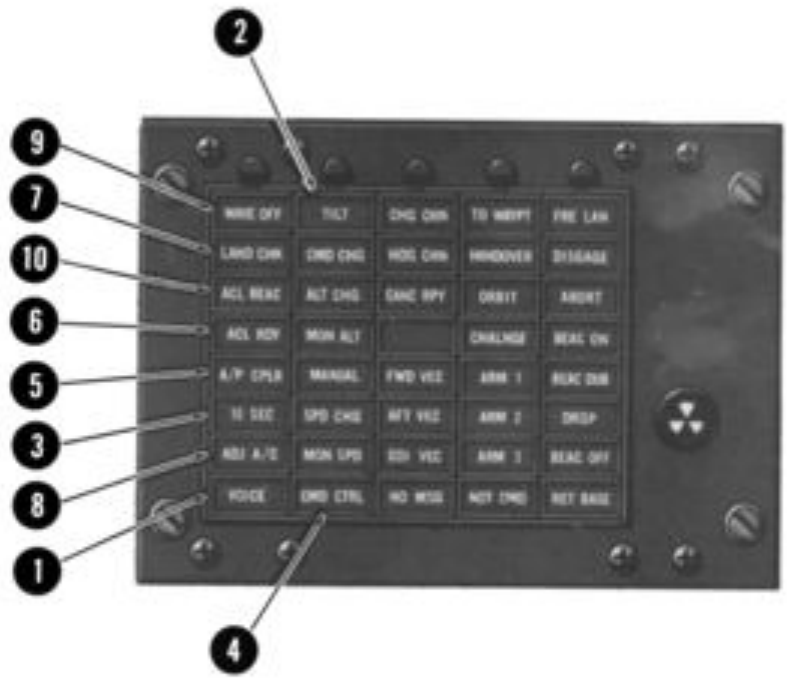
Note

- Having any of the following modes active or the associated display posted on the PTID at the time of AVIA display selection will inhibit posting of the AVIA display:

  1. Nav Grid
  2. IFT Menu
  3. IFT
  4. IFT D/L
  5. A/G
  6. TARPS

- When AVIA displays are selected, an "M" appears on the PTID momentarily indicating tape read.

PILOT'S DDI REPEATER



RIO'S DIGITAL DATA INDICATOR (DDI)

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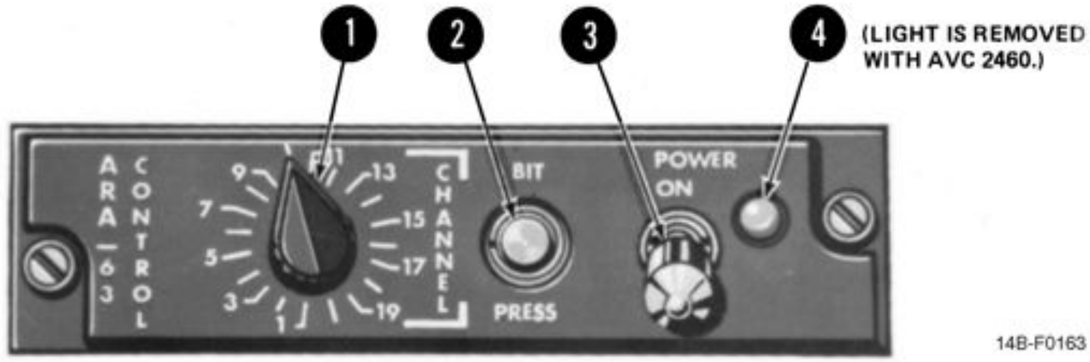
Figure 17-4. ACL Advisory Lights (Sheet 1 of 2)

NOMENCLATURE	FUNCTION
1 VOICE	Indicates carrier air traffic control center (CATCC) (AN/SPN-42) not available for ACL. Standard voice commands to be used, and select ILS or tacan steering for display.
2 TILT	Indicates no data link (D/L) update for last 2 seconds during ACL mode. Disengages (automatically) the DFCS. For modes other than ACL, it indicates no message received during last 10 seconds, therefore the RIO should change antenna position.
3 10 SECONDS	During ACL, indicates ships motion is added to glidepath information and D/L commands. For other modes indicates 10 seconds or less before any action indicates for an arrival at a specific point in the approach path.
4 CMD CONTROL	Indicates aircraft is under D/L control for landing.
5 AP CPLR	Indicates that the aircraft can be coupled to the ACL system for a Mode I or Mode IA approach. Remains illuminated in conjunction with the CMD CONTROL warning light after coupling is accomplished.
6 ACL READY	Indicates aircraft has been acquired by CATCC and that glidepath information is being transmitted to aircraft for zero pitch and zero bank. Error symbols are not available on the VDI.
7 LANDING CHK	Indicates CATCC has a channel available for ACL and that aircraft should be prepared for carrier landing. Complete appropriate landing checklist. Positive D/L contact has been established.
8 ADJ A/C	Indicates that an aircraft is in (or close to) own aircraft's traffic pattern.
9 WAVE OFF	Indicates unsafe condition for landing' execute briefed wave-off procedures. Automatic DFCS disengagement and aircraft reverts to manual control.
10 ACL BEAC (RIO only)	Informs RIO that CATCC requests that AN/APN-154 beacon should be turned on.

Figure 17-4. ACL Advisory Lights (Sheet 2)



NOMENCLATURE	FUNCTION
1 CHANNEL selector	Twenty possible channel selections by rotation of selector knob.
2 BIT PRESS-to-test	Depressing button activates BIT test circuitry. Landing symbols available on button VDIG if LDG MODE and AWL/PCD steering are selected on pilot display control panel (PDCP) and ILS is selected on the HUD MODE or VDI MODE switches.
3 POWER switch (lock-lever)	ON — Activates receiver decoder for all-weather carrier landing. OFF — Turns system off. Lock-lever switch must be lifted to OFF.
4 Indicator light (light is removed with AVC 2460)	Lights when AN/ARA-63 is on.

Figure 17-5. AN/ARA-63 Decoder Panel

Both landing and nonlanding modes are available for display. The pilot determines the mode by selecting on the pilot display panel either LDG for landing mode or any other mode selection for nonlanding mode. In either mode, AOA and VV are indicated by a moving caret and a fixed scale.

Note

When AVIA displays are selected, targets will be inhibited on the PTID.

17.2.8.1 Angle-of-Attack Vertical Velocity. In landing mode, AOA scale range extends from 10 to 20 units AOA and, in nonlanding mode, from 0 to 20 units. A brightened line (-) in landing mode represents 15 units AOA. Vertical velocity (in feet per minute) is scaled from +500 to –1,500 in the landing mode and from +5,000 to –5,000 in the nonlanding mode (see Figure 17-6 and Figure 17-7).

Note

- Twenty units of AOA is the maximum value obtainable from the CSDC for display on the PTID.
- The PTID display of AOA may vary a maximum of ±1.5 units from the pilot AOA indicator; therefore, the pilot indicated AOA remains the primary reference.

When aircraft vertical velocity exceeds the scale limits, the caret indicator flashes and a dot appears inside the caret indicating an exceeded condition. At 18 units of AOA in either landing or nonlanding mode, the caret indicator begins flashing and is pegged with a dot inside the caret at 20 units.

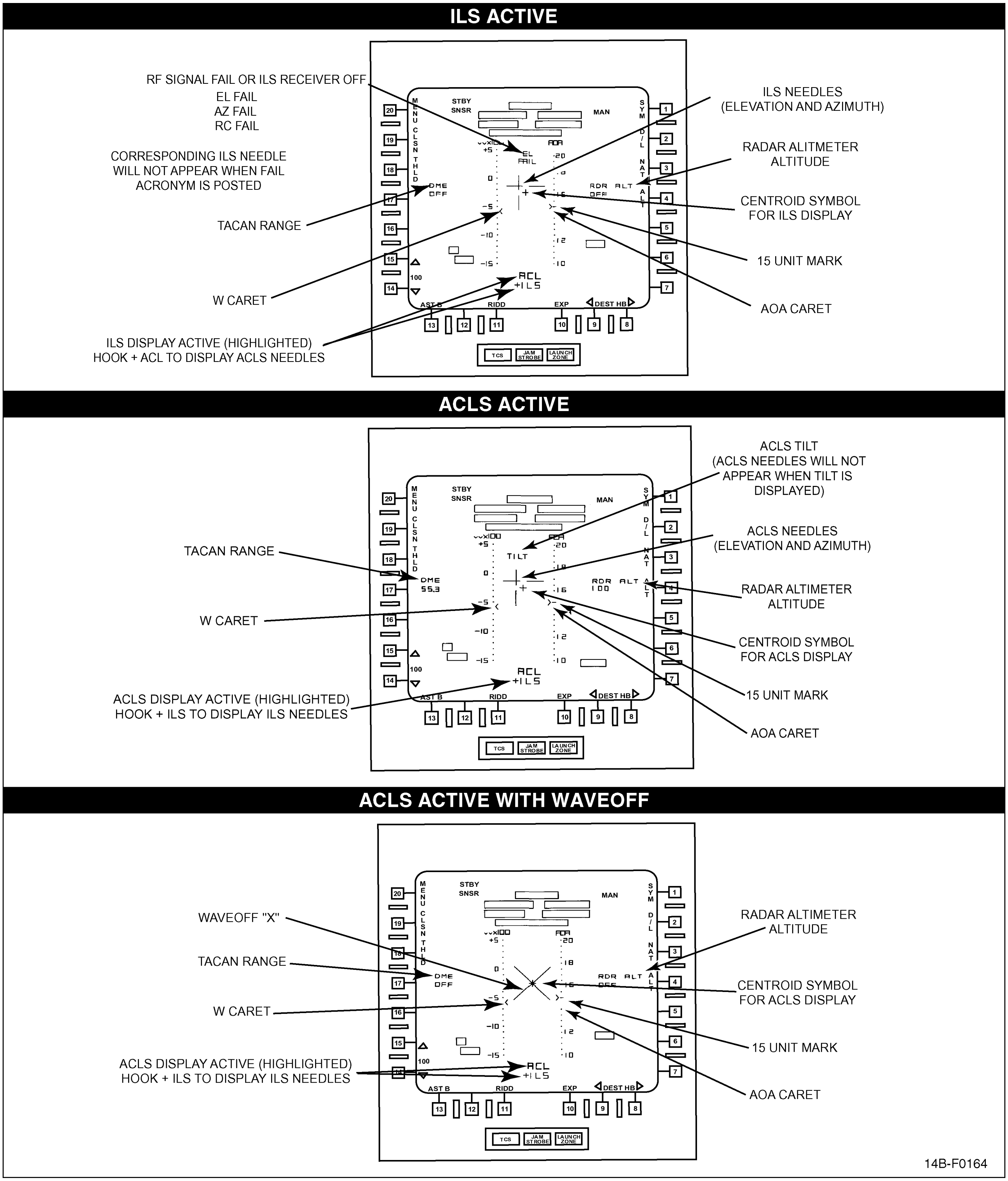


Figure 17-6. PTID Landing Mode Displays, ILS Active

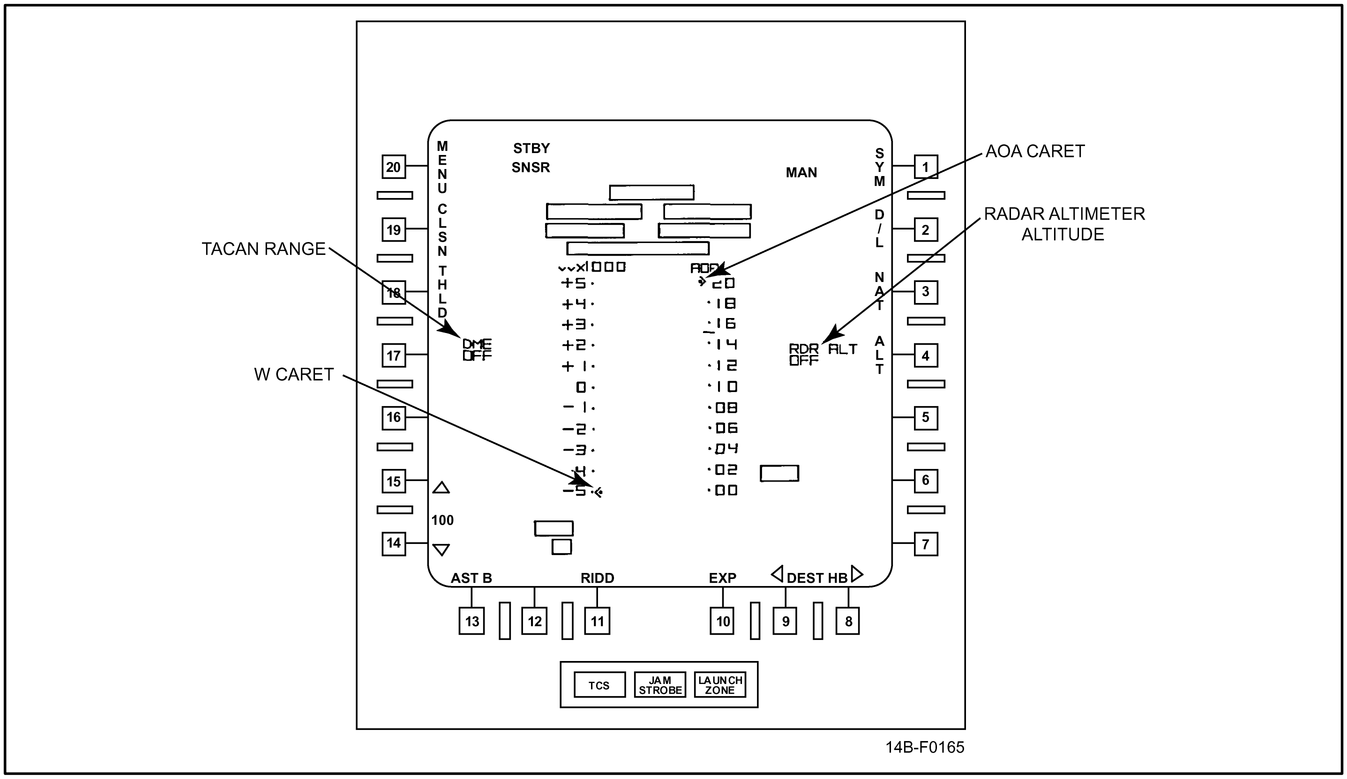


Figure 17-7. PTID Nonlanding Mode Display

17.2.8.2 Instrument Landing System. ILS and ACLS data, which provides vertical glideslope error and lateral displacement error, is presented in landing mode only. In both landing and nonlanding modes, azimuth and elevation errors from the reference glidepath are displayed on the PTID as moveable, crossed vectors (needles) (see Figure 17-6).

Note

- Fly the aircraft into the needles to correct for glidepath errors. For example, if the needles are up and right, fly the aircraft up and right.
- When the landing mode is displayed and +ILS is hooked with the hand control unit, ILS becomes active and the ILS is highlighted on the display.

In the ILS mode if the elevation deviates beyond ±1.4°, the horizontal needle on the PTID is deflected to the top or bottom of the display and begins blinking. If the azimuth deviates beyond ±t6.0°, the vertical needle is deflected to the left or right and begins blinking. If there is a loss of azimuth, elevation, or both signals from the receiver, the warning AZ FAIL, EL FAIL, or RC FAIL appears in the upper center of the PTID (see Figure 17-6).

17.2.8.3 Automatic Carrier Landing System. By hooking the +ACL acronym on the PTID, the ACLS display replaces the ILS and the ACL is highlighted. If the ACLS data becomes invalid, the azimuth and elevation needles are cleared. When a waveoff signal is received, a waveoff “X” appears in the azimuth and elevation needles are cleared. If no message is received for more than 2 seconds, a TILT acronym appears on the PTID (see Figure 17-6).

17.2.8.4 D/L RAD Test Display. When the ACLS mode and D/L RAD is selected by the pilot, the azimuth needle deflects to the left and the elevation needle deflects up. The needles hold their position momentarily, then disappear from the display. Every 6 seconds the needles repeat this cycle.

17.2.8.5 Angle-of-Attack Vertical Velocity. In landing mode, AOA scale range extends from 10 to 20 units AOA and, in nonlanding mode, from 0 to 20 units. A brightened line (-) in landing mode represents 15 units AOA. Vertical velocity (in feet per minute) is scaled from +500 to –1,500 in the landing mode and from +5,000 to –5,000 in the nonlanding mode (see Figure 17-6 and Figure 17-7).

Note

- Twenty units of AOA is the maximum value obtainable from the CSDC for display on the PTID.

- The PTID display of AOA may vary a maximum of ±1.5 units from the pilot AOA indicator; therefore, the pilot indicated AOA remains the primary reference.

When aircraft vertical velocity exceeds the scale limits, the caret indicator flashes and a dot appears inside the caret indicating an exceeded condition. At 18 units of AOA in either landing or nonlanding mode, the caret indicator begins flashing and is pegged with a dot inside the caret at 20 units.

17.2.8.6 Instrument Landing System. ILS and ACLS data, which provides vertical glideslope error and lateral displacement error, is presented in landing mode only. In both landing and nonlanding modes, azimuth and elevation errors from the reference glidepath are displayed on the PTID as moveable, crossed vectors (needles) (see Figure 17-6).

Note

- Fly the aircraft into the needles to correct for glidepath errors. For example, if the needles are up and right, fly the aircraft up and right.

- When the landing mode is displayed and +ILS is hooked with the hand control unit, ILS becomes active and the ILS is highlighted on the display.

In the ILS mode if the elevation deviates beyond ±1.4°, the horizontal needle on the PTID is deflected to the top or bottom of the display and begins blinking. If the azimuth deviates beyond ±t6.0°, the vertical needle is deflected to the left or right and begins blinking. If there is a loss of azimuth, elevation, or both signals from the receiver, the warning AZ FAIL, EL FAIL, or RC FAIL appears in the upper center of the PTID (see Figure 17-6).

17.2.8.7 Automatic Carrier Landing System. By hooking the +ACL acronym on the PTID, the ACLS display replaces the ILS and the ACL is highlighted. If the ACLS data becomes invalid, the azimuth and elevation needles are cleared. When a waveoff signal is received, a waveoff “X” appears in the azimuth and elevation needles are cleared. If no message is received for more than 2 seconds, a TILT acronym appears on the PTID (see Figure 17-6).

17.2.8.8 D/L RAD Test Display. When the ACLS mode and D/L RAD is selected by the pilot, the azimuth needle deflects to the left and the elevation needle deflects up. The needles hold their position momentarily, then disappear from the display. Every 6 seconds the needles repeat this cycle.

17.2.8.9 Tacan Distance Measuring Equipment/Radar Altitude Displays. Tacan range to a selected station and radar altitude are displayed on the PTID in landing and nonlanding modes. An OFF indication appears if the tacan or the radar altimeter is selected off or there is an equipment failure. If aircraft altitude exceeds 5,000 feet AGL, the radar altitude will also display OFF (see Figure 17-6 and Figure 17-7).

Note

Selection of ACM, PLM, MRL, PAL, or VSL will cause an exit of AOA, VV, ILS, and ACLS (AVIA) displays to tactical mode.

17.3 SURFACE SUBSYSTEMS

17.3.1 Automatic Landing System (AN/SPN-46). The AN/SPN-46 radar uses a conically scanning antenna beam of kA-band energy, which is received at the aircraft in direct proportion to its position within the antenna coverage area. This microwave energy is received as amplitude modulation of the pulsed carrier and, by means of the beacon augmentor, the AM is put on the I-band beacon for retransmission back to the ship as an active radar signal. The AM on this retransmitted signal is therefore identical to the AM received at the aircraft. By relating the amplitude of the returned signal to the AN/SPN-46 antenna position within its conical scanning area, the system knows the exact location of the aircraft in relation to the axis of the conical scan, which is the desired glidepath. From this information, the system can generate corrections to bring the aircraft to the desired glidepath. From this information, the system can generate corrections to bring the aircraft to the desired glidepath.

Note

The AN/SPN-46 system has unique software that is compatible with F-14 DFCS aircraft incorporating OFP 4.4 or subsequent only.

To satisfy the system capability and landing-rate requirements, the shipboard subsystem landing control central AN/SPN-46 has a dual-channel configuration. This provides increased system reliability through redundancy. At full operational capability, both channels are in use, controlling two aircraft on the glideslope at the same time. Two aircraft are normally spaced approximately 60 seconds apart along the glideslope. In addition, the three operating modes act as backups for each other should partial system failure occur.

17.3.2 AN/SPN-41 Instrument Landing System. The aircraft ILS uses carrier or shore-based AN/SPN-41 (C-scan) transmitters. The system operates in the K-band, between 15.4 and 15.7 GHz, on any of 20 channels. The transmitted azimuth signal produces a 2° beam, which is scanned +20° from the deck centerline. The transmitted elevation signal produces a 1.3° beam with a scan pattern from 0° to 10° above the horizon. A proportional azimuth angle for steering is 6° right or left of centerline; proportional elevation angle for steering is 1.4° from the reference glideslope (above or below). Operating range is approximately 20 nm. The signal is transmitted in J-band on a carrier frequency of 15.4 to 15.7 GHz.

The AN/SPN-41 can be used to guide the pilot to the window of the AN/SPN-42 radar for an ACL mode I approach and as an independent glideslope and azimuth display during a mode I approach. Should the AN/ SPN-42 radar system fail, the AN/SPN-41 can be used for mode II approaches.

17.4 ACLS PROCEDURES

The successful completion of a mode I or mode IA ACLS approach is dependent on the proper performance and complex interaction of a variety of shipboard and aircraft systems. It is the responsibility of the aircrew to verify that all ACLS-related aircraft systems are functioning properly and that proper procedures are followed in order to ensure a safe coupled approach.

17.4.1 Preflight. During the exterior preflight, the aircrew should ensure that both beacon antennas are in good repair and not painted. The receive antenna is located on the lower starboard fuselage just aft of the radome and is mounted flush with the fuselage. The transmit antenna is a blade antenna located on the aft portion of the chin dome (IR/TV pod). Poor condition of these antennas will seriously degrade beacon performance and will result in degraded tracking capability by the AN/SPN-42 system.

17.4.2 Poststart Checks. Following start, the aircrew should verify proper operation of the beacon and data-link systems along with associated lights and indications by performing the prescribed built-in tests. In addition, the pitch parallel actuator should be checked during OBC to make sure that the force link is not totally or partially disconnected. If any of these systems are not functioning properly, a coupled approach will not be possible.

17.4.3 Approach Phase. In ACL, the purpose of the approach phase is to get the aircraft to the acquisition window (Figure 17-8). At the marshaling area, some 20 miles astern of the carrier, the aircraft about to land are stacked according to fuel status and other relevant parameters that determine landing priority, the ILS (AN/ARA-63) system is energized, and the proper channel and displays are selected. The pilot, in concurrence with the controller, has the option of choosing from three display submodes to aid in reaching the radar acquisition window:

1. Data-link vector
2. Tacan
3. AWL/PCD-ILS.

All are directly selectable on the pilot display control panel. Switching between submodes requires a choice between VEC, tacan, and AWL/PCD steering. If a submode selected becomes invalid, the steering information will cease. The pilot has the option of reselecting another landing display submode.

During the letdown from marshaling, an AN/SPN-42 channel is assigned to the aircraft and a computer program of aircraft control parameters is selected. A data-link discrete message, (the first of a series to be transmitted) landing check, is sent to the aircraft to initiate communications with CATCC and to indicate to the pilot that an AN/SPN-42 channel is available. The aircraft will usually already be in a landing configuration upon receipt of landing check.

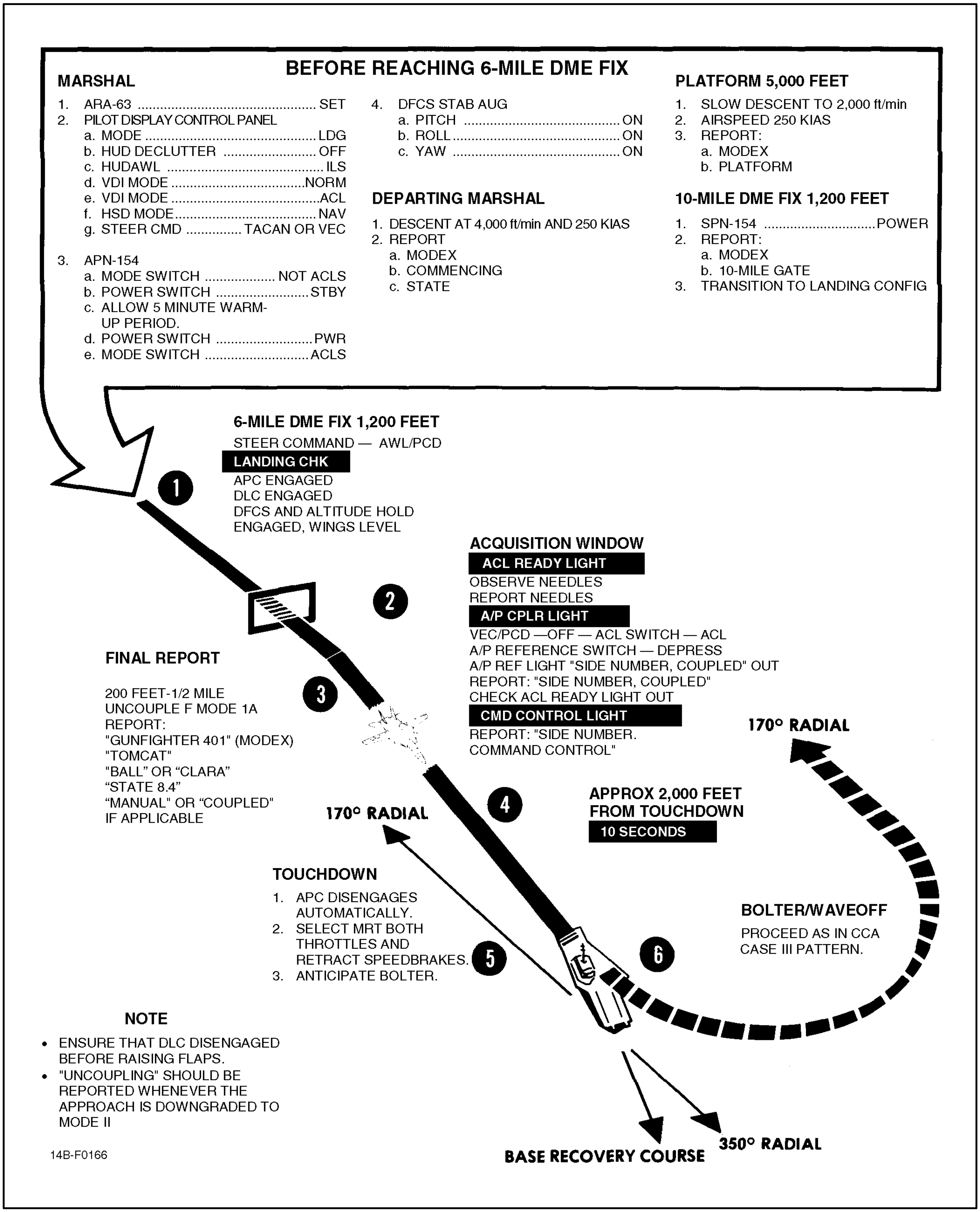


Figure 17-8. ACLS Mode I and II Approaches

17.4.3.1 Data-Link Vector Approach. When vector (VEC) is selected, the D/L vector display is added to the basic landing display. Command heading relative to the heading tape is added to the VDI, along with altitude and airspeed error symbols on the right and left side, respectively. When the double bar is above the reference bar, it means the aircraft is below commanded altitude or commanded speed. Data-link vector information is available only for the approach phase; that is, to the radar acquisition window. When the aircraft is vectored (D/L vector commands) to the acquisition window, the pilot has to make a new submode selection for the descent phase. This is not the case with the tacan and ILS submodes, as both tacan and ILS information are available throughout landing, from marshaling to touchdown.

17.4.3.2 Tacan Approach. The vertical precision course vectoring symbols bar is used for tacan deviation, along with carrier deck heading, through the data link, if available, on both the HUD and VDI. The receipt of the data-link waveoff in any landing submode causes the breakaway symbol to be displayed.

17.4.3.3 AWL/PCD-ILS Approach. ILS information from the AN/SPN-41 is available during both the approach and descent phase. Selection of AWL/PCD on the pilot display panel enables vertical and lateral glideslope error display. Final determination of the AWL/PCD mode is governed by the ILS/ACL selection that provides for separate HUD and VDI selection.

If the pilot intends to make a mode I landing, he will normally display ILS (AN/SPN-41) information on the HUD (HUD selection switch to ILS) and prepare the VDI for automatic carrier landing (AN/SPN-42) data (VDI selection switch to ACL) to be displayed as soon as it becomes available (i.e., from the radar acquisition window on). Note that this configuration is desirable but not mandatory.

17.4.4 Landing Phase. As the aircraft continues its approach and passes through the 4-nm ACLS radar acquisition window, a smooth transition, not requiring pilot action, occurs. If tacan or ILS display information has previously been selected (for the approach phase), the pilot could use this information to land. Assume, however, that AWL/PCD has been selected, ILS information is being displayed on the HUD, and the VDI selection switch is in ACL.

At the radar acquisition window, the AN/SPN-42 radar acquires the aircraft with the aid of the airborne radar beacon augmentor and the system automatically sends a discrete indicating radar lock-on, which illuminates the ACL READY light. Transmission of vertical and lateral glideslope error, derived by the AN/SPN-42 radar, commences. These glideslope error signals drive the precision course director steering of the ACL display on the VDI while the HUD continues to display ILS (AN/SPN-41) error information.

17.4.4.1 Mode I Landing Sequence

Note

- ACLS mode I/IA approaches are authorized for F-14 DFCS aircraft incorporating OFP 4.4 or subsequent only.
- Refer to paragraph 2.23.4.7, Automatic Carrier Landing, for further information on ACL.

The approach controller (Figure 17-8) generates an ACLS coupler available discrete that illuminates the A/P CPLR light and indicates that the pilot has the option of coupling the DFCS to data-link pitch and bank commands. At this time, the aircraft should be in the landing gear down, full flaps, speedbrakes extended approach configuration with direct lift control (DLC), autothrottle approach power compensator (APC), and autopilot altitude hold mode engaged.

WARNING

ACLS mode I/IA approaches are not authorized with the THROTTLE MODE switch in MANUAL.

Note

- Engagement of autopilot altitude hold mode is not required for ACL coupling; however, application of 2 to 3 pounds of stick force while attempting to couple will cause the AUTOPILOT caution light to illuminate and coupling can not be accomplished. It is imperative that any stick force be avoided while depressing the autopilot reference pushbutton to ensure coupling.

- The AWG-9 should be in STBY or PULSE search to avoid beacon interference problems.

With a valid ACLS coupler discrete (A/P CPLR light), the autopilot can be armed in the ACL mode with the A/P REF light illuminated, indicating that a pilot relief mode (in this case, ACL) has been selected, but not engaged (altitude hold mode will automatically disengage). The pilot can then couple the autopilot ACL mode to the data link by means of the autopilot reference pushbutton on the control stick, at which time, if the DFCS is functioning properly and the ACL mode interlocks are satisfied, the AP REF light will be extinguished. The pilot should report coupled and the controller will then send a discrete command control message that illuminates the CMD CONTROL light. The Naval Tactical Data System (NTDS) begins transmitting ACLS data-link pitch and bank commands to the aircraft. The autopilot actuates the appropriate control surface to execute the desired command, while the autothrottle APC maintains approach angle of attach by controlling the throttle setting.

Note

- In the autopilot ACL mode, the ACLS control laws utilize DLC to augment glideslope control. DLC engaged is an interlock requirement for the ACL mode. DLC disengagement during the approach will result in automatic downgrade.

- Between the time the autopilot ACL mode is engaged (A/P REF light extinguished) and transition to command control (CMD CONTROL light illuminated), the aircraft may experience a slight altitude deviation of less than 100 feet. Normal system operation should correct for this deviation prior to tip-over.

- Care should be taken not to couple above glideslope. If above glideslope or reference altitude when initial pitch commands are sent, the resulting nose down correction may cause a force link disconnect resulting in automatic decouple and an inability to perform mode I/IA approaches until maintenance action is performed.

- Care should be taken not to couple after tip over or prior to tip over with greater than 500 foot per minute rate of climb or descent. If coupling is attempted after tip over, degraded system performance should be expected, possibly requiring a PTO no later than 200 feet or ½ mile on final. If excessive climb/ descent rate is established prior to coupling, system control authority may be insufficient to arrest the trend and capture reference altitude.

If the aircraft exceeds the mode I flightpath control envelope, the system automatically sends a signal to uncouple the DFCS (A/P CPLR light extinguished). The approach may be continued in mode II or mode III. If the flightpath error increases to the point where a large maneuver is required to bring the aircraft back on course, the controller will send a waveoff message which is displayed on the HUD and VDI and illuminates the WAVEOFF light. This discrete also disconnects the autopilot (if engaged) and the DFCS reverts to basic stability augmentation. The controller then transfers the guidance of the aircraft to the bolter/ waveoff controller, who directs the pilot back into the landing sequence.

If the information stored in the data link is not updated within any 2-second period during the descent, the TILT light illuminates (missed message) and the DFCS automatically disconnects the ACL and autopilot modes and reverts to basic stability augmentation. The pilot can continue the descent in mode II or mode III.

At 12.5 seconds from touchdown (approximately 2,200 feet from the touchdown point), the 10 SECOND light illuminates, indicating that deck motion data is being added to the glidepath commands. This information is in the form of a slight increase (or decrease) in aircraft altitude to adjust for the movement of the touchdown point caused by the ship's motion (roll, pitch, and heave).

Between 12.5 and 1.5 seconds from touchdown, the CATCC sends an automatic waveoff discrete if any part of the carrier-based equipment fails and up to 5 seconds from touchdown if the aircraft exceeds the AN/SPN-46 flightpath control envelope. Waveoff signals may also be issued by the final controller between lock-on and touchdown and the landing signal officer between 1 mile and touchdown. Approaches must be waved off at precision approach weather minimums (200-feet altitude and ½-mile visibility) if the pilot cannot see the meatball.

CAUTION

The paddle switch will disengage the autopilot. Use of the paddle switch to disengage DFCS for mode IA landing is not recommended since DLC will also be disengaged. The pitch and roll SAS switches will remain engaged.

At 2 seconds from touchdown, the landing system freezes the pitch and bank commands and the DFCS holds the aircraft's attitude to touchdown unless the pilot elects to disengage from the ACL mode via pilot takeover. See paragraph 2.23.4.7, Automatic Carrier Landing, for pilot takeover procedures.

CAUTION

If the pilot and/or LSO recognizes a course drift immediately prior to or at command freeze, the pilot will be required to make a lateral correction to prevent unacceptable deviation from centerline.

17.4.4.2 Mode II Landing Sequence. The early phases of a mode II descent (Figure 17-9) are identical to a mode I descent sequence. The aircraft to be recovered is directed through the marshaling area, received LANDING CHK, and arrives at the ACLS radar acquisition gate. When the lock-on discrete (ACL READY) message is received, the pilot continues to fly the aircraft manually (using APC as desired) in response to VDI and/or HUD displays.

If there is an equipment failure, the system (CATCC) will send a voice discrete signal that illuminates the VOICE light and the AN/SPN-42 error information displayed on the VDIG will be invalid. The pilot then expects to receive standard voice commands and will probably use the redundant ILS information or switch to tacan display.

As long as the aircraft is located within the AN/SPN-42 flightpath control envelope for mode II, the descent is continued until visual contact is made with the Fresnel lens optical landing system meatball. All waveoffs in mode II are given by the final controller or the LSO. Approaches are terminated at weather minimums (200-foot altitude and 0.5 mile visibility) if the pilot cannot see the meatball.

At any time before 12.5 seconds from touchdown, the pilot can switch from a mode II manual to a mode I automatic flightpath control, providing the coupler available discrete is being received and the ACL interlock is true.

17.4.4.3 Mode III Landing Sequence. Mode III descents follow the same general sequence as that of mode I and II, but mode III approaches are talkdown landings (i.e., all flightpath corrections are provided by voice and no computerized discrete signals are sent). The use of APC is optional. Approaches are terminated at the weather minimums if the FLOLS (meatball) is not visible to the pilot for continuing the landing.

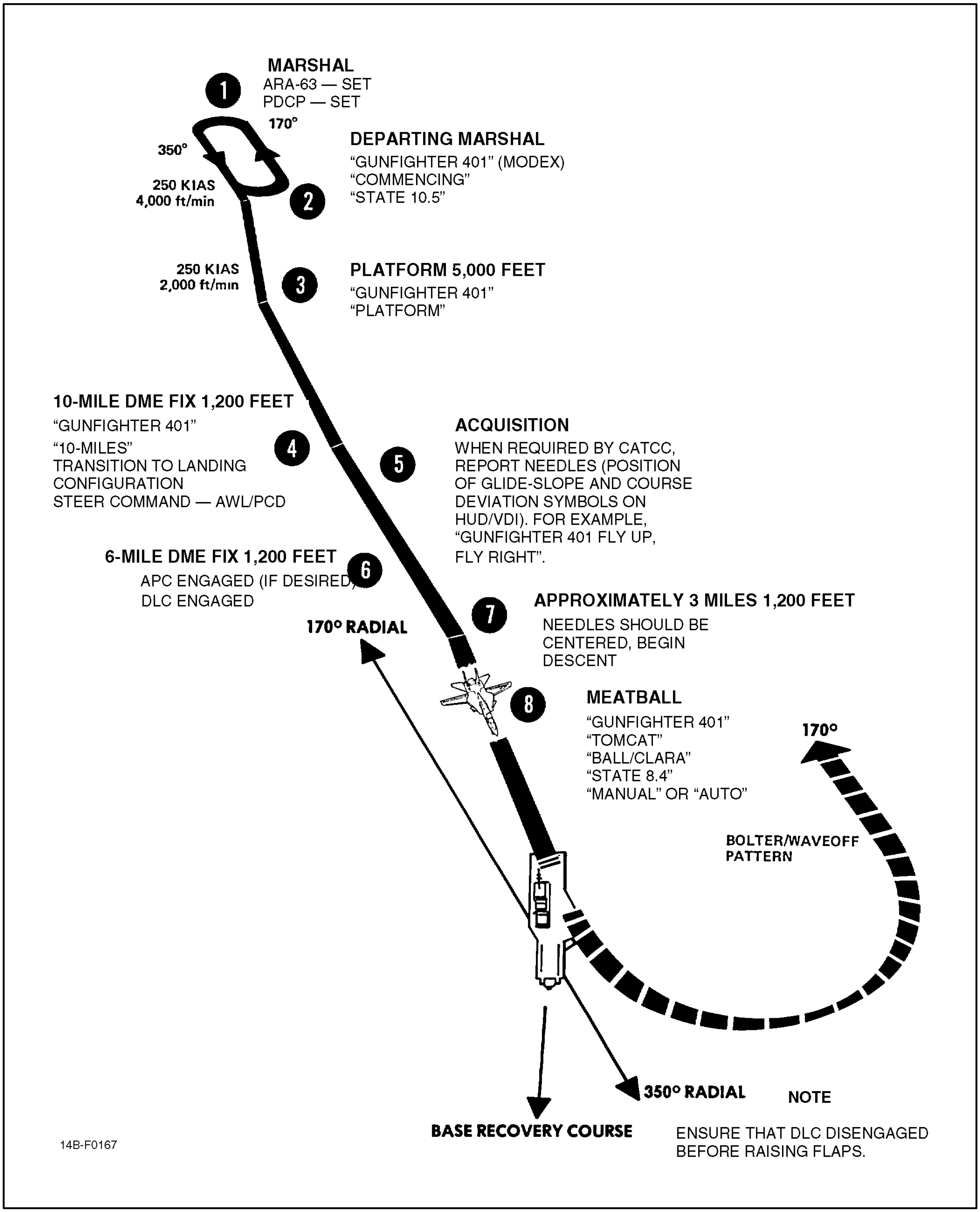


Figure 17-9. SPN-41 ILS Approach

CHAPTER 18

Extreme Weather Operations

18.1 ICE AND RAIN

18.1.1 Icing. Icing conditions should be avoided whenever possible. Before flight, check freezing levels and areas of probable icing from weather service.

The primary concern with flying in icing conditions is ice accumulation sufficient to cause engine damage. Ice accumulation on engine probes located between the engine guide vanes and above the No. 3 inlet ramp is not detectable from the cockpit. Aircraft maneuvers or landing impact can dislodge accumulated ice and severely FOD the engine. Visual detection of icing on exterior surfaces and/or illumination of the pilot's INLET ICE caution light should be treated as indications of the potentially more serious problems described above. The following precautionary action should be taken immediately in a known or suspected icing environment:

1. ANTI-ICE switch — ORIDE/ON.
2. CABIN AIR DEFOG lever — FWD DEFOG.
3. Engine instruments — Monitor Frequently.

Carefully monitor rpm and EGT indications. A reduction of rpm or an increase in EGT accompanied by a loss of thrust is an indication of engine icing.

4. Avoid clouds and other areas of visible precipitation.
5. If unable to avoid precipitation, adjust aircraft Mach or altitude as necessary to remain outside the icing zone shown in Figure 18-1. The aircrew can read free airstream temperature (T_S) from CSDC flycatcher 71-00031 as shown in Figure 18-2.

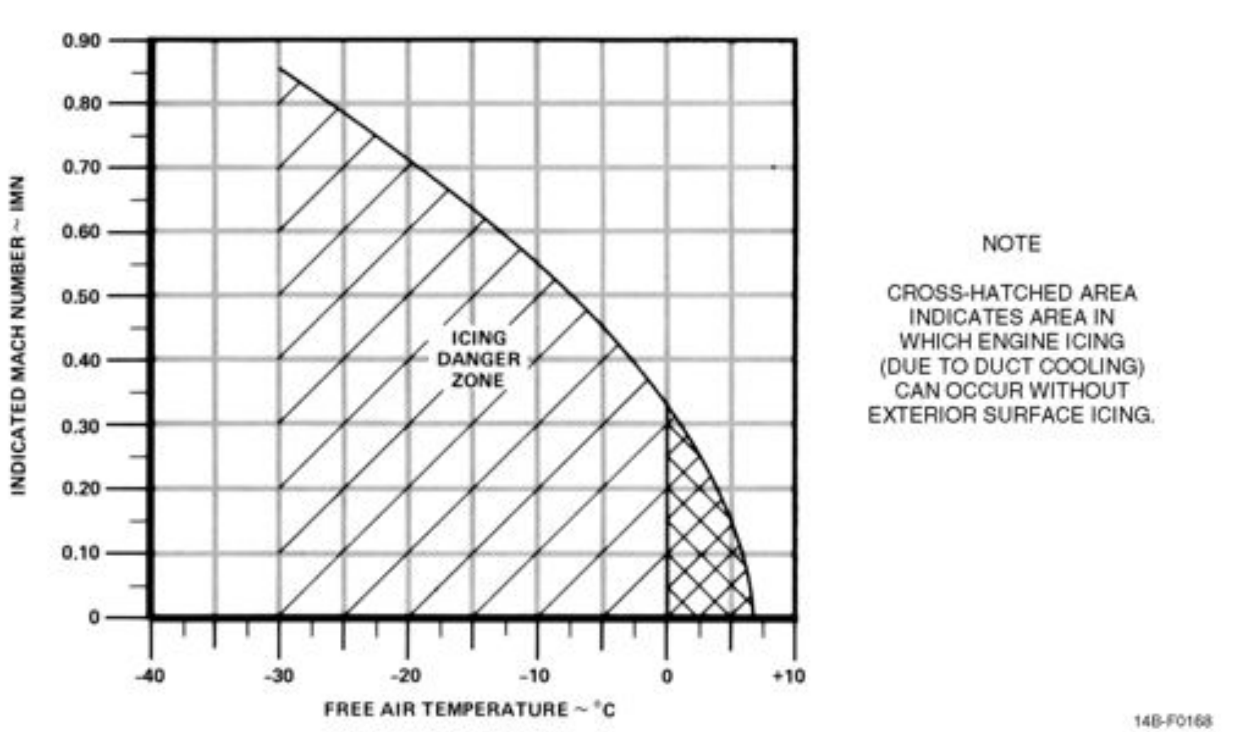


Figure 18-1. Icing Danger Zone

DIGIT		CODE	PARAMETER	EXAMPLES		
				1	2	FAIL
Right	8	1 2 4	Always Zero Always Zero Always Zero	0	0	0
	7	1 2 4	Validity (1 = Valid) Always Zero Always Zero	1	1	0
	6	1 2 4	Always Zero Always Zero Always Zero	0	0	0
	5	1 2 4	Always Zero Always Zero Always Zero	0	0	0
	4	1 2 4	Always Zero 0.5 °C 1.0 °C	6	2	X
	3	1 2 4	2.0 °C 4.0 °C 8.0 °C	5	3	X
	2	1 2 4	16.0 °C 32.0 °C 64.0 °C	1	2	X
Left	1	1 2 4	Sign (1 = Minus) Parity (odd) Always Zero	0 or 2	1 or 3	X

Examples:

1. 01560010 = +27.5 °C

2. 12320010 = –38.5 °C

Failure xxxx0000 Not valid reading

NORMAL: XXXX0010

Figure 18-2. CSDC Flycatcher Word 71-00031

Extended operations in icing conditions should be considered an emergency situation. If time and fuel permit, a descent below the freezing level is recommended. If unable, altitudes above approximately 25,000 feet or ambient temperatures below –30 °C are generally free of icing conditions. If inadvertent or unavoidable operation in known or suspected icing conditions has occurred, an effort should be made to eliminate the ice before landing by remaining well below the freezing level for an extended period of time.

WARNING

Icing conditions can cause heavy ice accumulation in the inlet ramp areas or on engine probes and the compressor face. Aircraft maneuvers and arrested landings may dislodge this accumulation and cause extensive engine FOD or failure. A straight-in field landing is preferred. Minimum power setting after landing is recommended.

CAUTION

Operation of main flaps/slats and maneuvering devices increases the likelihood of a flap/slat lockout because of shearing of the torque tube. Attempt to descend below the freezing level for 20 to 30 minutes before operating main or maneuvering flaps/slats.

18.1.2 Rain. Whenever rain is encountered, turn ANTI-ICE switch to AUTO/OFF.

Note

In heavy rainfall, maintain a minimum engine power setting of 70-percent rpm. This will assure adequate acceleration margin and prevent possible engine speed hangup.

18.1.2.1 Takeoff in Rain. Takeoffs performed with standing water on the runway may result in unstable engine operation because of water ingestion.

18.1.2.2 Landing in Rain. Selecting ON with the WSHLD AIR switch controls a blast of air that blows rain off the windshield. Be aware of the possibility of flameout in a heavy rain and of reduced braking action because of a wet runway.

18.2 HYDROPLANING

Operations on wet or flooded runways may produce four conditions under which tire traction may be reduced to an insignificant value.

1. Dynamic hydroplaning
2. Viscous hydroplaning
3. Reverted rubber skids
4. Combined viscous and dynamic hydroplaning.

Note

Hydroplaning has been experienced in the F-14 at speeds down to 40 knots.

18.2.1 Dynamic Hydroplaning. Dynamic hydroplaning is a condition in which a fluid separates the tires from the runway surface. When standing water on a wet runway is not displaced by the tire fast enough to allow contact over the complete footprint area of the tire, the tire rides on a wedge (or film) of water over all or part of the footprint area. Total dynamic hydroplaning occurs when the pressure between the tires and the runway lifts the tires off the runway surface to the extent that a nonrotating tire will not spin up (landing) or a rolling, unbraked tire will slow in rotation and may actually stop (takeoff). Total dynamic hydroplaning speed is represented by the following mathematical formulas: 9 times the square root of the tire inflation pressure for a rotating tire (as in takeoff); 7.7 times the square root of the tire inflation pressure for a nonrotating tire (as in landing).

Dynamic hydroplaning is insensitive to vertical load changes (weight) but is greatly affected by tire inflation pressure and tire wear. Since the fluid cushion is incapable of developing any appreciable shear force, braking and sideforce coefficients become almost nonexistent.

18.2.2 Viscous Hydroplaning. Viscous hydroplaning occurs when the tires are separated from the runway surface by a thin film. Viscous fluid pressures in the tire-ground contact zone of rolling tires build up with speed to the danger levels required for hydroplaning only when water covered pavement are smooth or smooth acting, as when contaminants considerably more viscous than water coat the pavements. Since a tire operating on a surface with rubber deposits, paint, fuel, or oil can only partially displace the trapped water film, considerably higher hydroplaning pressures will be developed in the tire footprint area with these more viscous fluids. Even slight amounts of precipitation, for example, a heavy dew that coats the pavement with a thin film of fluid, can produce this effect. Because the tire footprint separates from the runway with less fluid depth and at a lower relative groundspeed than dynamic hydroplaning speed, viscous hydroplaning is potentially more dangerous than dynamic hydroplaning and is not greatly affected by changes in vertical tire load or tire inflation pressure. Grooved tires offer a greater advantage than smooth tires in reducing the effects of viscous hydroplaning. The runway pavement surface texture is also an important factor in combating viscous hydroplaning effects.

18.2.3 Combined Dynamic and Viscous Hydroplaning. Loss of tire friction with increasing or decreasing speed on wet or flooded runway pavements can be caused by the combined effects of viscous and dynamic hydroplaning. Figure 18-3 shows a pneumatic tire rolling at medium speed across a flooded pavement in a partial hydroplaning condition. The first zone shows the fraction of the tire footprint that is supported by bulk water (dynamic); the second zone, the fraction supported by a thin film of water (viscous); and the third zone, the fraction essentially in dry contact with the peaks of the pavement surface texture. The length of the first zone represents the time required for a rolling tire in this speed condition to expel bulk water from under the footprint; correspondingly, the length of the second zone represents the time required for the tire to squeeze out the residual thin water film remaining under the footprint after the bulk water has been removed. Since fluids cannot develop shear forces of appreciable magnitude, it is only in the third zone (essentially dry region) that friction can be developed between the tire and the pavement for steering, decelerating, and accelerating a vehicle. The ratio of the dry contact area (third zone) to the total tire footprint area (zones 1, 2, and 3) multiplied by the coefficient the tire develops on a dry pavement, yields the friction coefficient the tire develops for this flooded pavement and speed condition. As speed is increased, a point is reached where the third zone disappears and the entire footprint is supported by either bulk water or a thin film. This speed condition is called combined viscous and dynamic hydroplaning. As speed is further increased, a point is reached where bulk water penetrates the entire footprint; this condition is called dynamic hydroplanin-g. If the runway is not flooded (no bulk water), such as on a runway covered with heavy dew, it is possible for the second zone to cover the entire footprint as speed is increased or decreased. The pavement would have to be smooth or smooth acting, as in the case where contaminants are present, for this to take place; this is called viscous hydroplaning.

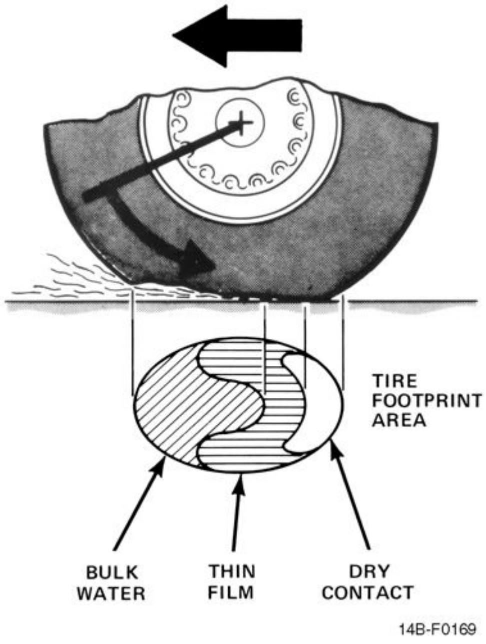


Figure 18-3. Combined Viscous and Dynamic Tire Hydroplaning

18.2.4 Reverted Rubber Skids. A reverted rubber hydroplaning condition (also called reverted rubber skid) takes place when a wheel skid has started on a wet runway and enough heat is produced to turn the entrapped water to steam. The steam in turn melts the rubber in the tire footprint. The molten rubber forms a seal preventing the escape of water and steam. Thus, the tire rides on a cushion of steam that greatly reduces the coefficient of friction. On inspection of the portion of the tire involved, a patch of rubber would show signs of reverting to its uncured state and, hence, the name, reverted rubber. Once established, this condition may persist to very low groundspeeds. The characteristic marks on a pavement for the reverted rubber skid are white, as opposed to the black marks left on the pavement during a dry skid. These white marks are associated with the cleaning process of super heated steam and high pressures that are present in the skid. The reverted rubber condition tends to make all runway surfaces smooth acting. Pavement surface texture, which has a large effect on traction losses from dynamic and viscous hydroplaning, has but little effect for the reverted rubber case with the possible exception of grooved surfaces. NASA research confirms the theory that the reverted rubber skid is the most catastrophic for aircraft operational safety because of the low braking friction and the additional fact that tire cornering capability drops to zero when the wheels rotation is stopped.

18.2.5 Landing on Wet Runway. Refer to Chapter 7 for landing discussion.

18.3 TURBULENCE AND THUNDERSTORMS

Unless the urgency of the mission precludes a deviation from course, intentional flight through thunderstorms should be avoided to preclude the high probability of damage to the airframe and components by impact of ice, hail, and lightning. Flameouts because of water ingestion or compressor stalls caused by rapid changes in flight attitudes could also occur. Radar provides a means of navigating between or around storm cells. If circumnavigating the storm is impossible, penetrate the thunderstorm in the lower third of the storm cell, away from the leading edge of the storm cloud, if possible. It is recommended that the autopilot functions of the DFCS be disengaged. Structural damage could result with the automatic functions operating.

18.3.1 In the Storm. Maintain a normal instrument scan with added emphasis on the attitude gyro VDI. Attempt to maintain a constant pitch attitude and, if necessary, accept moderate altitude and airspeed fluctuations. In heavy precipitation, a reduction in engine speed may be necessary because of the increased thrust resulting from water ingestion. If compressor stalls or engine stagnation develops, attempt to regain normal engine operation by momentarily retarding the throttle to IDLE, then advance to the operating range. If the stall persists, shut down the engine and attempt to relight. If the engine remains stagnated at reduced power and the EGT is within limits, maintain reduced power until clear of the thunderstorm. While in the storm, the longitudinal feel trim, angle-of-attack, total temperature, windshield overheat, static pressure correction, and cabin pressurization systems may experience some abnormalities because of rain, ice, or hail damage. No difficulty should be encountered in maintaining control of the aircraft; however, the rapid illumination of numerous warning lights may be somewhat distracting to the pilot if he is not prepared.

18.3.1.1 If Necessary to Penetrate a Thunderstorm

1. Slow to between 275 to 300 KIAS.
2. ANTI-ICE switch — AUTO/OFF.
3. AUTO PILOT switch — OFF.
4. Loose equipment — Secured.
5. Tighten lapbelt and lock shoulder harness.
6. Cockpit lights — On Bright.
7. Fly attitude and heading indicators primarily while in extreme turbulence because altimeter and airspeed will fluctuate.

Note

During severe icing conditions, the pilot can expect to lose airspeed indications even with the pitot heat on. Ground-controlled intercept stations, if available, can aid the pilot with tracking assistance through thunderstorm areas.

Severe turbulent air at high altitudes may cause the inlet airflow distribution to exceed acceptable limits of the engine, thereby inducing compressor stalls. To avoid compressor stalls during flight because of turbulent air, maintain 275 to 300 KIAS at all altitudes.

18.4 COLD-WEATHER OPERATIONS

A careful preflight will eliminate many potential hazards found in cold-weather operations. Inspect engine intakes for accumulation of ice and snow. If possible, preheat the engine for easier engine starts. When removing ice and snow from the aircraft surfaces, be careful not to damage the aircraft. Also, use precautions not to step on any no-step surfaces that could be covered with ice or snow. Check the pitot-static tube for ice as well as the fuel pressurization ram/air intakes, and yaw, pitch, and angle-of-attack transducers.

Moisture in the fuel system greatly increases operational problems in cold weather. At lower temperatures, the water-dissolving capacity of fuel is greatly reduced and will result in considerably more water accumulation (as much as several gallons of water to 1,000 gallons of fuel). If the water separation occurs at below freezing temperatures, the water will crystallize on fuel drain and internal valves. Any water accumulation will settle to the bottom of the tanks and freeze up the fuel drains.

Normal operating procedures as outlined in Chapter 7, Normal Procedures, should be adhered to with the following additions and exceptions.

18.4.1 Preflight

1. Check entire aircraft to ensure that all snow, ice, or frost is removed.

WARNING

Snow, ice, and frost on the aircraft surface are a major flight hazard. The result of this condition is a loss of lift and increased stall speeds.

2. Shock struts and actuating cylinders — Free of Ice and Dirt.
3. Fuel drain cocks — Free of Ice and Drain Condensation.
4. Pitot tubes — Ice and Dirt Removed.
5. Exterior protective covers — Removed.

18.4.2 Engine Start. Be sure that the aircraft is adequately checked before engine start.

When operating in subfreezing temperatures, moisture in the air entering the aircraft from the starting unit may freeze, causing ECS malfunctions. Starting the aircraft with the AIR SOURCE in OFF will prevent the problem. The AIR SOURCE in BOTH ENG should be selected after both engines have been started and the starter air disconnected. ECS malfunctions after engine start may still occur because of moisture internally present in the aircraft.

If this occurs, select:

1. TEMP mode selector switch — MAN.
2. TEMP control thumbwheel — Full Hot (14).
3. WSHLD AIR switch — ON.
4. With both engines at IDLE, the ECS should thaw in about 20 minutes. During this warmup period leave all avionics and WCS off.

If external fuel tanks installed:

5. MASTER TEST switch — FLT GR UP.

Advance throttles as necessary to 80 percent maximum to check for GO light and positive external transfer. Once airborne, external fuel transfer should not be delayed to ensure complete external tank transfer.

Note

- If external transfer does not initiate or is incomplete, flight below the freezing level for 20 to 30 minutes will allow frozen valves to thaw permitting external transfer.
- A standard serial interface failure (CSI) acronym during AWG-9 powerup caused by a frozen ground cooling interlock can be cleared by pulling the GND PWR/ COOLING INTERLK cb (8F4) for 2 to 3 minutes.

In severely cold weather, allow a short time for warmup before increasing rpm out of the idle range. If oil pressure is low or fails to come up in a reasonable length of time, shut down. Attempt another start after heating the engines.

WARNING

If abnormal sounds or noises are present during starting, discontinue starting and apply intake duct preheating for 10 to 15 minutes.

18.4.3 Taxiing. Avoid taxiing in deep or rutted snow since frozen brakes will likely result.

To ensure safe stopping distance and prevent icing of aircraft surfaces by melted snow and ice blown by jetblast of a preceding aircraft, increase spacing between aircraft while taxiing at subfreezing temperatures.

18.4.4 Takeoff. When operating from runways that are covered with excessive water, snow, or slush, highspeed aborts may result in engine flameout because of precipitation ingestion. The probability of flameout is highest when throttles are chopped. With a double flameout, normal braking, anti-skid and nosegear steering will be lost as hydraulic pressure decreases with engine spool down. Check applicable takeoff distance charts, NAVAIR 01-F14AAP1.1.

Thrust available will be noticeably greater in cold temperatures during the takeoff run.

CAUTION

> Before initial takeoff roll, ensure that all instruments are sufficiently warmed up. After takeoff, cycle landing gear a few times to prevent the possibility of the gear freezing in the wheelwells.

18.4.5 Landing. Frozen downlock microswitch actuators caused by moisture combined with extremely cold temperatures can cause spurious unsafe-down indications when landing gear is extended. Use antiskid during the landing roll.

CAUTION

> Hard braking on an icy or wet runway, even with ANTI-SKID on, could result in dangerous skidding.

18.4.6 After Landing. During operations where the temperature is below freezing with heavy rain or expected to drop below freezing with heavy rain, the aircraft may be parked with wings forward (20°), and flaps in the full-down position.

18.4.7 Before Leaving Aircraft. Weather permitting, leave the canopy partially open to allow for air circulation. This will help prevent canopy cracking from differential cooling and decrease the possibility of windshield and canopy frosting.

18.5 HOT-WEATHER AND DESERT OPERATIONS

Check for accumulation of sand or dust in the intakes. Normal starting procedures will be employed.

Normal operating procedures as outlined in Chapter 7, Normal Procedures, should be adhered to with the following additions and exceptions:

1. Expect higher temperatures than normally obtained in operating ranges.
2. Engine ground operation should be minimized as much as possible.

18.5.1 Taxiing. While taxiing in hot weather, the canopies may be opened, if necessary, to augment crew comfort. Do not operate the engines in a sand or dust storm, if avoidable. Park the aircraft crosswind and shut down the engines to minimize damage from sand or dust.

18.5.2 Takeoff. The required takeoff distances are increased by a temperature increase. Check the applicable Takeoff Distance charts, NAVAIR 01-F14AAP-1.1.

CAUTION

> Do not attempt takeoff or engine operation in a sandstorm or dust storm, if avoidable. Park aircraft crosswind to prevent sand or dirt from blowing into the intake or exhaust ducts and, subsequently, causing engine damage.

18.5.3 Landing. Anticipate a slightly longer landing distance and the possibility of turbulence because of thermal action of the air close to the ground. Use the defogging system if necessary, in warm, humid weather.

PART VII

Communications — Navigation Equipment and Procedures

CHAPTER 19

Communications

19.1 COMMUNICATIONS AND ASSOCIATED EQUIPMENT

Figure 19-1 lists the communication-navigation identification equipment associated with the aircraft weapons system. For information on the AN/AWG-9 weapons control system, defensive electronic countermeasures equipment, and data-link system, refer to NAVAIR 01-F14AAA-1A.

CAUTION

Operation of electronic equipment for more than 5 minutes without adequate cooling will permanently damage the equipment.

19.1.1 Communications Antenna. Four VHF/UHF/L-band dual-blade antennas provide omnidirectional coverage for VHF/UHF voice, UHF data link, tacan, and identification friend or foe/selective identification feature transponder (APX-72) operation. Tacan and VHF/UHF 2 voice communications use one set of antennas; UHF 1 voice communications, the data-link and IFF transponder, another set of antennas. Refer to general arrangement illustration (FO–1 and FO–2) for antenna locations. The IFF interrogator (APX-76) antenna is an integral part of the AWG-9 WCS antenna.

Each individual system is connected to the appropriate portion of an upper or lower antenna through a coaxial switch and diplexer. The V/UHF 2 ANT switch on the RIO communication TACAN CMD panel must be used to select the upper or lower antenna manually; there is no automatic actuation function in these aircraft.

The data-link (D/L) antennas are similarly selected manually. Upper or lower antenna is selected by means of ANTENNA switches on the DATA LINK control panel (Figure 19-2). The UHF 1 voice communication ARC-159 antenna is shared with the D/L antenna system and is always on the opposite antenna from the one selected by the ANTENNA switch.

The upper UHF 2/tacan antenna is the first one aft of the canopy on the turtleback, and the lower antenna is imbedded in the bottom of the left ventral fin. Only one antenna is used at a time. Automatic switching between antennas prevents loss of tacan information. If a signal is lost or is too weak to hold receiver lockup, the tacan automatically cycles between the two antennas every 6 seconds seeking a stronger signal. During this cycling and search period, memory circuits retain range tracking for 8 to 12 seconds and bearing tracking for 8 seconds.

The IFF antenna lobing switch is controlled by the IFF ANT switch (Figure 19-2) on the RIO right outboard console. In AUTO, the lobing switch cycles the receiver-transmitter between upper and lower antenna. In the LWR (lower) position, only the lower antenna is used to receive and transmit signals. The upper antenna pattern has a slight forward tilt; the lower pattern a slight aft tilt.

Note

It is often necessary to select LWR to improve ground station reception.

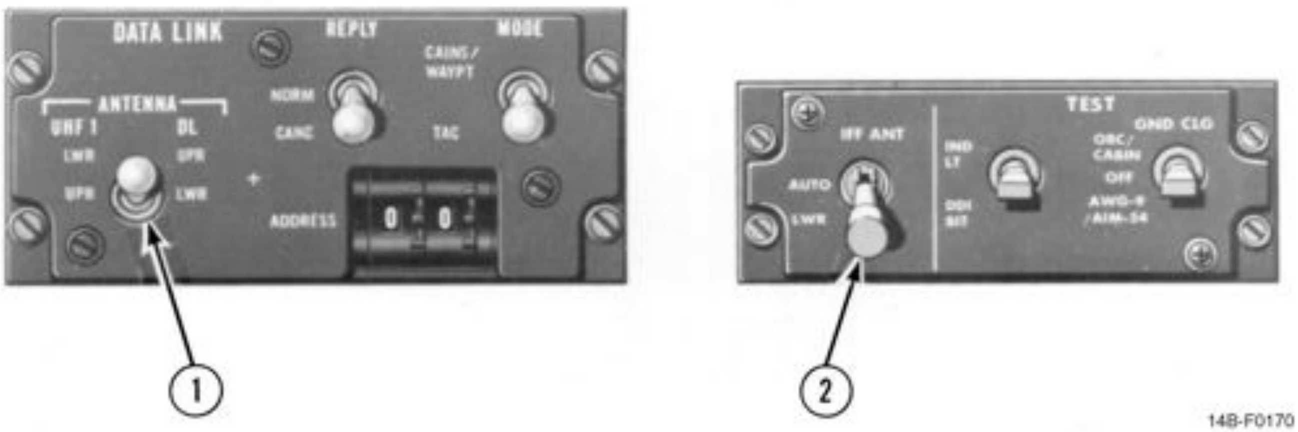
19.2 INTERCOMMUNICATIONS

The ICS provides normal, backup, or emergency communications between crewmembers. It also combines and amplifies audio signals received from other electronic receiving equipment (ECM, Sidewinder tone, IFF/SIF, radar altimeter, and voice radios, etc.).

Identical ICS control panels (Figure 19-3) are on the pilot and RIO left side consoles. The ICS consists of four amplifiers, two at each cockpit station, which permit duplex operation during normal operation. If one amplifier fails, it may be bypassed by selecting either the B/U (backup) or EMER (emergency) position on the ICS control panel. This permits continued ICS operation.

TYPE AND DESIGNATION	FUNCTION	RANGE	OPERATOR	LOCATION OF CONTROLS
INTERCOM (LS-460B)	Provides voice communications between crewmembers and between cockpit and groundcrew, also various warning and weapon tones and voice communications.	Within the aircraft and groundcrew personnel	Pilot, RIO, and groundcrew personnel	Pilot and RIO left console and in the nosewheel well
TACAN (AN/ARN-84(V))	Navigation also provides bearing and distance information to local stations.	Line of sight up to 300 miles, depending on altitude.	Both	Left console
UHF DATA LINK AN/ASW-27B	Provides two-way digital message communication.	Line of sight up to 180 nautical miles.	Both	RIO right console
UHF 1 COMMUNICATIONS SET (AN/ARC-159(V)1)	Provides two-way voice communications.	Line of sight up to 180 nautical miles.	Both	Pilot and RIO left console
VHF/UHF 2 COMMUNICATIONS SET (AN/ARC-182(V))	Provides two-way voice tone communication.	Line of sight up to 200 nautical miles.	Both	RIO left console.
UHF DIRECTION FINDER (AN/ARA-50)	Provides bearing information to selected UHF stations.	Line of sight up to 180 nautical miles.	RIO only	RIO only
VOICE SECURITY EQUIPMENT (KY-58)	Cryptographic encoding and decoding of voice communications. Used with communications radios.	Same as radio in use.	RIO	Left console
IFF TRANSPONDER (AN/APX-72)	Responds to interrogations by other aircraft or ground stations.	Line of sight.	RIO	Right console
IFF INTERROGATOR (AN/APX-76B)	Requests identification from other aircraft.	Line of sight.	RIO	DDD and right console
RECEIVER DECODER (AN/ARA-63A)	Provides glide-slope signals for carrier landing system.	Line of sight up to 20 nautical miles.	Pilot	Right console
RADAR ALTIMETER (AN/APN-194)	Displays height above earth's surface.	0 to 5,000 feet.	Pilot	Radar altimeter indicator on pilot's instrument panel
RADAR BEACON (AN/APN-154)	Aids in tracking by ship and ground-based x-band radars. Provides down link for automatic carrier landing system.	Line of sight.	RIO	Right console

Figure 19-1. Communication and Associated Equipment



NOMENCLATURE	FUNCTION	
(1) UHF 1 ANTENNA select switch	LWR —	Selects lower UHF 1 and upper D/L antenna.
	UPR —	Selects upper UHF 1 and lower D/L antenna.
(2) IFF ANT switch	AUTO — between	Antenna lobing switch cycles receiver-transmitter upper and lower-antenna pattern coverage.
	LWR —	Only the lower-antenna pattern below aircraft is used.

Figure 19-2. Communication Antenna Switches

Note

If two amplifiers fail at the same station, intercommunication is impossible.

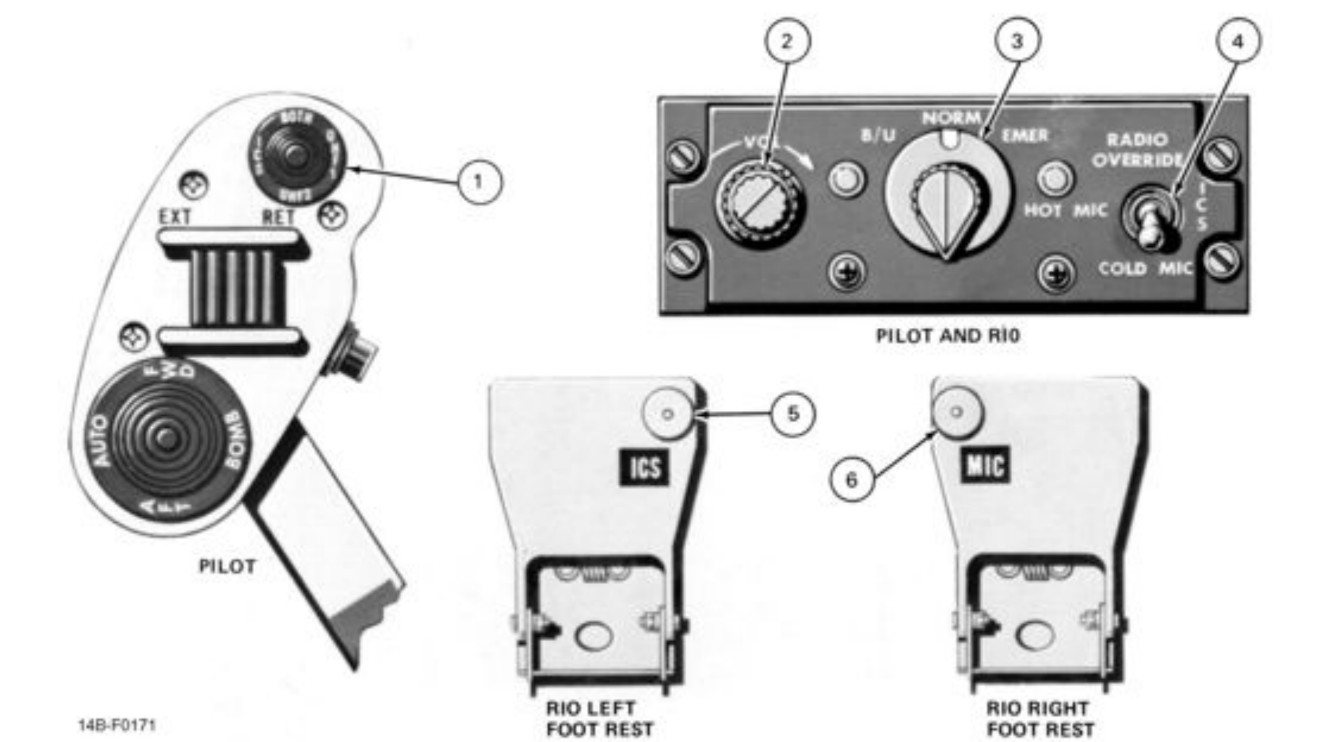
The external interphone connection is in the nose wheelwell. When pilot ICS switch is set to HOT MIC, ground personnel can communicate with the cockpit stations.

19.2.1 Audio Warning Signals. Audio warning signals from the weapon system are available to either or both crewmen through the ICS. Each signal has a distinct tone. A visual display accompanies most audio signals so that the flightcrew can expect the tone and interpret its meaning. Most audio signals may be attenuated or turned off if not required, allowing the flightcrew to concentrate on more critical tones. Critical warning tones cannot be attenuated by any mode of ICS operation.

Figure 19-4 provides a glossary of audio warning signals available within the aircraft weapon systems. Two 28 Vdc circuit breakers, ICS NFO (6F3) and ICS PILOT (6F2), control power to and provide circuit protection for the ICS. Power to both circuit breakers is from dc essential bus No. 1. Approximately 1 minute of warmup is required in order to achieve normal operating temperature.

19.2.2 ICS System Checkout. When the computer signal data converter, under on-board check control, applies a BIT command to the DECM systems, they generate a tone in the crew headsets through the ICS.

19.2.3 Pilot Volume/Tacan Command Panel. The VOLUME/TACAN CMD panel on the pilot left console has three volume controls for regulating audio signals from the ALR-67, VHF/UHF 2, and the Sidewinder (SW) missile lock-on (Figure 19-5).



NOMENCLATURE	FUNCTION	
1 Pilot radio ICS button	ICS —	Function selector. Overrides UHF/VHF communications.
	BOTH —	Keys both UHF 2 (ARC-182) and UHF 1 (ARC-159) radios.
	UHF 1 —	Keys ARC-159 radio for operation.
	UHF 2 —	Keys ARC-182 radio for operation.
2 VOL control		Controls intercommunication audio level at that cockpit station. Audio level at other station not affected.
3 Amplifier selector	B/U —	(Backup) used to bypass a fault amplifier and uses a backup output amplifier at own station.
	NORM —	(Normal) used when all amplifiers are functioning properly.
	EMER —	(Emergency) used to bypass faulty amplifier and makes use of input amplifier of other station. No HOT MIC.
		CAUTION With the front cockpit amplifier selector switch in the EMER position, engine stall/overtemperature and Sidewinder tones will not be available to the pilot.

Figure 19-3. Intercommunication Controls (Sheet 1 of 2)

NOMENCLATURE	FUNCTION
4 Function selector	RADIO OVERRIDE — Attenuates noncritical radio audio to emphasize intercommunication when urgent. HOT MIC — Intercommunication without keying. COLD MIC — Intercommunication only when pilot actuates ICS keying switch on inboard throttle or RIO actuates keying switch on left foot reset.
5 RIO's ICS button (left foot rest)	Permits intercommunication when COLD MIC is selected on the function selector control. Overrides UHF communications.
6 RIO's MIC button (right foot rest)	Permits transmission on UHF 1, UHF 2, or BOTH radios as selected on the communications/tacan command panel.

Figure 19-3. Intercommunication Controls (Sheet 2)

CAUTION

With the front cockpit amplifier selector switch in the EMER position, engine stall/overtemperature and Sidewinder tones will not be available to the pilot

Note

- Selection of EMERG on the amplifier selector switch in either cockpit allows use of other cockpit's input amplifier.
- The RIO can obtain a Sidewinder and engine stall/overtemperature tone by selecting EMERG on ICS panel. This allows the RIO to use the pilot's amplifier.

19.2.4 RIO Communication/Tacan Command Control Panel. Allows RIO to select either UHF 1 (AN/ARC-159), V/UHF 2 (AN/ARC-182), or both radios for transmitting. The V/UHF 2 ANT switch allows selection of upper or lower antenna to minimize interference between dual UHF or data-link operation. Opposite antenna selection, frequency separation greater than 55 MHz, or turning one radio off is recommended. In addition, the DATA LINK panel provides lower or upper antenna selection for UHF#1 and D/L operation. See Figure 19-6 for RIO communication/tacan panel.

The TACAN CMD pushbuttons provide for transfer of tacan control functions between pilot and RIO. The crewmember (PLT or NFO) in control illuminates when selected. For additional information on the tacan system, refer to Chapter 20.

The UHF 1 VOL control allows the RIO to adjust the audio level of the ARC 159 UHF 1 radio. The KY MODE switch is operative only when the KY-58 is installed.

19.3 AN/ARC-159(V) 1 UHF 1 RADIO

The UHF 1 (ARC-159) radio provides air-to-air and air-to-surface voice communications. Radio frequency range extends from 225.000 to 399.975 MHz. The equipment allows AM mode transmission and reception on any of the 20 preset channels and a guard channel (243.000 MHz). Guard frequency may be monitored simultaneously with any other frequency selected. The ARC-159 has a possible 7,000 frequencies available by manually tuning in 25-kHz steps.

The ARC-159(V) 1 radio is a solid-state, self-contained unit with a minimum RF output of 10 watts. All controls for operation of the radio are on the front panel of the radio. The radio is located on the pilot left console (Figure 19-7).

Note

The UHF 1 (ARC-159(V) 1) ADF position is not functional; use the DF mode of V/UHF 2 ARC-182.

TONE	POSITION	CONTROLS	FUNCTION	CHARACTERISTICS
SIDEWINDER	Pilot	TONE VOLUME panel	Missile acquisition	High frequency, increases in intensity with positive lockon.
ALR-67	Pilot and RIO	TONE VOLUME panel (PILOT) ECM panel (RIO)	Threat radar caution. Missile launch warning.	Low to high frequency, determined by scan rate and PRF of threat radar. Low-to high-frequency warble when tone is present.
AN/ALQ-126	RIO	DECM control panel	Threat radar caution	Raw PRF sound.
Radar Altimeter	Pilot and RIO	Radar altimeter indicator (pilot)	Low-altitude warning	1,000 Hz tone, modulated at 2 pulses per second, lasting for 3 seconds.
APX-72	RIO	IFF control panel	Valid mode 4 interrogation	PRF of interrogation pulse 2,000 and 6,000 Hz.
TACAN	Pilot and RIO	Tacan control panel	Station identification	International morse code with three-letter designation.
AN/ARC-159	Pilot and RIO	UHF CONTROL PANELS	Own aircraft DF transmission.	1,020 Hz
AN/ARC-182	Pilot and RIO	V/UHF control panel	Other aircraft DF reception.	1,020 Hz, international morse code, voice.
ENGINE STALL/ OVERTEMPERATURE	Pilot	None	Engine stall detection and/or EGT overtemper-ature warning.	Modulated 320 Hz for 10 seconds maximum or until fault is removed, whichever comes first.

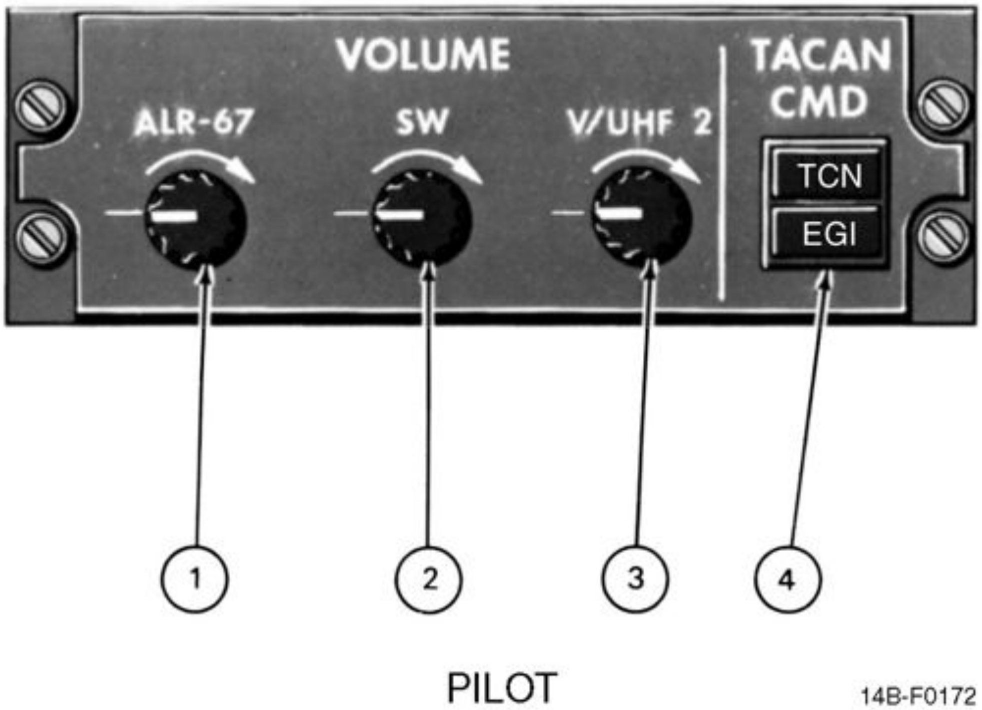
Figure 19-4. Glossary of Tones

The ARC-159 UHF 1 antenna is shared with the D/L antenna system and is always on the opposite antenna from the D/L. To minimize mutual interference between UHF 1 and V/UHF 2 when using dual UHF communications capability, opposite antenna selection is recommended or frequency separation greater than 55 MHz. To minimize mutual interference between UHF communications and D/L operation when using D/L capability, opposite antenna selection for V/UHF 2 and D/L and a frequency separation greater than 55 MHz is recommended, along with turning UHF 1 or V/UHF 2 radio OFF. UHF communication interference with the D/L may cause the TILT light to illuminate and the autopilot ACL or VEC/PCD mode to disengage. Data-link interference with the UHF radios may cause audible chirping at the D/L message reply rate.

19.4 VHF/UHF RADIO 1 (AN/ARC-182)

The ARC-182 radio provides multimode, multichannel, air-to-air/air-to-surface voice, tone, and antijam (Have Quick) communications. The ARC-182 control panel (Figure 19-8) is located on the RIO left console. Frequency range extends in four bands from 30 to 88,108 to 156, 156 to 174, and 225 to 399.975 MHz on any of 11,960 channels (separated by 25 kHz). Transmission and reception are available in AM or FM bands. The modulation is selected automatically by the radio except in the 225 to 399.975 band (toggle switch) 30 preset channels are available. Guard frequency of each band may be monitored simultaneously with any other frequency selected.

The radio is used with the ARA-50 to provide automatic direction finding to the transmitting station. The ARC-182 operates with secure-voice equipment (KY-58). Upper and lower antenna installations provide reliable line-of-sight communications to 200 nm (depending on altitude and atmospheric conditions). A remote indicator on the pilot instrument panel indicates the channel or frequency selected.



NOMENCLATURE	FUNCTION
1 ALR-67 volume control	Clockwise rotation increases tone in pilot's headset. Provides threat alert and warning tones representing received threat radar signals.
2 SW (Sidewinder) volume	Clockwise rotation increases missile tone in pilot's headset. Counterclockwise control rotation turns tone to low.
3 V/UHF 2 volume control	Clockwise rotation increases tone or voice from ARC-182 in pilot's headset.
4 TACAN CMD control	Illuminates TCN or EGI, indicating BDHI steering to TACAN or EGI.

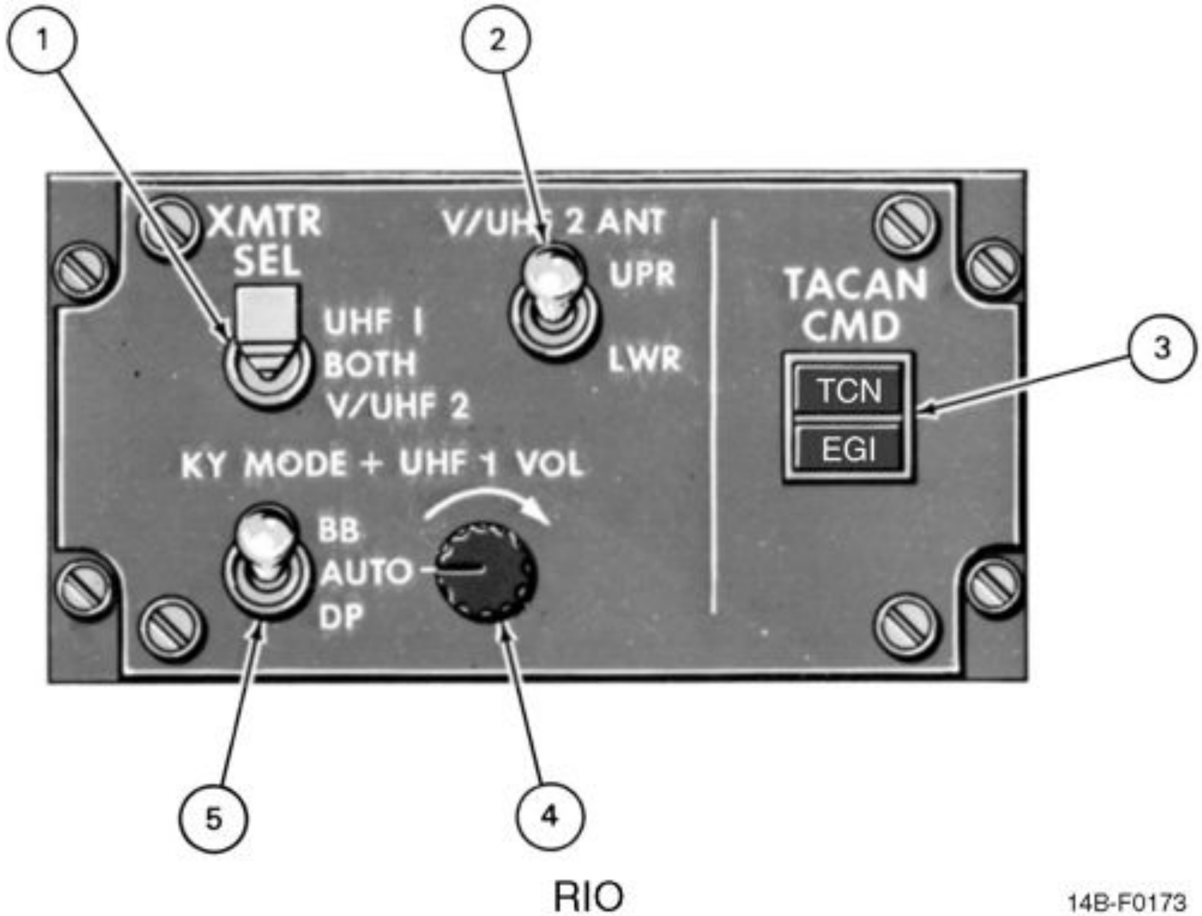
Figure 19-5. Pilot VOLUME/TACAN CMD Panel

Note

Transmissions on both UHF 1 and VHF/UHF 2 radios, while operating on the same frequency, may result in a squeal. This is a normal condition caused by RF interaction between the two radios operating on the same frequency in close proximity to each other.

19.4.1 Preset Channel(s) Load

1. MODE selection — T/R or T/R&G.
2. Frequency mode control — PRESET.
3. CHAN SEL switch — Select Channel 1.
4. Frequency mode control — READ.
5. Frequency select switches — Slew to Desired Frequency.
6. Frequency mode control — LOAD (frequency is stored in memory for CH 1).
7. Frequency mode control — READ, Verify Frequency Display.



NOMENCLATURE	FUNCTION	
1 XMTR SEL switch	Selects desired VHF/UHF communications radio for transmission or reception.	
	UHF 1 —	Selects ARC-159(V) UHF 1 radio.
	V/UHF 2 —	Selects ARC-182 VHF/UHF 2 radio.
	BOTH —	Selects both UHF 1 and V/UHF 2 radios.
2 V/UHF 2 ANT switch	UPR —	Selects upper antenna for V/UHF 2.
	LWR —	Selects lower antenna for V/UHF 2.
3 TACAN CMD control switch/indicator	Illuminates when selected TCN or EGI, indicating BDHI steering to TACAN or EGI.	
4 UHF 1 VOL control	Controls RIO's audio level of pilot's UHF ARC-159(V) 1. Clockwise rotation increases volume.	
5 KY MODE switch (operational only with KY-58 installed)	BB —	Normal mode for FM transmission.
	AUTO —	Provides automatic selection of BB/FM and DP/AM. Changes as the frequency on the ARC-182 is changed.
	DP —	Normal mode for AM transmission. UHF 1 (ARC-159) is capable of DP mode only.

Figure 19-6. RIO Communication/TACAN CMD Panel

NOMENCLATURE	FUNCTION
1 VOL control	Adjusts level of audio signal. Full counterclockwise rotation provides minimum volume.
2 Squelch switch	SQL — Squelch circuit is operational and background noise is removed automatically by reducing receiver gain. OFF — Disables the squelch circuit, restoring the receiver to full gain.
3 Frequency tuning	Four frequency tuning switches are used to tune transceiver when the mode switches (spring return) selector switch is set to MANUAL. The left switch controls the hundreds and tens digits, the second switch controls units, the third switch controls tenths, and the right switch controls hundredths and thousandths. Forward deflection of the switch increases the numeric reading, and aft deflecting decreases the numeric reading.
4 FREQ/(CHAN)	Displays frequency when mode selector switch is in MANUAL, or displays UHF channel when mode switch is in PRESET.
5 READ switch	Deflection of the switch causes the frequency display to read the preset channel frequency.
6 BRT/TEST control	Clockwise rotation increases the brightness of FREQ/(CHAN) readout: counterclockwise rotation provides dimmest readout. Turn past full bright to read 888.888.
7 LOAD pushbutton (spring return)	Depressing pushbutton loads the display frequency of the preset channel.

Figure 19-7. AN/ARC-159(V) 1 UHF 1 Control Panel (Sheet 1 of 2)

NOMENCLATURE	FUNCTION	
8 Function selector	ADF —	The UHF 1 ARC-159 ADF function is not functional; use the DF mode of the VHF/UHF 2 ARC-182.
	BOTH —	Energizes both the main transceiver and the guard receiver
	MAIN —	Main transceiver is energized permitting normal transmission and reception. Receive or transmit function is selected by the microphone push-to-talk switch.
	OFF —	Secures UHF 1 radio.
9 CHAN SEL control	Selects any one of 20 preset frequency channels when the tuning selector switch is set to PRESET.	
10 Frequency chart	Used to record preset channel frequencies.	
11 Mode selector switch	GUARD —	Main transceiver is energized and shifted to guard frequency of 243.0 MHz permitting transmission and reception. In this position, both preset and manual frequency selections are not available.
	MANUAL —	Frequency tuning controls are used to tune the main transceiver to any frequency (7,000 available) within the range of the set. The frequency selected is displayed in the readout window. In this position, PRESET selections are not available.
	PRESET —	Used to tune the transceiver to any of 20 preset channels using the PRESET channel selector. The selected channel is displayed on the readout window.
12 TONE pushbutton (spring return)	Depressing pushbutton causes a steady tone (1,020 Hz) to be transmitted on the frequency or channel selected.	

Figure 19-7. AN/ARC-159(V) 1 UHF 1 Control Panel (Sheet 2)

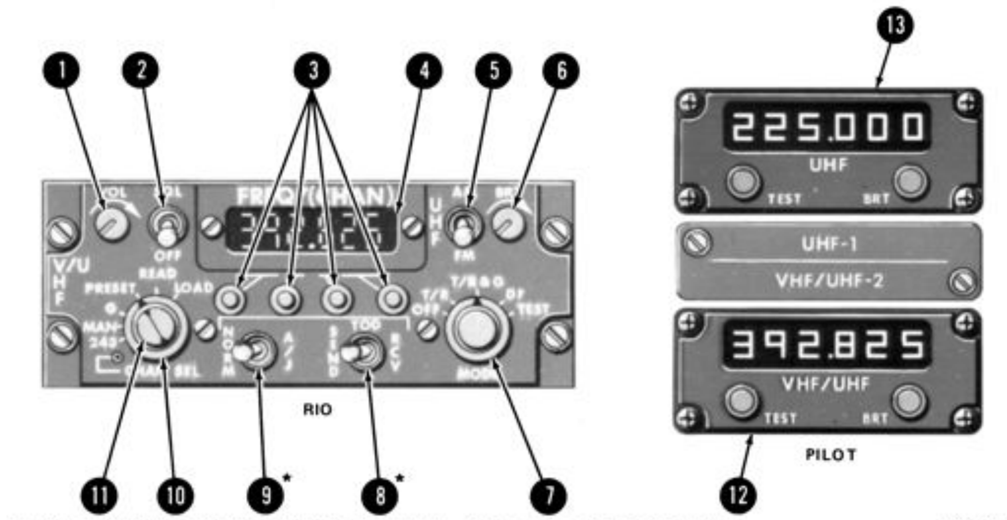
8. Enter frequency in quick reference directory for CH 1 (if desired).
9. Repeat steps 2 through 8 for subsequent channels.

19.4.2 Built-In Test. BIT isolates faults in the RT to one module, two modules, and three modules. BIT should be initiated anytime the FREQ/(CHAN) display blanks or indicates an erroneous readout. Proceed as follows:

1. MODE selector — TEST.
2. BRT control — As Required.
3. BIT requires approximately 10 seconds, observe FREQ/(CHAN) display).
   a. No fault is indicated by 888.888.
   b. Faults are indicated by a number that identifies the module or modules at fault.

Figure 19-9 lists the most common BIT fault codes and their respective module failures.

19.4.3 Have Quick (Antijam) Mode. Have Quick is a tactical antijam system that utilizes frequency hopping, a method where frequencies are changed many times per second. The frequency hopping patterns, stored in memory and frequency tables, are selected by word of day, net numbers, and a given date. The antijam mode of the ARC-182 is enabled by selecting a net number and by placing the NORM/AJ switch to A/J once all the variables have been entered into the radio. For two or more radios to successfully communicate on a Have Quick net, each radio must have the same time of day, word of day, and operating net. The AN/ARC-182s Have Quick II systems are compatible with older Have Quick I systems.



* THESE SWITCHES ONLY AVAILABLE ON C-11128A AND C-11984 CONTROL PANELS

NOMENCLATURE	FUNCTION	
1 VOL control	Adjusts level of audio signal. Clockwise rotation increases audio level.	
2 Squelch switch	SQL —	Squelch circuit is operational and background noise is removed by reducing receiver gain.
	OFF —	Disables squelch circuit restoring receiver to full gain.
3 Frequency tuning switches (spring return)	Four frequency tuning switches are used to tune transceiver when the tuning selector switch is set to MAN (manual). The spring-loaded switches increase the frequency in the up position and decrease frequency in the down position. The left switch controls the hundreds and tens digits, the second switch controls units, the third switch controls tenths, and the right switch controls hundredths and thousandths.	
4 FREQ/(CHAN) display	Displays incandescent digital readouts of selected frequency or channel. In TEST mode indicates receiver transmitter fault locations.	
5 UHF mode switch	Operational when tuned to frequencies in the 225.000 to 399.000 MHz band.	
	AM —	Selects amplitude modulation signals. Varies with atmospheric conditions, susceptible to electromagnetic interference.
	FM —	Selects frequency modulation signals. Reduces electromagnetic interference.
6 BRT control	Varies the FREQ/(CHAN) display light intensity. Clockwise maximum intensity.	
7 MODE selector	OFF —	Secures VHF/UHF radio, unless frequency mode switch is set to 243.
	T/R —	Energizes transmitter and main receiver.
	T/R&G —	Energizes transmitter, main, and guard receivers.
	DF —	Provides automatic direction finding from 108 to 399.975 MHz.
	TEST —	Indicates built-in-test (BIT) RT; displayed on FREQ/(CHAN) indicator. Refer to Built-In-Test this chapter.

Figure 19-8. AN/ARC-182 VHF/UHF Control Panel (Sheet 1 of 2)

NOMENCLATURE	FUNCTION	
8 TOD switch	RCV —	Allows reception of TOD messages on preset channel selected.
	SEND —	Allows transmission of TOD messages on preset channel selected.
9 NORM/AJ	NORM —	Used for normal VHF/UHF communications.
	A/J —	Provides jam resistant communications.
10 Frequency mode switch (outer dial)	243 —	Tums on the receiver-transmitter (takes precedence over operational mode control) and causes the transmitter main receiver, and guard receiver to tune to 243.000 MHz (UHF guard frequency). All functions except VOL SQL and BRT are disabled.
	MAN —	Permits manual selection of an operating frequency using the frequency tuning switches. Transmitter and receiver are disabled during a frequency change.
	G —	Tunes the receiver-transmitter to the guard frequency in the band to which the RT was last tuned.
	PRESET —	Allows selection of any one of 40 present operating frequencies with CHAN SEL switch. Selected channel is displayed in the two center digit readouts of the FREQ/(CHAN) display. Channels 31 through 40 are for Have Quick (antijam) use.
	READ —	Displays the frequency (rather than channel) of preset channel selected.
	LOAD —	Automatically places the displayed frequency into the memory for the selected preset channel.
11 CHAN SEL switch (inner dial)	Enables any 1 of 40 preset channels when the frequency mode switch is set to PRESET.	
12 VHF/UHF 2 remote channel/frequency indicator	Displays to the pilot digital readout of frequency or channel selected by RIO for VHF/UHF 2 radio.	
	TEST —	Initiates an internal electronic sequence that tests indicator (no fault indicated by 888.888).
	BRT —	Varies the digital readout light intensity. Maximum light intensity is full clockwise.
13 UHF 1 remote channel/frequency indicator	Displays digital readout of frequency or channel selected by the pilot for UHF 1 radio.	
	TEST —	Initiates an internal test of the indicator (no fault indicated by 888.888).
	BRT —	Varies the digital light intensity. Maximum intensity if full clockwise

Figure 19-8. AN/ARC-182 VHF/UHF Control Panel (Sheet 2)

MODE	DISPLAY	FAULT	INTERPRETATION
RCV	.	RMT or RT	SELECT TEST MODE
XMT	.	LOW PWR	SELECT TEST MODE
TEST	.	RMT CTRL	DEFECTIVE CONTROL
TEST	888.888	NONE	RT AND CTRL OK
TEST	4 6 5	RT	MODULES 4, 5 OR 6 BAD
TEST	0 6 1	VSWR	RT OR ANTENNA SYSTEM
TEST	6 5 1	FWD PWR	RT OR ANTENNA SYSTEM
TEST	1 5 7	RT	MODULES 1, 5, OR 7
TEST	3 3 3	RT	MODULE 3 BAD

Figure 19-9. Common BIT Indications

19.4.4 Have Quick Load Instructions. Have Quick antijam voice communication entry uses preset channel 40. The contents of preset channel 40 designates the loading mode in which the unit is operating. The following loading codes are used to operate and load in Have Quick II:

1. 220.000 — Operate in Have Quick II
2. .025 — MWOD load mode
3. .050 — MWOD erase mode
4. .075 — FMT load mode

If the aircrew desires to enter Have Quick without loading or verifying, 220.00 should be loaded into preset channel 40 using the procedures in paragraph 19.4.4.13. Otherwise, Have Quick I processing is used.

19.4.4.1 Net Selection. Have Quick I and II use the same method of net selection. A net is a six-digit number that selects the frequency table that will be hopped on. Net numbers are in the form of AXX.XYY, where A indicates a Have Quick net, X is a number from 0 to 9 defining the net, and YY is either 00, 25, 50, or 75, which determines the combat or training operational mode. The operational modes are:

1. COMBAT
   a. 00 — Operate in Have Quick I
   b. 25 — Have Quick II NATO
   c. 50 — Have Quick II Non-NATO
   d. 75 — Not used
2. TRAINING
   a. 00 — Have Quick I Training
   b. 25 — Have Quick II Training
   c. 50/75 — Not used.

The 1,000 combat nets range from 000 to 999. The variables in these net numbers refer the radio to specific frequencies and algorithms within the radio memory. There are five Have Quick I training nets displayed as A00.X00, where X is 0 to 4. There are 16 Have Quick II training nets displayed as A0X.X25, where X.X is 0.0 to 1.5. The variables in these training net numbers tell the radio the training frequency on which to begin hopping. Training nets are activated by a special WOD (300.0XX) in segment one of the WOD used for that day. The last two digits determine the hop rate. The same applies to the last two digits of the first segment of combat WODs.

19.4.4.2 Word of Day/Multiple Word of Day. A WOD/MWOD is a transmission security variable. Have Quick I radios use a WOD consisting of six-segments off six digits each. Have Quick II radios use a MWOD that adds a seventh segment containing a two-digit date tag and five more MWODs for six days of operation without reloading WODs. The WOD/MWOD is loaded into the radio to key the Have Quick system to the proper hopping pattern, dwell time, and hop rate. The hop rate is included in the first segment of each WOD/MWOD, XXX.XYY, where YY is 00, 25, 50, 75, denoting slow to fast hop rates. When operating with Have Quick I systems, only one of the six MWODS is used. See Figure 19-10.

19.4.4.3 Time of Day. TOD is a signal that synchronizes Have Quick radios to a common time for antijam operation. There are two ways to enter TOD. One method involves receiving Universal Time Coordinated (UTC) over the air on a manually selected UHF frequency after power up. The second method involves using the self-start (emergency time start) mode, which is used when acting as master clock to transmit that time to other Have Quick systems. Within this TOD signal is the operational day. This is transmitted with the TOD or loaded manually as in the self-start procedure. Refer to TOD Load, paragraph 19.4.4.12. The codeword for TOD is “Mickey.”

19.4.4.4 MWOD Load Entry

1. Frequency mode control — PRESET.
2. CHAN SEL switch — Select Channel 40.
3. Frequency mode control — READ.
4. Frequency select switches — Select 220.025.
5. Frequency mode control — LOAD.

Note

If MWODs are being loaded to replace existing ones, the old MWODs should be erased using the procedures in paragraph 19.4.4.9. This procedure will erase all MWODs in the radio memory.

1.1 289.950	2.1 295.850	3.1 290.450	4.1 275.950	5.1 270.450	6.1 300.050
1.2 299.000	2.2 289.600	3.2 279.000	4.2 269.300	5.2 259.000	6.2 249.000
1.3 298.100	2.3 288.000	3.3 278.500	4.3 268.000	5.3 258.600	6.3 248.900
1.4 297.000	2.4 287.900	3.4 277.400	4.4 267.000	5.4 257.800	6.4 247.100
1.5 296.000	2.5 286.300	3.5 276.500	4.5 266.700	5.5 256.000	6.5 246.100
1.6 295.000	2.6 285.300	3.6 275.100	4.6 265.500	5.6 255.500	6.6 245.200
1.7 11	2.7 12	3.7 13	4.7 14	5.7 15	6.7 16

8.1 = Operational day
1.1 through 1.6 are WOD 1 segment numbers.
1.7 is the date tag for WOD 1.
2.1 through 2.6 are WOD 2 segment numbers.
2.7 is the date tag for WOD 2.
3.1 through 6.7 are the same as above for WODs 3 through 6.
8.1 is the current operational day, which should match one of the date tags.

Notes:

(1) If the current operational day was 11 (MWOD location 1), Have Quick II combat net would be used with a hop rate of 50 (included in the last two digits of segment 1.1). An appropriate Have Quick II operational net should be chosen.

(2) If the current operational day was 16, Have Quick II training net would be used because the first segment of MWOD location 6 (6.1) is the special training segment. The hop rate would be 50 (last two digits of first segment). An appropriate Have Quick II training net number should be chosen.

Figure 19-10. Example of an ARC-182 Have Quick II MWOD Fill

19.4.4.5 MWOD Load

1. Frequency mode control — Preset (1.1 will be displayed).

2. Frequency Select Switches — Select Desired WOD and WOD Segment Using Middle Two Frequency Select Switches.

3. Frequency mode control — READ, Display Shows Frequency Indicating Desired WOD Segment.

Note

If the MWODs were erased using the MWOD erase procedure in paragraph 19.4.4.9, the display will show 000.000 indicating that they had been erased.

4. Frequency select switches — Select Desired Frequency WOD Segment.

5. Frequency mode control — LOAD, Desired Frequency Loaded into Memory.

6. Repeat steps 1 through 5 to load remaining MWODs.

Note

- The desired frequencies are located in segments 1 through 6 of each MWOD. The date tag for each MWOD is loaded into the seventh segment and is a two-digit number corresponding to the operational day on which that MWOD is to be used. It can be loaded or changed using the two middle frequency select switches and the MWOD segment loading procedures above.

- The crew may not enter an out-of-range WOD frequency, segment, or date tag. When two identical date tags are loaded, the last date entered is valid and the old date is set to zero. If the old date is viewed, 00 will be displayed.

- The MWOD is not entered into the memory of the unit until the date tag is loaded. Thus, if a segment of an MWOD has been changed after the MWOD was initially entered, the date tag must be reentered to accept the MWOD change.

19.4.4.6 MWOD Load Exit

1. Frequency mode control — MAN, Ready To Receive TOD.

Note

When MANUAL is selected on the frequency mode control to exit a load mode, the code to operate in Have Quick II antijam without entering a load mode (220,000) will automatically be loaded into preset channel 40.

19.4.4.7 Operational Date Load. The operational date is the calendar date of the mission day. The range is 1 through 31. The MWOD that is used by the unit for frequency hopping is the MWOD whose date tag matches the operational day. Thus, if an operational day is entered or received via TOD transmission and no date tag exists for that operational day, an error will occur and be displayed. The operational day is loaded as follows:

1. Perform steps 1 through 5 of paragraph 19.4.4.4. Step 1 is not required if already in MWOD load.

2. Frequency mode control — PRESET, Last WOD and Segment Selected Will Be Displayed.

3. Frequency select switches — Select 8.1.

4. Frequency mode control — READ, Last Operational Date or 00 is Displayed.

5. Frequency select switches — Select Desired Date.

6. Frequency mode control — LOAD, Operational Date is Loaded into Memory.

Note

Out of range (<1 or >31) operational dates may not be entered.

19.4.4.8 MWOD Verify. The aircrew may view the MWODs at any time for verification by reading the MWOD locations using steps 1 through 3 in paragraph 19.4.4.5.

19.4.4.9 MWOD Erase. The following procedure enables the aircrew to erase all MWODs stored in the nonvolatile memory. This procedure is recommended before reloading all MWODs with new frequencies.

1. Frequency mode control — PRESET.
2. CHAN SEL switch — Select Channel 40.
3. Frequency mode control — READ.
4. Frequency select switches — Select 220.050 To Initiate MWOD Erase Function.
5. Function mode control — LOAD, Display Will Go Blank Indicating MWODs Have Been Erased.

19.4.4.10 FMT Training Frequency Load. The Have Quick II FMT training net operates similar to combat Have Quick II, as both the date tag and operational day functions are used. The FMT net, however, hops on its own set of 16 frequencies loaded into a separate training WOD. Additionally, a special MWOD segment for FMT (300.0XX, where XX is the hop rate) is loaded into the first segment of the MWOD being used (usually 1.1, but any of the six MWODs can be used as long as the date tag for the MWOD whose first segment contains 300.0XX matches the operational day). The frequencies actually hopped on, however, are located into a separate FMT WOD that can be accessed with the FMT load code loaded into preset channel 40. Once the 16 training frequencies (7.01 to 7.16) are loaded, it is not necessary to reload them. Additionally, it is not necessary to reload the special FMT MWOD segment once it is loaded, as long as the date tag used is within the same MWOD as the special FMT segment. If using the self-start method of TOD, the operational day as well as the date tag must be loaded into segments 8.1 and 1.7 (or the seventh segment of whichever MWOD is being used), respectively. Thus, combat Have Quick II and FMT can be used interchangeably simply by loading one or more of the MWOD first segments with the special training WOD segment. On every day that the operational day matches the date tag of the MWOD with the special FMT segment loaded into its first segment, the unit will hop on the FMT training frequencies regardless of the contents of the other segments within that MWOD. See Figure 19-10, note 2.

1. Frequency mode control — PRESET.
2. CHAN SEL switch — Select Channel 40.
3. Frequency mode control — READ.
4. Frequency select switches — Select 220.075.
5. Frequency mode control — LOAD.
6. Frequency mode control — PRESET, First FMT Frequency Segment (7.01) is Displayed
7. Frequency select switch — Select Desired FMT Segment.
8. Frequency mode control — READ.
9. Frequency select switches — Select Desired FMT Training Frequency.
10. Frequency mode control — LOAD, Desired FMT Training Frequency is Stored in Memory.
11. Repeat steps 6 through 10 to load remaining desired FMT training frequencies. The load function is exited by placing the frequency mode control to MAN.

19.4.4.11 FMT Net Operation. Once the training frequencies have been loaded or verified, Have Quick II FMT net can be operated as follows:

1. Perform steps 1 through 5 of paragraph 19.4.4.
2. Frequency mode control — PRESET.
3. Frequency select switches — Select Segment 1 of Desired MWOD To Be Used (1.1, 2.1, 3.1, etc.).
4. Frequency mode control — READ, Display Shows Frequency Indicating Desired WOD Segment.
5. Frequency select switch — Select Special FMT Segment With Desired Hop Rate (300.0XX = 00, 25, 50, 75).
6. Frequency mode control — LOAD, Desired Frequency Loaded into Memory.
7. Frequency mode control — PRESET.
8. Frequency select switches — Select Segment 7 (date tag) of the Same MWOD Used Above (1.7, 2.7, 3.7, etc.).

9. Frequency mode control — READ, Display Shows Two-Digit Date Tag Previously Loaded or 00.

10. Frequency select switches — Select Desired Date Tag.

11. Frequency mode control — LOAD, Desired Date Tag Loaded into Memory.

12. Frequency mode control — MAN, Ready To Receive TOD.

19.4.4.12 TOD Load. TOD maybe loaded in any of the following ways.

1. Emergency or forced start entry of time/date is performed by holding the TOD switch in receive (RCV) position until decimal point flashes, then momentarily setting TOD switch to SEND. Selecting the operational day is performed using steps in paragraph 19.4.4.7.

2. To receive time/date over air (broadcast) in normal mode, momentarily push TOD switch to RCV when TOD is transmitted over manually selected UHF frequency. This will allow acceptance of TOD for 1 minute.

3. To transit time/date over air (broadcast) in normal mode, momentarily push TOD switch to SEND while on a manually selected UHF frequency. At this time, TOD signal is sent and a tone will be heard.

4. To receive new time in A/J mode or to update clock, momentarily push TOD switch to REC. This will allow acceptance of TOD for 1 minute.

5. To transmit time/date over air (broadcast) in A/J mode, momentarily push TOD switch to SEND. This will send TOD signal to all units that are in A/J and using the same net.

19.4.4.13 Antijam Mode Selection. If entering Have Quick II from a previous load mode, selecting MAN from that mode will automatically perform steps 1 through 5 below. In this case, proceed to step 6.

Note

TOD can be received from power up. It is not necessary to enter any other load or operate mode first.

1. Frequency mode control — PRESET.

2. CHAN SEL switch — Select Channel 40.

3. Frequency mode control — READ.

4. Frequency select switches — Select 220.000.

5. Frequency mode control — LOAD, the Radio is Now Prepared To Operate in Have Quick II.

6. Frequency mode control — MAN.

7. TOD — Received.

8. Frequency select switches — Select Desired Net Frequency.

9. NORM/A/J switch — Select A/J on Command to "Go Active;" First Digit of Net Frequency Will Display as "A."

19.4.4.14 Have Quick II Error Code. See Figure 19-11 for a list of Error Codes.

ERROR DISPLAY	FREQUENCY MODE CONTROL	CONTROL ERROR
XX.XXX	MAN	Invalid MWOD and Date
XX.XXX	MAN	Invalid Net Number
XXX.XXX	MAN	No TOD
X.X	PRESET	Invalid MWOD and Date
X.X	PRESET	Invalid Net Number
X.X	PRESET	No TOD
The "X" in the error display column represents digits 0 to 9.		

Figure 19-11. Have Quick II Error Codes

19.4.4.15 Have Quick Basic Troubleshooting Procedures

1. Broken communications when A/J selected — Verify all segments of the current WOD or all the FMT frequencies are correct.

2. Lack of an “A” in the first digit of the net frequency displayed on the radio — Receive another TOD transmission to resynchronize the radio.

3. Broken communications after time once good communications have been established — Receive another TOD transmission either in A/J or normal mode to resynchronize the radio.

4. Invalid MWOD or date tag error code — Verify all MWOD segments for the current day.

5. Invalid net error code — Verify that the correct net is being used.

6. No TOD error code — Attempt to receive another TOD from the master. If still unable to receive TOD, use the self-start method and attempt to transmit TOD to other net participants if practical.

19.5 AN/ARA-50 UHF AUTOMATIC DIRECTION FINDER

The UHF automatic direction finder is used with the ARC-182 radio. ADF provides relative bearings to transmitting ground stations or other aircraft. It can receive signals on any 1 of 30 preset channels or on any manually set frequency in the 108 to 399.975 MHz range.

The system has a line-of-sight range, varying with altitude. Operating power is 115 Vac from the essential No. 2 bus, 28 Vdc from the essential No. 2 bus, and 26 Vac through the RIO circuit breaker panels. The system requires a 5-minute warmup period. During the warmup time, failure indications should be disregarded.

The system uses the AS-909/ARA-48 ADF antenna. Bearing to transmitting stations is displayed on the pilot/RIO BDHI (No. 1 needle), pilot HSD, and RIO multiple display indicator. The ADF signal is interrupted during voice UHF transmissions.

19.6 VOICE SECURITY EQUIPMENT (TSEC/KY-58)

The security equipment is integrated, and operates, with the VHF/UHF 2 and UHF 1 communication sets to permit secure voice in a hostile environment. It shall be operated as directed by appropriate authority. Theory of operation and practical application are covered in the operation manual, KAO-124B/TSEC (KY-58).

The communications/tacan panel and the KY-58 control panel (Figure 19-12) on the RIO left side console are the only cockpit controls for operating the KY-58 in either cipher or plain-language modes. Electrical power is from the dc essential bus No. 1 with circuit protection on the RIO de essential No. 1 circuit breaker panel. The KY-58 has two basic modes of operation: plain (P) and cipher (C). The plain mode is used during normal UHF communications. The cipher mode is used when secure voice communications are desired. The radio sets must be ON to attain secure operation. The receiving station must be properly equipped to receive transmissions in the proper cipher mode.

Note

Do not transmit plain voice on one radio during cipher receptions or while transmitting on the other radio.

19.6.1 KY-58 Operation

19.6.1.1 Prelaunch

1. Determine that proper code has been set by personnel qualified in voice security equipment.

2. VHF/UHF radios — ON.

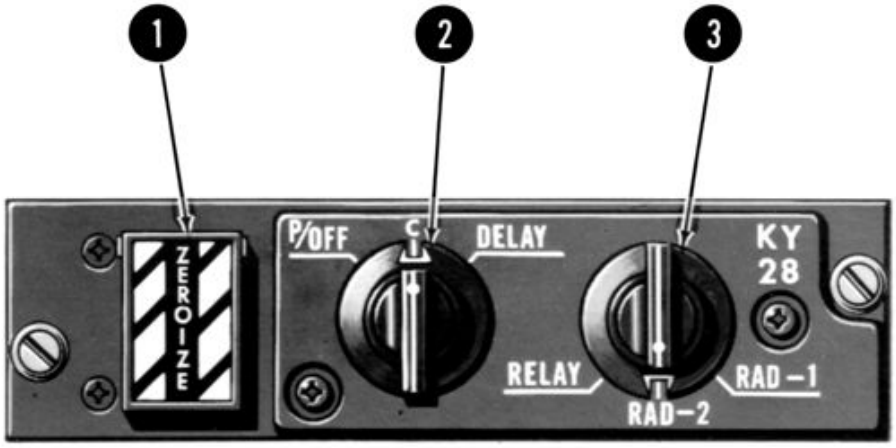
3. Power mode switch — C.

4. Radio selector — RAD-1 or RAD-2.

5. If a ground test of equipment is desired, establish two-way, plain-text radio communications on the plain-voice radio with a suitable ground station and request an equipment check.

6. After a 2-minute warmup period, on the cipher selected radio listen for a steady, unbroken tone in the headset followed by a double-pitched broken tone.

7. Key the appropriate radio selected for transmission, hold for approximately 2 seconds, and release. Double-pitched broken tone will cease and no sound will be heard.



NOMENCLATURE	FUNCTION	
(1) ZEROIZE switch	Guard lifted. The preset codes are erased and must be reset on the ground by qualified personnel before the cipher (C) mode can be used.	
(2) Power-Mode switch	P/OFF –	UHF radio is used as a plain language receiver/transmitter. Removes power from the system.
	C –	Used to transmit and receive secure voice communications over the UHF radio in accordance with preset codes. Applies power to KY-58 system. Aircraft electrical power must be on and KY-58 must be in “C” position for codes to be set by appropriate personnel.
	DELAY –	Provides a time delay between push-to-talk and actual transmit.
(3) Radio select switch	RELAY –	Relay position: re-transmits information between other facilities. (Relay position is not operational.)
	RAD-2 –	Selects V/UHF 2 for secure voice.
	RAD-1 –	Selects UHF 1 for secure voice.

Figure 19-12. KY-58 Control Panel

8. Key radio and hold. A single-beep tone will be heard in approximately 1-1/2 seconds. When this tone is heard, the equipment is ready to cipher transmission.

9. After beep tone is heard, establish two-way cipher radio communications with a cooperating ground station and check for readability and signal strength.

10. Set power mode and radio selector switches in accord with the tactical

Note

If a ground check of the equipment is not practical, the above procedures may be used to perform an in-flight check of the equipment situation.

19.6.1.2 Postlaunch. The speech security equipment shall be operated as directed by appropriate authority.

19.6.1.3 After Landing

1. ZEROIZE switch — ZEROIZE (as briefed). Zeroize the code as directed by appropriate authority.

2. Power switch — OFF.

19.7 IN-FLIGHT VISUAL COMMUNICATIONS

Communications between aircraft are visual whenever practicable. Flight leaders shall ensure that all pilots in the formation receive and acknowledge signals when given. The visual communication chapters of the NATOPS Aircraft Signals Manual, NAVAIR 00-80T-113, should be reviewed and practiced by all pilots and RIOs. Common visual signals applicable to flight operation are listed in Figure 19-13, sheets 1 through 2.

19.8 GROUND HANDLING SIGNALS

Communications between aircraft and ground personnel are visual whenever practicable, operations permitting. The visual communications chapters of NAVAIR 00-80T-113 should be reviewed and practiced by all flightcrew and groundcrew personnel. For ease of reference, visual signals applicable to deck/ground handling are listed in FO–17. During night operations, flashlights or wands shall be substituted for hand and finger movements.

MEANING	SIGNAL	RESPONSE
GENERAL CONVERSATION		
Affirmative (I understand.)	Thumb up, or nod of head.	
Negative (I do not know.)	Thumb down, or turn of head from side to side.	
Question (repeat); used in conjunction with another signal, this gesture indicates that the signal is interrogatory.	Hand cupped behind ear as if listening.	As appropriate.
Wait	Hand held up in a fist with palm outward.	
Ignore last signal	Hand waved in an erasing motion in front of face, with palm forward.	
Perfect, well done	Hand held up, with thumb and forefinger forming an O and remaining three fingers extended.	
Numerals, as indicated	With forearm in vertical position, employ fingers to indicate desired numerals 1 through 5. With forearm and fingers horizontal, indicate number which, added to 5, gives desired number from 6 through 9. A clenched fist indicates zero.	Nod of head (I understand). To verify numerals, addressee repeats. If originator nods, interpretation is correct. If originator repeats numerals, addressee should continue to verify them until they are understood.
Take over communications	Tap earphones followed by lead change signal.	Execute.
CONFIGURATION CHANGES		
Lower or raise landing gear.	Rotary movement of hand (flashlight at night) in cockpit, as if cranking wheels, pause, drop below canopy rail.	Execute when hand/flashlight drops.
Speed brakes	Open and close four fingers rapidly and repeatedly. Flashlight at night — a series of flashes followed by a steady light; light out for execution.	Execute.
Lower or raise flaps.	Rotary movement of hand (flashlight at night) in cockpit as if cranking wheels, pause, drop below canopy rail.	Execute when hand/flashlight drops.
Sweep wings aft.	Hand held up, palm aft, and swept aft along canopy rail; at night, flash- light swept aft along canopy rail.	Execute when hand/flashlight drops.
Sweep wings forward.	Hand held up, palm forward, and swept forward along canopy rail; at night, flashlight swept forward along canopy rail.	Execute on head nod/light out.
FUEL AND ARMAMENT		
How much fuel have you?	Raise fist with thumb extended in a drinking position.	Indicate fuel in tens of gallons or hundreds of pounds by finger numbers.
Arm or safety missiles and ordnance.	Pistol cocking motion with either hand.	Execute and return signal.
FORMATION		
OK	Section leader gives thumbs-up signal.	Stands by for reply from wingman, holding thumbs-up until answered.
Commence take off power turn-up.	Leader gives a two-finger turn-up signal.	Wingman returns two-finger signal and executes.
I have completed my takeoff checklist and am, in all respects, ready for (section) takeoff.	Section takeoff leader raises arm overhead and waits for response from wingman.	Wingman gives thumbs-up, indicating checklist complete, and ready in all respects, for takeoff, then lowers arm and stands by for immediate section takeoff.

Figure 19-13. In-Flight Visual Communications (Sheet 1 of 2)

MEANING	SIGNAL	RESPONSE
Takeoff path is clear. I am commencing takeoff.	Section takeoff leader lowers arm.	Wingman executes section takeoff.
Take combat cruise.	Leader holds up open hand palm out towards his wingman and pushes out and in.	Execute.
Leader shifting lead to wingman.	Leader pats self on head and points to wingman. At night, leader aircraft switches lights to bright, and turns anti-collision light on. If an external light failure, leader shines flashlight on hard hat, then shines light on wingman.	Wingman pats head and assumes lead. At night, wingman puts lights on dim, and turns grimes light off when he accepts the lead. If an external light failure, wingman shines flashlight at leader, then on his hard hat, turns external lights to dim, and assumes lead.
Leader shifting lead to division designated by numerals.	Leader pats self on head, points to wingman, and hold up two or more fingers.	Wingman relays signal; designated division leader assumes lead.
Take cruising formation.	Thumb waved backward over the shoulder.	Execute.
I am leaving formation.	Any pilot blows kiss.	Nod (I understand.)
Aircraft pointed out, leave formation.	Leader blows kiss and points to aircraft.	Execute.
Directs plane to investigate object or vessel.	Leader beckons wing plane, then points to eye, then to vessel or object.	Wingman indicated blows kiss and executes.
Refers to landing of aircraft, generally used in conjunction with another signal: 1. I am landing. 2. Directs indicated aircraft to land.	Landing motion with open hand: 1. Pats head. 2. Points to another aircraft.	Execute. Alternate – signal Lower gear.
1. Join up or break up, as Appropriate 2. On GCA/CCA final: Leader has runway/ship in sight.	Flashing external lights.	1. Comply. 2. Wingman continues approach in accordance with standard operating procedures.
Wingman cross under.	Leader raises forearm vertically.	Execute.
Section cross under.	Leader raises forearm vertically and moves arm in pumping motion.	Execute.
Refers to CV Case I/Case II Pattern: 1. Spin whole flight. 2. Indicated aircraft spin.	1. Leader gives a two finger turnup signal. 2. Turnup signal followed by number of aircraft to spin.	1. Execute 2. Counting from last aircraft in flight specified number of aircraft execute spin.
AIR REFUELING		
Extend Drogue	Form cone-shape with hand, and move hand aft.	Tanker execute.
Retract Drogue	Form cone-shape with hand, and move hand forward.	Tanker execute.
Secure Turbine	One finger turn-up signal followed by cut signal.	Tanker execute.
FORMATION SIGNALS MADE BY AIRCRAFT MANEUVER (COMBAT OR FREE CRUISE)		
Single aircraft cross under in direction of wing dip.	Single wing dip	
Section cross under.	Double wing dip	Execute.
Close up.	Series of small zooms	Execute.
Join up; join up on me.	Porpoise aircraft.	Expedite join-up.

Figure 19-13. In-Flight Visual Communications (Sheet 2)

CHAPTER 20

Navigation

20.1 NAVIGATION SYSTEM OVERVIEW

The F-14B Upgrade Navigation System includes the F-14 Mission Computer (FMC), the H-764G Embedded GPS/INS (EGI), the Computer Signal Data Converter (Replacement) [CSDC(R)], the A/A24G-39 Attitude Heading Reference Set (AHRS), the C-12284/A Control Display Navigation Unit (CDNU), and a Signal Data Converter (SDC). The CDNU acts as the Bus Controller for the MIL-STD-1553B Navigation Bus (NAVBUS) linking the EGI, CSDC(R) and CDNU. Bulk storage of Navigation System waypoints and flight plan data is available on a Mission Data Loader (MDL) cartridge installed in the RIO's cockpit. The CSDC(R) provides the interface between the Navigation System and the FMC and uses EGI analog data to provide the weapon system with the continuous attitude information required to stabilize the radar antenna. The TACAN Command Switch in each cockpit is used to select the source of steering information — either the AN/ARN-84 TACAN or the EGI Navigation System — for display on cockpit instruments. The switches are coupled so that selection of EGI steering in one cockpit causes the switch in the other cockpit to change as well. The CDNU always displays EGI derived data regardless of whether TACAN or EGI steering is selected for display on the flight instruments (VDI, HUD, HSD, and BDHI). The SDC takes digital steering data from the CDNU and converts it to analog useable by a BDHI. A single SDC provides range and bearing to the BDHI in both cockpits. The F-14B Upgrade Navigation System is diagrammed in FO–18.

20.1.1 Embedded GPS/INS (EGI). The EGI is a Ring Laser Gyro (RLG) IMU complemented by an embedded five-channel GPS receiver to provide precise position in addition to the highly accurate RLG velocity and attitude measurements. A Kalman filter is used to optimally combine the data from both sensors resulting in a navigation system with essentially no drift. See Figure 20-1.

The EGI provides three separate position solutions simultaneously:

1. GPS
2. Blended
3. Free Inertial

The GPS solution uses the timing signals transmitted by the NAVSTAR GPS constellation of satellites to determine position near the earth's surface. As long as four satellites are being tracked, extremely accurate position and time are available even when the EGI is in an alignment mode. The receiver also provides aircraft velocity in three dimensions. During steady state flight, the velocities are quite accurate, but during accelerated flight, the update rate causes the velocities to lag slightly. Both position and velocity are updated once per second.

The Blended solution is the primary solution determined by the EGI, and is available for use as soon as the EGI estimates its drift rate is less than 5.0 nm/hr (refer to paragraph 20.3, "EGI Alignment Modes" below). The solution utilizes a Kalman filter that includes states for all gyros and accelerometers plus states for line-of-sight GPS satellite data. It does not "Update" the INS position in the manner of earlier GPS integrations using separate INS and GPS units. Rather, the Kalman filter processes each satellite signal separately, using it to refine the position derived from the IMU. A solution with full GPS accuracy requires track on four satellites.

The EGI has the ability to exclude GPS measurements from the Kalman filter if the operator desires (e.g., if the aircraft is operating in areas of known spoofing). There are, therefore, two possible Blended solutions: Blended (Aided) and Blended (Unaided). They are NOT available simultaneously, as there is only one Kalman filter routine in the EGI. The F-14 Navigation System uses the Blended (Unaided) solution when GPS aiding is

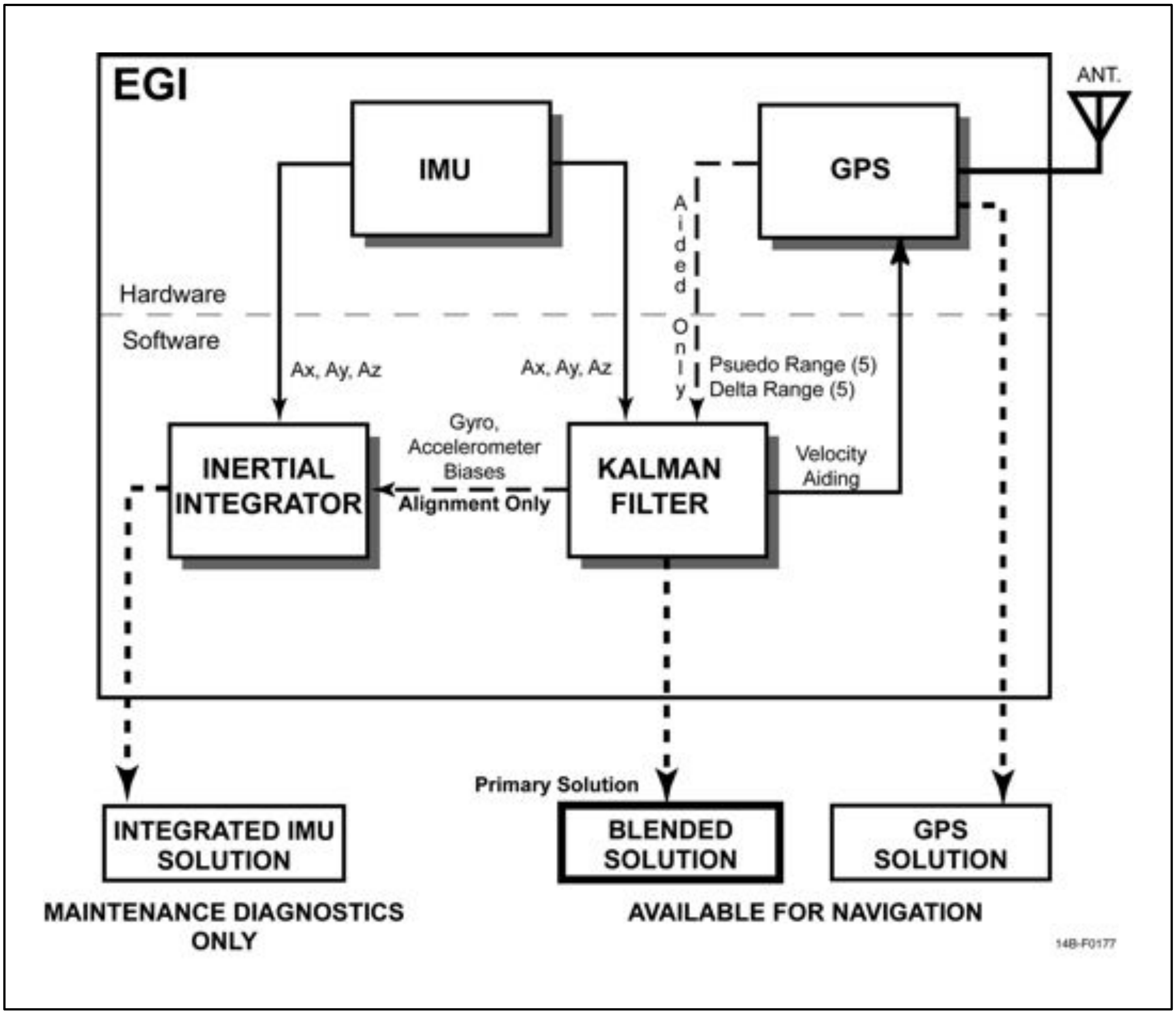


Figure 20-1. EGI Schematic

not desired instead of the Free Inertial solution because the Blended solution continues to refine the gyro and accelerometer biases after alignment is completed, thus providing a more accurate solution. See the discussion about alignment below.

Note that the EGI automatically excludes GPS information if a GPS BIT failure is detected or GPS data are invalid; no operator action is required.

The Free Inertial solution is similar to that provided by an INS without GPS or a Kalman Filter (see paragraph 20.1 below). The EGI provides this solution by integrating the accelerations measured by the IMU over time to get the distance traveled from a known starting position. After initial alignment — which determines IMU orientation — the Free Inertial solution will drift slightly from the correct solution by an amount dependent on small gyro and accelerometer errors. During alignment, the Kalman filter estimates the gyro and accelerometer errors, and stores them as biases for use in refining the Free Inertial solution. These estimates are frozen at the transition from Alignment to Navigate mode. Even with these biases available, the accuracy of the Free Inertial solution will not be as good as one that uses a Kalman Filter. This type of solution is available as a submode of the Blended solution. Refer to paragraph 20.12.1.

The Free Inertial solution is provided to give the aircrew an IMU only, dead reckoning solution for IMU diagnostic purposes. It cannot be used in navigation calculations by either the CDNU or FMC, nor does the solution in any way affect calculations for the Blended solution.

Note

The EGI Free Inertial solution will normally show a different position than either the Blended solution (Aided or Unaided) or GPS. This is due to the normal drift inherent in an IMU only solution. The Blended (Unaided) solution will also drift, but its drift characteristics are improved over the Free Inertial because the Kalman filter continues to refine the gyro and accelerometer biases used by the Blended solution.

20.1.1.1 EGI Modes. The EGI has ten modes of operation. In addition to Off, Initialize and Navigate, there are seven separate alignment modes: Gyro Compass, Stored Heading, SINS In Motion Align (IMA), SINS Stored Heading, GPS IMA, Manual IMA and Air Data IMA. Selection of all modes except OFF is done automatically based on the NAV MODE SEL switch position, aiding data available, the state of the parking brake, and any detected motion. When power is applied to the EGI (accomplished by turning the NAV MODE SEL switch to any position besides OFF), the unit transitions from Off to Initialize, and then to one of the alignment modes. The transition to Navigate can either occur automatically or by RIO action. Refer to the alignment procedures in paragraph 20.3

20.1.2 Computer Signal Data Converter (Replacement) [CSDC(R)]. The CSDC(R) is the interface between the Navigation System and the F-14 Mission Computer (FMC). It accepts analog attitude data from the EGI for radar antenna stabilization, and for use by the FMC in backup dead-reckoning navigation calculations. It also acts as a remote terminal on the NAVBUS, receiving position and velocity data from the EGI, and RNAV data from the CDNU. It processes this information for display on the VDI, HSD, HUD and PTID.

The CSDC(R) determines the overall Navigation System operating mode. It tracks various parameters including NAV MODE SEL switch position (from the FMC), the solution requested and various navigation system failure indications from the CDNU, the operating mode of the EGI and various validity discretes from the EGI, AHRS and FMC to determine the best overall system mode. There are eight possible modes (besides Off) with attitude and navigation solutions determined as shown in Figure 20-2. See paragraph 20.12.1 for a full description of the Navigation System modes.

20.1.3 Control Display Navigation Unit (CDNU). The CDNU provides control of the EGI (including entry of data required to align the EGI), transfers bulk navigation data stored on the MDL, and provides Area Navigation (RNAV) guidance calculations. BIT test and status information for NAVBUS components are accessible via the CDNU. The CDNU is the primary control unit for the Navigation System, with navigation data sent to flight instruments in accordance with operator selection using the PDCP and TACAN command switch.

SYSTEM MODE	SYMBOL	ATTITUDE SOURCE	POSITION SOURCE	VELOCITY SOURCE
Blended (Aided)	BD	EGI	GPS/INS	IMU
Blended (Unaided)	IN	EGI	INS Only	IMU
GPS	G	EGI	GPS Only	IMU
IMU/AM	IM	EGI	FMC Dead Reckoning	FMC Dead Reckoning
AHRS/EGI	AE	AHRS	EGI (Aided — GPS/INS Unaided — INS)	IMU
AHRS/GPS	AE	AHRS	GPS	GPS
AHRS/AM	AH	AHRS	FMC Dead Reckoning	FMC Dead Reckoning
NAV FAIL	—	None	None	None

Figure 20-2. System Modes

The CDNU can access a database of up to 20,000 waypoints stored on the MDL for use in RNAV calculations. Two hundred of these can be designated as a “Reversionary Database” and downloaded into CDNU non-volatile memory. Waypoint files contain fields for position (in either Latitude/Longitude or Military Grid Reference System (MGRS) coordinates), altitude, five character ICAO identifier, Flight Mode (see paragraph 20.12.2.1.4), waypoint type (airfield, navaid, etc.) and navaid frequency.

20.2 NAVIGATION SYSTEM COMPONENTS

The F-14B (Upgrade) Navigation System consists of the EGI, CDNU, CSDC(R), and the MDL. All but the MDL are connected via a dual redundant MIL-STD-1553B Navigation Bus (NAVBUS). The MDL is on the Avionics Bus (AVBUS), and is accessed by the CDNU through the EGI. The EGI is a remote terminal on both the NAVBUS and AVBUS. The SDC is an ancillary device that translates CDNU digital information to a form that can be used for display on the BDHI. It uses an ARINC-429 output from the CDNU.

20.2.1 H-764G Embedded Global Positioning System/Inertial Navigation System (EGI)

20.2.1.1 Inertial Measurement Unit (IMU). An inertial navigation system (one without GPS) is a dead reckoning system; it derives speed as a function of aircraft accelerations. These accelerations are measured by the Inertial Measurement Unit (IMU) portion of the EGI. Three mutually orthogonal accelerometers are used to measure acceleration in three dimensions. These outputs result in XYZ velocity components after integration and correction for the earth’s rotational velocity (coriolis acceleration).

The X, Y, and Z velocities in the IMU platform coordinate system can be resolved through wander angle to put these velocities in the earth referenced North/East/Down (NED) system. Further integration about the north and east axes provide increments of latitude and longitude. Navigation in this manner provides knowledge of aircraft position, direction, and velocity at all times.

The IMU contains a precision machined sensor block, which provides mountings for the three accelerometers, and a triad of mutually orthogonal digital ring laser gyros to provide information about the orientation of the accelerometers in space. The inertial electronics provide the circuitry necessary to acquire, digitize, accumulate, and temperature compensate the accelerometer and gyro output signals. These signals are then integrated to provide the Free Inertial solution of the EGI.

20.2.1.1.1 Accelerometers. An accelerometer is essentially a restrained mass that is free to move along one axis. An acceleration along that axis causes the mass to be displaced, and this displacement causes a current to flow in a sensor. The size of the current is proportional to the acceleration, so by measuring this current the IMU can determine a value for the acceleration.

Because an accelerometer cannot distinguish between aircraft accelerations and gravity, a means must be provided to establish its orientation. To accomplish this, the accelerometers are mounted on a platform with a triad of ring laser gyros.

20.2.1.1.2 Gyros. The EGI employs ring laser gyros (RLGs) to determine its orientation in space. An RLG uses two beams of laser light rotating in opposite directions along a path within a sealed and enclosed cavity. As the unit changes orientation, the distances the beams travel differ. This difference is measured using an inter-ferometer, and is directly proportional to the rotation rate of the RLG. Unlike conventional spinning mass gyros, the platform on which the RLGs are mounted does not maintain a constant orientation in space. Instead, it is fixed inside the EGI chassis and rotates with the airframe to which it is attached.

Before any navigation can take place, the EGI needs to establish the orientation of the IMU in space, and quantify any small accelerometer or gyro bias errors present. This process is known as alignment. The wander angle is determined at this time and is defined as the angle between true north counter-clockwise to the IMU’s Y-axis (aligned with the nose of the aircraft) at the time of alignment. The amount of drift inherent in an unaided (no GPS) INS system is dependent on the precision with which the initial orientation is measured, and the estimate of gyro and accelerometer errors (gyro and accelerometer biases).

20.2.1.2 GPS. The Navigation Satellite Timing and Ranging (NAVSTAR) Global Positioning System (GPS) is a radio navigation system using satellites in twelve hour orbits to provide timing signals derived from onboard atomic clocks. These signals can be used to triangulate a three dimensional position near the earth using an appropriate receiver. The receiver detects the timing signals, compares them to its own clock then converts the time obtained into a distance to the satellite using the speed of light as a conversion factor. By obtaining signals from four satellites, the receiver can determine position in three dimensions plus identify its own small clock error.

The satellites transmit two different GPS signals in combination on two different frequencies. C/A-code (Coarse/Acquisition code) is used to help the receiver acquire the GPS signal and provide hand-over information to the primary navigation signal, the P-Code. GPS signals use two frequencies, L1 (1575.42 MHz) and L2 (1227.60 MHz); C/A-Code normally is only transmitted only on L1, and P-Code (or Y-Code, see below) is transmitted on both L1 and L2. Dual frequencies allow the receiver to make an estimate of ionospheric refraction, and help to improve overall GPS jamming tolerance.

Both the C/A-Code and P-Code contain a navigation message with information about satellite position, time, the health of the satellite, and the complete constellation almanac. A Hand-Over Word is included in the navigation message that tells a receiver tracking C/A-Code which part of the P-Code sequence the satellite is currently transmitting. The theoretical accuracy of both C/A-Code and P-Code signals is similar. The advantage of P-Code is derived from its transmission on two frequencies, and the subsequent ionospheric refraction estimate.

The GPS utilizes a cryptographic scheme to convert the P-Code signal into a Y-Code signal. By encrypting the primary navigation signal, GPS can be rendered impervious to "spoofing" — the intentional transmission of a false signal to mislead recipients. This function is termed "Anti-Spoof" (A-S), and its use is mandated for all US military GPS users. The EGI is commanded to this mode by the CDNU when the initial position is entered on either the EGI START 1/2 page or the EGI START 2/2 page. The operator then has the option of enabling C/A- or P-Code navigation if necessary by toggling Line Select Key 4 (LSK4) on the CDNU GPS RNAV Page. The Y-Code selection is the default position at CDNU power-up.

Note

There is normally never a mix of P-Code and Y-Code satellites. Y-Code and P-Code can not be transmitted at the same time by a single satellite, and Y-Code will normally be initiated on all satellites simultaneously upon command from the master control station.

20.2.1.3 GPS Accuracy. The quality of the received signals and the orientation of the satellites determine the actual quality of the position estimate provided by GPS. Jamming, obstructions, and multipath can degrade the quality of the received signal, while satellite constellation geometry can introduce position errors (termed Geometric Dilution of Precision — GDOP). The GPS receiver in the EGI has been designed to minimize these errors.

GPS provides two levels of accuracy. The Precise Positioning System (PPS) is capable of accuracy better than 16 meters Spherical Error Probable (SEP) (i.e., 50% of the time the calculated position will be within a sphere 16 meters in radius centered on the actual position). It is intended for military use only. PPS also provides time with an error of less than 100 nanoseconds.

Standard Positioning System (SPS) accuracy is variable. When the satellites transmit their timing signals, small, continuously varying errors are injected into the navigation message of both the C/A-Code and the P/Y-Code signals to reduce the position and time accuracy a receiver calculates. The size of the errors are encrypted and also sent as part of the satellite transmission. A PPS receiver requires that the matching crypto-codes be loaded to resolve the error. These are the same crypto-codes used for the Anti-Spoof function.

The injected errors, termed "Selective Availability (SA)," are controlled by the US Air Force on behalf of the Department of Defense (DoD) so that, in a conflict, an enemy will not be able to use the system. In peacetime, the DoD guarantees SPS precision will not exceed 100 meters horizontally with 95 percent confidence (i.e., the horizontal position will be within 100 meters at least 95 percent of the time).

Note

It is not necessary to receive P-Code (or Y-Code) in order to make use of the Precise Positioning System. Nor does receipt of P-Code guarantee that PPS is in use. C/A-Code contains all the information required to provide a PPS solution. All that is necessary is that the appropriate crypto-codes be loaded into the receiver so that the error message can be decrypted.

The receiver outputs a Figure of Merit (FOM) which provides, in a single digit number, a rough indication of the overall quality of the navigation solution. FOM ranges from 1 to 9, and includes estimates of signal quality and GDOP. A properly operating GPS receiver, in PPS mode, will normally display a FOM of 1, a SPS receiver (i.e., one in which the crypto-codes are not loaded) will display a FOM of 4, and a functional receiver without a navigation solution will display a FOM of 9. Intermediate values will appear, especially when the receiver first begins to track satellites, and when degradation due to jamming or signal loss occurs.

For operational use, the best indication of GPS accuracy is the Estimated Horizontal Error (EHE). This is an estimate, produced by the GPS Kalman filter, of the horizontal position error accounting for all possible error sources. This estimate is provided to the RIO on the GPS RNAV page of the CDNU.

Note

The CDNU RNAV pages also provide an EHE for the Blended and Free Inertial Solutions. When Aided, the Blended EHE should be very similar to the GPS EHE. When a switch to Blended (Unaided) occurs, the EHE will degrade over a period of a few minutes until it reflects the Free Inertial EHE.

20.2.1.3.1 Loss of GPS Signal. The GPS antenna, located on the aircraft turtle back midway between the UHF-1 and UHF-2 blade antennas, requires a clear view of the sky for optimum GPS reception. During maneuvers, parts of the airframe may block the view of specific satellites causing a loss of signal to occur. The short outage periods associated with maneuvers will not significantly degrade the accuracy of the EGI derived position when in Blended mode, but some variance in the FOM and Estimated Horizontal Error (EHE) may be noticed. Extended periods of signal loss which might be significant will be signaled to the aircrew by illumination of the NAV COMP light in the rear cockpit accompanied by a “GPS Invalid” status message on the CDNU. Depending on the display configuration selected by the Pilot on the PDCP, and the GPS Flight Mode, the loss of reliable GPS may be indicated by blinking deviation bars on the HSD, an OFF indication on the BDHI, and a spinning No. 2 needle on the BDHI. When GPS signal loss is experienced, the EGI Blended solution will revert to Blended (Unaided) accuracy regardless of the actual mode selected. No actual mode change will occur, however.

20.2.1.4 Kalman Filter. A Kalman filter is a mathematical algorithm that samples a measured quantity and outputs an estimate of that quantity and the associated measurement errors. The filter does this by sampling multiple sources for a single quantity (like position), compares the measurements, then uses the statistical characteristics of the errors to mathematically extract the desired value. from the IMU and the GPS, along with CSDC(R) supplied quantities (TAS, altitude, rate of climb, and heading) to determine position, velocity, and acceleration as well as estimates of IMU and GPS errors for these quantities. The The EGI uses a Kalman filter that combines the raw outputs EGI Blended solution is the output of the Kalman filter.

During alignments, the EGI Kalman filter provides initial accelerometer and gyro biases to the Inertial Integrator for use in calculating the Free Inertial solution. Once the EGI switches to NAV mode, the Kalman filter no longer updates these biases. The GPS solution uses a separate Kalman filter built into the GPS receiver, so loss of the EGI processor will not affect the GPS Solution.

20.2.1.5 EGI BIT. The EGI performs three separate BIT sequences that together are capable of identifying and isolating a minimum of 98 percent of all faults. The three sequences are Startup, Periodic, and Initiated Bit. Additionally, an instrument test is provided that enables the aircrew to determine the status of the hardware that transmits attitude information to the CSDC(R). If any fault is detected by the EGI, diagnostic data are transmitted to the CDNU for display, and the faults are recorded in EGI non-volatile memory. In addition, if any faults are detected that affect the IMU (including EGI system processor faults) or the analog attitude interface, the EGI will send signals via hardwire discrete lines to the CSDC(R) that will enable transition to an appropriate backup mode.

20.2.1.5.1 Startup BIT. When the EGI is switched from “Off” to any operating mode, Startup BIT checks the system for faults and out-of-specification conditions. The Startup BIT routine includes a combination of Periodic and Initiated BIT functions, and emphasizes the testing of components that could cause a total loss of navigation capability.

20.2.1.5.2 Periodic BIT. Periodic BIT (PBIT) automatically operates after completion of Startup BIT and checks all non-disruptive EGI tests. It is capable of performing preflight, post flight and inflight diagnostics to detect and isolate faults. The complete PBIT function occurs once every second on a time-share basis with other processing.

20.2.1.5.3 Initiated BIT. The RIO must specifically command Initiated Bit (IBIT) via the CDNU. When Line

Select Key 2 (LSK2) on the CDNU System Test Page is depressed, the EGI Test Page appears. Pressing LSK1 will then initiate a test of all non-disruptive Startup and Periodic Bit functions for the IMU and EGI processor systems, and command the GPS receiver into its diagnostic mode. IBIT is available both on the ground and during flight.

Note

While in IBIT, GPS Navigation Data are not available. The EGI will continue to provide navigation solutions in the Blended (Aided) and Blended (Unaided) modes, but the two will be identical, and equivalent to the Unaided case. IBIT can take up to 4 minutes to complete, and it may take the GPS receiver an additional few minutes to reacquire sufficient satellites to provide valid position information.

20.2.1.5.4 Exercise Cockpit Instruments. The RIO can verify that the attitude interface between the EGI and CSDC(R) is operating properly by selecting the Exercise Cockpit Instruments on the CDNU System Test Page (LSK6). The attitude displays on the PTID, HSD, VDI, and HUD will slowly cycle through their entire range until the RIO again depresses the Line Select Key. This test cannot be selected if the aircraft is airborne.

20.2.2 CDNU. The C-12284/A Control Display Navigation Unit (CDNU) (Figure 20-3) is the primary control and display interface for the EGI-based navigation system. The CDNU, installed on the RIO's left-hand console, is the bus controller for the NAVBUS, controlling the exchange of digital information between the EGI, the CSDC(R), and itself.

CAUTION

If the CDNU is off, the NAVBUS will not function, so position and velocity data will not be available. The EGI will still pass attitude information to the CSDC(R) via its analog interface and the navigation mode will revert to IMU/AM. The EGI will retain its capability to navigate with no degradation in its alignment. When communication with the EGI is restored, the navigation mode will return to that selected before communication was interrupted.

20.2.2.1 CDNU Controls and Display. The CDNU front panel contains a number of pushbutton keys that allow the operator to enter data, select functions, and change display pages. These keys are grouped by function. The specific function and action of some CDNU keys vary with individual CDNU page displays.

Symbolic aids are used to indicate which entries may be made, which functions are active, and which selections are possible. These are shown in Figure 20-4.

20.2.2.2 CDNU Display. Electronic pages and a page tree structure (shown in FO–19) are used on a Cathode Ray Tube (CRT) to display information and provide control of various navigation system functions. Pages are accessed by pressing the function keys, dedicated keys, arrow keys, or Line Select Keys (LSKs) as required. Each page consists of an eight line (22 characters per line) display. Not all lines will be utilized for each page. Lines 1, 3, 5, and 7 are data lines, and are divided into two parts — left screen and right screen — that correspond to the adjacent LSK. The title, information, and annunciation lines are located between the data lines. Annunciation messages, displayed on the annunciation line, alert the operator to conditions requiring attention.

20.2.2.2.1 Line Select Keys. Eight Line Select Keys (LSKs) are used to initiate functions selected, insert data from the scratchpad, change the mode of operation, or change display to the page indicated when a Go To Arrow is displayed (see Figure 20-4). The LSKs will operate in a rotary or toggle manner depending on the mode or function indicated on the display. Rotary operation will be active if there are more than two options available to the RIO (e.g., AIDED/UNAIDED/GPS), and toggle operation will be active if there are only two options (e.g., ON/OFF). Options are selected by pressing the LSK adjacent to the appropriate CRT message. Data are entered into the scratchpad from the keyboard, and is then entered into the proper data line by depressing the appropriate LSK.

Generally, LSKs on the left side of the CDNU enter data on the left side of the data line, and LSKs on the right, enter data on the right side of the CDNU display. When the scratchpad is empty, LSKs are used to select options displayed on the associated data line. The CDNU generally responds to operator entries within one second.

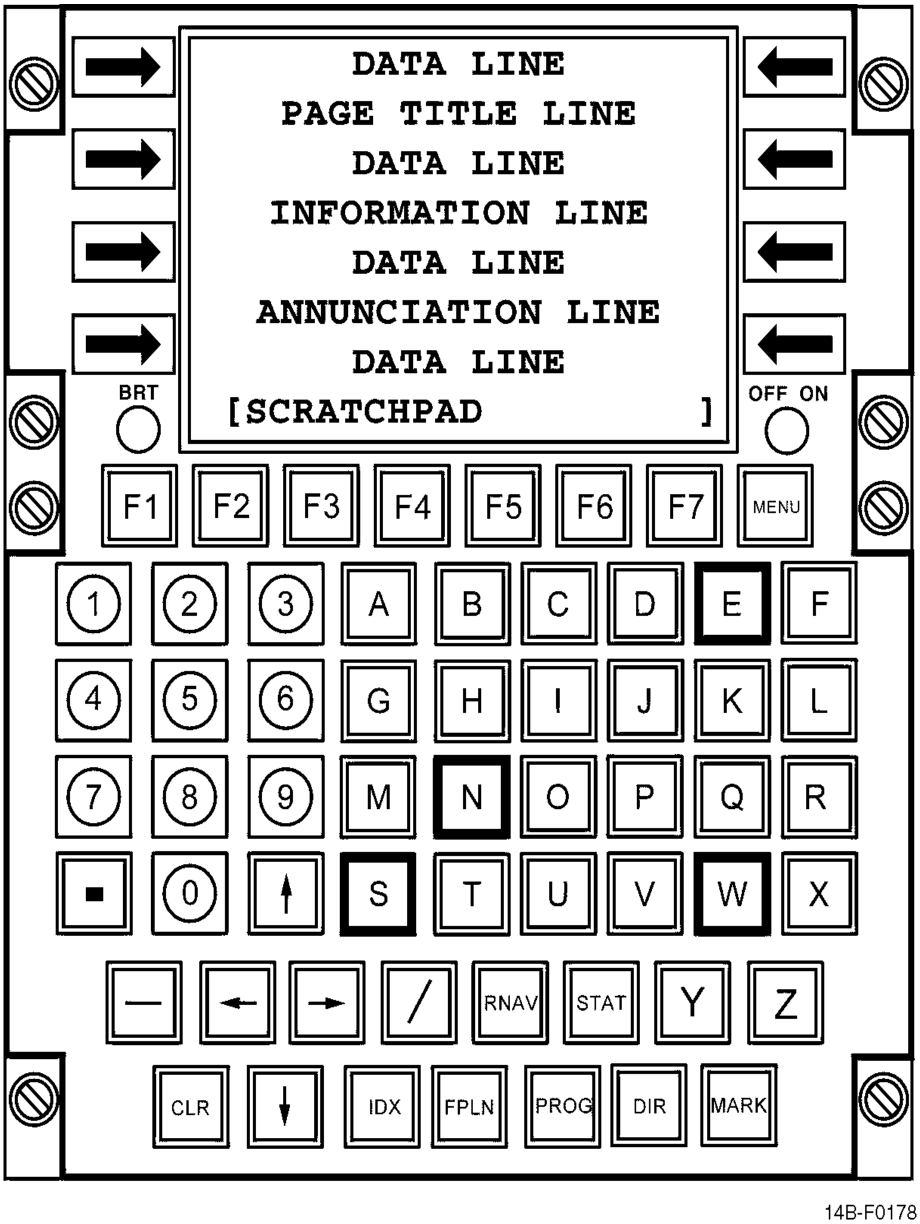
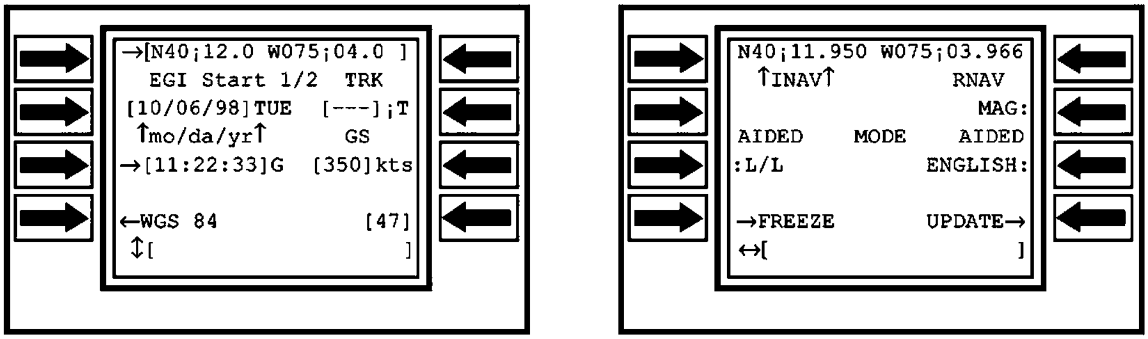


Figure 20-3. Control Display Navigation Unit — Front Panel



← →	Go To Arrow. Pushing the Line Select Key will access a different page. (Arrow points toward Key)	---	No computed data is available or meaningful.
→ ←	Pushing the Line Select Key will select the item or enable the mode. (Arrow points toward text.)	[ ]	Data entry from the scratchpad is possible/required.
*	Function is Enabled.	↕	Vertical page or line scrolling is possible.
:	Alternate selections are available.	↔	Lateral page scrolling is possible.
√	Check status pages for BIT failures.	✥	Lateral and vertical page scrolling is possible.

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Figure 20-4. CDNU Standard Display Symbols

20.2.2.2.2 Alphanumeric Keys. Alphanumeric keys allow the selection of either numbers or letters for entry into the scratchpad. The “N” “S”, “E”, and “W” keys are highlighted so they may be easily located when entering position in Latitude/Longitude coordinates.

20.2.2.2.3 Function Keys. The function keys, F1 through F7, allow the operator to perform specific, aircraft related functions without accessing a particular CDNU page. Figure 20-5 lists the function associated with each key. Depressing the MENU Key displays the MENU Page, a quick reference guide to the available functions.

20.2.2.2.4 Dedicated Select Keys. The FPLN (flight plan), PROG (progress), DIR (direct), RNAV (area navigation), and MARK dedicated select keys allow the RIO to call up and display navigation data on the CRT. The STAT (status), MENU, and IDX (index) dedicated select keys permit access to a variety of information applicable to the general flight operation and maintenance of the navigation system.

20.2.2.2.5 Scratchpad. The scratchpad, enclosed by brackets, is the bottom line on the display, and is used to display data entered using the alphanumeric keys. Error messages will also be displayed in the scratchpad if operational or data entry conditions are not met. The scratchpad is a buffer to hold all keystrokes prior to executing the input. Incorrect scratchpad entries are cleared with the CLR key. The scratchpad is automatically cleared when the system accepts valid inputs.

20.2.2.2.6 Page Scrolling. Arrow keys are provided to permit vertical and horizontal scrolling of pages [e.g., switching between the EGI Start 1/2 and EGI Start 2/2 pages (vertical), and between RNAV pages (horizontal)]. Special arrow characters (Figure 20-4) are displayed adjacent to the left-hand scratchpad bracket to indicate the type of scrolling available.

KEY	FUNCTION
F1	Enables the transfer of the current STEER-TO point to the FMC. Operates as a toggle (On/Off), default is ON.
F2	Sends the first eleven waypoints contained in the active flight plan to the FMC. These are stored in the FMC waypoint 1–11 Pseudo-Files.
F3	Sends the first six waypoints contained in the active flight plan to the FMC. These are stored in the six "special" waypoints available using the TAC DATA category on the Computer Address Panel. (The order of FMC storage for CDNU waypoints 1–6 is: Fixed Point, Initial Point, Home Base, Defended Point, Hostile Area, and Surface Target.)
F4	Unused
F5	Toggles the source of Flight Mode determination between the PDCP and the CDNU. Default is <P> (PDCP).
F6	Unused
F7	Data For?/Copy What?

Figure 20-5. CDNU Function Keys

Page scrolling advances an entire page at a time to the next set of data (e.g., the next intercept). Vertical scrolling is accomplished by pressing the "↑" and "↓" arrow keys. Pressing the "↑" arrow key moves one toward the beginning of a set of data (e.g., a lower numbered intercept). Lateral page scrolling is accomplished by pressing the "←" and "→" arrow keys. Holding the arrow keys causes page scrolling to continue until the key is released.

20.2.2.2.7 Clear Key. The CLR (clear) key is considered a special function control key. The first time the key is pressed, the last character entered into the scratchpad is deleted; pressing the CLR key again deletes all remaining characters. Holding down the clear key will continually clear characters in the scratchpad in the opposite order to their entry until all characters have been removed. Error messages can be cleared by depressing the CLR key when the message appears. The key will also clear certain annunciation messages when the scratchpad is blank and annunciation messages are displayed on line six of the display.

When the CLR key is depressed, it refreshes the CDNU display. On pages such as the RNAV pages, data fields like present position, which is normally updated once a second, will be updated immediately.

20.2.2.3 Data Entry. This section describes acceptable data entry formats, valid data ranges and display formats. They are applicable to all CDNU pages unless stated otherwise.

Data entry valid ranges for a given field are only limited by the display resolution with assumption of fixed decimal point and positive entries (i.e., a four digit numerical field with no decimal point will accept entries from 0 to 9999). When a computed value is too large to fit in a given field, it will saturate at the highest possible value (e.g., if a distance field has four digits, a distance of 10234 will be displayed as 9999).

All navigation related quantities may be displayed in either metric or English units unless specifically stated elsewhere (e.g., altitude related quantities, which are always displayed in feet and feet/minute). When metric units are chosen the unit labels are changed appropriately.

20.2.2.3.1 Entry and Display of Waypoints. Flight plan waypoints and other horizontal locations are entered in one of three basic formats:

1. Position coordinates — either as a latitude/longitude waypoint pair or as a Military Grid Reference System coordinate.

2. ICAO Identifier — position labeled with up to a 5 character alphanumeric. The appropriate data are extracted from a database contained in the MDL or downloaded to CDNU nonvolatile memory

3. ICAO Identifier/Bearing/Distance — position is defined at the specified bearing and distance from a database waypoint with the indicated identifier.

a. Entry and Display of Latitude/Longitude Waypoints. Latitude/longitude waypoints are entered in the form of degrees and decimal minutes. The required format is an "N" or "S" followed by four digits (with a decimal point and up to three additional digits optional), followed by "E" or "W" followed by five digits (with a decimal point and up to three additional digits optional). Leading zeros are required as no delineators are used between degrees and minutes. All waypoints are stored, and calculations made, using thousandth of a minute precision.

Note

Do not enter spaces between degrees and minutes or between latitude and longitude entries. Do not put a "/" or any other character between entries. A typical entry will have the form:

"Nddmm.mmmWdddmm.mmm"

(where dd = degrees and mm = minutes) with digits to the right of the decimal points optional.

Latitude/longitude waypoints are displayed left-justified to the nearest tenth of a minute on all CDNU pages, except on the Area Navigation pages and the Waypoint Data page where thousandths of minutes are displayed.

b. Entry and Display of Military Grid Reference System Waypoints. Military Grid Reference System (MGRS) coordinates are entered as three components:

1. Grid zone designation
2. Meter square identification
3. Grid coordinates

CAUTION

The CDNU is only capable of converting MGRS coordinates based on the WGS-84 datum. MGRS coordinates from maps or charts using other datums will likely be in error. When using MGRS coordinates, ensure that the WGS-84 datum is selected on the EGI START 1/2 page. Coordinates may change if any other datum is selected, and position errors may result. Figure 20-6 contains a complete list of the Datums available.

Note

The datum selection on the EGI START 1/2 page is for the GPS receiver in the EGI. Only the GPS solution shown on the RNAV GPS page (or RNAV INAV page if GPS mode is active) will be affected.

Display format for MGRS waypoints is the grid zone designation followed by one space followed by the 100,000 meter square identification followed by a space followed by the grid coordinates. Six-digit grid coordinates (i.e., 100 meter precision) are used everywhere except on the Area Navigation pages and the Waypoint Data page where ten-digit coordinates (1 meter precision) are used. This yields roughly the same display precision used in the latitude/longitude format.

c. Entry and Display of Identifier Waypoints. Identifiers are entered as up to 5 alphanumerics. Identifier waypoints are displayed left justified, with alphabetic characters always displayed as capital letters. If the Identifier exists in either the primary or reversionary database, entry of the identifier provides access to the complete waypoint data record. If no match exists, "NOT IN DATABASE" is displayed.

d. Entry and Display of Identifier/Bearing/Distance Waypoints. Identifier/bearing/distance (IBD) waypoints are entered as an identifier, followed by a "/", followed by the bearing, optionally followed by a "T" or "M" (True/Magnetic reference), followed by a "/", followed by distance, followed optionally by an "N" or "K" (nautical miles or kilometer reference).

Bearings are entered as up to three digits optionally followed by a decimal point and an additional digit. The bearing is displayed to the nearest degree with leading zeros in all places except the Waypoint Data page where it is displayed to the nearest 0.1 degree. A special display character is used to indicate whether the bearing reference is True or Magnetic.

Distances are entered as up to four digits, optionally followed by a decimal point, and up to two additional digits. Display precision depends on the CDNU page format.

DATUM NO.	DATUM NAME	DATUM ABBREVIATION
1	Adindan	Adindan
2	Arc 1950	ARC 1950
3	Australian Geodetic	Austrln Geodetic
4	Bukit Rimpah	Bukit Rimpah
5	Camp Area Astro	Camp Area Astro
6	Djakarta	Djakarta
7	European 1950	European 1950
8	Geodetic Datum 1949	Geodetic 1949
9	Ghana	Ghana
10	Guam 1963	Guam 1963
11	Gunung Segara	G. Segara
12	Gunung Serindung 1962	G. Serindung
13	Herat North	Herat North
14	Hjorsey 1955	Hjorsey 1955
15	Hu-Tzu-Shan	HU-TZU-SHAN
16	Indian	Indian
17	Ireland 1965 (Eire 1965)	Ireland 1965
18	Kertau 1948 (Malayan Revised Triangulation)	Kertau (Malayan)
19	Liberia 1964	Liberian 1964
20	User Entered*	—
21	Luzon	LUZON
22	Merchich	Merchich
23	Montjong Lowe	MonTjong Lowe
24	Nigeria	Nigeria
25	North America 1927 CONUS	N AM 1927 CONUS
26	North America 1927 Alaska and Canada	N AM 1927 Al/Can
27	Old Hawaiian, Maui	Old Hawaii Maui
28	Old Hawaiian, Oahu	Old Hawaii Oahu
29	Old Hawaiian, Kauai	Old Hawaii Kauai
30	Ordinance Survey of Great Britain 1936	Ordnce GB 1936
31	Qornoq	Qornoq
32	Sierra Leone 1960	S. Leone 1960
33	South America (Provisional South America 1956)	S Am Prov 1956
34	South America (Corrego Alegre)	S Am Cor. Alegre
35	South America (Campo Inchauspe)	S Am Campo In.
36	South America (Chua Astro)	S Am Chua Astro
37	South America (Yacare)	S Am Yacare
38	Tananrive Observation 1925	Tananrive 1925
39	Timbalai 1948	Timbalai 1948
40	Tokyo	Tokyo
41	Voirol	Voirol
42	Special Datum, Indian Special	Special Indian
43	Special Datum, Luzon Special	Special Luzon
44	Special Datum, Tokyo Special	Special Tokyo
45	Special Datum, World Geodetic System 1984	Special WGS-84
46	World Geodetic System 1972	WGS-72
47	World Geodetic System 1984	WGS-84

* Datum 20 is not used by the EGI as installed in the F-14.

Figure 20-6. Horizontal Datum List

If the optional "T"/"M" or "N"/"K" are not entered, the English/Metric toggle state (selected on the Integrated RNAV page) determines the format, with bearing referenced to Magnetic North. IBD waypoints are displayed left justified with all spaces suppressed.

A bearing/distance vector waypoint calculator is also provided. Bearing/distance may be entered without the identifier. In this case, pressing a LSK adjacent to a L/L, UTM coordinate, or identifier, will display the offset L/L or UTM coordinate in the scratchpad. These coordinates may then be used to insert a waypoint in the flight plan.

20.2.2.3.2 Use of Magnetic Variation and Declination. Magnetic variation is used in converting most horizontal angles from True to Magnetic reference. Two operations related to radio navigation aids which have a station declination are exceptions. Station declination in this case refers to the alignment offset (from true north) associated with the station. It may be different than the Magnetic Variation at the station. Courses into these waypoints and any vector waypoints (e.g., IBDs) described relative to these waypoints use station declination rather than magnetic variation in the required computations.

20.2.2.3.3 Entry and Display of Bearings and Courses. Bearings are only entered as a part of IBD waypoints. Courses are entered as integers. Both are range checked for 0 to 360 (inclusive) so that two entries are possible for North. Display of any computer generated values are range limited from 1 to 360 (i.e., "0" is not a possible display). Bearings and courses are always displayed with leading zeros.

20.2.2.3.4 User-Defined Labels. A user-defined, 5 character alphanumeric label may be attached to latitude/longitude and MGRS waypoints in the flight plan and mark list. User-defined labels are entered as "/" followed by up to 5 alphanumerics. These labels are displayed with the "/" in the first position to insure that there is no confusion between these and identifier database points. Duplicate user-defined labels are not allowed. When a label has been attached to a waypoint, only the label can be viewed on the Flight Plan or Mark List page. Accessing the Waypoint Data page will provide the additional information.

20.2.2.3.5 Entry And Display Of Time and Date. Time is entered with no extra characters (spaces, slashes, or colons) between hours, minutes and seconds. Seconds are optional, so that four or six digits are acceptable ("hhmmss" or "hhmm" format). If no time or date is available for a given field, blanks are displayed. All times are entered and displayed as Universal Coordinated Time (UTC). Dates are entered with "/" delineators and written in the order of month/day/year ("mm/dd/yy" format).

20.2.2.3.6 Data For?/Copy What? Waypoints, and all their associated data, may be copied in their entirety by using Function Key 7. Pressing F7 alternately writes "DATA FOR?" and "COPY WHAT?" into the scratchpad. "DATA FOR?" permits access to the detailed Waypoint Data page, and "COPY WHAT?" copies a waypoint with all associated attributes into the scratchpad.

20.2.2.3.7 Deletion of Data. Most data entry fields may have the associated data deleted by entering a dash "-" in the scratchpad and pressing the LSK adjacent to the desired field. The primary exceptions are waypoints with user supplied names (i.e., those with a slash ("/") as the lead character). These must have the name removed by depressing the "/" key followed by the LSK adjacent to the waypoint. Once this is accomplished, the waypoint can be deleted using the dash.

20.2.3 AN/ASQ-215 Mission Data Loader (MDL). The Mission Data Loader (MDL) provides bulk storage of mission essential data. Refer to NATOPS Supplemental Flight Manual (NAVAIR 01-F14AAP-1A) for a complete description of the MDL. The Data Transfer Module (DTM), can be loaded at a TAMPS station with a range of navigation and mission computer data. Navigation data are transferred to the CDNU using a special pass-through function of the EGI, which is a remote terminal on both the AVBUS and the NAVBUS. See Figure FO–18. The CDNU sends a request for the data to the EGI, which then passes them to the Mission Data Processor (MDP). The MDP commands the MDL to send the requested data to the EGI, which then transmits them to the CDNU.

Note

> Because of the data rate supported by the EGI pass-through function, transfer of large blocks of data (e.g., a full 50 waypoint flight plan) may take a few minutes to complete.

The MDL may contain two separate waypoint databases, a magnetic variation (MAGVAR) table, up to twelve flightplans, and the current GPS almanac. The waypoint databases contain 5-character alphanumeric identifiers and the associated data for each waypoint, as well as the effective dates of the information. These waypoint definitions cannot be edited.

The primary waypoint database is maintained on the MDL. When a DTM is inserted into the MDL, identifier indices are automatically transferred into CDNU memory to speed the search process when a specific waypoint is requested. Transfer of the indices to the CDNU takes approximately 60 seconds. The primary waypoint database is not available until this process is complete. Data for up to 20,004 waypoints can be stored in the primary database. The exact number is limited, however, by the amount of non-navigation, mission computer data that are required for a particular mission.

The reversionary database is stored in CDNU non-volatile memory for use when the MDL has failed or is not installed, or the requested data are not in the primary database on the MDL cartridge. This database contains 200 waypoint identifiers and can be transferred from the MDL into CDNU memory upon operator request. Reversionary database operation is transparent and identical to the primary database, requiring no special procedures to access.

A magnetic variation database is maintained in CDNU non-volatile memory for conversion of references from True to Magnetic North. This database is automatically transferred from the MDL cartridge each time the cartridge is inserted if it is more recent than the existing CDNU database. Once loaded, a magnetic variation database remains in effect until the CDNU software is changed, or when overwritten by insertion of a new cartridge containing a more recent magnetic variation database.

CAUTION

When new CDNU software is loaded (a maintenance function), the CDNU does not contain a Magnetic Variation table. There are no visual indications that the table is missing. When MAGVAR calculations are required, Magnetic Variation will default to the operator entered value on the Progress 3/3 page. The Magnetic Variation table may be loaded into the CDNU by first loading the table onto an MDL cartridge via TAMPS and placing the cartridge into the MDL receptacle in the aircraft.

The MDL Start page is accessed by scrolling up from the EGI Start 1/2 page or down from the EGI Start 2/2 page. Display line 3 contains the MDL cartridge label and date stamp; display line 3 is blank if no cartridge is installed. Display line 5 contains the date stamp for the MAGVAR table if it is loaded, otherwise it is blank. Pressing LSK4 on this page erases the flightplan currently loaded into the CDNU. Pressing LSK8 transfers the user to the Flight Plan Select 1/2 page.

The MDL page is used to load the reversionary database, flightplans, the GPS almanac, search the database for a specific waypoint, or load the CDNU operational flight software. The latter is a maintenance function requiring a special access code. This page is accessed directly from the INDEX page by depressing LSK5.

If a primary database exists on the MDL, this is indicated by “↑PRI↑” on display line 2 of the MDL Start page. If the reversionary database is being used, “↑REV↑” is displayed. Display line 1 displays the effective dates for the database; display line 3 displays the MDL cartridge label and data stamp. Display line 3 is blank if no cartridge is installed. Display line 5 displays the date stamp for the magnetic variation database in the CDNU; display line 5 is blank if the database does not exist.

20.2.4 Navigation System Caution and Advisory Lights/Legends

20.2.4.1 NAV COMP Light. The NAV COMP advisory light will illuminate any time a fault is detected in the EGI, CDNU, or SDC that could degrade the navigation solution, or when communication is lost between the EGI and CDNU (i.e., a NAVBUS failure occurs). The light will also illuminate any time a tolerance level for a particular mode of flight is exceeded. The NAV COMP advisory light should be treated as a cue to check the status indications on the CDNU. The RIO should read the CDNU annunciator line and, if necessary, the status page, to determine the exact nature of the fault (see Chapter 41).

20.2.4.2 IMU Light. If the IMU advisory light illuminates, there is either a failure in the EGI IMU or in the analog circuitry that sends attitude information to the CSDC(R). If the IMU light illuminates without a corresponding NAV COMP light, the fault is in the analog circuitry. In either case, attitude information for the VDIG and missile control system will be provided by the AHRS. If only the IMU light illuminates, the EGI is still providing a complete navigation solution to the CSDC(R) and CDNU; only attitude information to the flight instruments is affected. If both the IMU and NAV

COMP lights illuminate, in addition to bad attitude information, the Blended and Free-Inertial solutions from the EGI will be unusable. The GPS solution may still be available. Check the EGI status on the CDNU. Regardless of the nature of the fault, the CSDC(R) will switch the navigation system mode to the best available.

20.2.4.3 STANDBY/READY Legends. The Navigation status indicators on the PTID (STBY and READY legends) are used to interpret the status of the Navigation System. Figure 20-7 lists the possible combinations, the interpretation, and required actions, if any.

STATUS	INTERPRETATION
ALIGN	
STBY ON READY ON	• Coarse Align not complete.
(STBY and/or READY blinks — parking brake not set or hydraulic pressure low)	• "HS" blinks if NAV MODE is CVA and no GPS or SINS. If attempting a GPS IMA, wait for valid GPS solution. If no GPS and no SINS, enter carrier LAT, LONG, true HDG, and SPD on the CDNU CV Manual Page.
STBY ON READY OFF	Normal during align until ALIGN QUALITY ±3.0 nm/hr.
(STBY blinks — parking brake released for taxi)	
STBY OFF READY ON	Minimum Phoenix criteria met.
(READY blinks — parking brake released for taxi)	
STBY OFF READY OFF	ALIGN QUALITY <1.0 nm/hr.
(READY blinks — parking brake released for taxi)	
NAVIGATE	
STBY OFF READY OFF	Selected NAV MODE SEL position valid.
STBY OFF READY ON	A better NAV MODE SEL selection is available (INS or IMU if in AHRS, INS if in IMU).
STBY ON READY ON	NAV MODE SEL selection failed.

Figure 20-7. Standby and Ready Legend Logic

20.2.4.4 AHRS Light. If the AHRS advisory light illuminates, the AHRS self-test has detected a failure in that system. Illumination of the AHRS light does not mean the EGI has failed. The magnetic heading on the HUD and VDI is now commanded by the FMC, using back-up magnetic heading computations. These computations use the last known value of magnetic variation. Consequently, over long distances and time, heading will be degraded unless new values of magnetic variation are inserted as required. IFR flight should be avoided because the primary magnetic heading reference will be unreliable.

20.2.5 Navigation Power Supply. The navigation power supply (NPS) converts primary electrical power into the voltages required for the EGI and CSDC(R). A nickel-cadmium battery (the NPS battery) provides power to the EGI and CSDC(R) for at least 120 seconds if there is a power interruption or transient. The battery charging and switching circuits are controlled automatically so that backup power will normally always be available. If this battery ever falls below 19 volts, the EGI Continuous BIT routine will detect it, and a bit will be set in the status message displayed on the EGI Status page of the CDNU.

Note

Except when doing a CSDC(R) reset in accordance with F-14A/B Tactical Manual Pocket Guide (NWP 55-5-F14 PG) procedures, do not pull the CSDC(R) circuit breakers or secure aircraft power unless the NAV MODE SEL switch is OFF. Failure to follow this procedure results in unnecessary battery discharge. Pulling the circuit breakers, or moving the NAV MODE SEL switch out of the OFF position before aircraft power is applied will not drain the battery.

20.3 EGI ALIGNMENT MODES

Before the EGI can be used for navigation, the GPS must be initialized and the IMU must determine its orientation with respect to true north. This process is termed "alignment", and the EGI accomplishes this task automatically, with the exact alignment mode determined by the reference data available. The unit is capable of providing accurate position data as soon as the GPS unit acquires the four satellites necessary for a solution. However, attitude and inertial velocity measurements require the alignment procedure.

Power is applied to the EGI by selecting any mode other than OFF on the NAV MODE SEL switch, at which time the unit transitions to its power-up initialization (INIT) mode. In this mode it performs a Startup BIT; loads initial values for position, velocity, and time (PVT); loads the GPS almanac if necessary; checks the availability of data for a Stored Heading Alignment; and then transitions to the appropriate alignment mode.

Note

Unless operational requirements dictate otherwise, allow at least 10 seconds after selecting OFF on the NAV MODE SEL switch before selecting any "ON" position. This allows the EGI to store maintenance data in non-volatile memory.

Initial position, date, and time values must be entered via the CDNU. The EGI will use (and the CDNU will display) its last known values until new data are entered or GPS becomes available. While in INIT, all navigation outputs are set to zero, null, or invalid as appropriate. The RIO must verify the correct position appears in Line 1 of the CDNU START 1/2 or START 2/2 page. Upon verification that the position is correct, LSK1 should be depressed. If the entered position is the one to which the EGI initialized, the alignment will continue normally; if the position is significantly different (greater than approximately 20 miles), the alignment will restart.

Note

Initial position for alignment can only be entered using the CDNU; a CAP entry will have no effect. Information entered via the CAP goes only to the FMC, not the EGI. Communication with the EGI is only effected through the CDNU.

The EGI will perform a coarse alignment with the NAV MODE SEL switch in any position except OFF. However, full specified accuracy is only guaranteed if the NAV MODE SEL switch is left in an alignment position (GND or CVA) until ALIGN COMPLETE (a "Dot-in-Diamond") appears. See Figure 20-8. The only operator action required once power is applied is the entry of initial position using LSK1 on either the START 1/2 or START 2/2 page of the CDNU.

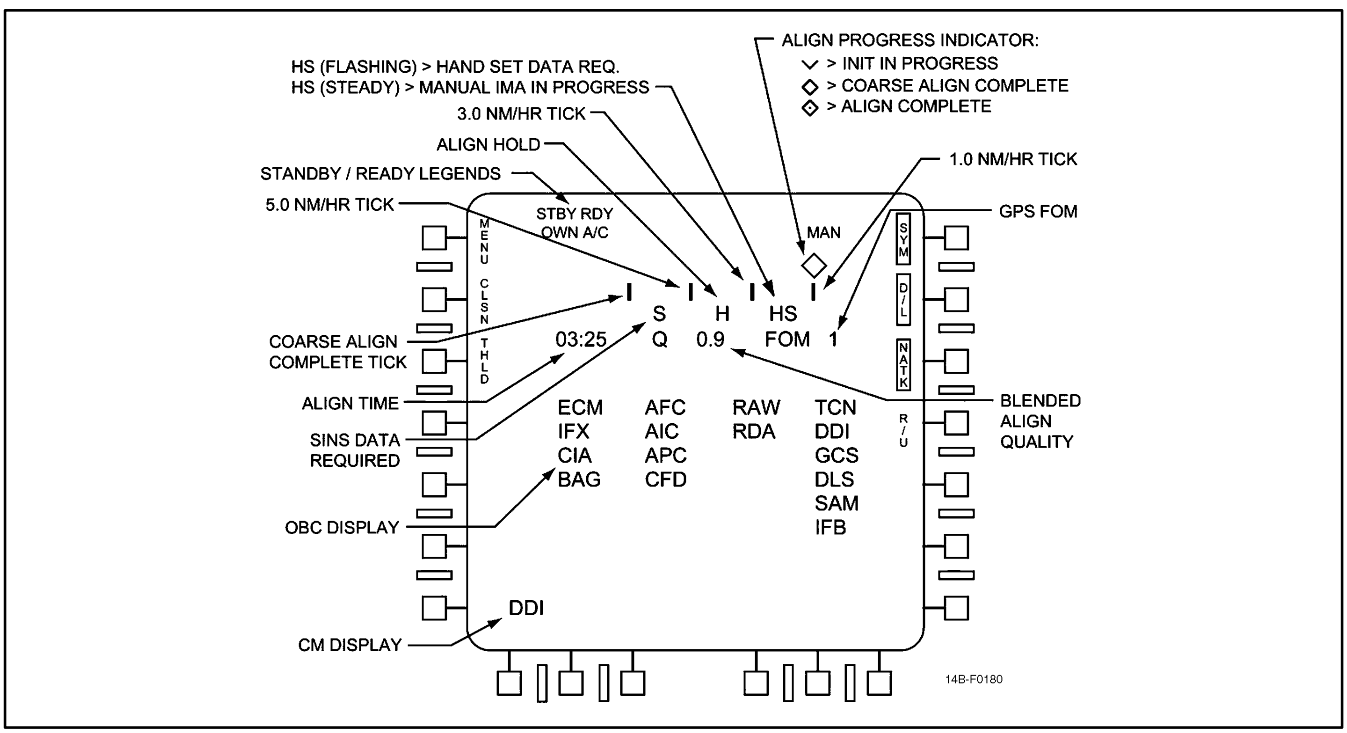


Figure 20-8. PTID Alignment Display

CAUTION

Entry of initial position from the CDNU is required to ensure proper operation of the Anti-Spoof (Y-Code only) Mode. If LSK1 on either of the CDNU “EGI Start” pages is not depressed during the alignment, the Anti-Spoof function may not operate properly, and the EGI may be susceptible to spoofing.

Note

- If power is applied to the EGI prior to the CDNU, depression of LSK1 on either of the CDNU START pages may be delayed until after the CDNU is functioning.

- Pressing LSK1 on either page reinitializes the GPS receiver, so momentary loss of GPS satellites can be expected. The EGI should reacquire satellites in 15–30 seconds.

- All available sources of reference data are used by the EGI Kalman filter to improve the quality of alignment. This includes GPS when in the aided mode, and air data (true airspeed, pressure altitude, and pressure altitude rate) at all times. The EGI provides the current status of the alignment for display on the CDNU and the PTID. Alignment Quality, GPS Figure of Merit (FOM), and Time in Alignment are updated every second. Discrete messages for Coarse Align Complete; 5.0 nm/hour, 3.0 nm/hour, and 1.0 nm/hour align quality; Align Hold; and Alignment Complete signals are also sent to the CDNU and CSDC(R).

When the RIO selects an alignment mode using the NAV MODE SEL switch, alignment data will normally be displayed on the PTID (Figure 20-8). This display can also be activated at any time, even while displaying tactical information, by depressing NAV FS-2 on the CAP. Information concerning the status of the alignment is displayed on both the PTID and the CDNU.

Note

- If an alignment begins without the Alignment Display appearing on the PTID, verify that NAV category FS-2 is selected (button illuminated) on the CAP.

- If the PTID Alignment Display is selected after the alignment is complete, the display will contain the Time In Align at the time the alignment was accepted. The Align Quality (Q) and GPS FOM readouts, however, will accurately reflect the current state of the EGI, including any improvements to the alignment (due to GPS aiding) made after selecting INS on the NAV MODE SEL switch.

The PTID will first display a caret (v) on the far left side of the alignment display, indicating that INIT is in progress. At COARSE ALIGN COMPLETE the caret transitions to a diamond (◊). As the alignment progresses, the diamond will move in steps across the alignment display from left to right aligning with four tick marks representing coarse align complete, 5.0 nm/hr, 3.0 nm/hr, and 1.0 nm/hr align quality, respectively. The display also shows the align time in minutes and seconds, Blended align quality in nm/hr, and the GPS FOM.

The actual alignment mode is shown on the right side of display line 3 of the EGI Start 2/2 page on the CDNU. The left side of the same line indicates the detected position of the NAV MODE SEL switch (that is, the position that the CSDC(R) is currently sending to the CDNU).

Alignment telltales are displayed between the tick marks if necessary. An “S” will appear between the first and second tickmarks indicating invalid SINS data (only in CV align). An “H” will appear between the second and third tickmark if the EGI goes into an align-hold state. An “HS” acronym will appear between the third and fourth tickmarks when a Manual In-Motion Alignment (IMA) is in progress. The “HS” will flash if hand set data for the Manual IMA are needed.

20.3.1 Transition to NAV Mode. During alignment, the Free Inertial and Blended solutions are “Coupled”, with gyro and accelerometer biases determined within the Kalman filter for both. Once the alignment is complete, the two solutions are decoupled, and the Free Inertial solution continues to use the bias information available at the time of de-coupling. The Kalman filter continues to refine those errors for use by the Blended solution. Thus, even if GPS becomes unavailable, the Blended solution will provide a more accurate position than the Free Inertial solution. The intent of the Free Inertial solution is to provide an IMU derived dead-reckoning solution for IMU diagnostic purposes only. Align quality, displayed on the PTID and CDNU during alignment, is the EGI's best estimate of what the Blended (Unaided) solution drift would be if the EGI were to transition to Navigate mode at that point.

The EGI signals the FMC when it has achieved full specified alignment accuracy. This is indicated to the aircrew by the appearance of a dot within the alignment status diamond on the PTID (See Figure 20-8). The time required to achieve ALIGN COMPLETE is determined by the total amount of time in alignment with good data, and the alignment mode used. If ALIGN COMPLETE is set, alignment will continue until the EGI senses a ground speed of 80 knots, or, until the RIO selects INS, AHRS, or IMU on the NAV MODE SEL switch.

Note

Full specified INS performance (see the specific alignment sections below) is only guaranteed if the alignment is allowed to proceed to completion, (i.e., the NAV MODE SEL switch stays in an alignment position (GND or CV) until achieving ALIGN COMPLETE and a dot appears in the alignment diamond on the PTID. If the switch is moved to NAV, AHRS, or IMU prior to ALIGN COMPLETE, the Blended solution will continue to improve, but the Free Inertial gyro and accelerometer biases will be frozen at the point at which the switch was moved out of alignment. Align time will stop incrementing, but blended align quality will show improvement.

20.3.2 GPS Initialization. Before the GPS can navigate, the GPS receiver must lock on to the satellite signals it will use to provide a position. To do this it uses a GPS almanac stored in its memory to determine where in orbit each of the satellites is. To properly use this information it must also know its own location, the current date and time, and its motion with respect to the earth. This information is supplied using the EGI Start 1/2 page.

Note

If the almanac is missing or is outdated, it can take the GPS 20 minutes or more to begin navigating. Errors in date, time, or position will increase the time to first fix (TTFF). Position errors of a few miles or time errors of a few minutes will not significantly degrade TTFF.

The EGI Start 1/2 page is accessed from the Index page using LSK2. This page is where the data required for alignment and GPS initialization are entered. It also provides a means to select the appropriate map datum from a list of 47 supported by the GPS. A datum is a model of the non-spherical earth used to determine the numerical value of Latitude and Longitude (or MGRS). Alternate datums are used to synchronize navigation with others using maps or charts based on one of the alternatives.

CAUTION

MGRS coordinates are not defined for all datums. Use of MGRS with the wrong datum can lead to significant navigation errors with no cockpit indications. Proper mission planning is required before any datum other than WGS-84 (the primary US military navigation datum) is used.

Note

The Blended and Free Inertial solutions always reference WGS-84. Only the GPS solution reflects the choice of datums selected on the EGI Start 1/2 page.

A "Restart Alignment" function is provided on the EGI Start 2/2 page (LSK3). If for any reason the RIO desires to restart the alignment from the beginning, depression of this LSK will force the EGI into INIT and from there into the alignment mode selected by the RIO.

20.3.3 Stationary Alignments. EGI stationary alignment logic is used whenever the parking brake is set, and the NAV MODE SEL switch is placed in the GND position to initiate an alignment. Two EGI modes are available in this case: Gyro Compass (GC) alignment and Stored Heading (SH) alignment.

20.3.3.1 Gyro Compass Alignment (GC). Gyro Compass alignment is the primary ground based inertial alignment mode of the EGI. Full specified performance (unaided INS drift of less than 0.8 nm/hr) is available after 4.0 minutes in this mode. GC alignments require an estimate of current position, GND selected on the NAV MODE SEL switch, and the parking brake set.

In GC, the priority for present position initialization by the EGI is:

1. GPS, if available
2. CDNU entered Latitude and Longitude
3. The position stored in the EGI at its last shutdown.

Note

The contents of Home Base or any other waypoint have no effect on the alignment.

The procedure for initiating a GC alignment is:

1. Parking Brake — SET
2. CDNU — ON

After CDNU SELF TEST complete:

3. NAV MODE SEL switch — GND
4. PTID — ON
5. FMC — ON
6. AWG-9 Cooling — AWG-9/AIM-54
7. CDNU Index Page LSK1 — DEPRESS (Select EGI Start 1/2 Page)

On either the EGI Start 1/2 or Start 2/2 page, ensure that present position is correct or enter a correct position.

8. CDNU LSK1 — DEPRESS

A momentary asterisk next to the position on display line 1 confirms that the Anti-Spoof function (Y-Code) is correctly initialized.

When ALIGN COMPLETE (Dot in diamond):

9. NAV MODE Switch — INS
10. Verify Blended Mode (BD acronym on PTID)

If the parking brake is released before a COARSE ALIGN COMPLETE indication and the GPS is navigating (i.e., the GPS is tracking four satellites), then the EGI will transition to INIT and then to GPS IMA mode (see below). If the parking brake is released before COARSE ALIGN COMPLETE and GPS is not available, the alignment will stay in INIT until GPS is available.

Note

If the alignment stops because the parking brake was released prior to COARSE ALIGN COMPLETE, LSK3 on the EGI Start 2/2 Page (RSTRT ALGN) should be depressed after the parking brake has been reset, unless a GPS IMA is desired.

If the parking brake is released after COARSE ALIGN COMPLETE, the EGI will suspend the alignment, set ALIGN HOLD, and wait for the parking brake to be reset An ALIGN HOLD indication will be posted on the PTID and CDNU, and the STBY and/or READY legends will flash to indicate the suspension. Align time does not increment while in ALIGN HOLD, but Align Quality may improve.

Note

- The EGI will not restart incrementing align time until 20 seconds after the parking brake has been reset.
- Once the EGI achieves ALIGN COMPLETE (Dot in Diamond appears), subsequent release of the parking brake will not cause an ALIGN HOLD. In this case the RIO should select INS on the NAV MODE SEL switch prior to releasing the parking brake.

20.3.3.2 Stored Heading Alignment (SH). Stored Heading Align is a fast, ground based inertial alignment where the IMU identifies the direction of local vertical, then initializes position and heading to the value it had at the last shutdown. Specified performance in this mode is the same as that for a normal GC alignment. A complete GC reference alignment must be successfully completed just prior to the last EGI shutdown, and the aircraft must not be moved after the reference alignment in order to transition to a SH alignment. When these conditions are met, SH will complete in 30 seconds. The parking brake must remain set throughout the SH alignment. If it is released, the EGI will transition to the GPS IMA mode.

If the EGI determines that any of the other required parameters (besides “parking brake set”) have not been met, it will revert to a GC alignment. The only indication that a SH has been done, is the presence of an ALIGN COMPLETE dot after thirty seconds of align time.

To set a reference alignment ashore or on board the carrier:

1. CDNU — ON
2. DATA LINK — ON (CV ops only)
3. D/L MODE — TAC

Note

Power transients will cause CAINS/WAYPT to be deselected. This will be indicated by a flashing HS acronym.

After CDNU SELF TEST Complete:

4. D/L MODE — CAIN/WAYPT (CV ops only)
5. NAV MODE SEL — GND/CVA
6. PTID Power — ON
7. WCS switch — STDBY

On EGI Start 1/2 or Start 2/2, verify present position is correct or enter the correct position, if required.

8. Continue until — ALIGN COMPLETE (Dot in Diamond)
9. NAV MODE SEL — OFF
10. CDNU — OFF
11. WCS — OFF

The procedure to accomplish a SH alignment once a reference alignment is obtained is the same as for a GC alignment.

20.3.4 In-Motion Alignments. The carrier alignment procedures are used when NAV MODE SEL switch is set to the CV position. These procedures should be used whenever the aircraft is in motion with respect to the earth (either because it is taxiing on the ground, is aboard a moving carrier, or is airborne). The EGI supports five types of In Motion Alignment (IMA): SINS IMA, SINS SH, GPS IMA, Air Data IMA, and Manual IMA. A SINS alignment can be done using either the rf data link or the deck-edge cable. An In-Motion Alignment is begun by selecting the CV position on the NAV MODE SEL switch; from that point, the mode the EGI uses to align is dependent on the reference data available. The data priority is:

1. SINS Data
2. GPS Data
3. Manual Handset Data

Note

Any time the EGI enters ALIGN HOLD with the NAV MODE SEL switch in CV and before COARSE ALIGN COMPLETE, the alignment will restart from the beginning.

20.3.4.1 SINS In Motion Alignment (SINS IMA). In SINS IMA, the EGI uses the Ships Inertial Navigation System (SINS) to align the IMU. The inertial inputs are received by the ASW-27 and transmitted to the EGI. These inputs include ship’s latitude, longitude, north and east velocity, as well as roll, pitch, heading, and heading rate. To align the EGI using SINS data, follow the following procedure:

1. CDNU — ON
2. DATA LINK — ON
3. DATA LINK mode — TAC

After CDNU SELF TEST Complete:

4. DATA LINK mode — CAINS/WAYPT
5. NAV MODE SEL — CVA
6. PTID Power — ON
7. WCS — STBY
8. CDNU INDEX Key — DEPRESS
9. CDNU Index Page LSK1 — DEPRESS (Select EGI Start 1/2 Page)

On either the EGI Start 1/2 or Start 2/2 page, ensure that present position is correct or enter a correct position.

10. CDNU LSK1 — DEPRESS

A momentary asterisk next to the position on display line 1 confirms that the Anti-Spoof function (Y-Code) is correctly initialized.

When ALIGN COMPLETE (Dot in diamond):

11. NAV MODE SEL — INS

12. Verify Blended Mode (BD acronym on PTID)

To transition to GPS IMA from SINS IMA, add the following steps to the above procedure:

9a. Ensure GPS is navigating (FOM $\leq$ 4)

9b. DATA LINK Mode — TAC

9c. On EGI Start 2/2 Page LSK3 — DEPRESS (RESTART ALIGN)

Note

- For ASW-27C equipped aircraft, if SINS data are not received as indicated by a SINS data required telltale (an “S” between the first and second tickmark) on the PTID, or a DDI “TILT” light, ensure fighter-to-fighter data link addresses (70–77) are not selected.

- With CVA selected on the NAV MODE SEL switch and CAINS/WAYPT selected as the Data Link Mode, the navigation system will default to the Blended (Unaided) mode. This is done to prevent discrepancies between the SINS data and the GPS-supplied data from corrupting the alignment. Selecting TAC on the Data Link Mode switch, or deselecting CVA on the NAV MODE SEL switch will return the navigation system to the mode (Aided, Unaided, or GPS) selected prior to starting the SINS Alignment.

The EGI enters SINS IMA mode whenever the NAV MODE SEL switch is placed in the CV position with “CAINS/WAYPT” selected on the DATA LINK MODE Switch, and a SINS SH is not available. A full performance alignment (unaided INS drift of less than 1.0 nm/hr) using this mode will take 5 minutes providing that there are no SINS data dropouts lasting more than 4 seconds. If a dropout occurs, or the parking brake is released, the alignment will be suspended. An ALIGN HOLD indication will be posted on the PTID and CDNU, and the STBY and/or READY legends will flash to indicate the suspension. If within 30 seconds the parking brake is reset, or SINS data again become valid, the alignment will continue. If the alignment is suspended before COARSE ALIGN COMPLETE, the alignment will restart with align time reset to zero. If SINS is lost for more than 30 seconds, and the Align Quality has not yet reached 3.0 nm/hr, the EGI will transition to MANUAL IMA. If Align Quality is better than 3.0 nm/hr, the EGI will transition to NAV mode.

20.3.4.2 SINS Stored Heading Alignment (SINS SH). SINS SH is the shipboard equivalent to the ground based SH alignment. In this mode the EGI uses stored spotting angle to reduce the time required for a full performance alignment to 4 minutes. A reference alignment must be performed in accordance with the procedure given above for SH, and the aircraft must not be moved relative to the ship. If SINS data drop out for longer than 4 seconds or the parking brake is released during SINS SH, the EGI will suspend the alignment and transition to SINS IMA.

20.3.4.3 GPS In-Motion Alignment (GPS IMA). GPS IMA is available any time GPS data are valid. The mode can be entered in three ways:

1. The RIO selects CV on the NAV MODE SEL switch with the DATA LINK MODE Switch in TAC

2. The aircraft reaches 80 knots and Weight-Off-Wheels (i.e., the aircraft is airborne) without an alignment.

3. The RIO selects GND on the NAV MODE SEL switch and the pilot releases the parking brake prior to a COARSE ALIGN COMPLETE indication

Note

The EGI will enter GPS IMA with the NAV MODE SEL switch in either GND or CV if the aircraft becomes airborne and the alignment is not complete (no “Dot-in-Diamond”).

If GPS IMA is entered before COARSE ALIGN COMPLETE (i.e., the alignment begins in GPS IMA), the alignment time for full EGI performance (unaided

INS drift of less than 0.8 nm/hr) will be 10 minutes. If GPS IMA is entered after a COARSE ALIGN COMPLETE indication in GC, the EGI can complete the alignment in 5 minutes, provided at least 2 of those minutes occur while the aircraft is in flight (i.e., the aircraft takes off after COARSE ALIGN COMPLETE, but before an alignment complete dot is posted). If GPS data are lost, the alignment will be suspended and an ALIGN HOLD indication will be posted on the PTID and the CDNU.

Note

> Once the EGI enters the GPS IMA mode, it will stay in that mode as long as GPS data remain valid and the NAV MODE SEL switch remains in an alignment position (GND or CV). If GPS is lost, the EGI will suspend the alignment if the NAV MODE SEL switch is in GND, and it will transition to Manual IMA if the switch is in CV (SINS data are not available). The EGI will transition to AIR DATA IMA if the aircraft is airborne.

20.3.4.4 Manual In-Motion Alignment (Manual IMA). If, after entering SINS IMA, the EGI fails to detect valid SINS data, it will transition to the Manual IMA mode. If this occurs, the RIO should enter the appropriate latitude, longitude, carrier heading, carrier speed and Z-lever arm on the EGI Manual Page of the CDNU.

CAUTION

- All the necessary data must be entered (i.e., all data must appear on the appropriate lines of the CDNU display) before the information will be sent to the EGI. The data are actually transferred to the EGI by the CDNU when the last item of data is entered by depression of the adjacent Line Select Key.
- If, during a Manual IMA, carrier heading changes by more than 10°, or carrier speed changes by more than 1 knot, the handset data must be re-entered on the EGI Manual Page of the CDNU. Data entry will also be required if the parking brake is released and reset.

Note

> Any time the “HS” telltale flashes on the PTID alignment display, the RIO should enter or re-enter the manual alignment data.

A Manual IMA will take 10 minutes, at which time an alignment complete dot will appear in the alignment progress diamond. Full specified accuracy for this mode is only 3.0 nm/hr unaided INS drift. For this reason, Manual IMA should be considered a backup mode. If the EGI is in Manual IMA and either SINS or GPS data become available, the RIO should depress LSK3 on the EGI Start 2/2 page (RSTRT ALGN) to restart the alignment. The EGI will not automatically transition to a better mode from Manual IMA.

20.3.5 In-Flight Alignments. If, for any reason, the EGI loses its alignment while airborne, or if it is necessary to launch before an alignment can be achieved, the EGI is capable of alignment in flight. The two modes available are GPS IMA and AIR DATA IMA.

20.3.5.1 GPS IMA Airborne. GPS IMA while airborne is equivalent to a GPS IMA done prior to takeoff. There are no restrictions on speed, heading, or maneuvers, only that GPS data be available. The time in alignment is 10 minutes (provided a GPS solution is available for that entire period), unless coarse alignment was completed in GC mode prior to take-off. In that case, the GPS IMA can complete in as little as 5 minutes, provided two of those minutes occur airborne. Inertial alignment quality for a GPS IMA while airborne will be the equivalent of a GPS alignment done on the ground or shipboard (i.e., < 0.8 nm/hr unaided INS drift). If GPS data are lost, the alignment will be suspended and an ALIGN HOLD indication will be posted on the PTID and the CDNU.

20.3.5.2 Air Data In-Motion Alignment (AIR DATA IMA). Air Data IMA can be used whenever the aircraft is airborne (ground speed greater than 80 knots and Weight-Off-Wheels), CADC data and AHRS magnetic heading are valid, and GPS data are not available. If the EGI is in GPS IMA while airborne, and GPS data become invalid for more than 90 seconds, the EGI will automatically attempt to transition to Air Data IMA. Once in Air Data IMA, if GPS data is recovered, LSK3 on the EGI Start 2/2 page (RSTRT ALIGN) must be depressed before GPS IMA can be used. The total time for an AIR DATA IMA is 35 minutes and the best inertial alignment quality it can produce is 3.0 nm/hr.

Note

AIR DATA IMA requires that true heading be provided to the EGI with a maximum error of 2.5°. The RIO should thus verify that an accurate value for magnetic variation is entered into the FMC.

Aircraft heading, speed, altitude, and the wind must remain constant for the entire alignment period. If the air data become invalid for more than 5 seconds, the EGI will enter ALIGN HOLD. If this happens, the alignment will reinitialize once the data again become valid, and the Align Time will begin counting from zero. This mode should be considered a backup.

20.4 NAVIGATION CONTROLS AND DISPLAYS

20.4.1 Navigation Displays. Tactical navigational information is displayed on the VDIG, PMDIG, and BDHI. The type of information displayed is predicated on the PDCP display mode and steering submode selected. System navigation information is displayed on the CDNU, PTID and HSD. Figure 20-9 is a summary of system outputs available to the displays. Figure 20-10 contains a list of data available in the PTID navigation readouts. Specific presentations for each navigation mode are presented in the navigation modes and steering section. All displays provide navigation information with respect to magnetic north. The navigation command and control grid displays are discussed in Chapter 25.

20.4.2 F-14 Mission Computer Navigation Controls. F-14 Mission Computer (FMC) navigation functions are controlled with the NAV MODE SEL switch and various soft keys on the PTID, the PDCP, and the computer address panel (See Figure 20-11). The computer address panel permits the insertion of navigation parameters into the mission computer, and the selection of information to be displayed on the PTID.

Note

Data entered via the computer address panel are used only by the FMC, they do not affect CDNU calculations. Likewise, except for the Waypoint Transfer Function (see below), data entered on the CDNU do not affect the FMC.

Failure indicators for the major assemblies of the navigation system are on the caution/advisory light panels in both cockpits; however, the pilot cockpit does not contain the NAV COMP or IMU indicator. The CDNU provides detailed information about the status of the Navigation System. Refer to Chapter 41.

Control of the pilot's displays (HUD, VDI, and HSD) and the RIO's multiple display indicator for navigation is achieved though the pilot's display control panel and the multiple display indicator control panel, respectively.

Note

For detailed information on CAP operation, refer to controls and displays in NAVAIR 01-F14AAP-1A.

The computer address panel is used to request FMC data for readout and to insert data for computation or display. Data inserted or read out from the FMC are displayed on the PTID. The CATEGORY switch on the lower end of the panel affects the function of the MESSAGE pushbutton. For navigation only, two categories are considered: NAV and TAC DATA.

20.4.2.1 Computer Address Panel Navigation Category. When the CATEGORY switch is set to NAV, the following matrix appears in the MESSAGE windows:

OWN A/C	TACAN FIX
*ALIGN DISPLAY	RDR FIX
*TARPS NAV FIX	VIS FIX
*WIND SPD+HDG	FIX ENABLE
*HUD REF PT STEER	MAG VAR (HDG)

*Function button in A/C may not be labeled, or may be labeled for an older software load.

For each window, there is a pushbutton. Depressing a pushbutton tells the FMC which function of the matrix is being initiated. When OWN A/C, WIND, or MAG VAR is depressed, data can be entered or displayed concerning each.

NAVIGATION SYSTEM OUTPUT	DISPLAY	
	PILOT	RIO
ADF Bearing	HSD, BDHI	Multiple Display Indicator, BDHI
Corrected Pressure Altitude (Aircraft)	HUD, Altimeter	PTID
Bearing to Destination	HSD, BDHI	CDNU, Multiple Display Indicator, PTID, BDHI
Command Course to Destination	HSD	CDNU, Multiple Display Indicator
Command Heading to Destination	HSD, VDI	CDNU, Multiple Display Indicator
Command Altitude and Airspeed	VDI	CDNU
Cross Track Error	HSD	CDNU, Multiple Display Indicator
Groundspeed (Aircraft)	HSD	CDNU, Multiple Display Indicator, PTID
Ground Track (Aircraft)	HSD	CDNU, PTID
Latitude and Longitude (Aircraft)	HSD (PTID Repeat)	CDNU, PTID
Magnetic Heading (Aircraft)	HUD, VDI, HSD, BDHI	CDNU, Multiple Display Indicator, BDHI, PTID
Magnetic Variation (Compass)	HSD (PTID Repeat)	CDNU, PTID
Range to Destination	HSD, BDHI	CDNU, Multiple Display Indicator, PTID
Roll and Pitch (Aircraft)	HUD, VDI, SAI, HSD (PTID Repeat)	SAI, PTID, DDD
Steering Error to Destination	VDI, HSD	Multiple Display Indicator
TACAN Deviation	HUD, VDI, HSD	Multiple Display Indicator
TACAN Range and Bearing	HUD, BDHI	Multiple Display Indicator, BDHI
Time to Go	HSD, (PTID Repeat)	CDNU, PTID
True Airspeed (Aircraft)	HSD, Airspeed Mach Indicator	CDNU, Multiple Display Indicator, PTID
True Heading (Aircraft)	HSD (PTID Repeat)	CDNU, PTID
Vertical Speed	HUD, VSI	CDNU
Wind Speed and Direction	HSD	CDNU, Multiple Display Indicator, PTID

Figure 20-9. Navigation Displays Summary

Normally, own-aircraft airspeed and magnetic heading are displayed on the PTID. If own-aircraft data file is hooked using the PTID cursor, heading will be magnetic. If OWN A/C pushbutton was selected (hooked) via the CAP, own-aircraft true heading, speed (ground speed), altitude, or course can be displayed on the PTID by depressing the appropriate prefix pushbutton (Figure 20-9 and Figure 20-10). Either the LAT or LONG pushbutton will display own-aircraft latitude and longitude. Depressing the SPD pushbutton on the CAP displays groundspeed and magnetic course. However, true airspeed and true heading are displayed when the HDG prefix pushbutton is depressed. Altitude is displayed on the left PTID readout (right is blank) when the ALT pushbutton on the CAP is depressed. To change or enter own-aircraft altitude, the procedure is to depress the ALT pushbutton followed by the desired quantity. While the data are being entered, they are displayed on the upper middle readout on the PTID. At the same time, the present data are being displayed on the two lower readouts. If the new data are correct, the RIO depresses the ENTER pushbutton, and the new value appears on the lower readout.

If the WIND pushbutton on the CAP is depressed, the PTID will display present wind speed (left readout) and magnetic direction (right readout). If an entry is desired, the WIND pushbutton is depressed, then either the SPD or HDG prefix pushbutton, and then the appropriate, numbers; knots (0 to 512) for speed or degrees (000 to 359) for magnetic direction are entered. The multiple display indicator data readout of WIND direction is always displayed as true.

LEFT READOUT	RIGHT READOUT	HOOK REQUIRED
LN (Lat. North)/LS (Lat. South)	LE (Long. East)/LW (Long. West)	
*GS (Ground Speed)	MC (Magnetic Course)	Yes
AS (True Airspeed)	*MH (Magnetic Heading	Own A/C VIA PTID Cursor
AS (True Airspeed)	*TH (True Heading)	Own A/C VIA CAP
GS (Ground Speed)	**MH (Magnetic Heading)	Yes
VM (Magnetic Variation)	MH (Magnetic Heading)	MAG VAR (Manual)
VC (Magnetic Variation)	MH (Magnetic Heading)	MAG VAR (Computed)
RA (Range)	*MB (Magnetic Bearing)	Yes
*RA (Range)	TG (Time to Go)	NAV Point
*RA (Range)	Blank (IF No LAR)	Sensor Target
—	or RM (Maximum Launch Range)	—
—	or RO (Optimum Launch Range)	—
—	or RI (Minimum Launch Range)	—
GS (Windspeed)	MD (Magnetic Direction)	Wind
—	AN (Angle)	CAT 1, 2, 3, or 4
*AL (Altitude)	—	Yes
*AD (Altitude Difference)	—	IP to Target
*NB (Number)	—	Special Test
*Indicates prefix selected.		
**Reads true heading if selected during alignment.		

Figure 20-10. PTID Readout Pairs

The MAG VAR pushbutton on the CAP is used for entering magnetic variation (MAG VAR) into the FMC, and displaying it on the PTID. Depressing the pushbutton displays alternating values of computed MAG VAR (vC) and manual MAG VAR (vM) on the left readout and displays magnetic heading (MH) on the right readout (Figure 20-12). The two values alternate every 2 seconds. As indicated on the CAP sign/direction buttons, plus corresponds to east variation and minus to west variation.

To enter manual MAG VAR into the FMC, depress the MAG VAR pushbutton. Then depress HDG, E or W, the angle in degrees and tenths, and ENTER. Tenths of a degree must be entered even if zero. The PTID displays including the NAV GRID will shift appropriately. Computed MAG VAR is continuously calculated in the FMC by comparing true heading from the EGI with magnetic heading from AHRS. The difference is stored as computed MAG VAR. The MAG VAR source used by the computer for displays and CAP entries is summarized in Figure 20-13.

Computed MAG VAR and manual MAG VAR are continuously compared by the FMC. If they differ by 5° or more, the acronym MV appears alternately with the system navigation mode acronym on the PTID and HSD. The acronym is cleared when the difference becomes less than 5°.

Note

When operating in SLAVED or COMP mode near a magnetic disturbance, such as aboard a carrier, the MV acronym should be expected to appear.

20.4.2.2 Computer Address Panel Tactical Data Category. When the CATEGORY switch is set to TAC DATA, the following matrix appears in the message windows:

WAY PT 1	HOME BASE
WAY PT 2	DEF PT
WAY PT 3	HOST AREA
FIX PT	SURF TGT
IP	PT TO PT

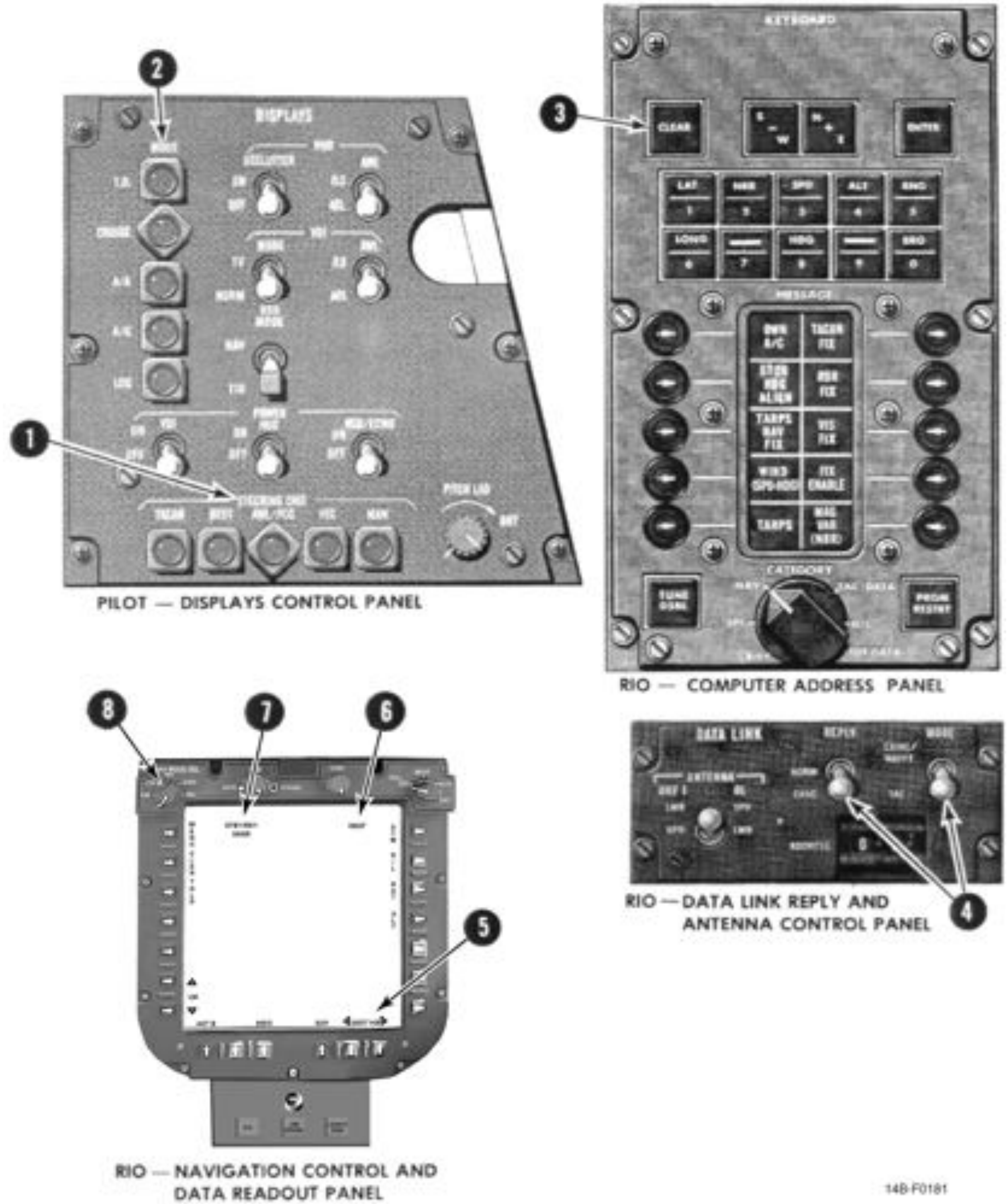


Figure 20-11. Navigation Controls (Sheet 1 of 3)

NOMENCLATURE	FUNCTION
1 STEER CMD pushbutton	Provides selection of the type of steering commands to be displayed. These push-buttons are mutually exclusive. TACAN — Provides TACAN steering and deviation from the selected TACAN radial, or To/From the selected CDNU Waypoint. DEST — Provides course to selected FMC destination point. AWL/PCD — Provides glideslope information during landing or precision course direction (vector) information during air-to-ground. VEC — Provides data link deviation steering. MAN — Displays manually selected course and heading.
2 MODE pushbutton	Mutually exclusive and rotates to identify the mode selected T.O.— Selects takeoff symbology for the HUD and VDI CRUISE — Selects cruise symbology for the HUD and VDI A/A — Selects air-to-air attack symbology for the HUD and VDI. A/G — Selects air-to-ground symbology for the HUD and VDI. LDG — Selects landing (ILS, ACL) symbology for the HUD and VDI.
3 Computer address panel	Enter, display, and update FMC Navigation data. Category switch is set to NAV for display of NAV matrix in MESSAGE window.
4 CAINS/WAYPT-TAC switch	CAINS/WAYPT — May be selected during data link alignment or when receiving waypoint data. If in INS, SINS IMA, or SINS SH modes, only SINS data are processed until alignment complete. GPS data are ignored. TAC — Allows manual selection of frequencies. **Note** • If switch is left in CAINS/WAYPT when aircraft takes off, switch automatically changes to TAC. • If during a SINS IMA the switch is unlatched to TAC by power transient, the INS will revert to a GPS IMA if satellites are available, if not it will go into align hold until they become available, or the switch is reset. • If the switch is in CAINS/WAYPT during OBC, DLS test results are invalid.
5 DEST rotary	Selects one of seventeen destinations prestored by the RIO either manually, or via the CDNU waypoint download function. These are the only points to which destination steering is provided. When selected, steering information is provided to the selected point and displayed on the multiple display indicator and VDI (when pilot has selected DEST steering). Steering information is range, command heading, command course, wind, TAS, and GS on the PMDIG. The VDI displays only command heading. The PTID symbols for the various waypoint types are shown below.

Figure 20-11. Navigation Controls (Sheet 2)

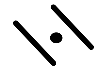
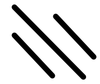
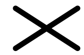
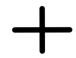
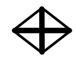
NOMENCLATURE	FUNCTION
5 DEST rotary	DEST 1–11 Selects stored numbered waypoint.  DEST 12 Selects the CDNU STEER-TO point.  FP Selects fixed point.  IP Selects initial point  ST Selects surface target  HB Selects home base. 
6 DATA READOUT source indicator.	Indicates source of data displayed on PTID readouts. WAYPT, ST, FIX PT, IP, home base (HB), OWN A/C, and TGT 1 refer to their corresponding data sources. SYMBOL indicates that a radar, data link, defended point, or hostile area has been designated for readout with specific data source indicated by brightening of the symbol. Blank indication indicates a message hook exists for which there is no symbol (for example, WIND).
7 EGI status indicators (STBY/ READY legends)	Combinations of the STBY and READY legends on the PTID are shown in Figure 20-7 along with appropriate interpretations and corrective action. After COARSE ALIGN COMPLETE, if both lights are on simultaneously, it indicates a degradation of the navigation mode selected. Refer to the CDNU Status Pages for clarifying information.
8 NAV MODE selector	Initiates alignment or manually selected operating mode of the navigation system. Any position other than OFF energizes the IMU/PSU and CSDC(R). OFF — Turns off the power to the EGI and CSDC(R). GND — Initiates stationary alignments (GC and GC SH). CVA — Initiates in-motion alignments (SINS, SIN SH, GPS, MANUAL IMA, and AIR DATA IMA). INS — Selects the Navigation mode of the EGI. AHRS — Selects AHRS/AM navigation mode. Attitude is supplied by the AHRS. Dead reckoning navigation is performed by the FMC using magnetic heading (AHRS), stored or entered magnetic variation, true airspeed from the CADC, stored or entered wind, and angle of attack from the CADC. If the EGI is operating normally, the alignment is retained. IMU — Selects IMU/AM navigation mode. Attitude is supplied by the EGI. Dead reckoning navigation is performed by the FMC using true heading (EGI), stored or entered magnetic variation, true airspeed from the CADC, stored or entered wind, and angle of attack from the CADC. If the EGI is operating normally, the alignment is retained.

Figure 20-11. Navigation Controls (Sheet 3)

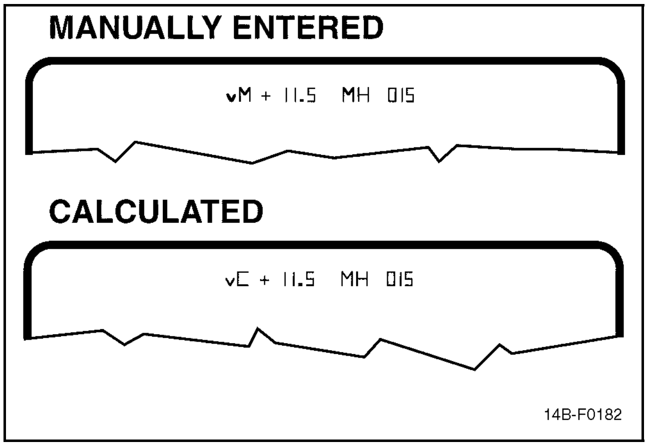


Figure 20-12. MAG VAR PTID Readout

CONDITION	MAG VAR SOURCE
COMP mode selected by pilot	Manual MAG VAR (vM)
RIO enters manual MAG VAR after selecting AHRS/AM navigation mode.	Manual MAG VAR (vM)
RIO updates MAG VAR after EGI or AHRS failure.	Manual MAG VAR (vM)
All other conditions	Current or last value of computed MAG VAR (vC)
If the RIO switches to AHRS/AM and does not enter (or reenter if no change) a MAG VAR value, computed MAG VAR (vC) will continue to be the MAG VAR source.	

Figure 20-13. MAG VAR Source Logic

Each function in this category has an accompanying PTID symbol, except PT TO PT function. When any one of these MESSAGE pushbuttons is depressed, the PTID symbol brightens and the activated MESSAGE pushbutton illuminates, indicating completion of a hook. The RIO can then perform the functions for which hooking was required. Additionally data concerning the hooked point may be displayed on the PTID readouts by depressing the appropriate prefix pushbutton.

Also, the latitude, longitude, and altitude of the hooked point may be entered by depressing either the LAT, LONG, or ALT pushbutton, followed by the desired numerals. As before, the desired numerals will appear on the PTID, and if correct, the RIO then enters the data into the FMC computer by depressing the ENTER pushbutton. Waypoint data for all eighteen mission computer waypoints can also be entered on the PTID NVD Waypoint Page.

Error source analysis and response to the MV acronym appearing in flight is summarized in Figure 20-14.

20.4.2.3 Navigation System Caution/Advisory Lights. The caution advisory panel on the RIO's right knee panel has three advisory lights that indicate failures within the navigation system (IMU, NAV COMP, AHRS). The panel also has two other advisory lights, C&D HOT and AWG-9 COND, that are indirectly related to navigation system operation. Illumination of either or both of these lights could mean degraded navigation operation because of improperly working displays.

20.5 NAVIGATION UPDATING

The GPS receiver in the EGI provides highly accurate position. As a result, there is very little need to update the solution to account for drift. Even if GPS is degraded to Standard Positioning System accuracy, the quality of the EGI Blended (Aided) solution will be much better than can be obtained using updates. For that reason, only “Map Bias” updates (temporary position offsets of a specific amount which are added on top of the Kalman filter solution) are allowed under normal circumstances. This feature allows the flight crew to modify their position to match other, non-GPS equipped units.

Note

- Only the Blended and Free-Inertial solutions will reflect the offset when a Map Bias update is performed. The GPS solution will always show the actual position computed by the GPS receiver.

- An asterisk will appear next to the position readout on the RNAV, Start, and Progress pages of the CDNU when a Map Bias is in effect.

When the actual Blended and Free Inertial solutions must be updated because of drift experienced when GPS is unavailable, Kalman filter updates are permitted. The NAV MODE SEL Switch must be in an Align position (GND or CVA), and the update will not take effect if GPS is available. These updates are termed “Optimal” updates, and actually modify the Blended solution and Free Inertial calculations.

STEP	CONDITION	ACTION	RESULTS
1	MV acronym displayed alternately with NAV mode in flight with no AHRS, IMU, or NAV COMP failure lights illuminated.	RIO manually enter new (corrected) MAG VAR.	MV acronym should be cleared.
2	Conditions in step 1 persist after actions in step 1 performed.	While in SLAVED COMPASS mode, NAV or IMU/AM selected on NAV MODE SEL switch, and level unaccelerated flight. Pilot should compare heading on VDI or HUD with standby compass.	If comparison agrees, the problem probably is in the EGI. To further verify this, continue to step 3.
3	Suspected source of vC error is the EGI	Pilot switch to COMP mode on AHRS compass controller. Compare VDI and HUD headings with standby compass.	If comparisons agree, the EGI heading is erroneous.
4	EGI heading is erroneous.	If GPS is available, RIO does a GPS IMA in flight (if necessary — check EGI Status Page on CDNU), and enters correct MAG VAR.	MV acronym should be cleared.
5	VDI/HUD headings did not initially agree with the standby compass in step 2. The problem source for VC error is the AHRS.	Pilot synchronize the AHRS by depressing HDG pushbutton. Switch to COMP mode is synchronization is not possible.	If switched to COMP mode, all computer and CRT display functions will now use EGI true heading with manual MAG VAR applied. The MV acronym may or may not clear. The BDHI will receive information from Magnetic Azimuth Detector (MAD) and may or may not be correct depending on what has failed in the AHRS.

Figure 20-14. MAG VAR Comparison Error Source Analysis and Responses

The Updates can also be used to modify the latitude or longitude in FMC position of the aircraft in the AHRS/AM and IMU/AM modes if the EGI has failed.

Similar navigation updating techniques are employed whether a Map Bias or Optimal position update is performed. For both, a ground reference point (latitude and longitude) position is required. The range and bearing of this position to present aircraft position is used to make the correction.

The general procedure for doing an update is:

1. Select the Map Bias page or Optimal Page on the CDNU (these pages are shown in Figure 20-15).

2. Establish a reference point using an FMC navigation point.

3. Determine the offset to that point.

4. Accept or reject the update based on the size of the offset.

5. Confirm that the CDNU reflects the update.

The latitude and longitude of the desired update point must be stored in one of eighteen FMC navigation waypoint locations (12 WPs, FIX PT, HOME BASE, HOST AREA, DEF PT, and IP) prior to initiating the Map Bias or Optimal update. This data may be stored prior to flight, by data link, by manual insertion, or by transfer from the CDNU. The point selected for the update must be hooked. The pre-stored latitude and longitude should be checked on the PTID. The CATEGORY select switch is rotated to NAV and the desired type of update selected.

Note

- Do not use SURF TGT as a reference for updating the navigation system. The surface target position symbol is repositioned with respect to own-aircraft vice own-aircraft being updated in reference to the surface target.

- In TARPS mode, SURF TGT functions as any other NAV file, therefore SURF TGT may be used for navigation updates. However, IP is reserved and is not available for updates in TARPS mode.

20.5.1 Radar Update. For a radar update, the FMC computes own-aircraft position by measuring radar range and bearing from the reference point coordinates in the track file.

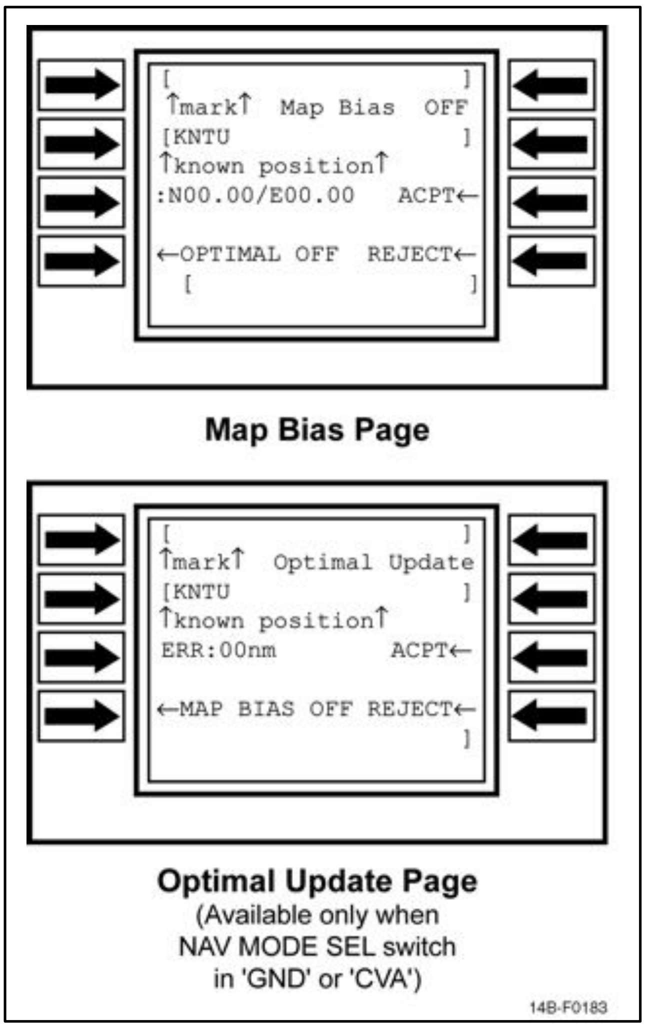


Figure 20-15. CDNU Update Pages

Once the update point is called up, its latitude and longitude are verified on the PTID readouts. The same point is then located on the DDD, using the hand control with the radar operating in the pulse search mode. DDD CURSOR is selected on the hand control and half-action is selected so that the DDD cursors are presented on the DDD. Once the cursors overlay the selected point, full action is selected. This tells the computer the point selected.

Note

RDR FIX may be selected before or after positioning DDD cursors.

When the RDR FIX pushbutton is depressed, the computer will compute the present position of the aircraft by measuring the range and bearing from the selected point. The difference between the computer position and the position determined by the EGI is then displayed on the PTID. If it is desired to enter this delta into the navigation computations, the FIX ENABLE pushbutton is depressed. However, if the observed delta does not appear to be correct, the computer and the readout can be cleared by deselecting the RDR FIX pushbutton. The fix may then be attempted again. Once FIX ENABLE is depressed on the CAP, the delta will appear on line five (5) of the Map Bias or Optimal page on the CDNU.

Note

Data line five (5) of on the CDNU Map Bias and Optimal pages may be toggled between delta latitude/delta longitude display or an error distance display in nautical miles.

Radar updating is performed as follows:

1. Select — CDNU Map Bias or Optimal page.
2. Hook — Desired navigation point.
3. PULSE SRCH pushbutton — DEPRESS.
4. On sensor control panel:
   a. STAB switch — IN.
   b. EL BARS switch — 1.
   c. AZ SCAN switch — AS DESIRED.
5. If Ground Map desired:
   a. CATEGORY Switch — TGT DATA.
   b. FB-1 — DEPRESS.

6. RDR FIX pushbutton — DEPRESS.
7. CURSOR pushbutton — DEPRESS.
8. HCU — Select HALF ACTION.
9. Cursor — is displayed on DDD.
10. Manipulate hand control — DDD cursor over desired ground map point.
11. HCU — FULL ACTION and RELEASE.

Note

This causes the DDD cursor to remain at the selected position.

12. Observe present position delta readout on the PTID.
13. If Delta is Unsatisfactory:
    a. Deselect — RDR FIX.
    b. Repeat — steps 2–11.
14. FIX ENABLE pushbutton — DEPRESS to accept update.
15. Confirm delta LAT/LONG appears on line five of the CDNU.

Note

To clear previous hooked DDD cursor position, go to half action and then release prior to initiating full action for new position hook.

20.5.2 TACAN Update. Updating the navigation system by TACAN requires that the waypoint used for the update be the same latitude and longitude as the TACAN station. The TACAN channel that corresponds to the station selected must be selected, and should be verified by listening to the identifier (coded tone) in the headset. To update the aircraft position with respect to the station, the TACAN FIX pushbutton is depressed. The FMC then computes own aircraft position error based on the range and bearing from the TACAN station. The delta is then observed and entered into the computer in the same manner as for radar updating.

TACAN updating is performed as follows:

1. Pilot Select — TACAN channel corresponding to desired update point.
2. Hook — Desired update point.
3. Select — TACAN on TACAN CMD panel.

Note

Failure to select TACAN on the TACAN command panel will result in the use of the CDNU active waypoint instead of the TACAN station when determining delta latitude and longitude.

4. Select — CDNU Map Bias or Optimal page.
5. CATEGORY switch — NAV.
6. TACAN FIX pushbutton — DEPRESS.
7. Observe present position delta readout on the PTID.
8. If Delta is Unsatisfactory:
    a. Deselect — TACAN FIX.
    b. Repeat — steps 3–6.
9. FIX ENABLE pushbutton — DEPRESS to accept update.
10. Confirm delta LAT/LONG appears on line five of the CDNU.

Note

When performing a TACAN update, aircraft MAGVAR must match the TACAN station's declination (see paragraph 20.2.2.3.2), otherwise, the update will be in error. An assumption is made by the FMC that the TACAN station bearing information is adjusted for the TACAN's declination, and that it is the same as the manually entered value of MAGVAR. TACAN declination will normally not be the same as the MAGVAR at the aircraft and may not be the same as the MAGVAR at the station. If the TACAN station is one of the waypoints stored on the MDL or in the CDNU database, TACAN declination can be found on the right side of Data Line 5 on the CDNU Waypoint Data page for that station. To illustrate the impact of MAGVAR error, assume that a TACAN station with a range of 100 nautical miles from ownship is used for an update. A 1 degree difference between MAGVAR and TACAN declination will result in a 1.74 nautical mile error in the update position.

20.5.3 Visual Update. A visual update is performed by flying over the previously entered FMC waypoint and depressing the VIS FIX pushbutton. A timing estimate must be made since the aircraft nose and fuselage may obscure the fix point for some time during the overflight. Also, it is difficult to estimate when directly overhead a ground reference point when altitude is greater than 10,000 feet. The delta then appears on the PTID. Again, this delta may be entered into the computer by depressing FIX ENABLE.

Visual updating is accomplished as follows:

1. Select — CDNU Map Bias or Optimal page.
2. Hook — Desired update point.
3. CATEGORY switch — NAV.
4. Overfly the selected pre-stored point and when over the point, depress the VIS FIX pushbutton on the CAP.
5. Observe present position delta readout on the PTID.
6. If delta is unsatisfactory:
   a. Deselect — VIS FIX.
   b. Repeat — steps 3–5.
7. FIX ENABLE pushbutton — DEPRESS to accept update.
8. Confirm delta LAT/LONG appears on line five of the CDNU.

20.5.3.1 CDNU Visual Update. A Visual Update can also be accomplished using the CDNU alone with the following procedure:

1. Select — CDNU Map Bias or Optimal page.
2. Enter a known position into Data Line 3 of the CDNU using LSK2.
3. Overfly known position, and when over the point, depress the MARK Key on the CDNU.
4. Enter the resulting position into Data Line 1 of the CDNU using LSK1.
5. Observe present position delta on Data Line 5 of the CDNU.
6. If delta is unsatisfactory:
   a. LSK8 — DEPRESS.
   b. Repeat — steps 2–5.
7. LSK7 — Depress to accept the update.

20.5.4 HUD Update (TARPS). The TARPS mode provides an additional update capability via the HUD. If the navigation system is operating accurately, the HUD diamond will be superimposed over the hooked target. If the pilot determines that the system is not accurate (diamond significantly off hooked target) the following procedure should be followed:

1. Select — CDNU Map Bias or Optimal page.
2. Hook — Desired waypoint.
3. PILOT — Visually identify the target.
4. CATEGORY switch — NAV.
5. TARPS NAV FIX — DEPRESS (Nav Cat FB-3) to read position delta (if desired).

PILOT:

6. Move target designate switch forward to cage CGTL in azimuth. This will position the designate diamond on the midpoint of the CGTL.
7. Fly aircraft to align CGTL with target.
8. Slew diamond up or down along CGTL on HUD by using the target designate switch until the diamond is superimposed on the target.
9. Move target designate switch forward to designate the target.

RIO:

10. Observe present position delta readout on the PTID.
11. If delta is unsatisfactory:
    a. Deselect — TARPS NAV FIX (FB-3).
    b. Repeat — steps 3–6.
12. FIX ENABLE pushbutton — DEPRESS to accept update.

Note

Accurate target altitude has a significant impact on the quality of the HUD navigational update. Additionally, the quality of an update increases with greater lookdown angles. Low grazing angles may induce navigational errors.

20.5.5 Data Link Update. A data link update is used to update the aircraft INS to the Tactical Data System (TDS) frame of reference. A prerequisite for a data link update is that the aircraft and TDS prebrief a common reference point latitude and longitude. The RIO must enter this LAT/LONG into the HOST AREA pseudo file. During the mission, TDS will uplink the common reference point as a data link waypoint. If the aircraft and TDS INS systems agree, the data link waypoint and HOST AREA symbols will be superimposed on the PTID. If an error is present, the two pseudo targets will be separated on the PTID.

The RIO can update the aircraft INS to the TDS as follows:

1. Select — CDNU Map Bias or Optimal page.
2. Hook — Datalink waypoint corresponding to prebriefed reference point.
3. CATEGORY switch — NAV.
4. Overfly the hooked data link waypoint and when over the point, depress press VIS FIX push button on CAP.
5. Observe present position delta readout on PTID.
6. FIX ENABLE pushbutton — DEPRESS to accept update.

After the data link update, the HOST AREA and data link waypoint symbols should again be superimposed on the PTID.

20.5.5.1 Fighter-to-Fighter Navigation Update. Net aircraft using fighter-to-fighter data link (FF/DL) can coordinate their navigation systems while in the FF/DL mode. Hooking an associated net aircraft symbol and pressing D/L FB-5 causes the coordinates of the hooked aircraft to be used as a reference for updating own-aircraft coordinates. The exact procedure is:

1. Obtain a radar STT on or fly in close formation with another net aircraft.
2. CATEGORY switch — D/L.
3. Hook — Net aircraft symbol.
4. CAP FB-5 — DEPRESS.

20.5.6 Position Marking. The SURF TGT position of the TAC DATA category may be used to mark the position of a pulse radar target, a visual target, or a TACAN station for display on the PTID. When displayed on the PTID, latitude, longitude, range, and bearing, are available, using the CAP or the navigation destination control on the PTID, or both.

Note

- Do not use SURF TGT as a reference for updating the navigation system. The surface target position symbol is repositioned with respect to own-aircraft vice own-aircraft being updated in reference to the surface target.
- In TARPS mode, SURF TGT functions as any other NAV file, therefore SURF TGT may be used for navigation updates. However, IP is reserved and is not available for updates in TARPS mode.

When a pulse radar target is to be marked and displayed on the PTID, the method is to first select the SURF TGT pushbutton. Next, establish the location via a radar fix. Select the DDD CURSOR and using the pulse system for radar mapping, designate the point of interest by placing the cursor over that point and selecting full action. Then select RDR FIX, which will present a delta from the hooked point to the surface target. Ignore the delta and select FIX ENABLE, which will position the surface target over the previously identified radar position. Now a very accurate readout of latitude, longitude and steering information is available to the point.

For visual targets, the method is the same, but a visual fix is required. A TACAN station that is providing good bearing and range may also be marked using the same method and following the TACAN fix procedures. When any of the above procedures are completed, the SURF TGT symbol is displayed on the PTID at the computed latitude and longitude coordinates.

The last method for special position marking is to hook any point on the PTID and select any waypoint on the CAP. The appropriate waypoint symbol now appears over the hooked point and its position is stored in the FMC.

Any waypoint selectable on the CAP may be used as a destination point (see paragraph 20.12.3 for a complete discussion of destination steering). If a position has been previously entered for one of the points, its symbol will appear on the PTID.

20.6 ATTITUDE AND HEADING REFERENCE SET (A/A24G-39)

In the absence of attitude information from the inertial navigation system, the attitude and heading reference set (AHRS) provides backup pitch and roll information to the CSDC(R) and to the FMC. At all times, the AHRS provides prime magnetic heading to the BDHI for direct analog display and to the CSDC(R) where it is converted to digital information for the VDIG, PMDIG, and the FMC. The AHRS also provides heading reference for the autopilot.

Note

The BDHI is the only analog cockpit display of magnetic heading. The other cockpit displays (HUD, VDI, PTID, HSD, multiple display indicator, and CDNU) are digital and receive their inputs from AHRS through the CSDC(R). Therefore, should there be a CSDC(R) failure, the only the BDHI will display AHRS magnetic heading.

Basic components of the AHRS include two-gyro platform (vertical and directional displacement gyros), an electronic control amplifier, and a compass controller (Figure 20-16). Also associated with the AHRS is a magnetic azimuth detector (MAD) and an electronic compensator. The platform consists of gyros, level sensors, gimbals, and associated electronics. The platform is unlimited in roll, but limited to 82° in pitch. If the EGI's IMU fails, the CSDC(R) automatically selects AHRS attitude information for display and autopilot control. The directional gyro is used to smooth the flux valve heading signal in the SLAVED mode or to provide a direct heading reference in the DG mode. The resulting heading is subsequently transmitted to and used by the BDHI, the CSDC(R), and the FMC.

Note

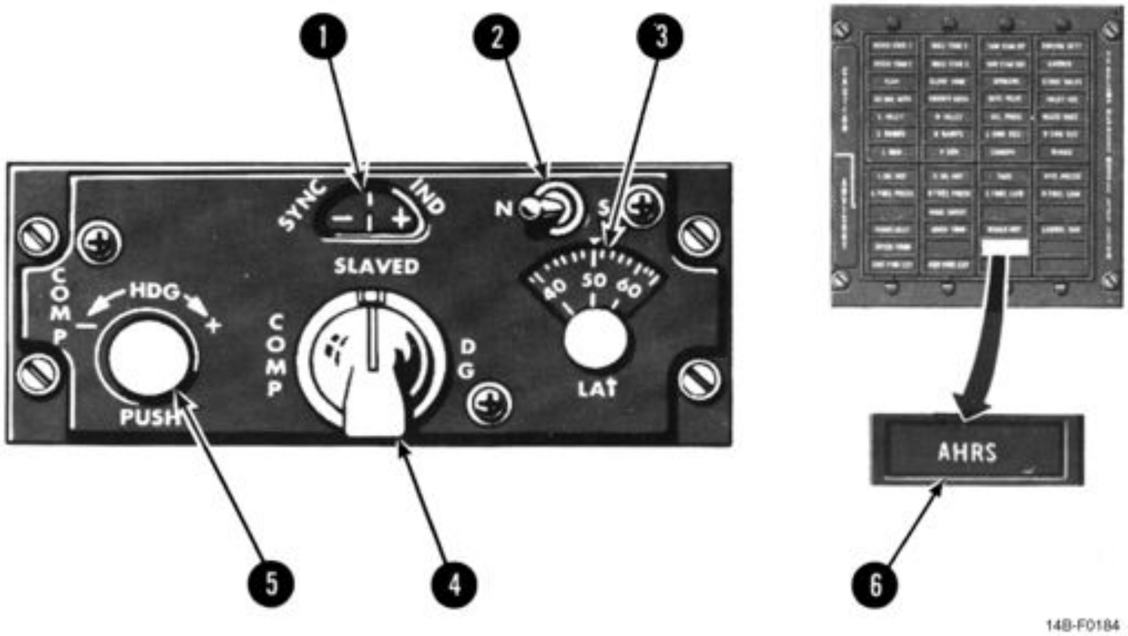
- IMU true heading is used in the INS mode for navigation. The IMU true heading must be converted to magnetic heading by adding or subtracting MAG VAR to produce a back-up magnetic value when required. Under normal system operation AHRS magnetic heading is used for all magnetic displays.

- AHRS does not have an all-attitude capability and will precess if pitch attitudes exceed ±82°. A gradual precession in roll, pitch, and heading can also be expected in sustained turns at slow rates (less than 6° per minute). Large roll and pitch precession errors can be corrected by flying straight and level, without accelerating, and pressing and holding the HDG set pushbutton on the compass controller panel. Pressing and holding this button corrects precession errors at a rate of 12° per minute minimum. The HDG set pushbutton should be held for at least 3 minutes. Before repeating the 3-minute cycle, it should be released for at least 1 minute.

- The DFCS uses AHRS as a backup for the INS data to provide autopilot capability in the event of EGI failure. The DFCS will detect an AHRS invalid signal airborne, however, the AHRS fault code will not be recorded in the DFP fault display unless the AHRS is actually being used at the time the failure occurred. In addition to an actual AHRS failure, The AHRS fault code can be caused by pressing and holding the heading set button, selection of COMP or DG mode, or manuevering in excess of ±82° pitch attitude.

20.7 DISPLACEMENT GYRO ASSEMBLY

The displacement gyro assembly includes a directional and a vertical gyroscope. The directional gyroscope establishes a reference from which heading deviation is measured. The vertical gyro provides a horizontal reference from which roll and pitch outputs are determined. These outputs are transmitted to the CSDC(R) and the DFCS. The DFCS receives steering error signals from the CSDC(R), based on changes in AHRS heading.



NOMENCLATURE	FUNCTION
1 SYNC IND	Indicates synchronization between AHRS directional gyro and magnetic azimuth detector. Indicator is deactivated in DG and COMP modes.
2 N-S Hemisphere select switch	In DG and SLAVED modes, hemisphere (N or S) in which aircraft is operating must be preselected to provide proper earth-rate correction.
3 LAT correction control	Used in DG and SLAVED modes: latitude from 0° to 90° must be preselected to allow for earth rate corrections.
4 COMP-SLAVED-DG mode switch	COMP — Compass heading is obtained directly from magnetic detector without stabilization by the platform directional gyro. This position is used if the directional gyro malfunctions and for emergencies only. The HUD, VDI, HSD, and multiple display indicator use manual magnetic variation (vM) automatically in this mode. SLAVED — Normal position gyro-stabilized magnetic heading is obtained from magnetic azimuth detector. DG — Directional gyro mode uses selected gyro heading; magnetic azimuth detector is not used.
5 HDG pushbutton	In SLAVED mode, the pushbutton synchronizes the directional gyro with the magnetic azimuth detector and sets magnetic heading on the BDHI. Pushbutton must be depressed and held until the synchronization indicator needle is bracketing the null mark. (Synchronization cannot be accomplished if aircraft is accelerating or decelerating by more than 75 knots per minute.) In DG mode, the pushbutton is depressed and rotated CW or CCW to set the selected heading on the BDHI. The pushbutton has no function in COMP mode. Fast erection in pitch and roll (12° per minute minimum) is obtained by depressing and holding pushbutton for up to 3 minutes (button must be released for at least 1 minute before repeating the 3-minute cycle).
6 AHRS advisory light	Green light illuminates when attitude or heading information from AHRS is unreliable.

Figure 20-16. Compass Controller

20.7.1 Electronic Control Amplifier. The amplifier supplies power to the displacement gyro and is the interface between the displacement gyro and aircraft subsystems. The amplifier also handles AHRS malfunction detection, gyro erection, and compass mode logic. It incorporates the electronics for slaving the heading gyro, compensation of magnetic heading errors, and AHRS mode selection.

20.7.2 Magnetic Azimuth Detector (MAD). The MAD provides the magnetic heading for the aircraft. It interfaces with the electronic control amplifier and gyro, which acts to stabilize and amplify the magnetic heading signals. The MAD is in the left vertical tail section and is commonly referred to as the flux valve.

20.7.3 Compass Controller Panel. The compass controller panel has the controls for selecting one of three compass modes when the AHRS is used as the heading reference (Figure 20-16).

Where magnetic heading references are unreliable, the system should be operated in DG mode. In areas where magnetic references are reliable, the system shall be operated in the SLAVED mode. When DG or SLAVED modes are inoperable, the COMP mode shall be employed for emergencies.

The AHRS operates from the ac essential no. 2 bus through the AHRS PH A, PH B, PH C circuit breakers (3C6, 4C1, 4C5) on the RIO's left side circuit breaker panel.

Note

If both the EGI IMU and the AHRS gyros fail, pitch and roll attitude indications are removed from the HUD, PTID, and DDD, and the IMU and AHRS advisory lights illuminate. Selecting COMP mode on the compass controller panel may restore valid magnetic heading information to the HUD, VDI, and HSD, and the AHRS advisory lights will go off. However, invalid pitch and roll attitude information will be restored to the HUD and VDI and should be disregarded.

20.7.4 AHRS Operation. As a compass, the AHRS operates in three modes: the directional gyro (DG) mode provides a free-gyro heading reference with earth-rate correction; the SLAVED mode provides a gyro-stabilized magnetic heading; and the compass (COMP) mode provides an emergency magnetic heading from the compass transmitter only. The random drift (precession rate) of the gyro in the DG mode does not exceed 1.5° per hour. This mode may be used at all latitudes, but is more useful when operating in regions where the magnetic field is weak or distorted. When the COMP mode is selected, the DFCS is automatically disengaged to prevent erratic steering commands. The COMP mode does not provide a sufficiently stable heading signal for DFCS operation and shall be used only for emergency operation. To erect the AHRS, press and hold the HDG set pushbutton on the compass controller (3 minutes on, 1 minute off cycle) until the needle of the synchronous indicator is bracketing the null mark.

AHRS does not have an all-attitude capability, and will precess in pitch and/or roll if pitch attitudes exceeding ±82° are attained. If the navigation system is operating in the INS or IMU/AM modes, attitude displays will continue to indicate properly when the AHRS pitch limit is exceeded, but all displays of magnetic heading will be in error and the advisory lights may be on or off. If this condition is encountered, accurate and stable magnetic heading displays on the HUD, VDI, HSD, PTID and multiple display indicator can be regained immediately by the following procedure:

1. Pull the AHRS PH A, B, and C circuit breakers (3C6, 4C1, 4C5).

2. Insert proper MAG VAR via the computer address panel.

This procedure will render the AHRS and BDHI magnetic heading indication inoperative and provide EGI IMU derived magnetic heading for the HUD, VDI, HSD, PTID, and multiple display indicator displays.

20.7.4.1 AHRS Reset Procedure. To regain the AHRS for both magnetic heading information and backup navigation/attitude capability, the following procedure is recommended.

1. While flying straight and level, reset the AHRS PH A, B, and C circuit breakers (3C6, 4C1, 4C5). (These breakers must be pulled for a period of at least 30 seconds before resetting.)

2. Allow 3 minutes of AHRS erection time, and then sync magnetic heading via the HDG pushbutton on the compass control panel.

A gradual AHRS precession in roll can be expected when in sustained turns (exceeding 3° per minute for extended periods of time). AHRS pitch and roll precession errors can be corrected by flying straight and level and pressing and holding the HDG pushbutton on the compass controller panel. Holding this button erects the AHRS at a rate of 12° per minute.

CAUTION

If an undetected AHRS failure occurs, an erroneous value of MAG VAR will be computed, and the Mv acronym will appear on the PTID. The flightcrew should isolate the navigation failure and correct it.

20.7.5 AHRS BIT. A validity signal from the AHRS is continuously monitored by the CSDC(R). Absence of this signal indicates an AHRS failure. The BIT monitors internal error signals and electrical characteristics of the AHRS; when the BIT detects an AHRS failure, the AHRS light on the caution advisory panel illuminates. When the CSDC(R) detects this failure, the FMC is informed and the failure is displayed on the PTID status indicator (STBY/READY legends). The FMC also informs the CM routines of the failure, providing an AHR acronym display on the PTID OBC CM readout.

20.8 COMPUTER SIGNAL DATA CONVERTER (REPLACEMENT) [CSDC(R)]

The CSDC(R) is the interface between the navigation system (EGI and CDNU), various auxiliary subsystems, and the FMC (see Figure FO–18). Specifically, the CSDC(R) consists of an analog-to-digital converter, a digital-to-analog converter, a MIL-STD-1553 data bus port, and a miniature general-purpose computer.

The CSDC(R) receives analog roll, pitch, and azimuth information, numerous discretes, and digital information via the NAVBUS from the EGI. The CSDC(R) also receives magnetic heading from the AHRS; radar altitude from the radar altimeter; TACAN range and bearing from the TACAN set; ADF bearing from the UHF/ADF system; true airspeed, Mach number, airstream air temperature, and pressure altitude from the CADC. Additional digital information is received via the NAVBUS from the CDNU. The CSDC(R) converts or re-scales all these inputs to the format required to output and display the following:

1. Pitch and yaw rate
2. True or magnetic heading
3. Present position
4. Wander angle

The CSDC(R) calculates the following quantities.

1. System Altitude
2. TACAN deviation and relative bearing
3. Command airspeed error
4. Command altitude error

The CSDC(R) furnishes the following data to the FMC for weapons system steering:

1. Aircraft present latitude and longitude
2. System altitude
3. Inertial velocities (Vx, Vy, Vz)
4. Vertical acceleration
5. Wander angle and magnetic heading
6. Pilot's selected manual command heading and CDNU generated course.

The CSDC(R) also operates with the FMC, VDIG and PMDIG to display various navigation parameters (Figure 20-9).

Note

Because the CSDC(R) no longer calculates the INS solution, selecting IMU will not dump the alignment parameters as was the case before installation of the EGI navigation system. Nor will cycling the CSDC(R) circuit breakers. After ALIGN COMPLETE, the RIO may select any position on the NAV MODE SEL switch (including GND and CVA) and the EGI will continue to navigate normally (although the source of steering data will change based on the selection). Once the switch is rotated back to INS, EGI steering will be restored with no adverse effects.

20.8.1 CSDC(R) BIT. The CSDC(R) continuously monitors its own program and electrical characteristics in addition to those of other systems. If a failure is detected, it is displayed on the PTID by the FMC and if the navigation functions fail (or a data quality parameter exceeds tolerance), the FMC illuminates the NAV COMP light on the caution advisory panel.

Note

CSCD(R) failures are often initially detected by OBC continuous monitoring. The acronyms include: CSD (CSDC(R) failure), CSI (standard serial interface failed), and WOW (weight-on-wheels).

Prior to and at the end of each flight, the RIO should check and record the contents of Flycatcher 71-00750. All zeros should be observed.

20.9 TACAN SYSTEM (AN/ARN-84)

The TACAN system provides continuous indications of slant range to 0.1 nm and bearing of 0.5° to any surface station selected. Slant range is available to other aircraft equipment with an air-to-air (A/A) mode. Operating range is line-of-sight to approximately 300 nautical miles.

The system provides 126 operating channels in each of two modes. Receiving frequencies for surface-to-air operation are 962 to 1,024 MHz and 1,151 to 1,213 MHz; for air-to-air operations the frequencies are from 1,025 to 1,150 MHz. TACAN uses two aircraft antennas, automatically switching between the two at 6-second intervals until a threshold signal is received.

20.9.1 TACAN Modes. The system, when operating in the REC or T/R modes, is capable of receiving valid signals from a ground station simultaneously with 99 other aircraft. When in the A/A mode, the system is capable of transponding with each of five cooperating aircraft, providing slant range information to each; however, the system will interrogate and lock on to only one. In the A/A mode, the second aircraft must be 63 channels apart. Only range is received because the aircraft antenna complement is not configured to receive or transmit bearing information. The TACAN control panel (Figure 20-17) is located on the pilot's left console.

Note

When the CDNU was added to the rear cockpit, the RIO's TACAN Control Panel was removed due to space limitations. Therefore, with the EGI navigation system installed, only the pilot can control TACAN channel selection.

Individual EGI/TACAN CMD pushbuttons (Figure 20-17) on the pilot's and RIO's left consoles provide for selection of either EGI or TACAN steering information on the HSD, VDI, HUD, and BDHI. The selection is indicated by a flip-flop indicator in each cockpit showing TCN (TACAN) or EGI. The pushbuttons are coupled so that selection of either TCN or EGI in one cockpit toggles the selection in both cockpits.

20.9.2 TACAN Displays. Bearing and distance information is displayed on the BDHI (bearing, distance, heading indicator), the HSD, and the multiple display indicator. Deviation, which is defined as the difference between actual TACAN bearing and manually-selected course bearing, is computed by the CSDC(R) and displayed on the HUD and VDI (VDIG) and the HSD. The PMDIG presentation of TACAN information includes TACAN bearing marker, deviation ticks, range-to-TACAN station, and course. The HUD and VDI display provide a TACAN deviation bar, which is coded (solid line — TO station, dashed line — FROM station on the HUD; bright bar — TO station, dark bar — FROM station for the VDI).

TACAN information is displayed on identical BDHIs on the pilot's and RIO's right upper instrument panels. The bearing and distance functions of the BDHI are activated when the TACAN mode select switch is set to T/R. In the REC and T/R modes, magnetic bearings are displayed by the no. 2 (large) needle, which unlocks and enters a search mode whenever bearing information is unreliable. Range information that is received in the T/R mode or, when operation with another aircraft in the A/A mode, is displayed in nautical miles on the distance counter. An OFF flag covers the counter window when range information is unreliable. TACAN information is also displayed in conjunction with other system modes on the pilot HSD, HUD, and VDI and on the RIO multiple display indicator.

20.9.3 TACAN Operation. The TACAN system takes approximately 2 minutes to warm up. If, after the warm-up period, the range and bearing indications continue to search when a reliable station is selected, circuit breakers should be checked, or another station checked.

The system has a memory feature so that tracking will not be interrupted by momentary disruption of received signals. A range signal that is lost after at least 10 seconds of tracking will be sustained by memory for 9 to 12 seconds. A bearing signal that has been tracked for at least 15 seconds will be retained for 3 to 8 seconds after signal loss.

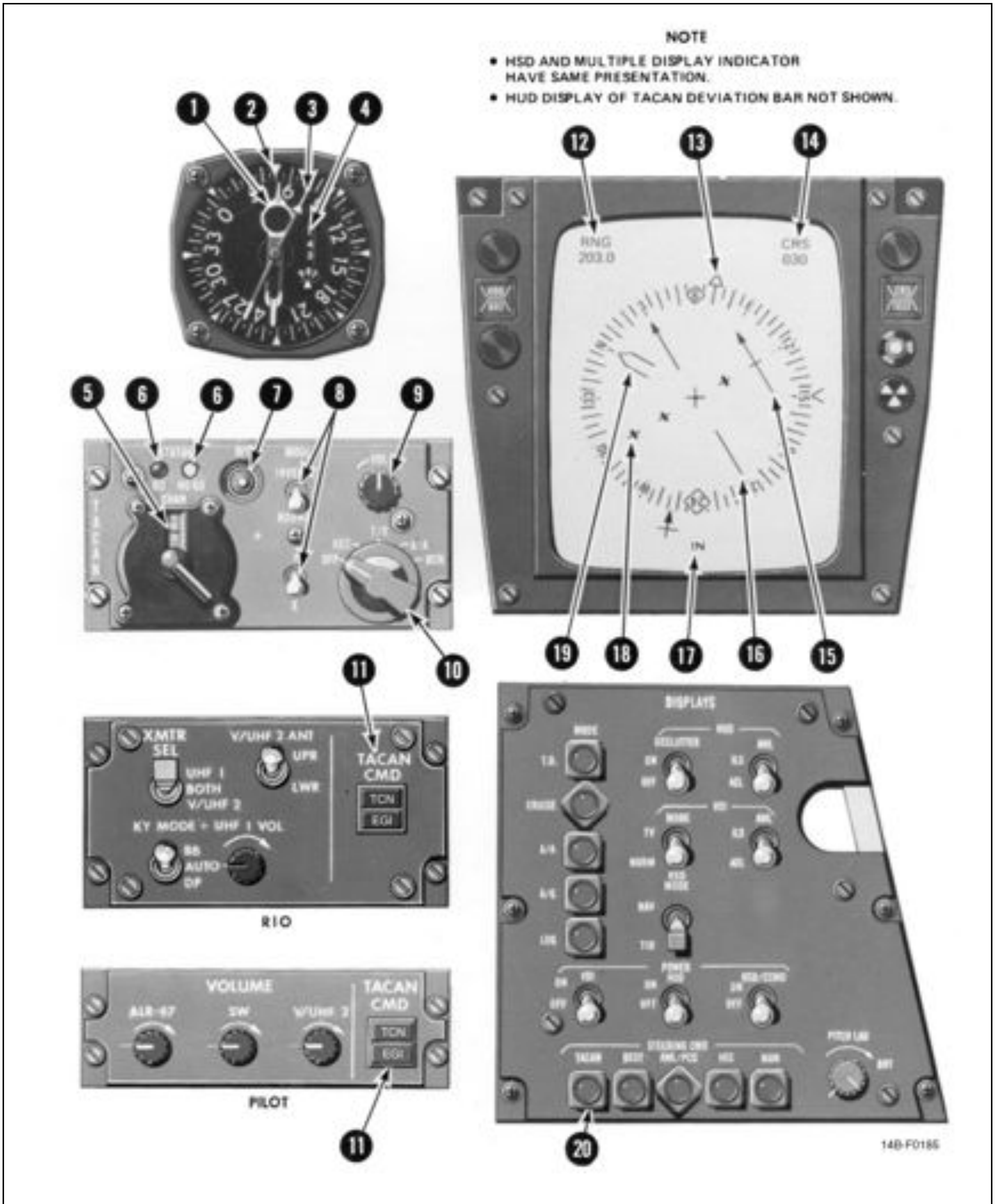


Figure 20-17. TACAN Controls and Displays (Sheet 1 of 2)

NOMENCLATURE	FUNCTION
1 No. 2 bearing pointer	Indicates magnetic course to selected CDNU Waypoint or TACAN station.
2 Compass rose	Top of instrument indicates aircraft magnetic heading.
3 No. 1 bearing pointer	Indicates bearing to UHF/ADF station selected.
4 Distance counter	Indicates range (nautical miles) to selected CDNU Waypoint (EGI mode), or to TACAN station or cooperating aircraft.
5 TACAN CHAN switch	Outer selects first two numbers and inner control selects last digit of desired TACAN channel (126 channels available).
6 STATUS lights	Indicates GO or NO-GO status of TACAN system during TACAN BIT.
7 BIT switch	Initiates interruptive self-test portion of built-in test feature.
8 MODE switch	NORMAL and X are fixed (other modes, INVERSE and Y, are available with AVC 2913 incorporated.
9 VOL control	Regulates audio level of station identification signal through ICS.
10 Function selector	OFF — Sets power off. REC — Provides only bearing information from surface station selected. T/R — Permits reception of bearing and slant range from surface station selected. A/A — Slant range from another air-to-air equipped aircraft is available, if such aircraft have selected TACAN frequencies 63 channels apart. BCN — Not operational. **Note** Items 12 through 20 appear on both the pilot's HSD and multiple display indicator, when selected.
11 TACAN CMD control switch	Illuminates when selected, TCN or EGI, indicating which navigation system (EGI or TACAN) is driving the BDHI/HSD.
12 RNG readout	Indicates range to CDNU Waypoint or TACAN station in tenths of a mile.
13 TACAN bearing pointer	Indicates direction to CDNU Waypoint or TACAN station relative to own-aircraft.
14 CRS readout	Indicates the course selected. When in TACAN, course is controlled by the pilot with the CRS control knob. When in EGI, course is controlled automatically by the CDNU or manually by the RIO using the CDNU.
15 Deviation bars	Indis difference between course selected and bearing to waypoint or TACAN station.
16 Course bars	Indicates course selected.
17 Navigation mode reference symbol	Indicates the navigation system mode: BD for Blended (Aided), G for GPS, IN for Blended (Unaided), IM for IMU/AM, AH for AHRS/AM, or AE for AHRS/EGI or AHRS/GPS.
18 Deviation ticks	Symbols used as scale for deviation bar. Each tick represents 6° of deviation when TCN is selected on TACAN CMD control switch, or the amount of crosstrack error when EGI is selected by TACAN CMD control switch. Each tick represents 2.0 nm for "Enroute" flight mode, 1.0 nm for "Terminal", and 0.15 nm for "Approach". See Figure 20-19.
19 ADF bearing symbol	Indicates bearing to ADF station selected.
20 TACAN-STEER CMD pushbutton	Enables TACAN steering symbology. When selected during T.O., CRUISE, or LDG, enables presentation of TACAN or CDNU data on the VDIG and PMDIG.

Figure 20-17. TACAN Controls and Displays (Sheet 2)

This allows automatic antenna switching without a loss of TACAN displays.

Power requirements for the TACAN system are provided by the ac essential bus no. 2 (phase A) through the TACAN ARN-84 circuit breaker (3D6) on the RIO's left panel, the dc essential bus no. 2 through the TACAN/BDHI circuit breaker (7E8) on the RIO's right aft panel, and the ac essential bus no. 2 (phase C) through the TACAN/BDHI INST PWR circuit breaker (4F6). During the minimum warm-up time, failure indications and erroneous readouts should be disregarded and self-test results may be inconclusive.

20.9.4 TACAN BIT. The TACAN system contains a built-in test that provides continuous automatic monitoring and interruptive self-test. The TACAN control unit has a momentary pushbutton (BIT switch) for starting a 22-second interruptive self-test sequence and two status lights labeled GO (green) and NO-GO (amber). The NO-GO light illuminates whenever any of the continuous monitor functions are NO-GO or if the results of the self-test cycle are NO-GO. The GO light illuminates momentarily (6 to 8 seconds) only at the completion of a satisfactory interruptive self-test cycle. Light circuitry is tested at the start of the self-test cycle. When the BIT switch is depressed, both GO and NO-GO lights illuminate; they go out when the BIT switch is released.

Note

BIT on TACAN stations within 2 nm may give an invalid indication. If a TCN acronym or NO-GO response is observed, while tuned to a local station, along with normal TACAN azimuth and range, the acronym and/or the NO-GO should be disregarded.

The normal BIT sequence is as follows:

1. Select TCN on the TACAN Command Panel.
2. Pilot set TACAN mode to T/R; allow 2 minutes for warmup.
3. Press and hold BIT button.
   a. Both GO and NO-GO lights illuminate (lights test)
   b. BDHI range OFF flag appears.
   c. BDHI bearing needle rotates counterclockwise.
4. Release button; both lights go out (self-test starts).
   a. After 5 to 6 seconds, BDHI and HSD range reads 2 nm; BDHI and HSD bearing reads 4°. (Identify TACAN station.)
   b. After 22 seconds; if good, green GO light illuminates, if bad, amber NO-GO light illuminates.

20.10 SIGNAL DATA CONVERTER (SDC)

The Signal Data Converter (SDC) is a digital-to-analog converter that processes signals from the CDNU for display on the BDHIs. Three signals are sent: Bearing to Waypoint, Range to Waypoint, and a Data Valid discrete bit. If either range or bearing are invalid, a Data Invalid signal will be sent causing the BDHI No. 2 needle to spin. The OFF flag will also appear over the Range window.

CAUTION

If the SDC circuit breaker is pulled, or the unit is removed from the aircraft, SDC Built-In-Test will indicate SDC "GO" even though there is no SDC function. See Chapter 41. If either of these events occur, and EGI is selected on the TACAN Command Panel, the BDHI will display an "OFF" flag.

20.11 BEARING DISTANCE AND HEADING INDICATOR (BDHI)

A bearing, distance, and heading indicator (BDHI) is on the right-hand side of the pilot and RIO instrument panels (Figure 20-17). It is a remote-type heading indicator that displays aircraft magnetic heading with navigation bearing data and range information. The compass card receives heading reference from the attitude heading reference set (AHRS). Controls on the pilot's compass controller panel permit the BDHI compass card to operate in a slaved or non-slaved (FREE DG) compass mode. A fixed index marker at the 12 o'clock position indicates magnetic heading.

Two servo-driven bearing needles indicate magnetic bearings to selected UHF (ADF), and TACAN stations or CDNU waypoints. The No. 1 (single bar) needle receives signals from the UHF (ADF) system; the No. 2 (double bar) needle receives signals from either the TACAN or the EGI systems depending on the state of the TACAN CMD control switch.

If the compass card is misaligned or a malfunction exists in the compass system, the No.1 needle will continue to point toward the signal source; however, the bearing to the station is displayed on the indicator as a relative bearing, the top of the indicator bezel being 000°. Under the same circumstances, the No. 2 needle will continue to indicate magnetic bearing to the selected station or waypoint, or will spin.

20.12 NAVIGATION SYSTEM INTEGRATION

20.12.1 Navigation Modes. The EGI continuously calculates attitude, position, and inertial velocities and makes these available to the CDNU and CSDC(R). There are three different solutions calculated simultaneously for position and velocity. As discussed in paragraph 20.1.1, only two of these solutions (Blended and GPS) are available for navigation. The third (Free Inertial) provides a general check of EGI IMU health, and can only be viewed on the INS RNAV page of the CDNU. It cannot be used for any navigation calculations or display. Two submodes are available in the Blended mode: Aided and Unaided. The primary navigation mode is Blended (Aided), with Blended (Unaided) and GPS available to the aircrew via a toggle on the EGI Start 2/2 page of the CDNU. These latter modes provide an INS only and GPS only solution, respectively, if operational considerations or equipment failure dictate. Additional backup modes are available if equipment failure occurs.

The actual navigation mode used by the aircraft is determined by the CSDC(R) based on equipment health and selections the RIO makes on the NAV MODE SEL switch and CDNU. Figure 20-2 shows the modes available, and the source used for attitude, position, and velocities in each mode.

20.12.1.1 Blended Navigation Modes. The EGI Blended Solution is the output of the EGI Kalman filter and can either be Aided or Unaided. In the Aided case, the EGI incorporates GPS data to refine the navigation solution. In the Unaided case, the GPS input is removed from the Kalman filter. This allows the aircrew to deselect GPS if required operationally (for example, in areas of known spoofing), while retaining the improved accuracy available from the Kalman filter. This improved accuracy always makes the Blended (Unaided) solution better than the Free Inertial solution, which is why the latter is not used for navigation.

20.12.1.1.1 Aided Mode. The Blended (Aided) mode is the Navigation System’s primary mode of operation. In it, the EGI takes full advantage of any GPS signals available to refine its position and velocity solutions (attitude is unaffected).

Note

The EGI must be tracking four satellites before fully specified GPS accuracy (less than 16 meters SEP) is available. If fewer satellites are tracked, the signals are incorporated in the Blended solution, but overall accuracy will degrade.

The Blended (Aided) mode is available as soon as the EGI completes coarse alignment, but actual aiding does not start until the GPS receiver begins tracking four satellites. The mode is indicated by a “BD” acronym on the PTID and HSD. If the GPS receiver in the EGI is functioning properly but no satellite signals are present, the Navigation Mode will remain Blended (Aided) with performance similar to the Unaided case. (The number of satellites the GPS is receiving is indicated on the GPS RNAV, the Blended RNAV, and the EGI Start 2/2 pages of the CDNU.)

20.12.1.1.2 Unaided Mode. The Blended (Unaided) mode is automatically selected upon failure of the GPS receiver in the EGI. It can also be selected using LSK8 on the EGI START 2/2 page of the CDNU if the aircrew believes GPS to be unreliable for some reason. In the Unaided mode, the EGI operates as if it were a conventional INS (i.e., one without GPS). This mode is indicated by an “IN” acronym on the PTID and HSD.

20.12.1.2 GPS Mode. The GPS mode utilizes the GPS solution from the EGI. It can be selected by the RIO using LSK8 on the EGI START 2/2 page of the CDNU if GPS only information is desired. In this mode, the GPS supplies position information and the IMU provides attitude and velocities. GPS mode is indicated by a “G” acronym on the PTID and HSD.

20.12.1.2.1 IMU/AM Mode. The IMU/AM mode is automatically entered upon failure of the NAVBUS or certain failures in the EGI. These failures are indicated by both the STBY and READY legends illuminating, as well as the NAV COMP light on the RIO’s CAUTION/ADVISORY panel. Mode entry is indicated by an “IM” acronym on the PTID and HSD. The RIO should select IMU/AM on the NAV MODE SEL switch to extinguish the STBY and READY legends.

The IMU/AM mode can also be entered manually by selecting the IMU/AM position on the NAV MODE SEL switch at any time. If the EGI is aligned when IMU/AM mode is selected, no degradation of the alignment will occur. The EGI will continue to operate normally, and INS may be reselected at any time with complete functionality available.

During the IMU/AM mode, the FMC performs dead-reckoning navigation, using heading information from the IMU and true airspeed from the CADC. The accuracy is degraded because of the inferior heading and speed information. Wind is applied, using either the wind last computed in the Blended or GPS mode, or manually entered through the CAP. In a similar manner, the IMU heading is referenced to the last computed Blended or GPS heading, or to a manually entered true heading. IMU attitude information is displayed to the pilot.

Note

After entering the IMU/AM mode due to a failure, check wind and MAG VAR values. If MV is in error, enter own-aircraft true heading on the CAP. If winds are in error, reenter the windspeed and direction. If the mode was entered by selecting IMU/AM on the NAV MODE SEL switch with the NAVBUS and EGI operating normally, no MAGVAR or wind updates are required.

20.12.1.3 AHRS/AM Mode. The AHRS/AM mode of navigation is another backup mode. It uses the last known aircraft position, either the last EGI generated position or a RIO inserted value, and extrapolates the present position of the aircraft. It is automatically selected when the EGI fails, or by switching to AHRS/AM on the NAV MODE SEL switch. If an EGI failure occurs, it is indicated by the STBY and READY status PTID legends, and the IMU and NAV COMP advisory lights illuminating. Additionally, the navigation status readout on the PTID changes to AH. Although the navigation mode automatically switches to AHRS when the EGI fails, the STBY and READY legends remain on the PTID until AHRS/AM on the NAV MODE SEL switch is selected. Selecting AHRS/AM with the EGI operating normally will not affect the quality of the EGI solutions.

In this mode, the AHRS provides heading information required for DR navigation in place of the EGI IMU. The CSDC(R) provides barometric altitude, altitude rate, and true airspeed as in the IMU/AM mode. Updated wind speed and direction and magnetic variation may be entered using the CAP.

The AHRS itself may be operated in any of three sub-heading modes selected on the compass controller panel.

SLAVED — Magnetic north referenced (flux valve), directional gyro is slaved to the flux valve, used where reliable magnetic heading reference is available.

DG — Free azimuth gyro, compensated for drift, used where magnetic reference is unreliable (polar operations).

COMP — Magnetic north reference direct (flux valve), no gyro damping. The HUD, VDI, HSD, and multiple display indicator use manual magnetic variation (vM) automatically in this mode.

Note

If both the EGI IMU and the AHRS gyros fail, pitch and roll attitude indications are removed from the HUD, PTID, VDI, and DDD. Magnetic heading indications become erroneous, and the IMU, NAV COMP, and AHRS advisory lights illuminate. Selecting COMP on the compass control panel may restore valid magnetic heading information to the HUD, VDI, and HSD and turn off the AHRS advisory light. However, invalid pitch and roll attitude information will be restored to the HUD, VDI, PTID, and DDD.

General navigation computations for the AHRS/AM mode are performed in the FMC just like in the IMU/AM mode. In flight, the RIO may switch from either the INS or the IMU/AM NAV MODE SEL switch position to the AHRS/AM position for comparison without degradation. The navigation system will automatically operate in the AHRS/AM mode with the NAV MODE SEL switch in INS if the EGI fails, as long as the FMC receives AHRS heading and CADC airspeed.

Note

If takeoff is initiated in AHRS/AM mode, MAG VAR and WIND must be manually inserted for proper navigation computations.

For the situation where the EGI is aligned and the AHRS/AM or IMU/AM mode is selected on the NAV MODE SEL switch, the STBY legend is off but the READY legend is on, indicating that the EGI based modes may be selected if desired.

20.12.1.4 AHRS/EGI. The AHRS/EGI mode is a backup mode entered upon failure of the EGI/CSDC(R) analog data path. This mode provides all of the steering and area navigation capability provided in the Blended mode, but attitude information is provided by the AHRS. An AE symbol will appear in the navigation status readout on the PTID and the IMU advisory light on the RIO's caution and advisory panel will illuminate. This mode is not aircrew selectable.

20.12.1.5 AHRS/GPS. The AHRS/GPS mode is similar to the AHRS/EGI mode except that the GPS solution is used. The mode can be reached if the EGI/CSDC(R) analog data path fails while the GPS system mode is selected, or if the IMU portion of the EGI fails. The navigation status readout will change to "AE" as in the AHRS/EGI case. Check the EGI status page on the CDNU to determine which mode is in effect. The IMU advisory light will be displayed as in the AHRS/EGI case.

20.12.2 CDNU Area Navigation Functions. The CDNU provides a number of area navigation (RNAV) functions that allows the aircrew to navigate from point to point without reference to radio navigation aids. It utilizes the position and velocity solutions available from the EGI in accordance with the overall Navigation System Mode. If a total EGI failure occurs, then the CDNU will continue to calculate a dead reckoning solution based on aircraft heading and airspeed. This solution is independent of that calculated by the FMC.

20.12.2.1 Waypoints and Flight Plans. The CDNU maintains several databases internally and on the MDL cartridge to support flight planning operations. The RIO can create and maintain a flight plan manually point by point, or one of the twelve flight plans stored on the MDL may be loaded using LSK3 on the MDL page.

Two databases of five character alphanumeric identifiers (IDs) are available. These ID definitions cannot be edited.

20.12.2.1.1 Primary Database. The primary ID database is maintained on the MDL. When a cartridge is inserted into the MDL, indices of selected identifiers are automatically transferred into CDNU memory to speed the search process when an ID is requested. This can take up to 60 seconds to complete, and the primary database is not available until it is finished.

20.12.2.1.2 Reversionary Database. The reversionary database is stored in CDNU non-volatile memory for use when the MDL has failed or is not installed, or the requested data are not in the primary database on the MDL cartridge. This database contains 200 waypoint identifiers and can be transferred from the MDL into CDNU memory on operator request. Reversionary database operation is transparent and identical to the primary database, requiring no special procedures to access.

20.12.2.1.3 Flight Plans. A flight plan contains an ordered list of up to 50 waypoints, stored in the order they are to be flown. The flight plan is maintained through addition, modification or deletion of waypoints. When waypoints are added in the middle of the flight plan, succeeding waypoints are automatically moved down the list. Similarly, when waypoints are deleted, the flight plan automatically eliminates all holes by moving waypoints up the list as required.

The area navigation (RNAV) function performs geometry and guidance computations to assist in execution of the flight plan by determining deviations from the desired flight plan and controlling sequencing of waypoints. Automatic leg sequencing is available at all times. A switching point is determined as a function of groundspeed and magnitude of course change to provide turn anticipation. Turn alerts for display on both the CDNU and the PTID are generated 10 seconds prior to reaching the switching point for the next leg.

Flight plan labels are operator assigned during preflight planning at the TAMPS station. Each label can be a maximum of 8 alphanumeric characters. If a flight plan is entered manually, the Flight Plan page has the default title of FLT PLN, otherwise, the flight plan title entered at the TAMPS station appears on Display Line 2 of the CDNU.

Flight plan selection is accomplished from the FPLN Select Pages of the CDNU. These pages may be accessed from either the MDL Start page or the MDL page. To activate a specific flight plan, press the LSK adjacent to the selected flight plan. A check mark (✓) will be displayed adjacent to the LSK indicating the selection, and FP DATA LOADING will be annunciated on display line 7. When ACTIVATE FPLN reappears press LSK8 twice to activate the flight plan.

To modify a flight plan without activating it, press the LSK adjacent to a check mark (✓). This will access the Modify FPLN page. Waypoints may be added, deleted, or the Flight Mode associated with the point may be changed. The flight plan thus modified will remain in non-volatile memory for later use provided another flight plan is not selected on the FPLN Selection pages.

Note

Changing a flight plan on the CDNU does not affect the flight plans stored on the MDL. Nor can a CDNU flight plan be sent to the MDL for storage.

20.12.2.1.4 Active Flight Plan Waypoint. The active waypoint is the waypoint to which all flight instrument and CDNU guidance displays are referenced. Pressing the FPLN key on the CDNU will access the Flight Plan page with the active waypoint displayed. Associated with the active waypoint are the following quantities:

1. Current desired inbound horizontal course,
2. Current desired inbound vertical angle (optional, contingent on entry of altitude),
3. Active waypoint position, or User-defined label (optional).
4. Current Flight Mode,
5. Altitude assigned to the active waypoint (optional — for CDNU fixed waypoints only),
6. Planned time of arrival (PTA) at the active waypoint (optional — for CDNU fixed waypoints only).

If a planned time of arrival is specified, the ground speed required to achieve it will be generated and displayed on the Progress 1/3 page.

20.12.2.1.5 Future Waypoints. Up to 49 future waypoints may be inserted for execution after the active waypoint is passed. To access these future points the flight plan is scrolled vertically with the arrow keys. When scrolled away from the active waypoint, two display formats are available:

1. Expanded display, showing full display of waypoint attributes, but with only two waypoints displayed per page.
2. Condensed display, showing only horizontal positions, but with four waypoints displayed at the same time.

20.12.2.1.6 Waypoint Transfer. The CDNU allows the RIO to send part of its current active flight plan to the FMC for storage in navigation pseudo files and subsequent display on the PTID. The number of waypoints passed is limited by the available memory in the FMC. There are eleven numbered waypoints and six navigation points (FIX PT, IP, HB, DEF PT, HOST AREA, and SURF TGT) available in the FMC. When transferring waypoint data to the FMC, numbered waypoints are referred to as “Normal waypoints” on the CDNU. and the other navigation points are called “Special Waypoints”. The twelfth numbered waypoint (pseudo file twelve) is reserved for automatic transfer of the CDNU’s active waypoint.

The PTID Navigation Waypoint Data (NVD) page is shown in Figure 20-18. (See NATOPS Chapter 29, NAVAIR 01-F14AAP-1A, for a complete NVD discussion.) When a transfer is made, the waypoint numbers (for normal waypoints) or navigation point acronyms (for special waypoints) brighten, indicating successful transfer. Those waypoint pseudo files with null data are overlaid with an “X”. Hooking any spot on the page (waypoint number or spot hook) dims brightened waypoints. Hooking a waypoint provides a readout of all data contained in the pseudo file along with an indication of the source (CDNU, Data Link, or CAP entry).

1. Active Waypoint Transfer

The CDNU automatically transfers data for its current active waypoint to the FMC (via the CSDC(R)), for display on the PTID. Active waypoint latitude,

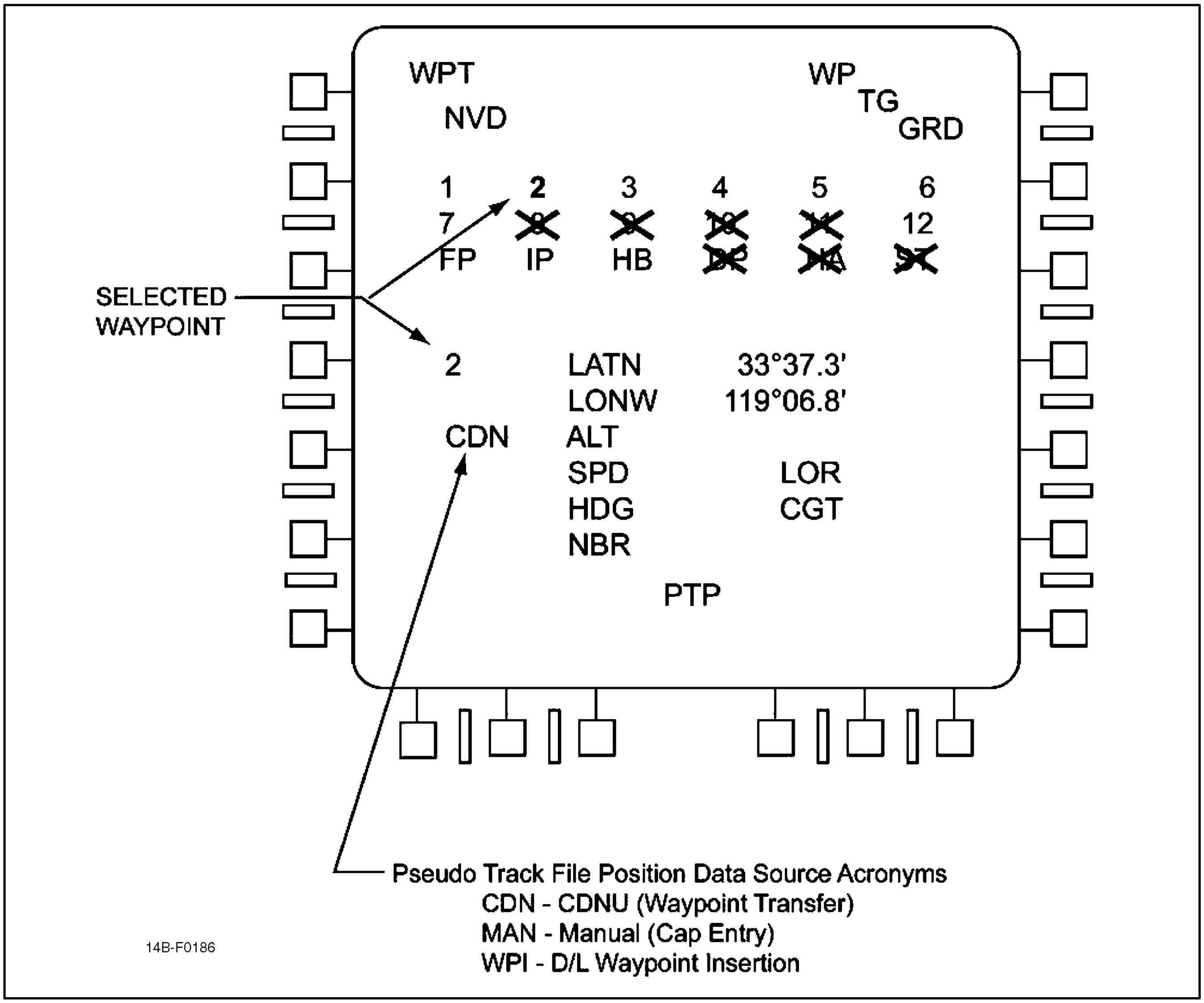


Figure 20-18. PTID Navigation Data (NVD) Waypoint Page with CDNU After CDNU Transfer

longitude, and altitude are transferred and stored in the Waypoint 12 pseudo file. This waypoint is given a special symbol on the PTID (see Figure 20-11). The transfer can be disabled by toggling Function Key 1 (F1) on the CDNU. The state of the toggle is shown on the Menu page. The power-on default for the selection is transfer enabled.

a. Special Waypoint Transfer. The CDNU has a “Special” flight plan transfer function that provides the ability to transfer the first six waypoints of the current active flight plan (the current active waypoint plus the next five) to the FMC for storage. The Active Waypoint is stored in the FIX PT pseudo file, the next flight plan waypoint is stored in IP, followed in order by HB, DEF PT, HOST AREA, and SURF TGT.

If there are less than six waypoints to be transferred, all of the waypoints in the flight plan are transmitted. If there is no active flight plan when the FPLN transfer option is selected, the CDNU annunciates “NO FPLN LOADED”. If less than six waypoints are transferred, the remaining waypoints are filled with null data.

To transfer the Special Waypoints, the RIO should ensure that the proper flight plan is active in the CDNU, then press the F3 key. Because all communication between the CDNU and the FMC takes place through the CSDC(R), if the latter fails, the CDNU will annunciate “✓ CSDC STATUS.”

FLIGHT MODE	SYMBOL	NAVIGATION INVALID RADIUS (98% PROBABILITY)	HORIZONTAL DEVIATION SCALING (FULL DEFLECTION — 2 DOTS)
Enroute	E	1000 meters	±4.00 nautical miles
Terminal	T	500 meters	±1.00 nautical miles
Approach	A	100 meters	±0.30 nautical miles

Figure 20-19. Flight Mode Scaling and EHE Limits

PDCP SELECTION	STEERING COMMAND				
MODE	TACAN	DEST	AWL/PCD	VEC	MAN
T.O.	Terminal	Enroute	Terminal	Enroute	Enroute
CRUISE	Enroute	Enroute	Enroute	Enroute	Enroute
A/A	Enroute	Enroute	Enroute	Enroute	Enroute
A/G	Enroute	Enroute	Enroute	Enroute	Enroute
LDG	Approach	Enroute	Approach	Enroute	Enroute

Figure 20-20. PDCP Flight Mode Selection Matrix

b. Normal Waypoint Transfer. The CDNU provides a "normal" flight plan transfer function. This enables the RIO to transfer the first eleven waypoints in the current CDNU (active) flight plan (starting with the active waypoint) to the FMC for storage in numbered waypoints 1 through 11 pseudo files. If there are less than eleven waypoints in the flightplan, any data in unused waypoint pseudo files are zeroized. If there is no active flight plan when the FPLN transfer option is selected, the CDNU annunciates NO FPLN LOADED.

To transfer the flight plan waypoints, the RIO should make the desired flight plan the active flight plan, then press F2 on the CDNU. By periodically depressing F2 as the aircraft flies through a CDNU flight plan, the points will be available for display on the PTID, providing the aircrew with a graphical display of their intended route.

Note

If the CSDC has failed, the CDNU will annunciate ✓ CSDC STATUS when attempting to transfer a flightplan.

The RIO can override the PDCP determined selection by pressing F5. Toggling F5 again returns control of Flight Mode selection to the PDCP. The override is also canceled anytime the pilot chooses a different combination of PDCP display mode and steering sub-mode. Power up default of Flight Mode selection is by PDCP. With the CDNU in control of the Flight Mode, pressing LSK6 on the Flt Pln page toggles the Flight Mode from Enroute ("E") to Terminal ("T") to Approach ("A").

When the PDCP is in control of the Flight Mode, the Flight Mode selections stored in the original flight plan or selected by the RIO on the CDNU are saved in non-volatile memory. When the RIO depresses F5, the stored Flight Modes, including the Flight Mode for the active waypoint, are restored.

Note

If the RIO takes control of Flight Mode selection, a sudden jump in the sensitivity of the deviation displays will result if the stored Flight Mode is different than that determined by the PDCP. The RIO should therefore coordinate any Flight Mode change with the pilot, prior to making the selection.

A Flight Mode may be assigned to each future waypoint in a flight plan. If no Flight Mode is assigned, the waypoint is given the "default" Flight Mode, and indicates that no Flight Mode switch will occur when that waypoint becomes active. The default state is always assigned to new waypoints as they are inserted, except, when the waypoint is the first in a new flight plan. Then the Flight Mode assigned is automatically enroute ("E").

20.12.2.1.7 Progress Toward Active Waypoint. The Progress pages provide situation awareness by displaying information such as current aircraft position, velocity, and deviations from desired flight plan. The Progress 1/3 page provides lateral guidance relative to the flight plan and the commanded ground speed to make good a planned time of arrival. The Progress 2/3 page deals with vertical guidance for the VNAV function. The Progress 3/3 page displays aircraft operating conditions that are independent of the flight plan. The Progress 3/3 page is accessed by scrolling up (once) or down (twice) from the Progress 1/3 page.

Note

Progress page navigation calculations are computed based on magnetic variation at the aircraft present position; computations on the Waypoint Data page are based on magnetic variation at the waypoint.

a. Ground Speed Command. Commanded ground speed is computed to make good the next planned time of arrival that has been assigned in the flight plan. This may be the active waypoint or a future waypoint. Commanded ground speed is displayed on the Progress 3/3 page, and is computed by dividing the flight plan distance to the waypoint by the time remaining until the planned time of arrival at the waypoint. Either the ground speed command, or the current error signal (indicated with either a “FAST” or “SLOW” label) may be displayed. If the next planned time of arrival is at a future waypoint and a holding pattern is planned prior to the waypoint for which the planned time of arrival applies, no time is inserted in the computation to account for the time in the holding pattern.

20.12.2.1.8 Duplicate Waypoint Identifiers. Duplicate waypoint names exist within the ICAO database. If the operator enters an ICAO identifier for which duplicate waypoints exist in either the primary or reversionary databases, the Ident Select Page will be presented to the operator. The operator then selects from the waypoints presented on this page. Up to 20 unique records with the entered ID are displayed for operator selection. If more than four matching identifiers are found, the Ident Select Page is vertically scrollable.

Note

If more than 20 duplicate waypoint names exist in the primary or reversionary databases, the first 20 records are displayed and “LIST TRUNCATED” is posted in the scratchpad.

Pressing the LSK adjacent to a particular waypoint twice (“CONFIRM SELECTION” appears after the first depression) selects the waypoint for the operation that raised the Ident Select page. Control is automatically returned to the requesting page and the requested operation is completed.

20.12.2.1.9 Reversionary Database Search. In addition to selecting waypoints by entering their ICAO identifiers, reversionary database waypoints can be accessed from the Waypoint Search page. Search of the database can be accomplished by waypoint type, (TACAN, VOR, VORTAC, Airports, or All), or by entering a partial or complete ICAO Identifier. LSK 8 on the Waypoint Search page allows operator entry of a partial waypoint identifier (1 to 5 alphanumeric characters) and then accesses the Waypoint List page displaying the waypoints whose identifiers begin with the entered string. When a search is performed and no matching waypoint is found, an error annunciation, “NOT IN DATABASE”, is displayed. (This function is not available for the primary database because of its large size.)

Selecting one of the search categories activates the Waypoint List page, containing a list of all waypoints in the category selected. If a TACAN channel is available for the selected waypoint, the channel is displayed on the Waypoint List page. When a search is attempted and the Reversionary Database has not been loaded, an error annunciation, “DATABASE NOT STORED”, is displayed. Using the up/down arrow, the Waypoint List page is scrollable forward and backward through all waypoints of the selected type, indicated by the operator key press from the Waypoint Search page. Pressing a right LSK accesses the Waypoint Data page for the adjacent waypoint.

20.12.2.1.10 Inserting Initial Waypoints. When the flight plan has been erased, the current integrated navigation solution of present position is inserted as the first history waypoint and the Flight Plan page indicates “*End of Flight Plan” in lieu of the active waypoint. To insert a waypoint into the flight plan:

1. Enter the desired waypoint (Position, ICAO ID, or ID/Bearing/Distance (IBD) — see paragraph 20.2.2.3.1 d.) into the scratchpad.

2. Press the left LSK at which “*End of Flight Plan” is displayed.

When airborne, “CONFIRM FLT PLN CHG” will be annunciated in the scratchpad; pressing the left LSK a second time will enter the point in the flight plan.

20.12.2.1.11 Inserting and Deleting Intermediate Waypoints. Intermediate waypoints may be inserted or deleted at any point in the flight plan that is desired. When waypoints are inserted, succeeding waypoints are automatically moved down the list. Similarly, when waypoints are deleted, the flight plan automatically eliminates all holes by moving waypoints up the list as required. Up to 49 future waypoints beyond the active waypoint may be added to the flight plan. The “FLIGHT PLAN FULL” message appears in the scratchpad if insertion of a 50th future waypoint is attempted. A waypoint is deleted from the flight plan by entering a “-” into the scratchpad then pressing the appropriate LSK for the waypoint to be deleted.

20.12.2.1.12 Editing Flight Plan Waypoints. Altitude, planned time of arrival, Flight Mode and user-defined label may be assigned to any future waypoint in the same manner as that described for the active waypoint. The only difference is future waypoints may have the default Flight Mode where this is not possible with the active waypoint.

20.12.2.1.13 History Waypoints. The five waypoints most recently passed are also maintained in the flight plan. These waypoints along with the associated altitude, Flight Mode and planned time of arrival may be reviewed by scrolling the Flight Plan page with the up arrow key. These waypoint definitions may not be edited or deleted but they may be used with Direct-To.

20.12.2.1.14 Bearing/Distance Vector Waypoint Calculator. A new waypoint which is a bearing/distance vector from an existing waypoint may be created in the scratchpad. This new waypoint may be inserted in the flight plan, if desired. The vector waypoint is calculated by entering the desired “bearing/distance” in the scratchpad and pressing the LSK adjacent to the base waypoint of interest. The CDNU displays the coordinates (either Latitude/Longitude or MGRS) of the vector waypoint at the specified bearing and distance from the specified point in the scratchpad. This location may then be entered wherever desired, but it does not affect the original waypoint in the flight plan.

The bearing and distance are entered as a bearing, optionally followed by a “T” or “M” (True/Magnetic reference), followed by a “/”, followed by distance, followed optionally by an “N” or “K” (nautical miles or kilometer reference). Bearings are entered as up to three digits, optionally followed by a decimal point and an additional digit. Distances are entered as up to four digits, optionally followed by a decimal point, and up to two additional digits. If the optional “T”/“M” or “N”/“K” are not entered, the bearing will default to Magnetic and English/Metric toggle state determines the distance format.

20.12.2.1.15 CDNU Waypoint Data Page. Several items of auxiliary data not visible on the Flight Plan page proper may be examined on the Waypoint Data page, which is accessed by pressing the LSK to the left of the waypoint with a blank scratchpad. Specifically, this page displays a high resolution position of the waypoint location as well as inbound course, distance and estimated time enroute to the selected waypoint. Enroute time is given both along the flight plan and directly to the waypoint. If the selected waypoint is identified by a database identifier, then frequency, elevation and station declination are displayed if available. Magnetic variation at the point is displayed in lieu of station declination for those stations that do not have an associated declination.

Note

Progress page navigation calculations are computed based on magnetic variation at the aircraft present position; computations on the Waypoint Data page are based on magnetic variation at the waypoint.

Figure 20-21 shows the Waypoint Data page. This page is also available for any horizontal position in the system by pressing F7 key which writes “DATA FOR?” into the scratchpad, then pressing the left hand line select adjacent the point of interest.

20.12.2.1.16 Enroute Courses. Three types of enroute courses can be executed via the CDNU: To-To, To-From, and Direct-To. The first two are determined based on the selection of automatic or manual waypoint sequencing. The third using the CDNU “DIR” key and the Direct To Flt Pln page.

LSK8 on the Flt Pln page is used to select between automatic sequencing (“AUTO”) and manual sequencing (“MAN”). Overfly sequencing (“OFLY”) is also available as a third option.

a. To-To Courses. To-To courses are used in conjunction with automatic or overfly leg sequencing to transition from one active waypoint to the next. The name indicates that guidance is always “To” the next waypoint, the course being automatically connected with the previous waypoint. In automatic sequencing, the switching point to transition to the next leg of the flight plan (i.e., the active waypoint switch) is computed prior to reaching each waypoint, providing turn anticipation. However, if the course change is greater than 120° or overfly is selected, the switching point is the waypoint itself, anticipating execution of a teardrop shaped turn after overflying the waypoint. In all cases, a lateral turn alert is generated ten seconds prior to reaching the switching point.

Overfly sequencing is identical to automatic sequencing except that no turn anticipation is calculated. The lateral turn alert is posted ten seconds prior to reaching the waypoint, and the switch to the next waypoint occurs when crossing the plane perpendicular to the course through the active waypoint.

b. To-From Courses. To-From courses permit guidance either “To” or “From” the active waypoint, without reference to the inbound course from the preceding waypoint. Manual sequencing may be selected at any time suspending advancement of the flight plan

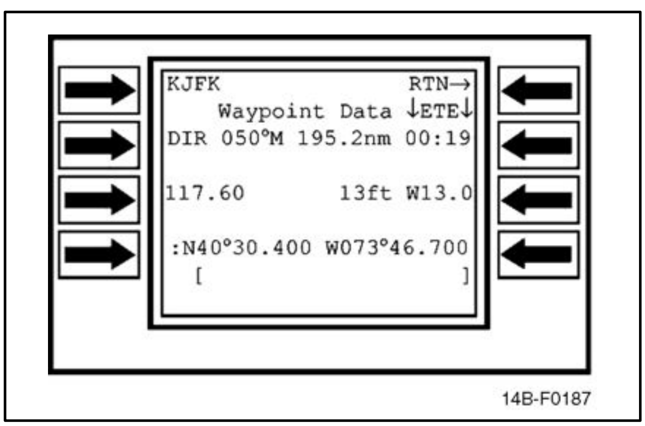


Figure 20-21. CDNU Waypoint Data Page

and causing guidance computations to continue to reference the active waypoint indefinitely. The lateral turn alert continues to be generated when manual sequencing has been selected, except that it now occurs ten seconds prior to reaching the waypoint proper in all cases. A “↓from↓” indication is generated on the Flt Pln page when passing through the plane perpendicular to the course at the waypoint. To advance the flight plan, the crew must either place the flight plan advancing mode back into automatic or perform a Direct To the next waypoint.

To-From courses permit explicit definition of the course through the active waypoint. The RIO may enter the desired course using LSK1 on the Flt Pln page. Recall that automatic leg switching usually occurs prior to passing the subject waypoint. Therefore, manual sequencing and course entry must be selected prior to the switch point to permit flying over or beyond the waypoint on the new course.

After application of the course edit, the deviation display and TO/FROM flag are then referenced to the RIO entered course rather than to the most recent history waypoint. If the aircraft is on course, editing a course by more than 90° would cause the active waypoint to be passed into history immediately. For that reason, course changes greater than 90° are not allowed with automatic leg sequencing selected and will result in “ERROR CRS CHG > 90” being displayed in the scratchpad.

c. Direct-To Courses. Direct-To courses are used to either bypass existing waypoints in the flight plan, or to insert an impromptu waypoint, interrupting the current leg. In each case, a system generated turn point is placed in the flight plan along the present track to provide turn anticipation and prevent S-turns during capture of the course to the waypoint.

Direct-To courses are activated by pressing the “DIR” key. “Direct To [ ]” is displayed on the top line or the Flt Pln page. Normal flight plan edits are not available in this mode of operation and only the horizontal position of the waypoints are displayed.

A Direct-To course may be initiated to any existing flight plan waypoint, including history waypoints by pressing the LSK to the left of the desired waypoint on the “Direct-To [ ]” Flt Pln page. If the waypoint selected for the Direct-To operation is a future waypoint, all intermediate waypoints are deleted from the flight plan.

Impromptu waypoints may be inserted into the flight plan by entering the desired position into the scratchpad, then pressing LSK1 (adjacent to "Direct-To [ ]"). The impromptu point may also be defined as a vector from the present position of the aircraft by inserting a bearing and range in the scratchpad instead of a position. Vector waypoints are handled in exactly the same manner as a normal waypoint. In both cases, the impromptu waypoint is inserted prior to the current active waypoint, which becomes the first future waypoint.

It is possible to insert an impromptu waypoint and bypass a number of future flight plan waypoints. First depress the "DIR TO" key on the CDNU, then enter the impromptu waypoint into the scratchpad. Finally, press the LSK adjacent to the waypoint where the original flight plan is to be resumed. This makes the impromptu waypoint the active waypoint and the selected waypoint the second waypoint in the flightplan.

After selecting a waypoint for the Direct-To operation, the normal Flight Plan page display is returned, with the course, vertical angle, offset and advance displays restored as appropriate. Ability to edit the flight plan is restored. The computer-generated turn point is inserted as a standard latitude/longitude or MGRS waypoint in history as the most recently passed point. The use of the Direct-To function has no affect on waypoint sequencing (AUTO/OFLY/MAN).

20.12.2.1.17 Mark List. Nine mark positions may be saved in nonvolatile memory and given a user-defined label in the same manner as on the Flight Plan page. The Mark List page records the position of the mark and the associated time of the mark.

To save a point in the Mark List, press the "MARK" key when the aircraft is directly over the point to be marked. This action puts the position (latitude/longitude or MGRS coordinates) in the scratchpad. Access the MARK page from the Index page and depress the LSK to the left of the position where the mark will be saved. The time of the mark will also be saved. Once a marked position is entered into the Mark List, pressing the LSK to the right of a position copies it to the scratchpad.

A waypoint may be retrieved from the flight plan and copied into the Mark List. First, use the vertical arrow keys (↑/↓) to scroll the Flt Pln page to the waypoint (active, history, or future) to be stored in the Mark List. Press the F7 key twice, entering COPY WHAT? into the scratchpad, then press the LSK to the left of the waypoint to be copied. This will enter the position (or user-defined label) in the scratchpad, as well as all available waypoint attributes (identifier, elevation, frequency, and declination). Go to the Mark List page and insert the waypoint normally.

20.12.2.2 Intercept Calculations. Up to nine moving targets may be simultaneously defined. Intercept solutions to these targets may be used in two ways:

1. The intercept solution may be inserted as the active waypoint for immediate (i.e., Direct To) execution.

2. The intercept solution may be inserted as a future waypoint to implement a future rendezvous with a moving target.

The Intercept 1/9a page is accessed from the Index page using LSK8. Subsequent pages (Intercept 2/9a and beyond) are reached by scrolling up or down until the desired page is visible. Current position, Ground Track, and Ground Speed is displayed or can be entered on the Intercept x/9a page (where "x" is the specific intercept number). Range and bearing to the intercept is also shown. Intercept x/9b page is accessed by using the left/right arrow keys to scroll from the Intercept x/9a page. The Intercept x/9b page displays the current Time to Intercept, point of closest approach if no intercept in possible, and the current true airspeed. A calculator function is provided to allow the RIO to enter an alternate true airspeed and see the effect on the time to intercept and point of closest approach miss distance. This calculator is available for all intercepts not inserted into the flight plan (based on Direct-To solution) and for the next intercept in the flight plan.

The CDNU calculates the true minimum time intercept to the moving waypoint. If intercept is not possible, a point of closest approach is computed. The calculations are based on a flat earth approximation about the equator. Therefore, the solution will slowly begin to degrade as the distance to the intercept point increases, and the intercept solution gets close to the poles.

Solutions are cyclically computed for all intercepts, whether inserted in the flight plan or not. If they are not inserted, the computations are performed as if they were Direct-To intercepts. Changes on the Intercept "a" page immediately affect the intercept solution in the flight plan.

20.12.2.2.1 Inserting Intercepts. An intercept can be inserted directly into the flight plan as the active waypoint by accessing the desired Intercept x/9a page and pressing LSK8 twice (confirmation is required). This calls up the Flt Pln page, and depressing the LSK next to the waypoint before which the intercept is desired enters it into the flight plan.

When an intercept is the active waypoint, the intercept location is cyclically updated based on current aircraft position and speed, the moving target definition, and current wind. The intercept point location is adjusted, as required, and the inbound course is edited to match the current Direct-To course into the waypoint.

When the intercept is inserted as a future waypoint, then the intercept location is updated based on the location of the flight plan waypoint immediately prior to the intercept, the distance along the flight plan to that waypoint, current aircraft speed, the moving target definition, and current wind. The estimated time of arrival at the waypoint immediately prior to the intercept is computed. Then the intercept point is computed from that point and time.

20.12.2.2.2 Intercept Passage. When an intercept is passed into history, the latitude/longitude of the intercept at the time of waypoint passage is recorded as the flight plan history waypoint. All parameters defining the moving target remain on the intercept page, but the intercept is removed from the flight plan.

20.12.2.3 Parallel Course Offsets. A parallel course offset may be applied to the flight plan. When an offset is applied, all displays keyed to the active waypoint (e.g., time and distance to go, cross-track error, etc.) are now referenced to the pseudo-waypoints at the intersection of the course change bisector and the offset course. Likewise, the leg switch point and the associated ten second alert are computed relative to the pseudo-waypoint. Cross track deviation is computed relative to the offset course.

To activate a parallel offset course, the RIO should enter an “R” or “L” signifying right or left of course and the amount of the offset into the scratchpad of the CDNU and depress LSK8 on the Flt Pln page. For example, to select an offset of 3.2 nautical miles left of the established course, enter “L3.2” into the scratchpad. The word “OFFSET” in brackets to the left of the “AUTO:/OFLY:/MAN:” rotary will change to the selected offset, in this case “L3.2”. To cancel the offset, enter a minus sign (“-”) into the scratchpad and depress LSK8 on the Flt Pln page.

Parallel course offsets may be applied, changed or deleted at any time the active waypoint is not identified as a holding pattern. If the waypoint identified as the holding waypoint becomes the active waypoint while an offset is defined, then the offset will be automatically canceled. Initiation of Direct-To function will also automatically cancel the parallel offset.

The parallel offset flight plan may contain ill conditioned geometry at waypoints with large course changes. To resolve this condition, the offset pseudo-waypoint is never displaced along the inbound leg track by more than two times the width of the offset. If the required course change is greater than 127°, the pseudo-waypoint would have to be moved along the inbound track by more than two times the offset value to achieve an intercept of the offset flight plan legs. In this case, the leg switch is made at the point displaced along track by two times the offset. This creates a discontinuity in the flight plan. When the new pseudo waypoint becomes active, the aircrew will immediately note a crosstrack error of up to twice the offset distance (for the case of a 180° course change). The aircraft then reacquires the new offset course as though it is an original course capture. See Figure 20-22.

20.12.2.4 Holding. A holding pattern may be associated with one fixed waypoint in the flight plan, called the holding fix. When the aircraft crosses the holding fix, holding guidance is activated, suspending normal leg sequencing until the holding pattern is canceled. Three parameters define the holding pattern: Inbound Course, Turn Direction, and Pattern Length. The CDNU Hold page (see Figure 20-23) is accessed from the Index page. If no holding course is entered, then the flight plan inbound course will be used when holding guidance is activated.

Holding definition may be in one of three states at any given time:

1. Pattern parameters defined but holding fix not designated,

2. Pattern parameters defined, the holding fix identified but holding guidance has not yet activated as the aircraft has not yet reached the holding fix

3. Holding guidance is active.

The state can be determined by examining display line 7 of the Hold page. If the holding fix has not yet been identified “APPLY” is displayed, indicating that

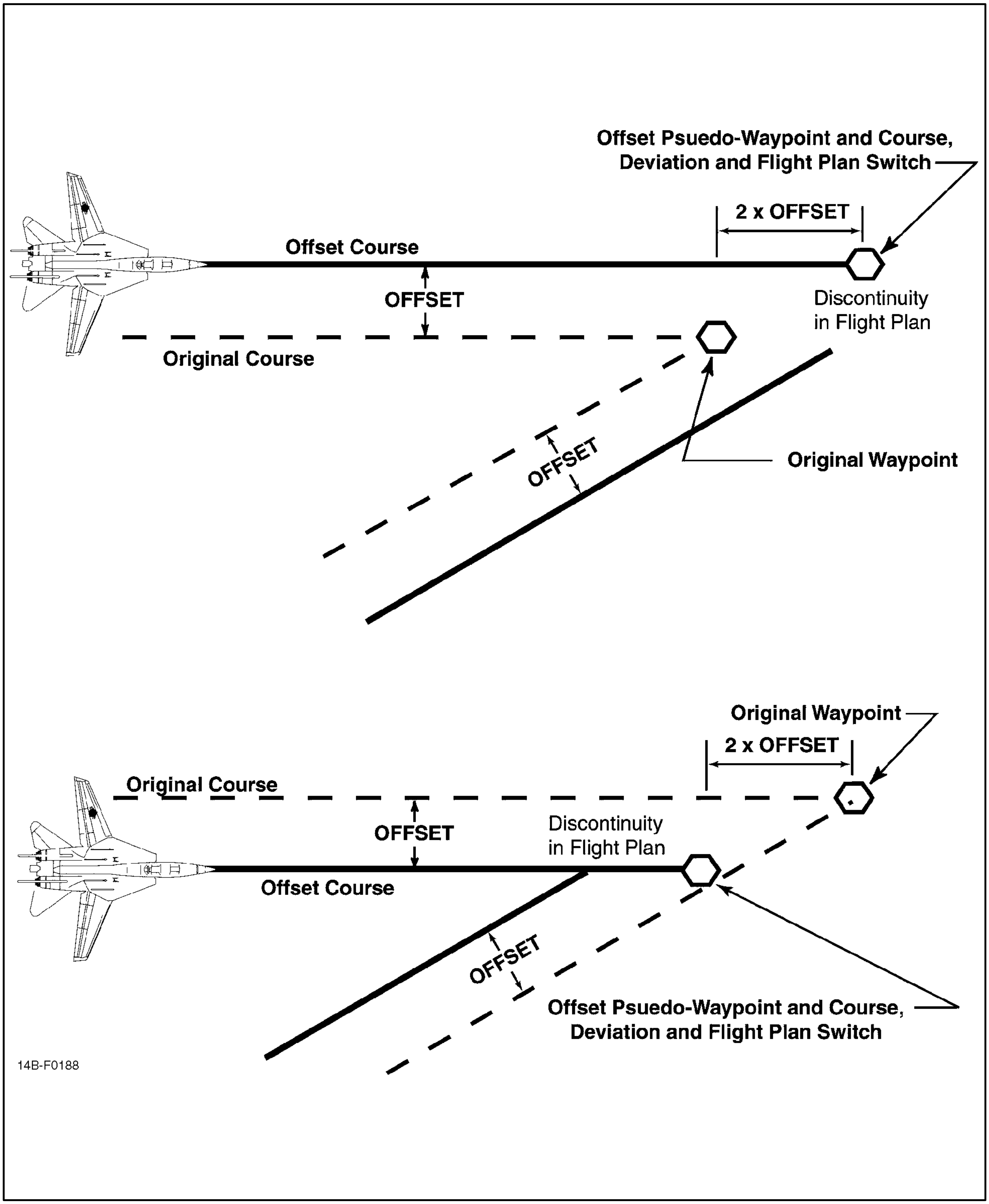


Figure 20-22. Parallel Offset Transition with Large Course Change

the holding definition may now be applied to the desired waypoint. If the holding fix has been identified but holding guidance is not yet active “REMOVE” is displayed, indicating that the holding pattern parameters may be removed from the currently defined holding fix without destroying the parameters. If holding guidance has become active “CANCEL” is displayed, indicating that the current pattern may be canceled, resetting the holding pattern parameters to default values when the current pattern is complete. Default values are CDNU calculated course, 5.0 nm legs, and right-hand turns.

After the desired holding pattern definition parameters have been entered, the active waypoint or future fixed waypoints may be designated as the holding fix. After pressing the “APPLY” key on the Hold page, the Flight Plan page is accessed with the message “HOLD AT?” in the scratchpad. The flight plan can be scrolled to the desired location to identify the selected waypoint as the holding fix by pressing the adjacent LSK. A special hold icon is displayed to the right of the designated waypoint as a reminder that it has been designated as the holding fix.

When the holding fix is passed for the first time, holding guidance computations are activated. At that time several changes occur, both in flight plan operation and page displays:

1. Automatic leg sequencing is suspended.

2. Course edits on the Flight Plan page may no longer be made. Inbound holding course edit may be made on the Hold page.

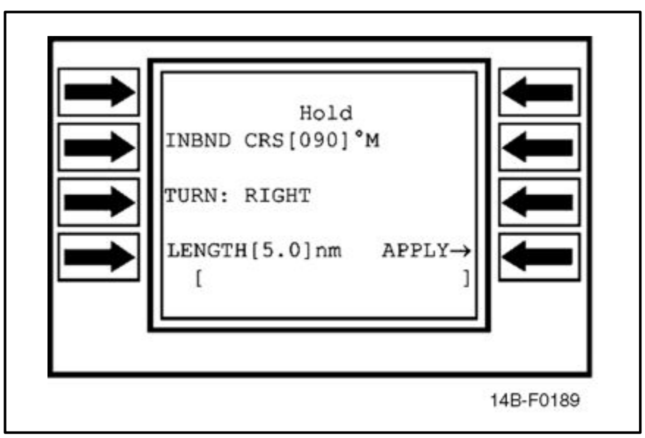


Figure 20-23. CDNU Hold Page

3. All displays reference the inbound course displayed on the Hold page.

The course display and “to” indicator on the Flight Plan page are replaced with “Holding” and “at”. The entry advisory display on display line 1 of the Hold page is changed to read “HOLD IS ACTIVE”. Vertical angle display is automatically changed to “MAINTAIN” and selection of other vertical angles is prohibited.

If any holding pattern definition parameters are changed while in the pattern, the changes are applied after the aircraft passes the holding fix (transition from “TO” to “FROM”).

When holding guidance has been activated, all course and lateral deviation displays now reference the inbound holding course, irrespective of whether the aircraft is on the inbound or outbound leg of the holding pattern. However, the ten second turn alert will be computed on the outbound leg as though there is a phantom waypoint on the outbound leg where the turn inbound should be initiated.

Holding patterns may be terminated in two ways:

1. Press LSK8 on the Hold page to cancel. In this case a leg switch to the next flight plan waypoint will occur when the fix is crossed again (if automatic flight plan advancing is selected).

2. The Direct-To function is activated to a future waypoint.

20.12.2.5 Vertical Navigation. Vertical navigation (VNAV) computations are intended for both enroute climbs or descents, and non-precision approach letdowns to a minimum safe descent altitude, always based on pressure altitude (received from the CADC via the CSDC(R)). Each fixed waypoint or its horizontal offset position may be given an assigned altitude to terminate either a climb, descent or constant altitude segment. Vertical navigation computations are only valid when the active waypoint has an assigned altitude.

Vertical progress toward the current waypoint is reported on the Progress 2/3 page. Current altitude, altitude rate, angle to the waypoint and vertical deviation relative to the desired vertical path (based on the desired vertical angle) are displayed. Additionally, a synchronize function is provided to automatically set the desired vertical path to the current vertical geometry. All values on the Progress 2/3 page are reported in feet and feet/minute, regardless of the English/Metric toggle.

A VNAV alert is generated for 10 seconds when the aircraft comes within 300 feet of the computed climb or decent path. This allows the pilot to anticipate the start of a climb or decent. The alert is also generated for 10 seconds when the aircraft comes within 300 feet of the desired crossing altitude.

Each fixed flight plan waypoint may be assigned a crossing altitude. A desired vertical angle to climb or descend into the crossing altitude must be defined before vertical navigation computations can be performed.

When a waypoint with an altitude defined becomes the active waypoint, an initial value for desired vertical angle is computed by the CDNU. If the previous waypoint had an altitude assigned, the CDNU determines the vertical path that passes through both waypoints at their assigned altitudes. If the previous waypoint does not have an associated altitude, the actual aircraft altitude when the waypoint becomes active is used. In both cases the magnitude of the desired vertical angle is limited to 6°.

20.12.3 Steering. Two basic types of steering are provided: navigation and attack. Navigation steering is computed on a great circle course to a fixed point on the Earth's surface or as a deviation from a selected course or heading that is equivalent to a rhumb line.

Note

- For attack steering, refer to NAVAIR 01-F14AAA-1A.
- The chaff counter can be displayed for the expanded chaff adapter when the ATTK MODE switch is in either MAN or CMPTR PLT. However, CMPTR PLT must be selected if TARPS HUD or VDI steering displays are required.

20.12.3.1 Navigation Steering. Navigation steering is computed on either a great circle course or rhumb line to a fixed point on the earth's surface, or as a deviation from a selected course or heading. Steering commands are normally calculated by the CDNU and sent to the CSDC(R) for display on the cockpit instruments. Steering will be calculated by the FMC in either IMU/AM or AHRS/AM backup modes, or when the pilot or RIO selects "TACAN" on the TACAN CMD panel. The point to which steering is referenced may be that used by the CDNU, the RIO's selected destination (eleven waypoints, fixed point, initial point, surface target, or home base), a TACAN station, ADF information, ACLS information, or data-link selected points.

The steering displays of the CDNU and FMC can be coordinated using the waypoint transfer function. This allows display of waypoints on the PTID in a manner that increases situational awareness. Figure 20-24 provides an example of how the displays work together to provide navigation data to the aircrew.

Note

With "EGI" selected on the TACAN CMD panel, steering will always be referenced to the CDNU Active Waypoint, regardless of what the pilot selects on the PDCP.

20.12.3.2 Display Modes and Steering Submodes. The pilot has the option of selecting any one of five VDIG display formats, depending on the flight phase, to provide him with the data necessary to accomplish the particular flight phase. These five display modes are arranged as five vertical, mutually exclusive pushbuttons on the pilot's display control panel. The five phases are takeoff (T.O.), CRUISE, air-to-air (A/A), air-to-ground (A/G), and landing (LDG).

Note

ACM selection overrides the CRUISE A/A and A/G modes; however, it does not override the T.O. or LDG modes.

In addition to controlling the VDIG formats, the display mode selections also control DFCS, armament and FMC logic.

In addition to the essential data such as altitude, vertical speed indicator, etc., the VDIG format also provides steering cues. In each of the PDCP display modes, the pilot has the capability of displaying several types of steering commands. Altogether there are five distinct steering command submodes: TACAN, destination (DEST), AWL/PCD, vector (VEC), and manual (MAN). The five selections are arranged horizontally along the bottom of the display control panel.

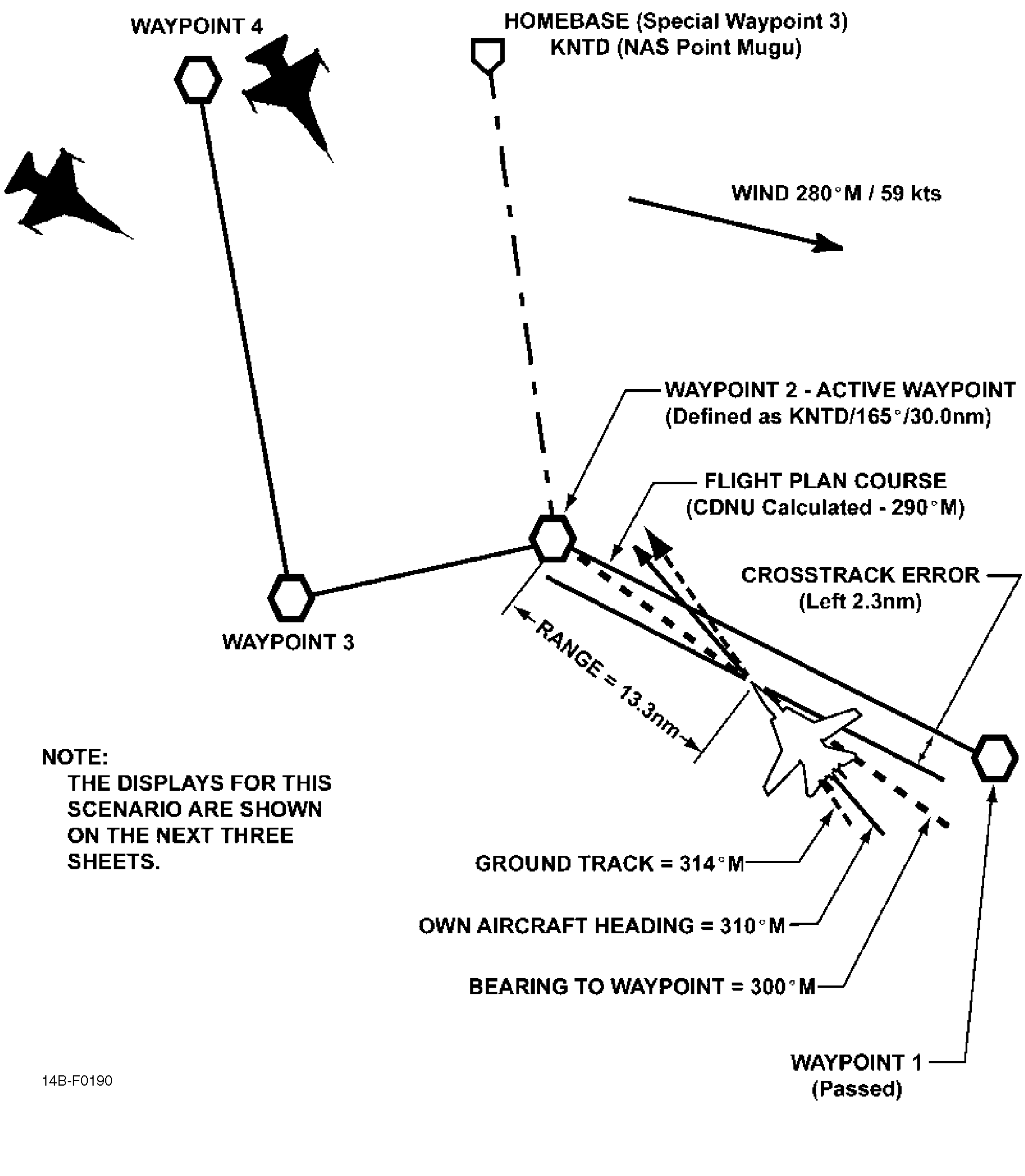


Figure 20-24. Coordinated Steering Displays (Sheet 1 of 4)

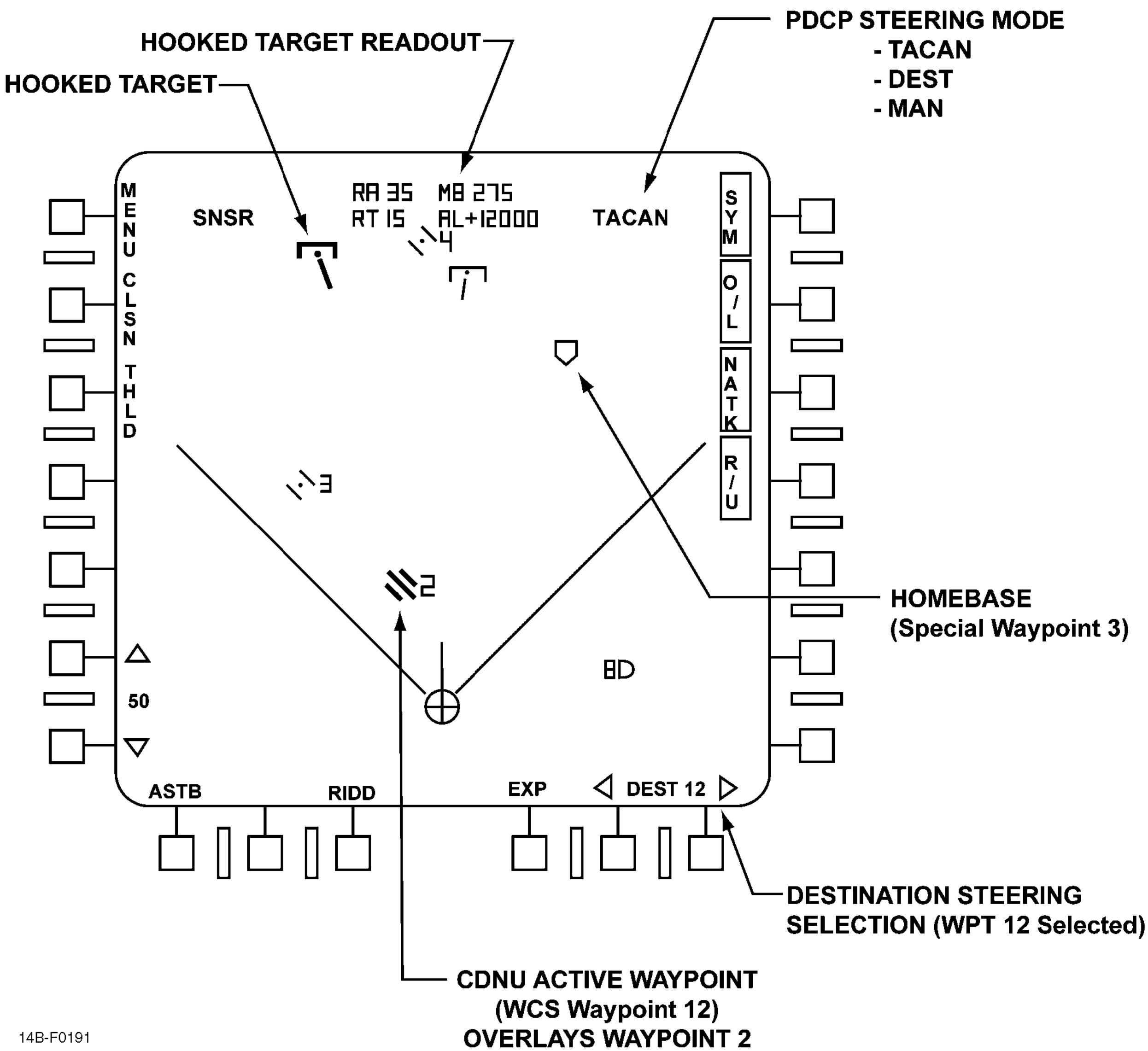


Figure 20-24. Coordinated Steering Displays (Sheet 2)

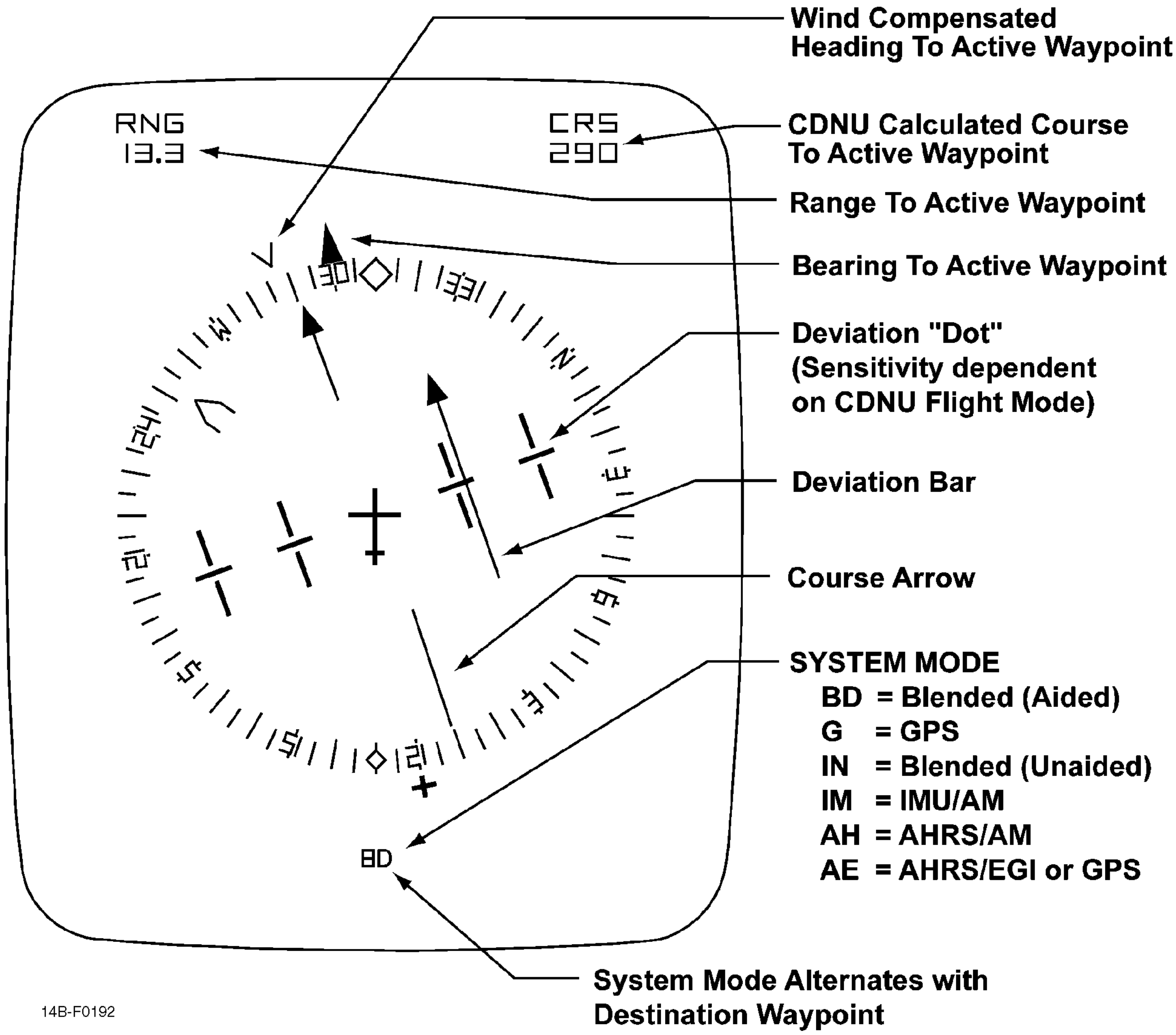


Figure 20-24. Coordinated Steering Displays (Sheet 3)

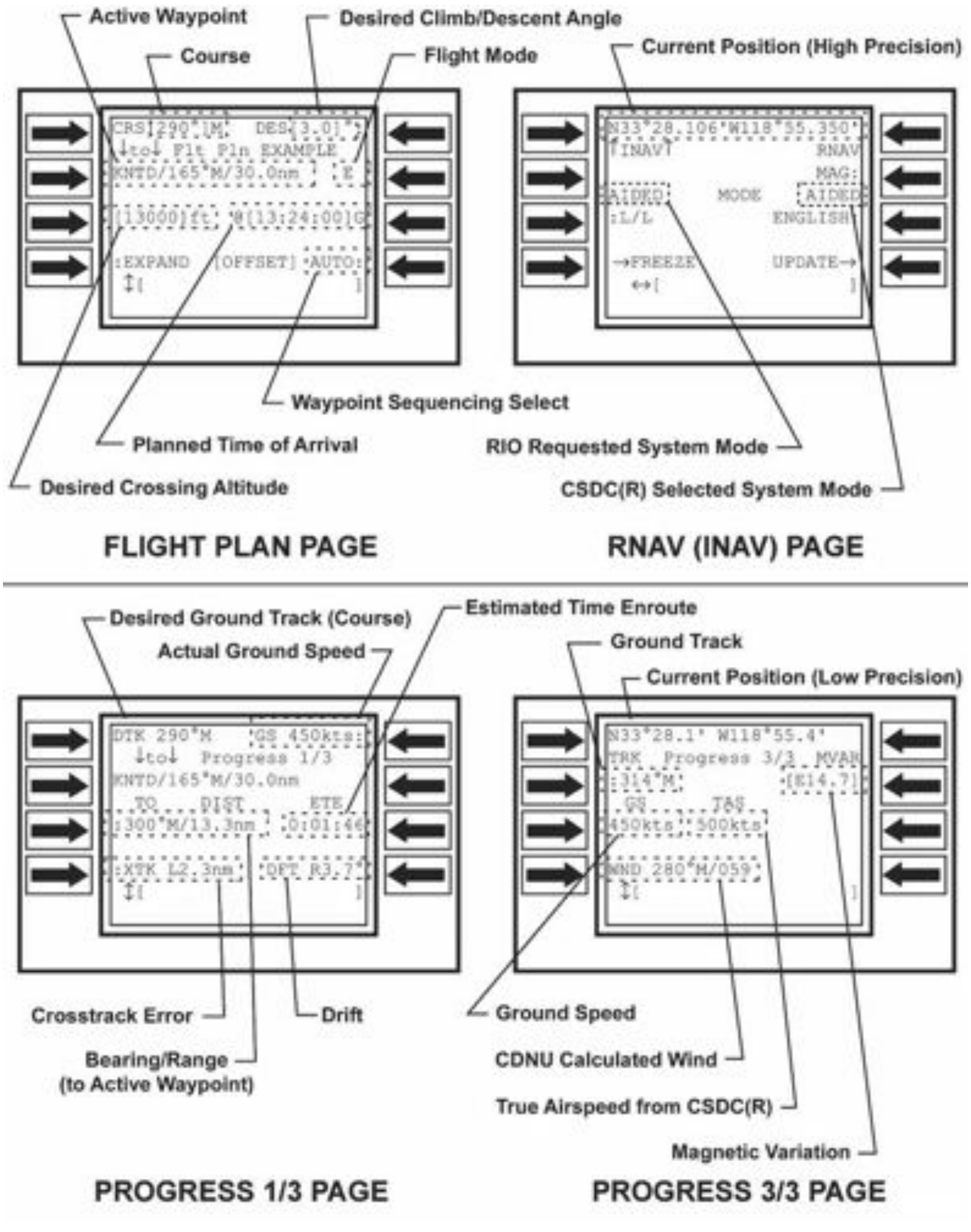


Figure 20-24. Coordinated Steering Displays (Sheet 4)

The five steering submodes determine the display format on the pilot's HSD and the RIO's multiple display indicator. The HSD and multiple display indicator present, in a horizontal plane, steering to the selected point. The HSD follows the five submodes when the pilot places the HSD-MODE switch to NAV. The RIO also performs the same function by setting the MODE switch on this multiple display indicator control panel to NAV. Also, when LDG is selected, the pilot has the option of displaying ILS or ACL information via switches that can be used to individually and independently select the HUD and VDI for display. A typical choice would be to select ILS (SPN-41/ARA-63) for the HUD and for D/L to VDI. Refer to Chapter 17 for all-weather carrier landing system procedures.

Note

All steering commands (such as command course and command heading) are processed to some extent through the FMC prior to display.

The STEERING indicator legend on the PTID provides a readout for the RIO to inform him of what submode the pilot has chosen.

20.12.3.3 Takeoff Steering. The takeoff flight mode is entered by depressing the T.O. pushbutton on the display control panel. The VDIG format displays a vertical speed indicator on the left side and an altitude scale on the right side (Figure 20-25). Prior to takeoff, the pilot should check the magnetic heading on top of the HUD and VDI against a known reference (that is, runway heading). The vertical speed indicator should be used to verify a positive climb after takeoff.

After takeoff, the navigation system normally computes wind and magnetic variation, which are needed for steering. For backup modes, the FMC uses the last computed or RIO-entered wind speed, direction, and magnetic variation.

20.12.3.3.1 Takeoff TACAN Steering. The TACAN steering submode functions in the same way, whether used for takeoff, cruise, or landing, by providing the pilot with either course deviation (if EGI is selected on the TACAN CMD panel) or TACAN deviation (if TACAN is selected). Course deviation is a measure of the cross track error calculated by the CDNU, while TACAN deviation is the angular difference between the bearing to the TACAN station (TACAN radial) and the command course (TACAN course) selected by the pilot with the CRS control on the HSD. The TACAN displays are available on the HUD, VDI, HSD, and multiple display indicator. The HSD and the ECMD also display range and bearing to the selected waypoint or TACAN station.

To enter the submode, the pilot depresses the TACAN pushbutton on his display control panel. If a valid course is available, the HUD and VDI display the deviation symbol. In addition to deviation, symbols on the HSD, multiple display indicator, HUD, and VDI indicate whether the course is toward or away from the waypoint or TACAN station. If TACAN is selected on the TACAN command panel, and the TACAN deviation is less than 90°, the TO symbol is shown; if greater than 90°, the FROM symbol is shown. If EGI is selected on the TACAN command panel, display of TO/FROM symbols depends on the TO/FROM selection on the CDNU. On the HSD and multiple display indicator, an arrow on the deviation bar pointing in the same direction as the course indicates a course toward the station; an arrow pointing in the opposite direction, indicates a course away from the station. On the HUD, a dashed line indicates FROM; a solid line TO. On the VDI, a dark bar indicates FROM; a bright bar, TO.

If TACAN is selected on the TACAN command panel, the deviation symbol moves 3° (linear) in the field of view on the HUD for a 6° deviation from the selected TACAN radial. These limits prevent the symbol from leaving the field of view or interfering with the scales on the left and right side. On the VDI, the deviation symbol is scaled to move 1.5 inches (linear) for a 6° deviation. If EGI is selected on the TACAN command panel, the deviation symbols deflect according to the CDNU Flight Mode in effect at the time. The HUD deviation symbol will move 3° and the VDI symbol will move 1.5 inches (linear) for each 4.0 nm crosstrack error in ENROUTE mode, 1.0 nm in TERMINAL mode, and 0.3 nm in APPROACH mode.

20.12.3.3.2 Takeoff Manual Steering. The manual steering submode is similar to the basic takeoff mode. The mode is entered by depressing the MAN pushbutton. The navigation system will then compute a command heading and display it on the VDI as a small triangle under the magnetic heading scale.

20.12.3.4 Cruise Steering. The cruise flight mode is entered by depressing the CRUISE pushbutton. There are four submodes available during cruise operations; destination, TACAN and vector. While it is physically possible to depress the AWL/PCD steering

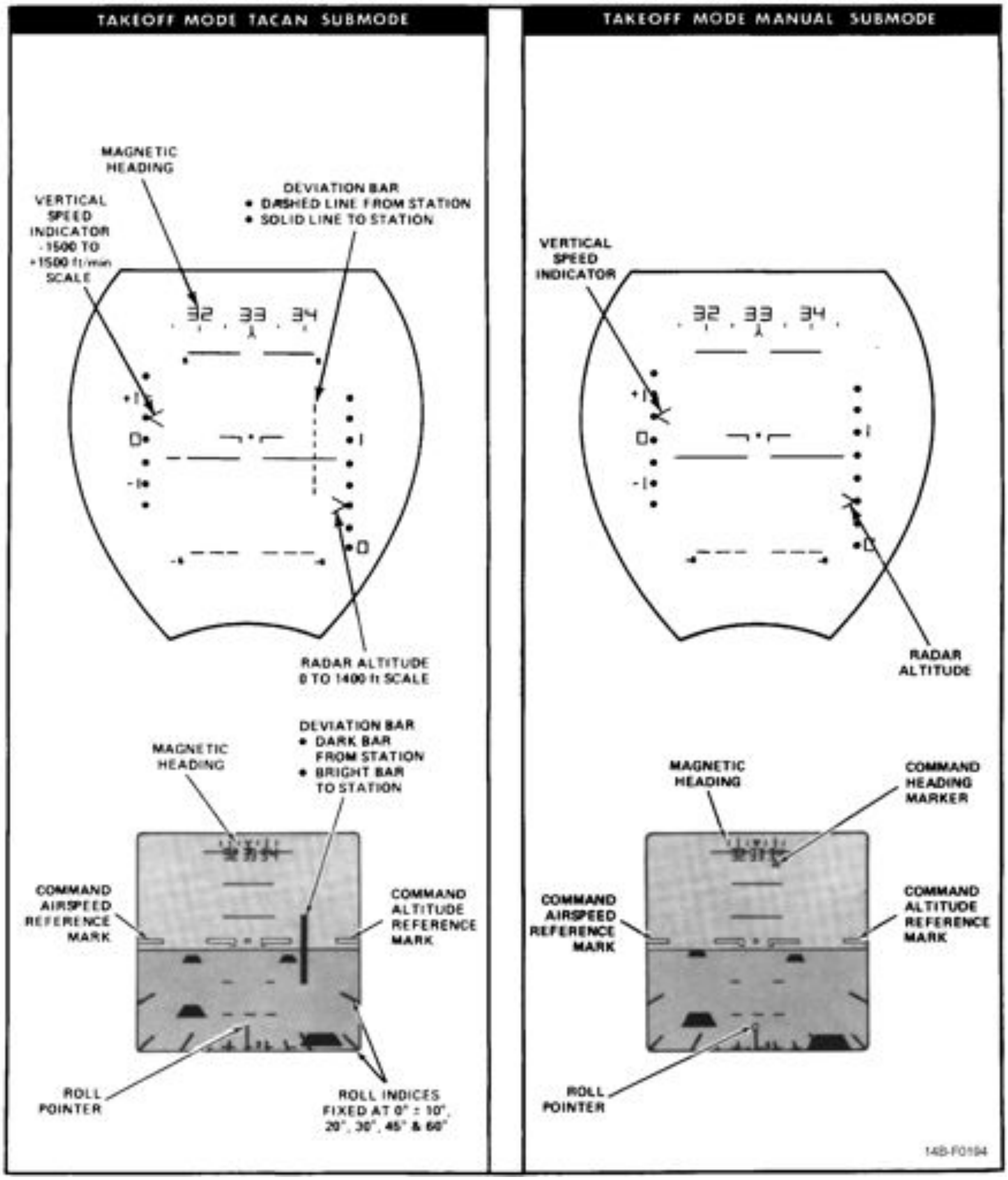


Figure 20-25. Takeoff Steering Displays

pushbutton on the display control panel, doing so has no operational value.

Note

Should the AWL/PCD submode be selected while in CRUISE, it will inhibit the display of other steering cues.

20.12.3.4.1 Cruise TACAN Steering. This submode is similar to that for takeoff. The flightcrew displays are shown in Figure 20-26 and are similar to the takeoff mode. Range to the selected waypoint or TACAN station is given on the pilot's HSD and BDHI, and on the RIO's multiple display indicator and BDHI. Selected course is also numerically displayed on the HSD and multiple display indicator. The VDIG format displays the deviation as described under Takeoff TACAN Steering. This deviation is also displayed on the HSD and multiple display indicator over a scale for easy reference. TO and FROM indications are provided on all indicators.

20.12.3.4.2 Cruise Destination Steering. This submode provides steering to the pilot as a command heading symbol on the VDI and command heading pointer on the HSD to a point selected by the RIO (Figure 20-27). To enter this submode, the pilot must depress the DEST pushbutton on the display control panel, and the RIO select the desired destination on the PTID. The destination can be any one of 20 waypoints stored in the FMC.

Note

In the destination steering submode, the destination selected by the RIO and the NAV MODE in use will be alternately displayed on the bottom center of the HSD.

20.12.3.4.3 Cruise Vector Steering. This submode utilizes the data link (D/L) system to provide command heading, altitude, and airspeed (Figure 20-28). In this submode, both the pilot's HDG and CRS controls are inhibited. The D/L provides the command steering to the destination along with command altitude in thousands of feet and command airspeed (Mach) error. If the D/L command airspeed is in knots, it is displayed on the airspeed/Mach indicator on the pilot's center console, and there is no HSD indication. Errors in either altitude or airspeed are indicated in each case by a pair of vertical lines. Zero error is indicated when the error symbol is centered on the reference line. As the symbol moves up or down, it indicates an altitude or airspeed high or low error. The commanded course or ground track as determined by D/L and the computed command heading necessary for a reliable ground track is displayed on the HSD. Wind direction, true airspeed, and groundspeed are displayed on the HSD and computed by the navigation system.

Note

In VEC mode, no ADF, TACAN, or EGI information is provide on the PMDIG.

20.12.3.4.4 Cruise Manual Steering. This submode functions in the same way as it does in takeoff. The command course is displayed on the HSD and the multiple display indicator. The command heading required to make the selected command course good is displayed as command heading markers on the HSD, multiple display indicator, and VDI (Figure 20-29). In this mode, TACAN or CDNU generated bearing to waypoint, and ADF bearings are also provided, but not range.

20.12.3.5 Landing Steering Modes. The landing steering mode is entered by the pilot depressing the LDG pushbutton on the display control panel. This mode can be engaged at any point from the Marshal point on. If a waveoff or bolter occurs, the pilot has only to depress the T.O. pushbutton and the takeoff steering mode is engaged.

The basic landing mode symbology is essentially the same as the basic takeoff mode. Exceptions are the addition of the angle-of-attack error symbol on the HUD, and velocity vector symbol and 5° pitch increments on the VDI.

Note

In all landing submodes, a VDIG breakaway symbol can be displayed upon receipt of a D/L waveoff message.

There are three steering command submodes that are applicable during landing. These are TACAN, VEC, and AWL/PCD. For the TACAN or VEC submodes of LDG, the HUD, VDI, and HSD displays are similar to the same submodes, respectively, as when in CRUISE, except that in LDG the HUD display includes the velocity vector symbol as well as the radar altitude symbol and the vertical speed indicator symbol. The HUD, VDI, and HSD displays for the TACAN landing submode are shown in Figure 20-30.

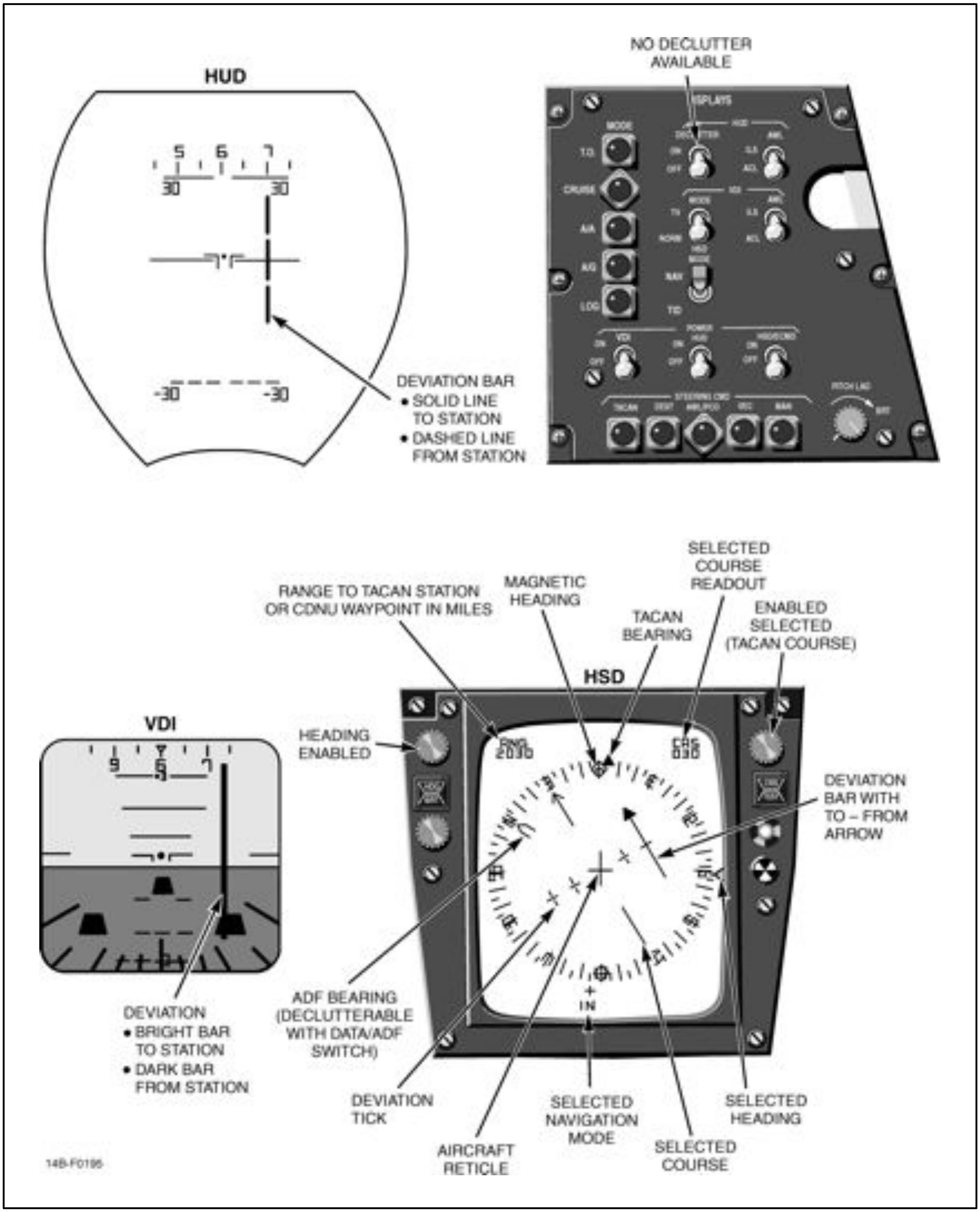


Figure 20-26. Cruise TACAN Steering Displays

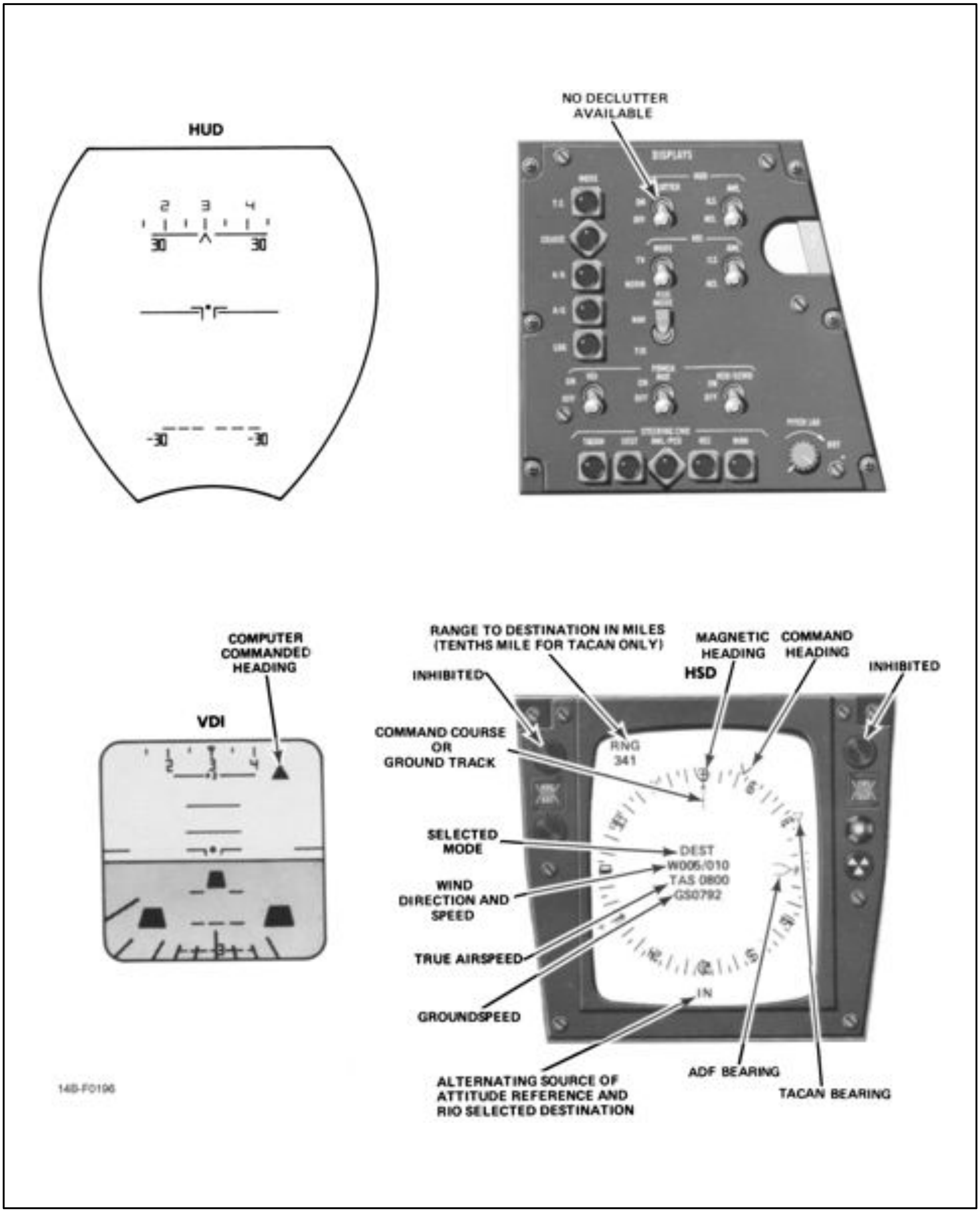


Figure 20-27. Cruise Destination Steering Displays

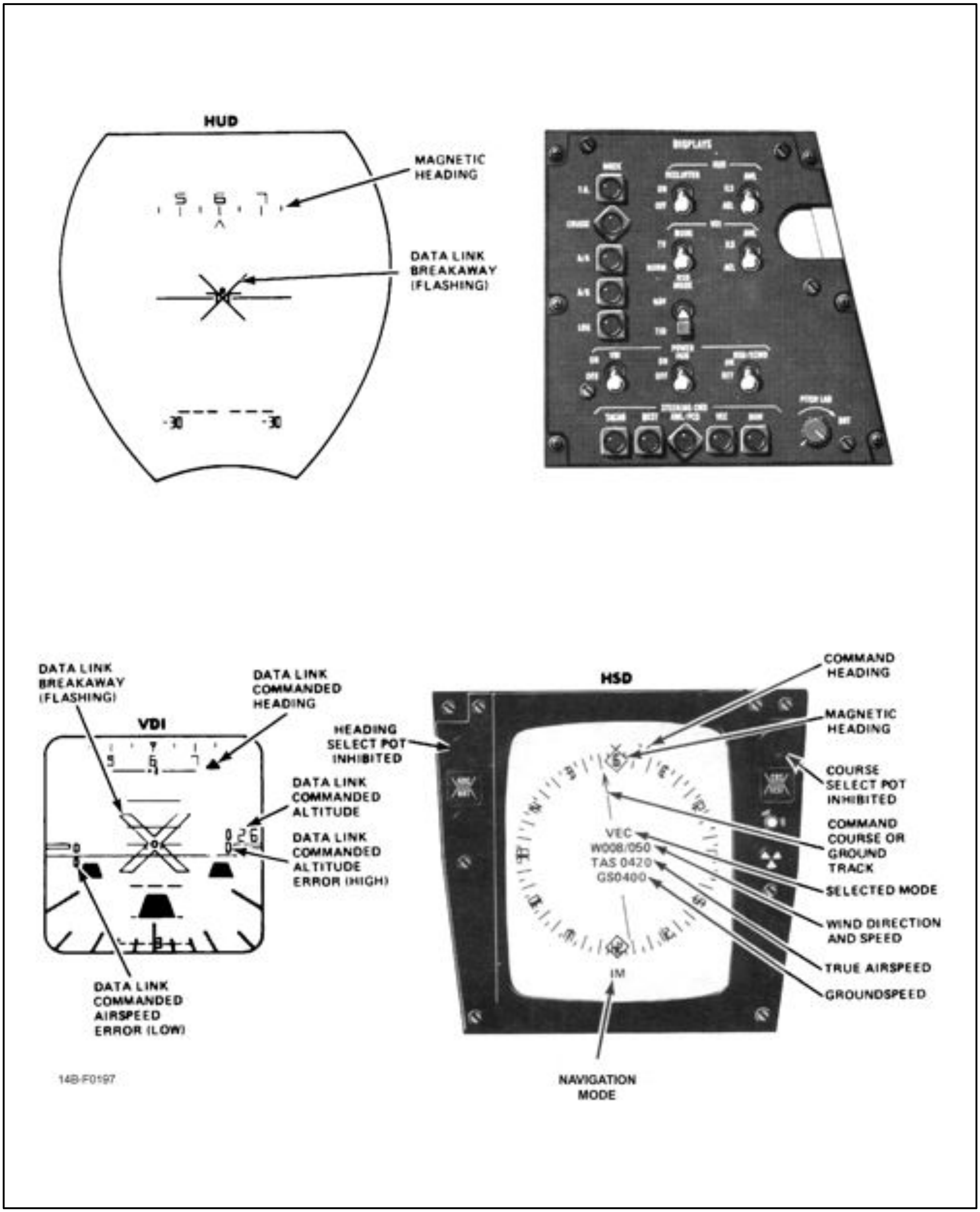


Figure 20-28. Cruise Vector Steering Displays

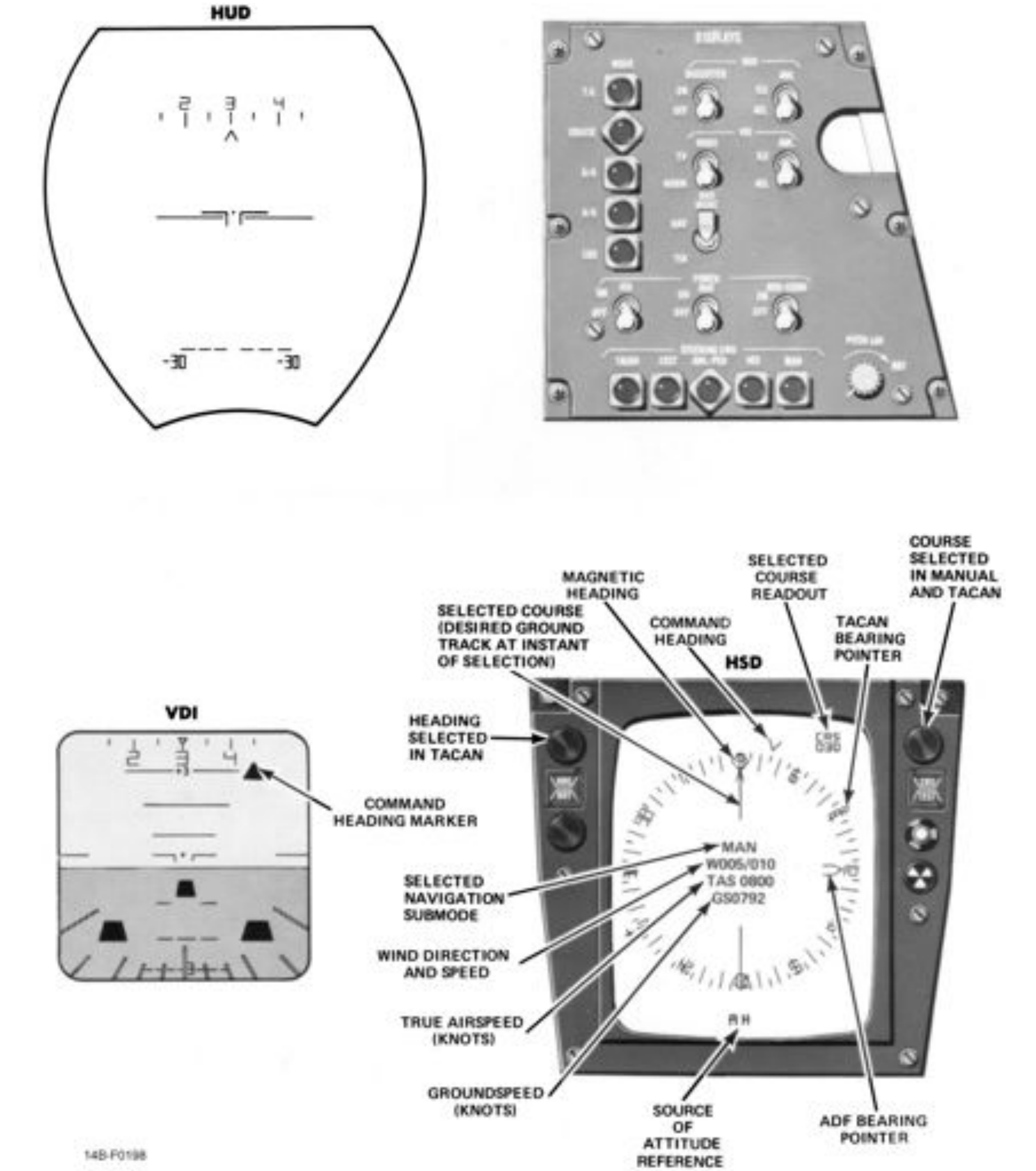


Figure 20-29. Cruise Manual Steering Displays

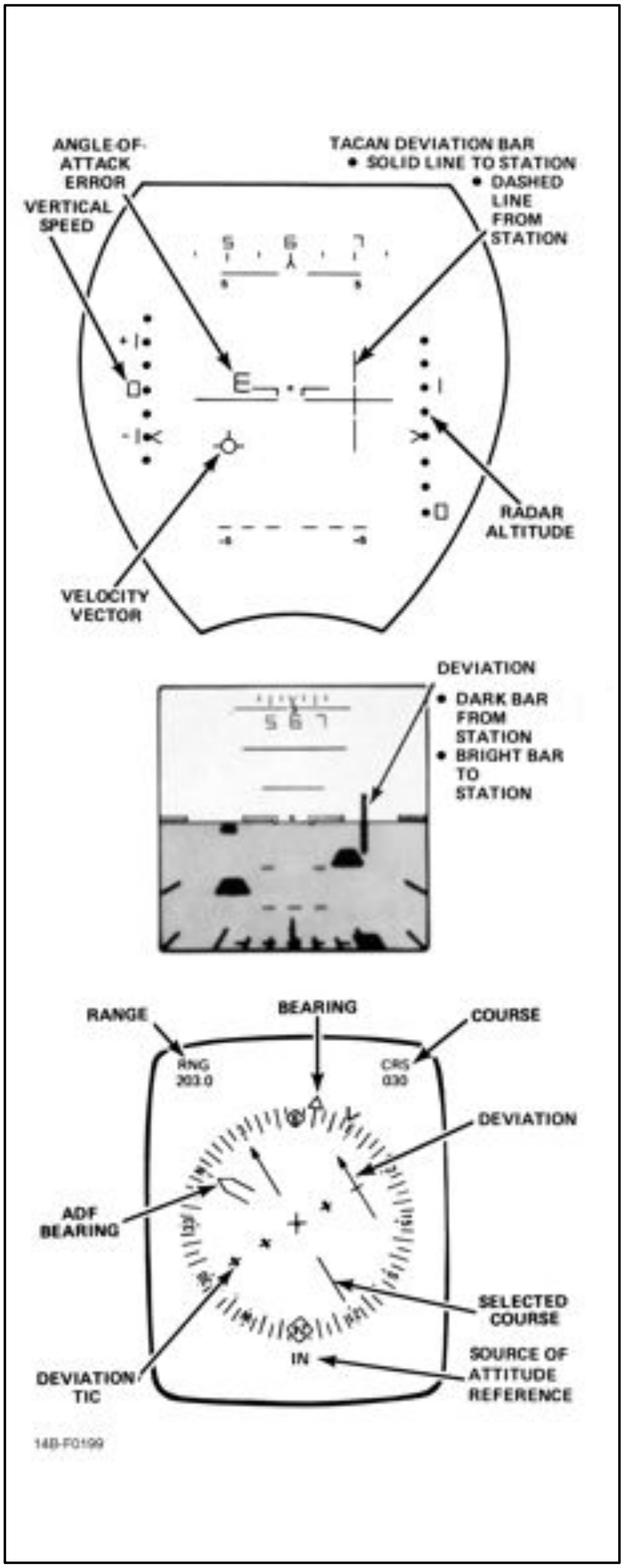


Figure 20-30. Landing TACAN Steering Displays

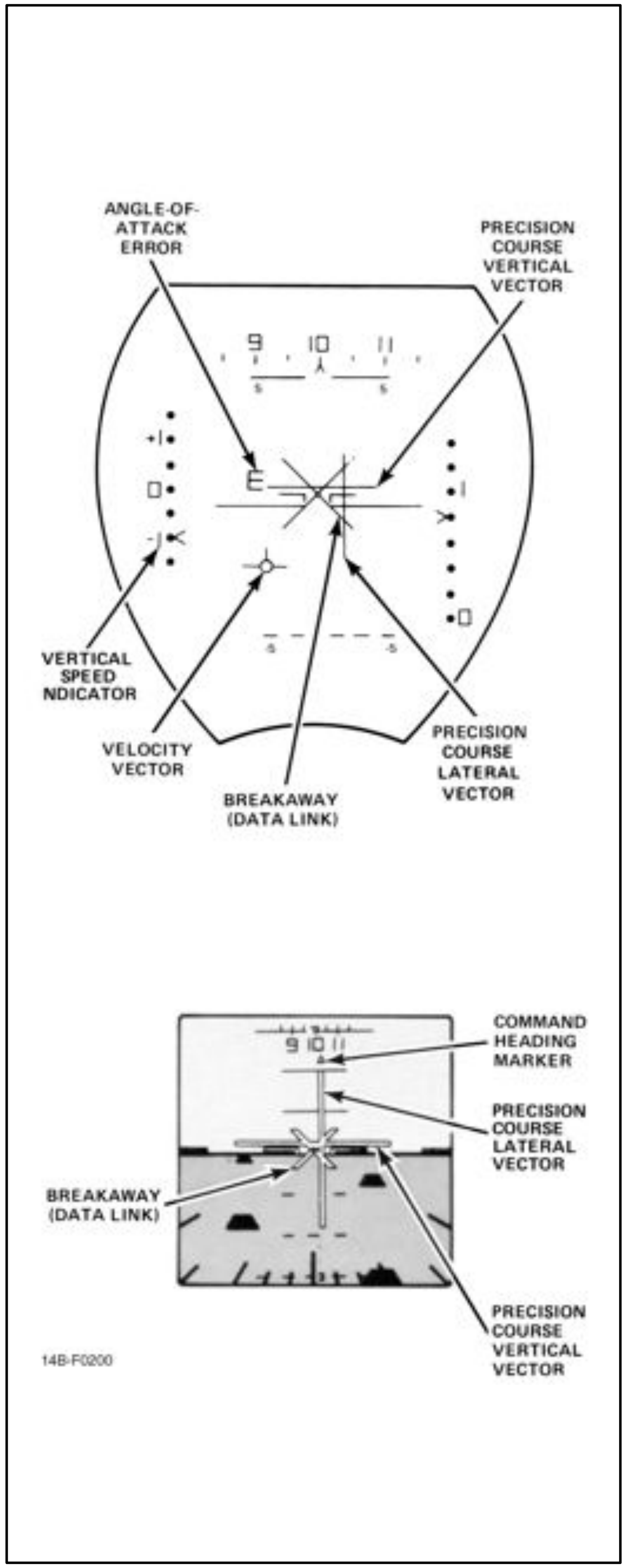


Figure 20-31. AWL Steering Displays

20.12.3.6 AWL Steering. If ILS information from the SPN-41/ARA-63 is available at the Marshalling area, the pilot may select the AWL/PCD submode. To observe glideslope displays, the HUD and VDI AWL switches on the pilot's display and control panel should be placed in the ILS position. The HUD and VDIG will then provide vertical and lateral precision course vector symbols, forming crossed pointers, and driven by the ILS (SPN-41/ARA-63) (Figure 20-31). On the HUD, full-scale vector deflection is limited to 2°. Full-scale vector deflection on the VDI is 1.5°. The HSD display at this time (AWL/PCD submode of LDG) will automatically show TACAN displays.

At the acquisition window, the pilot may continue with the ILS display, or, if ACL information from the SPN-42 data link is available, he may select ACL on the AWL switches for either the VDI or HUD displays, or both. The ACL display uses the same vertical and lateral precision course vector symbols as the ILS, but these are now driven by the SPN-42 data link. A typical display combination during the final stages of landing is ILS on the HUD and ACL on the VDI. With valid ACL data available, the AFCS may be engaged by selecting ACL on the VEC/PCD, OFF, and ACL switch located on the DFCS control panel.

20.12.3.6.1 Landing Vector Steering. When the VEC pushbutton is depressed, the data link vector symbology is added to the basic landing symbology (Figure 20-32). The command heading symbols now indicate the heading to be flown to make good the data link command course. In addition, altitude and airspeed error symbols are added to the right and left sides of the VDI, respectively. When the double bar is above the reference, the error means that the aircraft is below the commanded altitude or slower than the commanded airspeed.

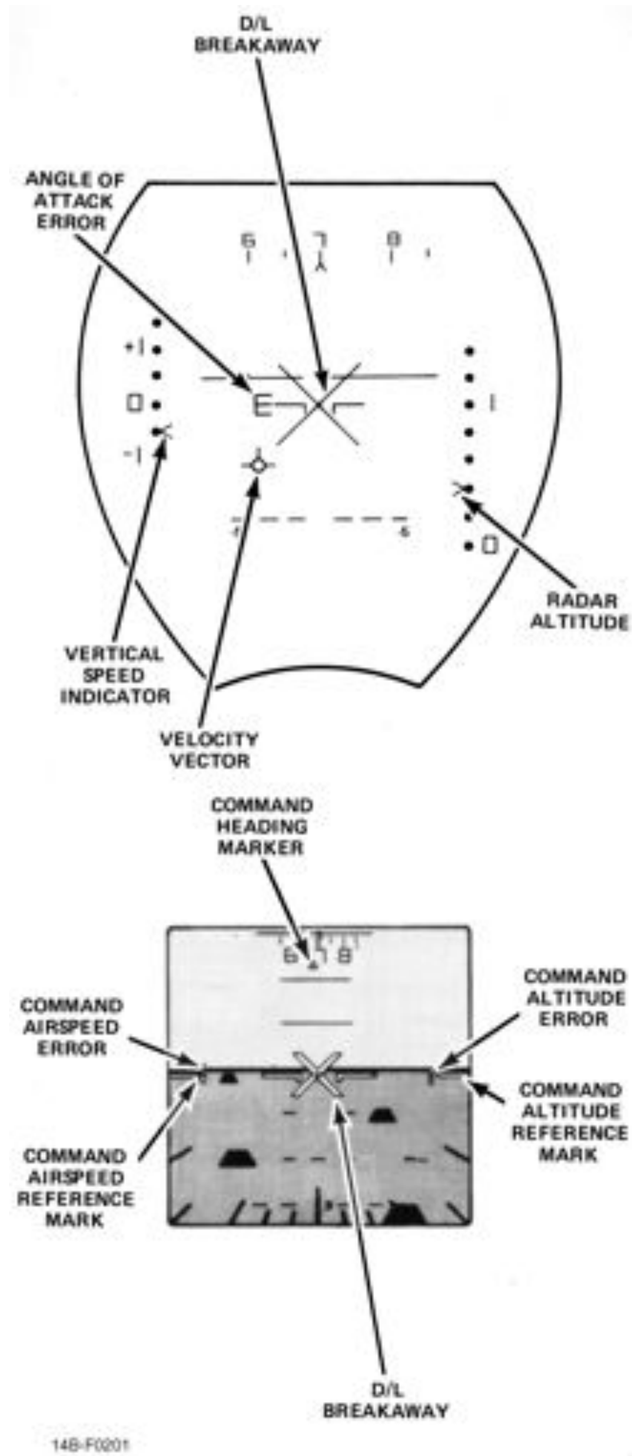


Figure 20-32. Landing Vector Steering Displays

CHAPTER 21

Identification

21.1 IDENTIFICATION TRANSPONDER (IFF/SIF) (AN/APX-72)

21.1.1 IFF/SIF Air Intercept Missile Transponder. The AIMS transponder system is capable of automatically reporting coded identification and altitude signals in response to interrogations from surface (or airborne) stations so that the stations can establish aircraft identification, control air traffic, and maintain vertical separation. The system has five operating modes (1, 2, 3/A, C, and 4). Modes 1 and 2 are IFF modes, mode 3 (civil mode A) and mode C (automatic altitude reporting) are primarily air traffic control modes, and mode 4 is the secure (encrypted) IFF mode. The IFF control panel is in the rear cockpit (Figure 21-1).

21.1.1.1 Master Switch. The MASTER switch applies power to all the AIMS transponder system components except the altimeter components. It is a five-position rotary switch placarded OFF, STBY, LOW, NORM, and EMER. The switch must be lifted over a detent to switch to EMER or to OFF. STBY should be selected for 2 minutes prior to switching to LOW or NORM to allow the transponder to warm up. In NORM, the transponder system is operational at normal receiver sensitivity. In LOW, the system is operational, but the transponder receiver sensitivity is reduced. In EMER, the transponder transmits emergency replies to mode 1, 2, or 3/A interrogations. The mode 3/A emergency reply includes code 7700. When EMER is selected, all modes are enabled regardless of the position of the selector switches. When the front seat ejects, a switch is tripped that automatically selects the emergency mode if the MASTER switch is in any position other than OFF.

21.1.1.2 IDENT-OUT-MIC Switch. The IDENT-OUT-MIC switch is a three-position toggle switch. The spring-loaded IDENT position adds an identification of position pulse to mode 1, 2, and 3/A replies for a period of 15 to 30 seconds. In MIC, the identification of position function is activated for 15 to 30 seconds each time the UHF microphone switch is pressed.

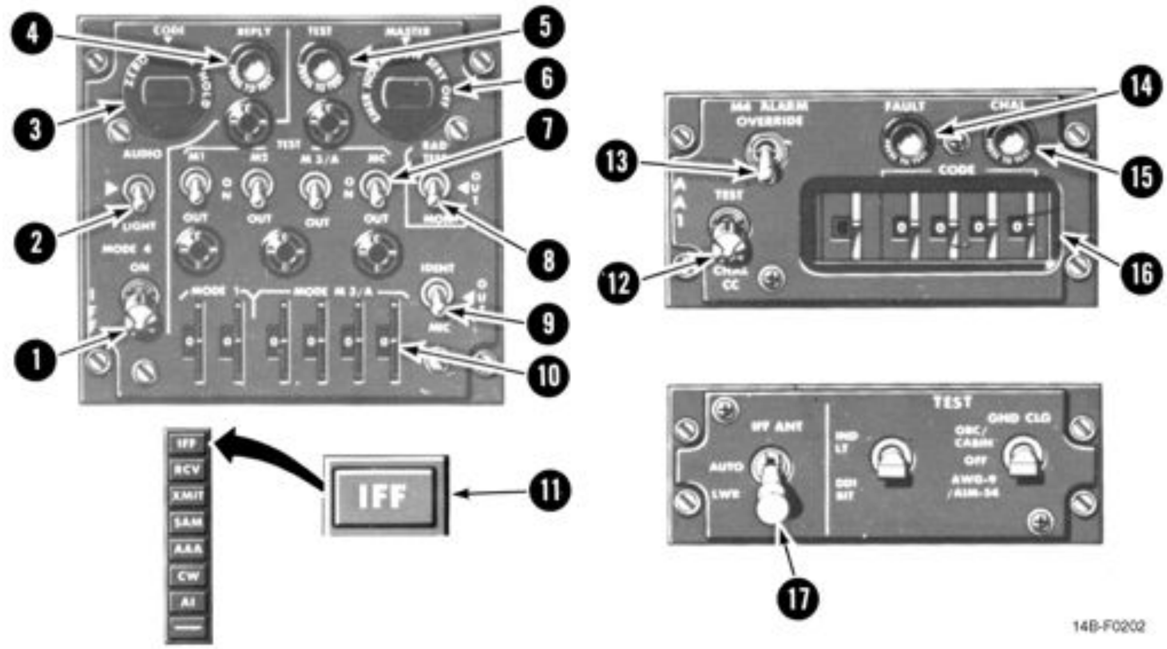
21.1.1.3 Mode 1, 2, and 3/A Code Selectors. The two mode 1 thumbwheel selector switches allow selection of 32 mode 1 codes and the four mode 3/A thumbwheel selectors allow selection of 4,096 mode 3/A codes. The mode 2 code cannot be changed during flight.

21.1.1.4 Mode Switches. The four mode switches (M-1, M-2, M-3/A, and M-C) each have OUT, ON, and spring-loaded TEST positions. The center position ON of each switch enables that mode. To test the transponder, press the mode switch of each mode to TEST.

Illumination of the TEST light indicates proper operation of that mode. The MASTER switch must be set to NORM for the test function to operate. The modes not being tested should be OUT when testing on the ground to prevent unnecessary interference with nearby ground stations. If a malfunction exists during these self-tests, an IFX CM acronym will appear on the tactical information display.

21.1.1.5 RAD TEST-OUT-MON Switch. The position MON of the RAD TEST-OUT-MON switch is used to monitor the operation of modes 1, 2, 3/A and C. When MON is selected, the TEST light will illuminate for 3 seconds each time an acceptable response is made to an interrogation on a selected mode.

The spring-loaded RAD TEST is used for testing. It enables a mode 3/A code reply to a TEST mode interrogation from a maintenance test set. It also enables a mode 4 reply to a VERIFY 1 interrogation from a surface station or a maintenance test set. A VERIFY 1 interrogation is a modified mode 4 interrogation that is designated for test purposes.



NOMENCLATURE	FUNCTION
1 MODE 4 switch	ON — Enables mode 4.
	OUT — Disablesk mode 4.
	See Figure 21-2 for Mode 4 caution/reply light logic.
2 MODE 4 AUDIO/LIGHT switch	AUDIO — Selects aural monitoring when mode 4 is being interrogated and REPLY light monitoring of MODE 4 replies.
	▶ — Disables light and aural monitoring of mode 4.
	LIGHT — Selects mode 4 reply light monitoring.
3 MODE 4 CODE switch	ZERO — Erases code 4 from KIR-1A and KIT-1A computers.
	B — Selects KIT-1A computer B code.
	A — Selects KIT-1A computer A code.
	HOLD — No longer functional (AFC 763 incorporated).
4 MODE 4 REPLY light	Illuminates to indicate mode-4 reply to interrogation.
5 TEST light	Illuminates when respective test switch is actuated; indicates proper operation of modes 1, 2, 3/A, and C. Master switch must be set to NORM.
6 MASTER switch	OFF — Deenergizes set.
	STBY — Energizes receiver-transmitter for immediate operation upon switching to an operating position.
	LOW — Provides reduced receiver sensitivity for response only to strong nearby interrogations.
	NORM — Allows full receiver sensitivity for response to maximum range interrogations.

Figure 21-1. IFF Control Panels (Sheet 1 of 2)

NOMENCLATURE	FUNCTION
	EMER — Provides full receiver sensitivity and generates emergency replies to mode 1, 2, (thumbwheel settings), and 3/A (code 7700) and a normal reply to mode C, when interrogated, whether mode switches are on or off.
7 MODE switches	TEST — TEST light illuminates if system is functioning properly.
	ON — Permits selection of interrogating modes to which the transponder will respond.
	OUT — Deenergized position.
8 RAD TEST-OUT-MON switch	RAD TEST — Not operational (for ground testing only).
	OUT — Deenergized position.
	MON — Allows RIO to monitor APX-72 reply (modes 1, 2, 3, and C) Test light will illuminate.
9 IDENT-OUT-MIC switch	IDENT — Momentary position provides IDENT reply for 15 to 30 seconds after releasing switch; replies to interrogation in modes 1, 2, 3/A.
	OUT — Deenergizes circuit.
	MIC — Transfers IDENT reply activation switch from Ident to radio microphone switch.
10 CODE selectors (MODE 1 and 3/A)	Code selectors are rotatable drums with imprinted numbers that appear in code selector windows, permitting selection of codes for mode 1 and 3/A.
11 IFF caution light	Indicates mode 4 Interrogation was received, but system has not generated reply.
12 TEST-CHAL CC switch	Momentary two-position center-return switch.
	TEST — Onboard transponder is triggered by onboard interrogator. Both sets must have same code setting. IFF solid lines are displayed on DDD at 3 and 4 miles.
	CHAL CC — A SIF interrogation cycle starts the 5 to 10 second challenge period. Only correct modes and code replies are displayed (two brackets only on DDD).
13 M4 ALARM OVERRIDE switch	Disables the mode-4 tone alarm to the RIO's ICS.
14 FAULT light	Indicates a malfunction of APX-76 receiver-transmitter, caused by receiver, video, or transmitter signals.
15 CHAL light	Remains illuminated for the duration of a challenge period indicating correct operation.
16 CODE selectors	First thumbwheel selects mode, 1, 2, 3A, 4A, or 4B. Last four thumbwheel rotatable drums with imprinted numbers appearing in code selector windows, permit selection of desired interrogation code.
17 IFF ANT switch	AUTO — Antenna lobbing switch cycles receiver-transmitter between upper and lower-antenna pattern coverage.
	LWR — Only the lower-antenna pattern below aircraft is used.

Figure 21-1. IFF Control Panels (Sheet 2)

21.1.1.6 Mode 4 Operation. Mode 4 operation is selected by setting the MODE 4 toggle switch to ON, provided that the MASTER switch is NORM or LOW. Setting the MODE 4 switch to OUT disables mode 4. The MODE 4 CODE switch is placarded ZERO, B, A, and HOLD. The switch must be lifted over a detent to switch to ZERO. It is spring loaded to return from HOLD to position A. Position A selects the mode 4 code for the present code period and position B selects the mode 4 code for the succeeding code period. Maintenance personnel mechanically insert both codes into the transponder. The codes are mechanically held in the IFF, regardless of the position of the MASTER switch or the status of aircraft power (AFC 763 incorporated).

The mode 4 codes can be zeroed anytime the aircraft power is on and the MASTER switch not OFF by turning the CODE switch to ZERO.

An audio signal, the REPLY light, and the IFF caution light are used to monitor mode 4 operation. The AUDIO/▲-LIGHT switch controls the audio signal and the REPLY light, but not the IFF caution light. In the LIGHT position, the REPLY light illuminates as mode 4 replies are transmitted. In the AUDIO position, an audio tone in the RIO's headset indicates that valid mode 4 interrogations are being received and the REPLY light illuminates if mode 4 replies are transmitted. In the ▲ position, the audio indications and the REPLY light are inoperative and the REPLY light will not press-to-test. (CAUTION and REPLY light logic are shown in Figure 21-2.)

21.1.1.7 IFF Caution Light. The IFF caution light on the RIO threat advisory lights panel illuminates when mode 4 is not operative. The light is operative whenever aircraft power is on and the MASTER switch is not OFF. However, the light will not operate if the mode 4 computer is not physically installed in the aircraft. Illumination of the IFF caution light indicates that: (1) the mode 4 codes are all zero, (2) the self-test function of the KIT-1A/TSEC computer has detected a faulty computer, or (3) the transponder is not replying to proper mode 4 interrogations.

If the IFF caution light illuminates, switch the MASTER switch to NORM (if in STBY) and ensure that the MODE 4 toggle switch is ON. If illumination continues, employ operationally directed flight procedures for an inoperative mode 4 condition.

21.1.1.8 Antenna Switching Unit. The aircraft has two IFF antennas and an antenna switching unit that electronically switches the transponder between the top and bottom IFF antennas at a nominal rate of 38 cycles per second. The aircraft also has an antenna switch placarded AUTO and LWR. In AUTO, the IFF receiver-transmitter automatically cycles between the upper and lower antenna. In LWR, only the lower antenna is used.

21.1.2 Altitude Computations. The control air data computer performs altitude computations. The computer outputs are altitude-information corrected for static position error. The synchro output is supplied to the altimeter, providing the crew with a corrected altitude indication. The digital output from the computer is applied to the transponder for transmission on mode C, is coded in increments of 100 feet, and is referenced to 29.92 inches of mercury.

The altimeter has a primary (servo) mode and a standby (pressure) mode of operation that are controlled by a spring-loaded self-centering mode switch placarded RESET and STBY. In the primary (servo) mode, the altimeter displays altitude (corrected for position error) from the synchro output of the altitude computer. In the standby mode of operation, the altimeter displays altitude directly from the static system (uncorrected for position error) and operates as a standard pressure altimeter. A dc-power internal vibrator is automatically energized while in the standby mode to minimize friction in the display mechanism.

21.2 IFF INTERROGATOR (AN/APX-76)

The AN/APX-76 provides radar identification of airborne and surface Mk 10 IFF systems. It operates in conjunction with the AN/AWG-9 radar and is automatically turned on whenever the AWG-9 power switch is placed to any position except OFF. A minimum warmup time of 3 minutes is required before successful operation or BIT can be performed. The system requires 115 Vac from the main ac bus through the IFF, A/A, ac circuit breaker (1I7) and 28 Vdc from the main dc bus through the IFF A/A DC circuit breaker (8F6). It is capable of interrogation and display of modes 1, 2, 3A, and 4 and of displaying EMERG and IDENT on the DDD.

TRANSPONDER (APX-72)	INTERROGATOR (APX-76)	CAUTION	REPLY (APX-72)
4 OUT (A) STBY	A	ON	OFF
4 ON (A) STBY	A	ON	OFF
4 ON (A) NORM	A	OFF	ON
4 ON (A) NORM	B	OFF	OFF
4 ON (B) NORM	A	OFF	OFF
4 ON (B) NORM	B	OFF	ON
4 ON (B) STBY	B	ON	OFF
4 ON (B) STBY	B	ON	OFF
4 ON (A) NORM RAD TEST	VERIFY BIT 1 (A)	OFF	ON
4 ON (A) NORM	VERIFY BIT 1 (A)	ON	OFF
4 ON (A) STBY	VERIFY BIT 1 (A)	ON	OFF
KIT ZERO	A OR B	ON	OFF

Figure 21-2. Mode 4 Caution and Reply Light Logic

The APX-76 system consists of five basic components: an antenna system, a receiver-transmitter, a switch amplifier, a synchronizer unit, and a control panel.

The IFF antenna is an integral part of the AWG-9 antenna. It consists of 12 dipole antennas mounted on the surface of the AWG-9 planar array antenna. The antenna azimuth and vertical coverage is the same as that of the AWG-9 antenna except that the beam width of the APX-76 is 13°. The transmitter operates at a fixed frequency of 1030 MHz and the receiver operates at a fixed frequency of 1090 MHz.

The APX-76 functions in both low and high PRF modes of the AWG-9; however, trigger pulses to the APX-76 are generated from different sources, depending on the operational mode of the AWG-9. When the AWG-9, pulse Doppler modes, including standby, the interface unit (WRA 461) provides the trigger pulses to the APX-76. These trigger pulses are delayed in the APX-76 and are sent back to the AWG-9. Replies from the interrogated transponder are decoded by the APX-76 and displayed in range and azimuth on the DDD. For pulse and pulse standby modes of the AWG-9, the trigger pulses to the APX-76 are generated in the radar synchronizer (WRA 010). The trigger pulses are delayed by the APX-76, then sent back and used to initiate a video display gate for normal IFF display on the DDD.

Note

The trigger pulses for low and high pulse repetition frequency modes of the AWG-9 are generated by different WRAs. If the interrogator fails to operate in one mode, APX-76 operation should be attempted in the other mode. Failure to work in either mode is a strong indication of the possibility that one of the components of the APX-76 is at fault.

A KIT-1A computer generates mode 4 interrogations and interpolates mode 4 replies. Display of mode 4 is the same as all other modes. The KIR-1A computer is powered by the same power source as the KIT-1A computer and the APX-72 transponder system. This prevents zeroing the mode 4 codes when the AWG-9 power switch is cycled. The remainder of the APX-76 is powered through the AWG-9 power switch.

21.2.1 IFF Self-Test. Prior to APX-76 operation, a self-test should be performed on the unit. The APX-76 contains a self-test function that provides closed loop testing in conjunction with the on-board APX-72 (IFF transponder). To perform the self-test, the RIO must set the mode and code switches on the control panel to correspond with the mode and code switches of the APX-72. The APX-72 must be in an operating mode (low, normal, or emergency) before performing the test. The RIO may then initiate self-test by holding the TEST/CHAL CC switch in TEST for 5 to 10 seconds.

Provided both the IFF and the APX-76 are functioning properly, two horizontal bars will be displayed across the DDD at approximately 3 and 4 miles. Illumination of the green CHAL light on the control panel, while the switch is being held in the test position, also indicates that the APX-76 made a valid interrogation. The bottom line on the DDD indicates that the APX-72 responded in mode and the top line indicates it responded in code. Both lines together indicate that the APX-76 is decoding properly. Biasing of the mode and code lines enables them to be spread across the entire DDD during test. If the first attempt to test the APX-76 fails because of lack of video on the DDD or the amber fault light on the control panel illuminates, the RIO should initiate a valid challenge by momentarily holding the CHAL CC/TEST switch in CHAL CC in order to reset the BIT flags associated with the APX-76. The APX-76 normally powers up with the BIT flags in the fault position. The system will continuously show a fault until the flags are reset. The APX-76 antenna is checked during the test by receiving actual video from the APX-72 antenna. Failure of any part of the APX-76 closed loop test will cause IFI to be displayed in continuous monitor. A further breakdown as to what portion of the system has failed can be verified by calling up the maintenance file. Tests of all modes of the APX-76 should be performed independently. Failure of one mode does not necessarily mean that all modes are malfunctioning.

Portions of the APX-76 are tested during class III OBC. During on-board check, CHALLENGE IFF is displayed on the TID in order to remind the RIO to reset the BIT flags by making a valid challenge. DDD video is not tested during OBC since that function requires the AWG-9 to be operating in a tactical mode.

21.2.2 APX-76 Operation. The operating mode of the APX-76 is determined by the setting of the six-position mode thumbwheel on the control panel. Modes 1, 2, and 3 are the normal operating modes. Modes 4A and 4B are crypto-secure modes requiring the installation of KIR equipment.

The white position on the first thumbwheel selects the APX-76 to standby and should be selected prior to AWG-9 power-down. Four-digital thumbwheels are located on the panel to provide code selections. Each thumbwheel has eight positions numbered from 0 to 7. The code selection is dependent on the mode selection. If mode 1 is selected, the code selection must be a multiple of 100 ranging from 0000 to 7300. If mode 2 or 3 is selected, the code selection may be any four-digit number from 0000 to 7777.

There are two ways to make a valid challenge of Mk 10 IFF systems. One is by depressing the IFF tile on the DDD. By depressing the tile, all targets replying in the mode selected on the control panel will cause a line to be displayed on the DDD just below the target's range and at the same azimuth as the target. Actual video return of the target may or may not be displayed. During the pulse search mode, target video may be displayed if the target falls within the radar beam width and produces enough skin return to be seen. If any of the targets are replying in the same code that the RIO has selected on the code thumbwheels, a second line will appear just above the target range and azimuth. IFF interrogation and the corresponding display continue for a maximum of 10 seconds or until the switch is released, whichever is shorter.

The second way to challenge a Mk 10 IFF transponder is to hold the CHAL CC/TEST switch in CHAL CC (CHALLENGE CORRECT CODE). The mode and code of all targets replying to the mode and code that the RIO has set will be the only IFF video displayed. Mode return alone will never be displayed if the CHAL CC switch position is used. IFF interrogation and display continue for a maximum of 10 seconds or until the switch is released, whichever is shorter.

Note

Flickering CHAL and fault lights may be observed when interrogating with the AWG-9 radar in the 5-, 10-, 20-, and 50-pulse range scale. In addition, an IFI acronym may be observed in the OBC file. This condition does not interfere with live video IFF targets on the APX-76 loop test.

21.2.3 IFF Displays. Display formats for IFF operation are shown in Figure 21-3. During IFF interrogation, the radar continues its normal operations. With the radar in a pulse mode (search, track, or acquisitions), the IFF returns are mixed with the radar video and appropriate pulse radar display formats are displayed on the DDD. The IFF range scale is defined by the radar range scale.

If the RIO commands an IFF interrogation during any pulse Doppler single target track or pulse single target track mode (PDSTT or PSTT) or when a target is designated (hooked) on the TID, an expanded IFF range

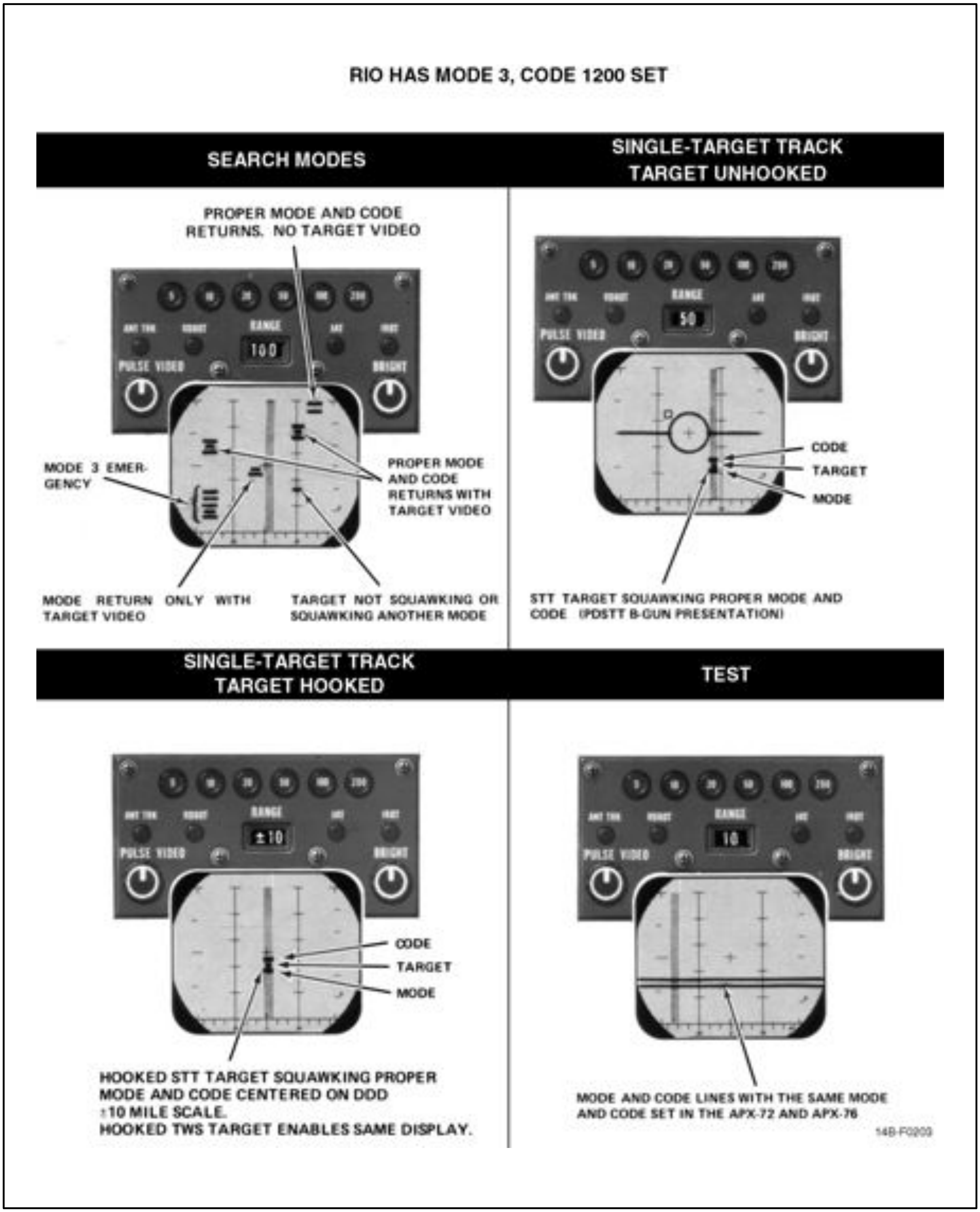


Figure 21-3. IFF Display Formats

display is generated on the DDD. The nominal target range is displayed at the vertical center of the DDD. The range scale is indicated on the range scale indicator at ±10 and it cannot be changed. The azimuth of the current radar mode is retained in the expanded IFF format. By unhooking the single-target track, normal range vs. azimuth is displayed along with the IFF display.

With the radar operating in the pulse Doppler mode, the DDD presentation is switched to a B-scan format. In this format, the pulse Doppler antenna scan pattern is retained but IFF range sweeps are displayed. A computer-generated symbol representing actual target range is displayed along with the IFF video on the DDD. The IFF scale is indicated on the range indicator. It may be changed by pressing the range-select pushbutton. In the pulse-Doppler, STT mode, the attack symbols are retained and the IFF sweep is displayed at the azimuth of the AWG-9 tracking antenna.

Note

During all STT modes, IFF video return may be difficult to detect because of DDD smearing.

When a target is detected, the RIO must tell the computer whether the target is friend or foe. The APX-76 cannot perform this function. It can only determine if Mk 10 IFF is being utilized by the target. If the sensor target has been data-link associated with a data-link file, the IFF contact will be sent to the tactical data system as part of the R3A message.

PART VIII

Weapon Systems

CHAPTER 22

Vertical Display Indicator Group (AN/AVA-12)

22.1 VERTICAL DISPLAY INDICATOR GROUP

The VDIG provides the pilot symbolic takeoff, cruise, air-to-air (A/A), air-to-ground (AG), landing, and test information. Electronically generated symbology portrays aircraft attitude, command, and tactical information. The information displayed depends on mission phase and the mode of operation the pilot selects for a given phase. Information for the mode selected is displayed simultaneously on a TV-like display called the vertical display indicator and on a projected-image-type heads-up display, which is coincident with the pilot's forward vision through the windshield. The VDI is a heads-down display. The HUD provides information to aid the transition from the heads-down display to visual acquisition of the target. Figure 22-1 (sheets 1 through 12) show the various HUD and VDI presentations for each mode and submode.

Figure 22-2 shows the relationship of the pilot's weapon select switch to the movable reticle (pipper) and the designator diamond.

22.1.1 VDIG Mode Controls. Controls for the VDIG modes are on the pilot display control panel (see Figure 22-3). A VDIG converter controls symbol enabling, positioning, and status by mode logic and signals from the computer signal data converter, AWG-9, or AWG-15, depending on the mode selected. Figure 22-4 (sheets 1 through 3) shows the VDIG symbols and their functions along with a pictorial comparison of the symbols as they appear on the HUD and VDI. During all the various modes except cruise, certain symbols may be removed from the HUD through the DECLUTTER switch on the display control panel. In addition, the VDIG has built-in-test capabilities for system checks on the ground and in flight.

Note

If information displayed on the HUD and VDI is different, determine which display is correct by use of the VDIG test modes (MASTER TEST) switch set to INST and by reference to other cockpit instruments. Eliminate the erroneous display with the corresponding power switch.

22.1.2 VDIG Data Freeze. Logic circuitry in the VDIG senses the receipt of pitch and roll information from the CSDC. If for any reason this information is not received by the VDIG converter for 200 milliseconds or more, the VDIG will turn off the steering symbol pitch lines on the HUD and the pitch ladder steering symbol, horizon line, roll pointer, ground texture and moving elements, and sky plane on the VDI.

22.1.3 Vertical Display Indicator. The VDI provides a in-the-cockpit vertical display to the pilot during medium and long-range missile attacks, initiation of visual identification passes, data-link vectoring, automatic carrier landing, aircraft flight attitude, and navigation. The VDI replaces the mechanical attitude director indicator of older aircraft systems as an aircraft attitude instrument providing pitch, roll, and heading. TV video can also be presented on the VDI from the television camera set, when installed.

Note

Selecting the TV position on the PDCP without a TCS installed will blank out the VDI presentation.

22.1.3.1 Attitude Information. Attitude information is displayed on the VDI by an aircraft reticle, a horizon line, ground and sky texture, and a pitch ladder. The aircraft reticle is fixed at the center of the display, and the horizon line and pitch ladder move about it in accordance with the aircraft pitch and roll attitudes.

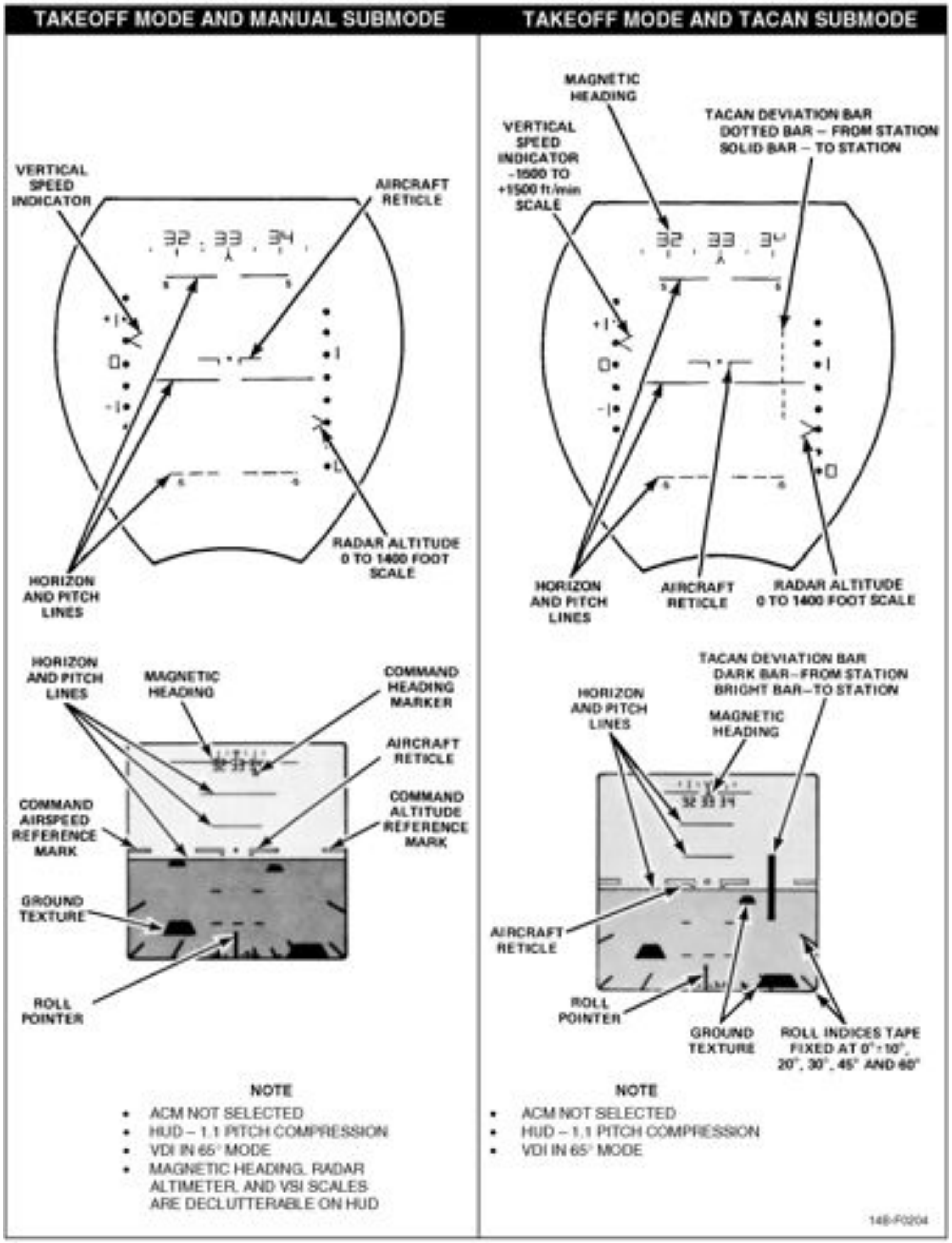


Figure 22-1. VDI and HUD Presentations (Sheet 1 of 12)

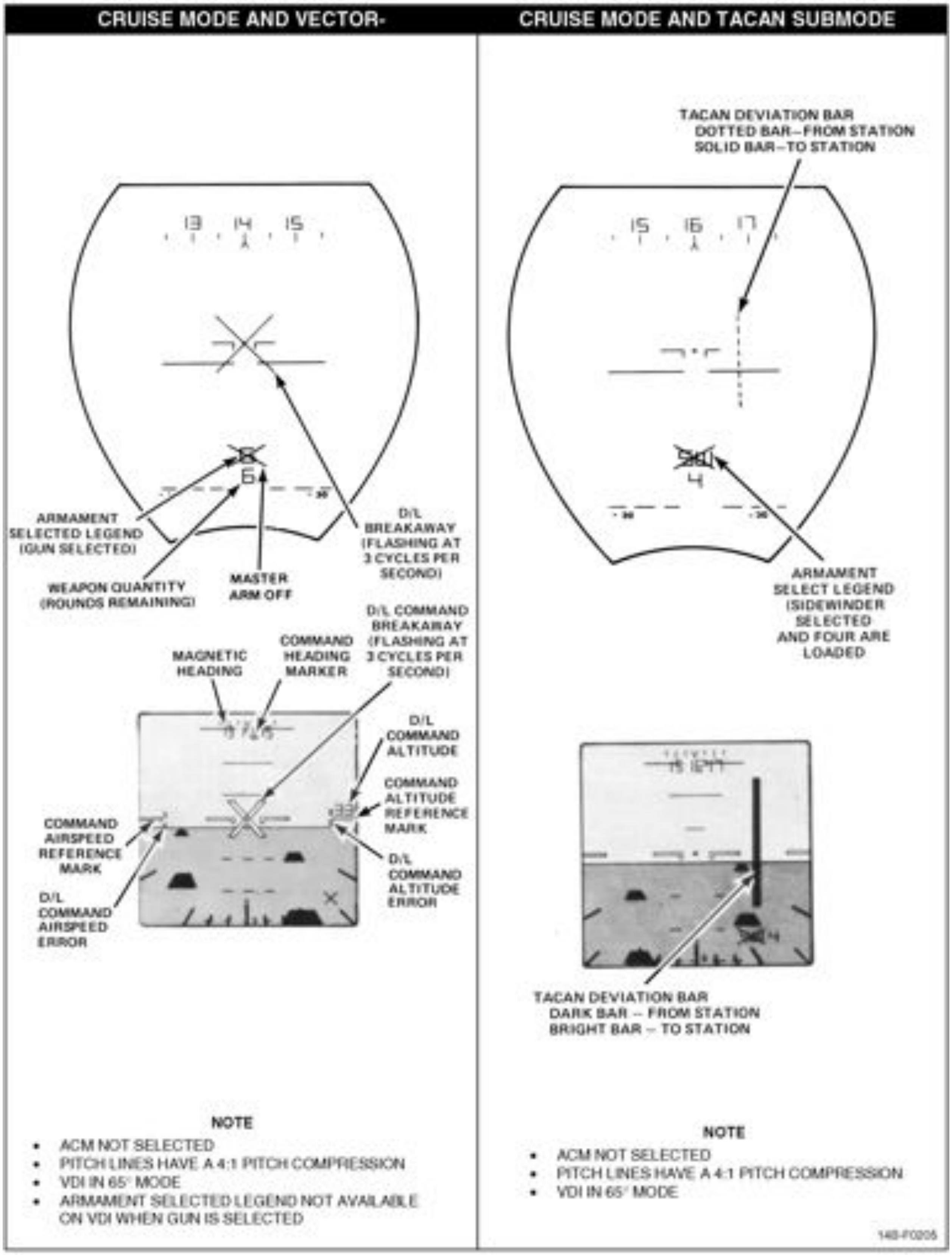


Figure 22-1. VDI and HUD Presentations (Sheet 2)

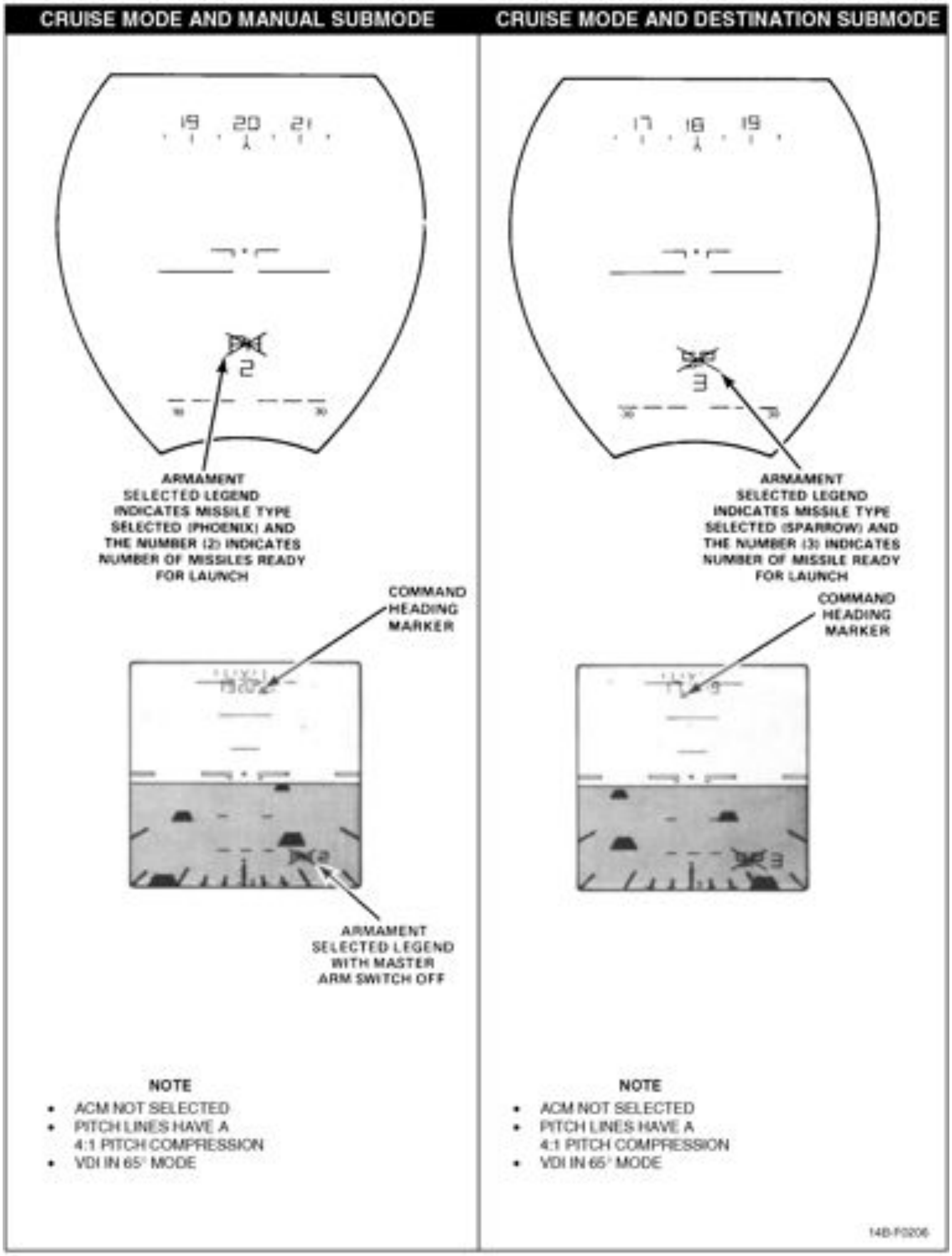
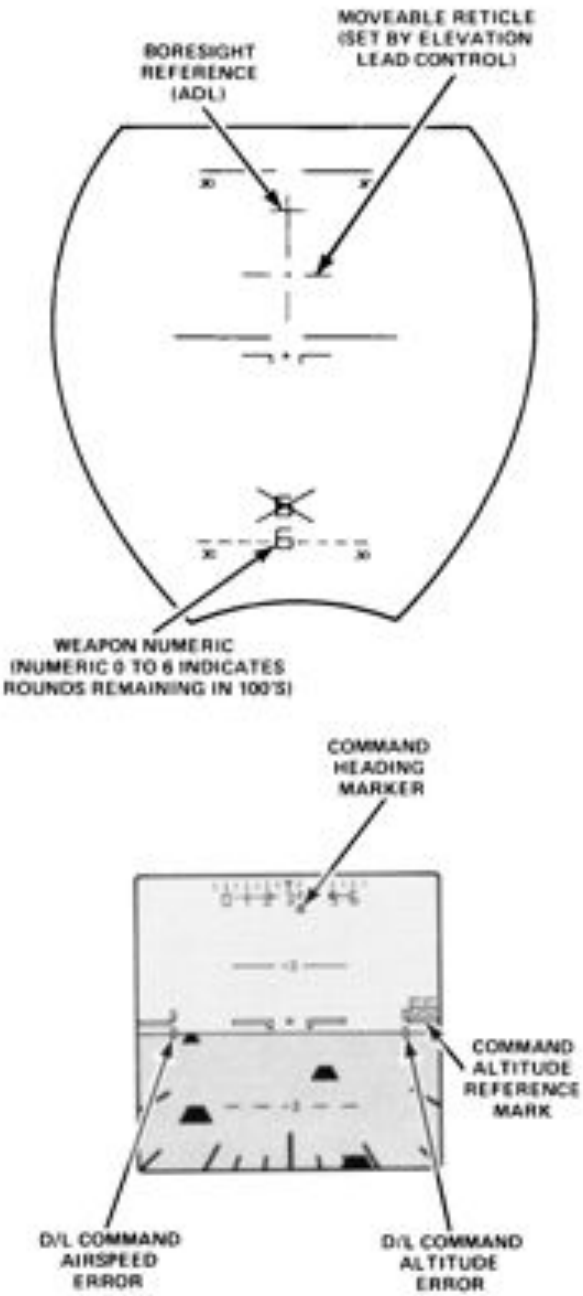


Figure 22-1. VDI and HUD Presentations (Sheet 3)

A/A MANUAL GUN MODE



NOTE

- THIS MODE CAN ALSO BE ENTERED BY SELECTING ACM
- GUN CAGE IS NOT SELECTED FOR THIS MODE
- PITCH LINES, HORIZON LINE, AND AIRCRAFT FIXED RETICLE ARE DECLUTTERABLE ON HUD

14B-F0207

Figure 22-1. VDI and HUD Presentations (Sheet 4)

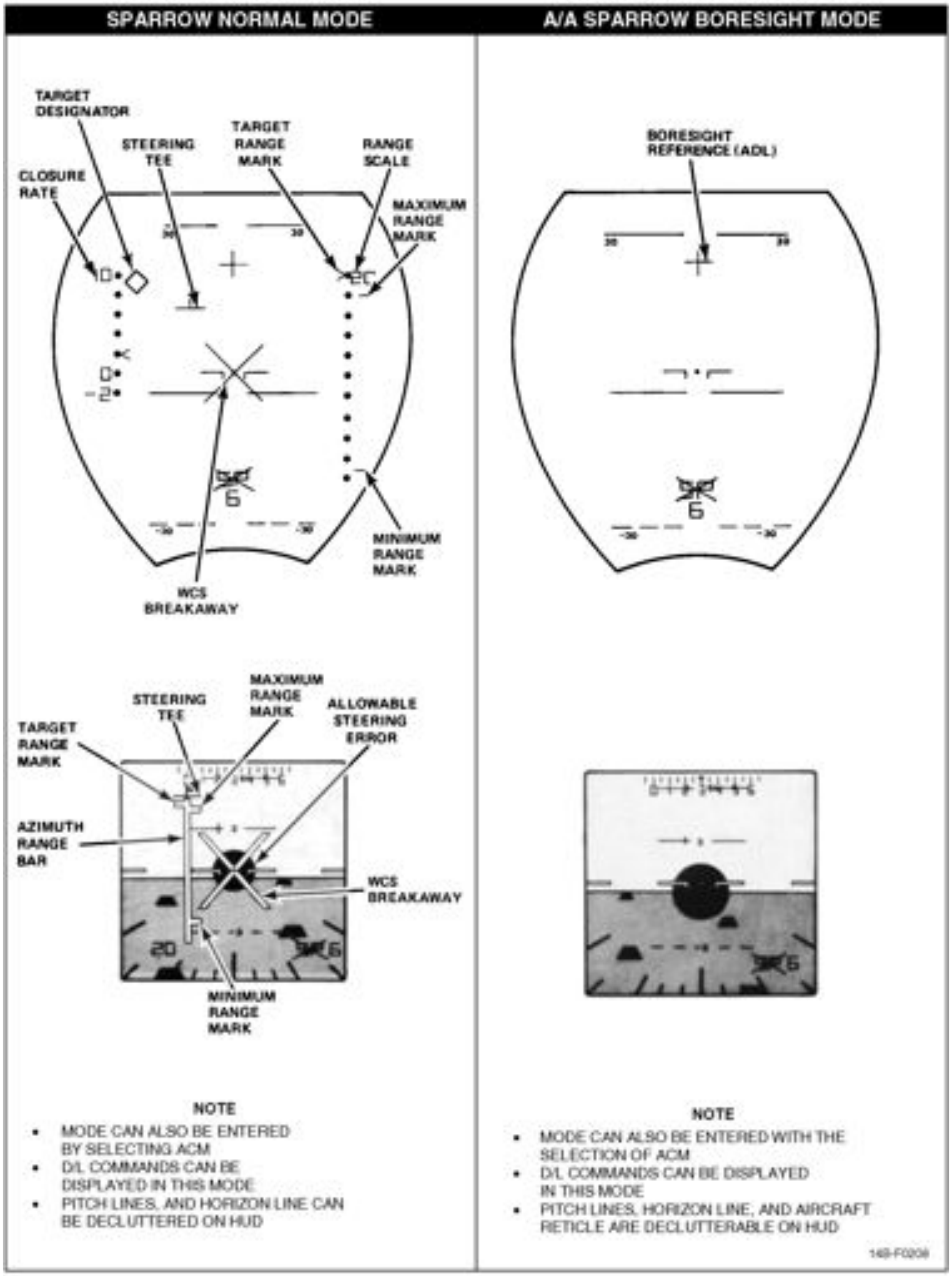
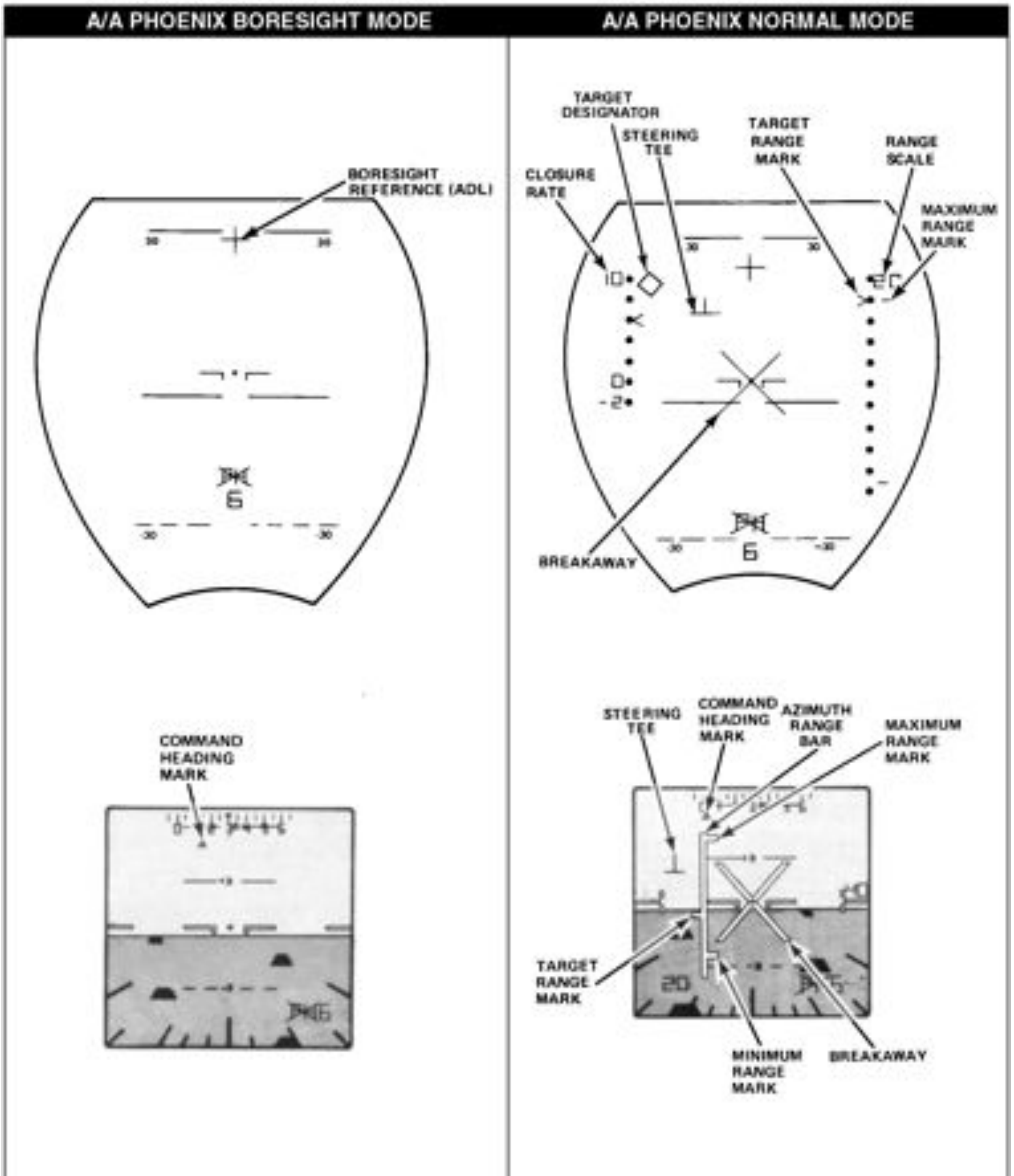


Figure 22-1. VDI and HUD Presentations (Sheet 5)



NOTE

- MODE CAN ALSO BE ENTERED BY THE SELECTION OF ACM
- D/L COMMANDS CAN BE DISPLAYED IN THIS MODE
- PITCH LINES, HORIZON LINE, AND AIRCRAFT RETICLE CAN BE DECLUTTERABLE ON HUD

NOTE

- MODE CAN ALSO BE ENTERED BY SELECTING ACM
- WCS BREAKAWAY IS AVAILABLE IN THIS MODE
- D/L COMMAND IS AVAILABLE
- PITCH AND HORIZON LINE CAN BE DECLUTTERED ON HUD

14B-F0209

Figure 22-1. VDI and HUD Presentations (Sheet 6)

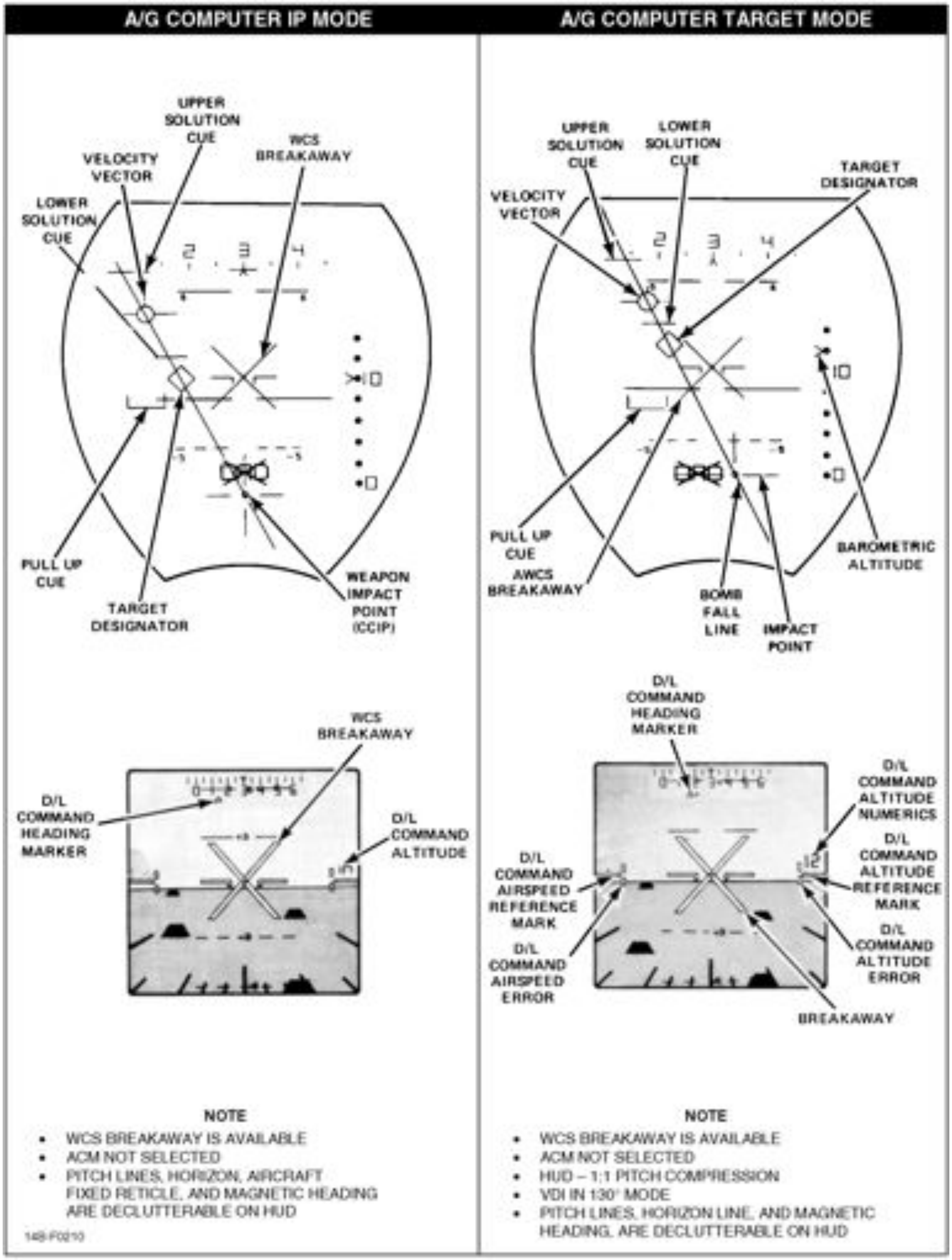
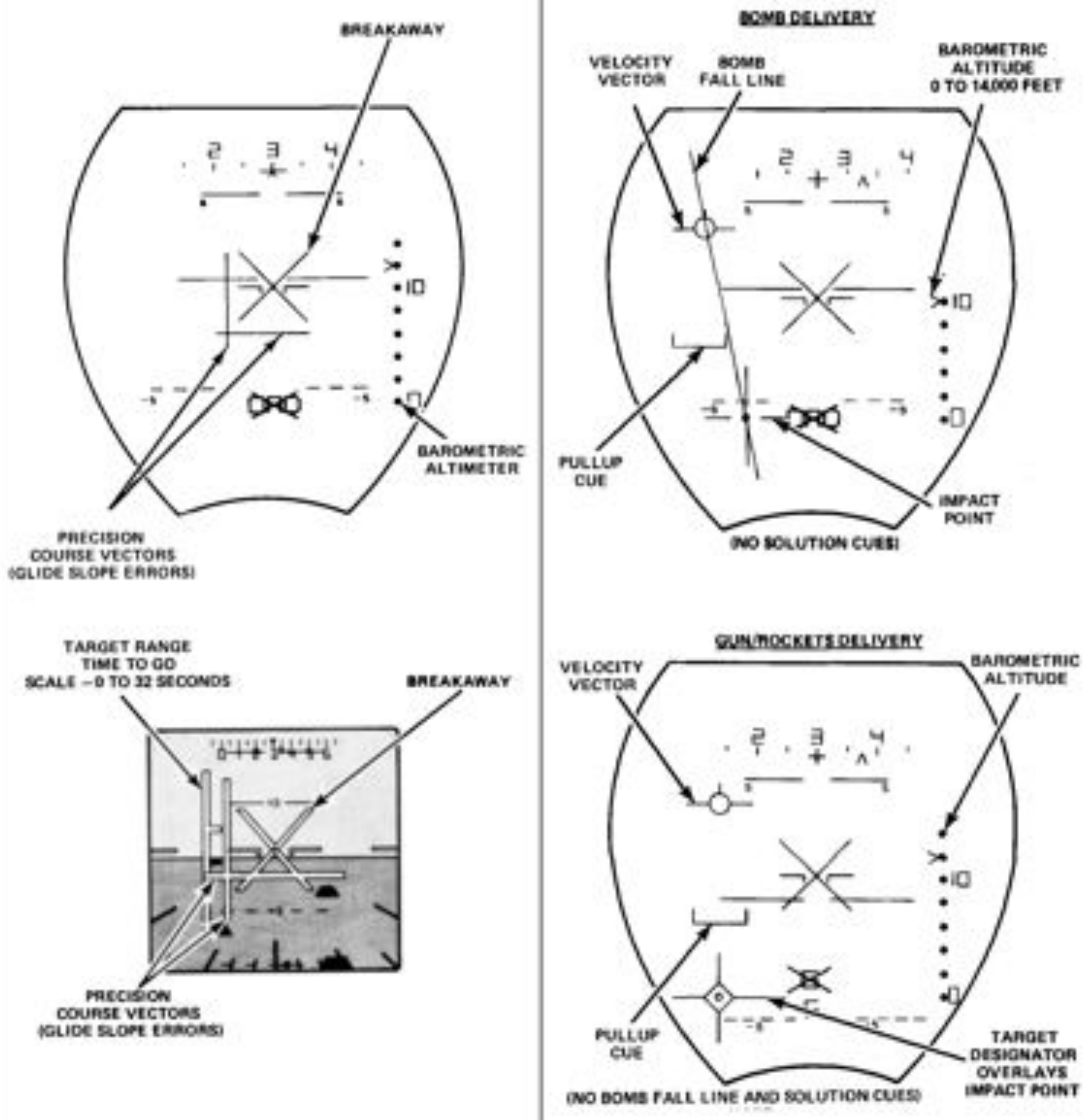


Figure 22-1. VDI and HUD Presentations (Sheet 7)

A/G PCD MODE	A/G COMPUTER PILOT MODE



NOTE

- D/L MUST BE OPERATING AND DATA LINK POWER SWITCH SET TO ON
- D/L BREAKAWAY IS AVAILABLE
- ACM NOT SELECTED
- HUD – 1:1 PITCH COMPRESSION
- VDI IN 130° MODE
- PITCH LINES, HORIZON LINE, AND MAGNETIC HEADING, ARE DECLUTTERABLE ON HUD

NOTE

- VDI IDENTICAL TO COMPUTER IP MODE
- ACM NOT SELECTED
- WCS BREAKAWAY IS AVAILABLE
- HUD – 1:1 PITCH COMPRESSION
- VDI IN 130° MODE
- PITCH LINES, HORIZON LINE, AND MAGNETIC HEADING, ARE DECLUTTERABLE ON HUD

14B-F0211

Figure 22-1. VDI and HUD Presentations (Sheet 8)

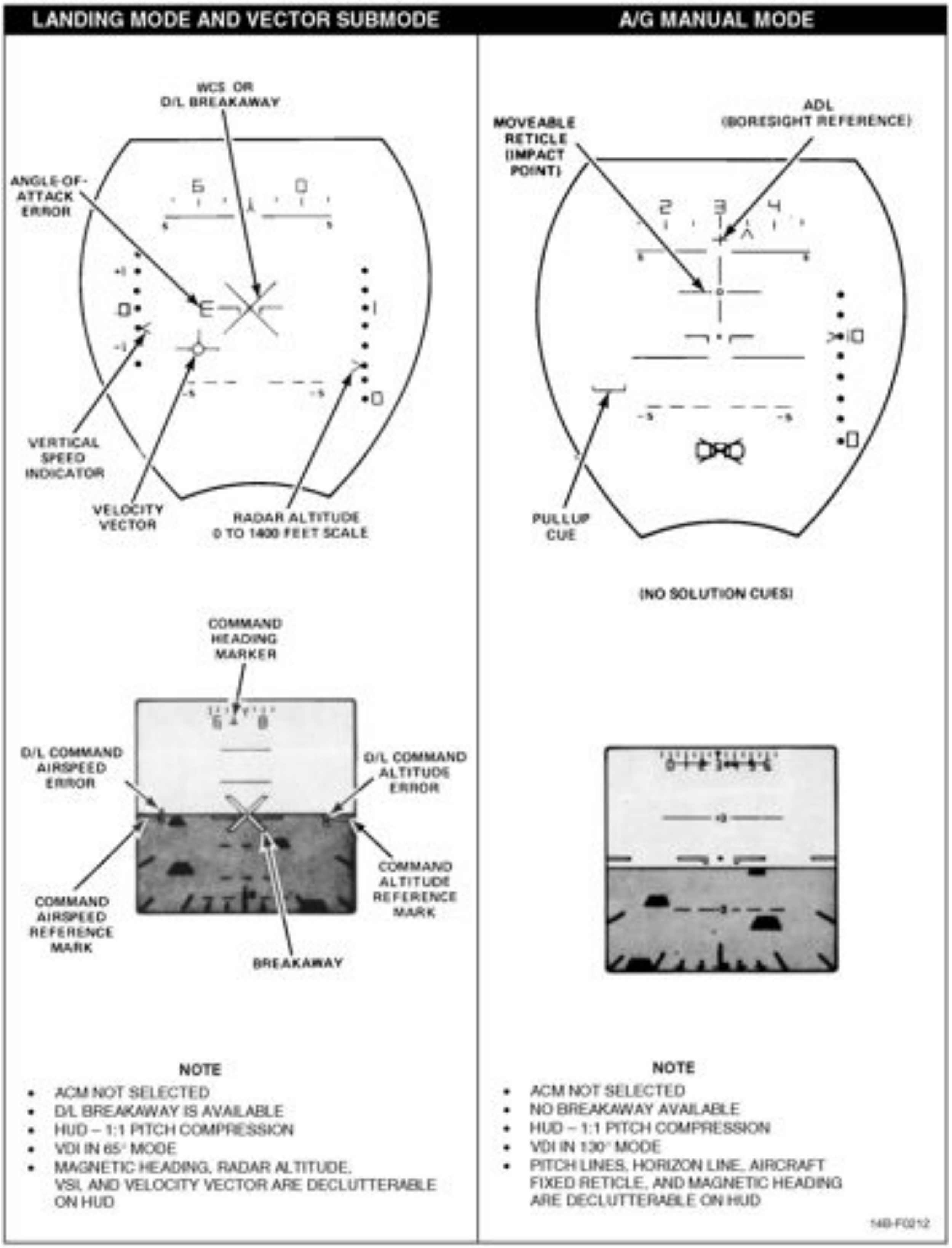


Figure 22-1. VDI and HUD Presentations (Sheet 9)

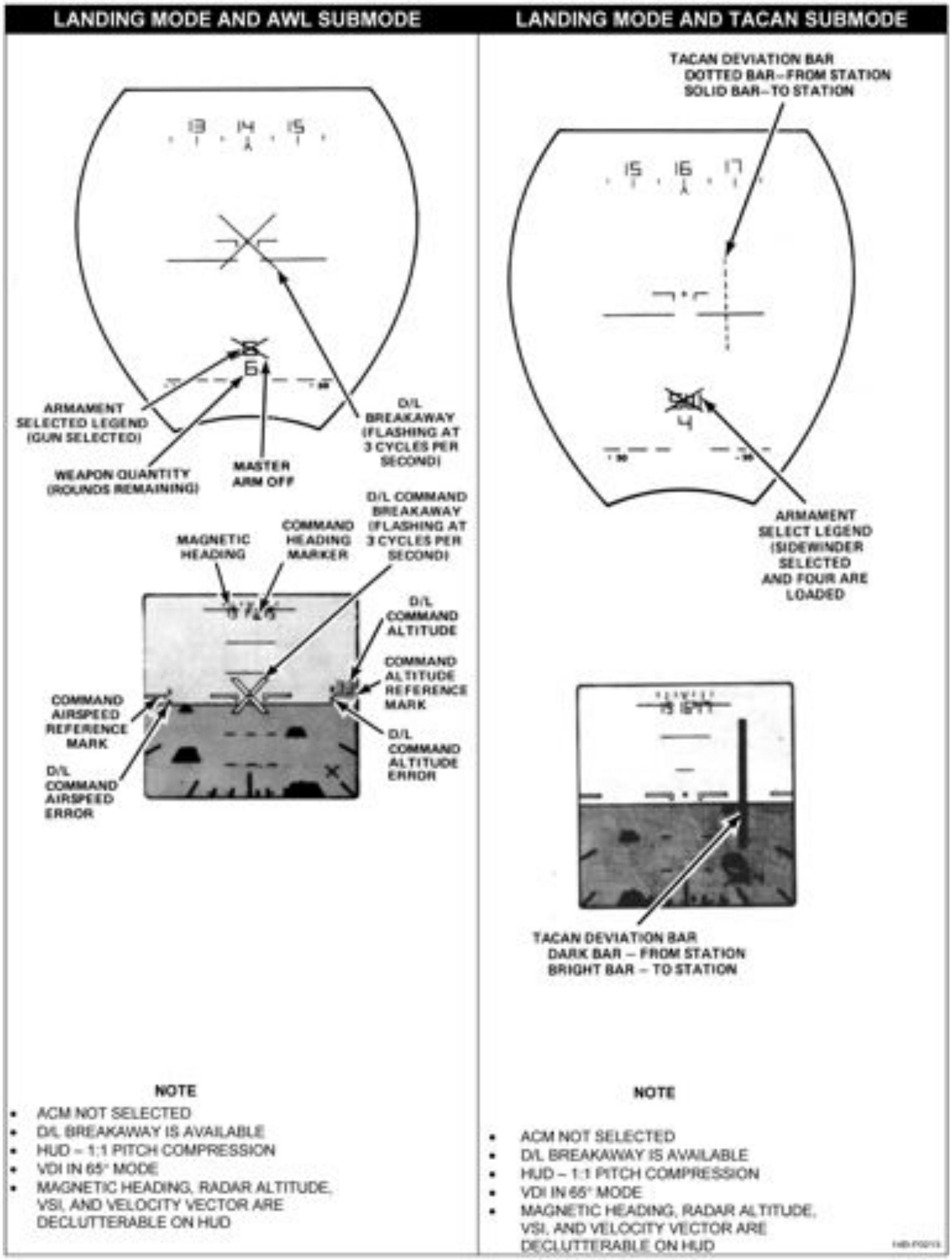
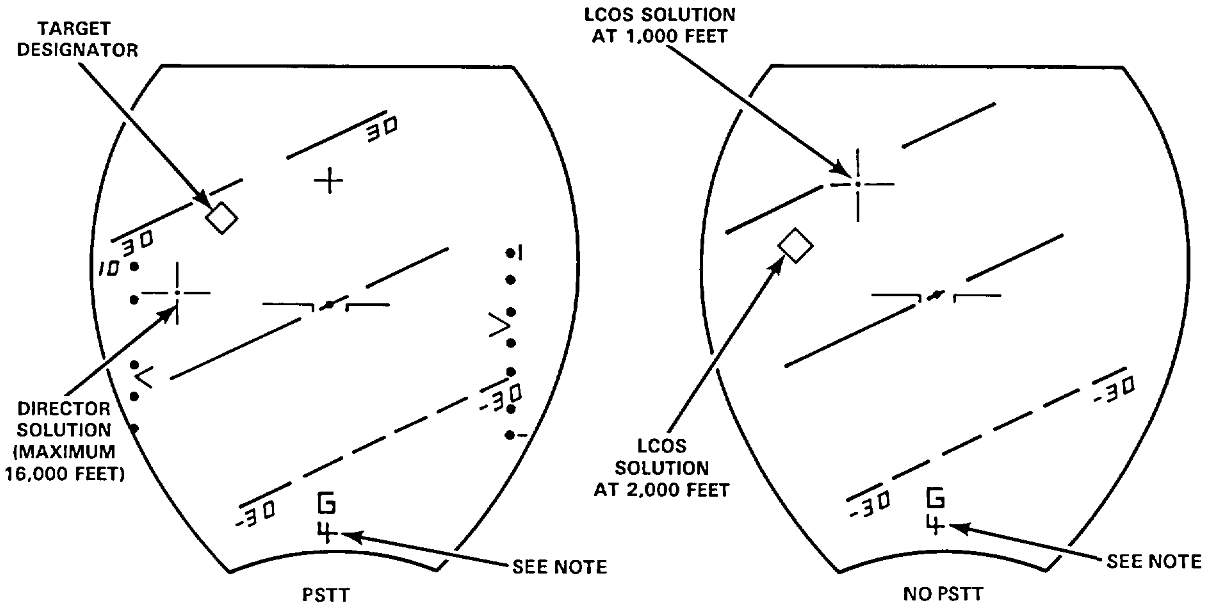


Figure 22-1. VDI and HUD Presentations (Sheet 10)

MMGS HUD DISPLAYS



NOTE

GSS SELECTED AND MASTER ARM ON

- INDICATES HUNDREDS OF ROUNDS REMAINING
- NUMERAL SEVEN IS DISPLAYED WHILE BULLETS ARE AT TARGET RANGE.

GSS SELECTED AND MASTER ARM OFF

- INDICATES TRIGGER SQUEEZE COUNT
- NUMERAL SEVEN IS DISPLAYED WHILE BULLETS ARE AT TARGET RANGE

GSS NOT SELECTED

- INDICATES HUNDREDS OF ROUNDS REMAINING.

14B-F0214

Figure 22-1. VDI and HUD Presentations (Sheet 11)

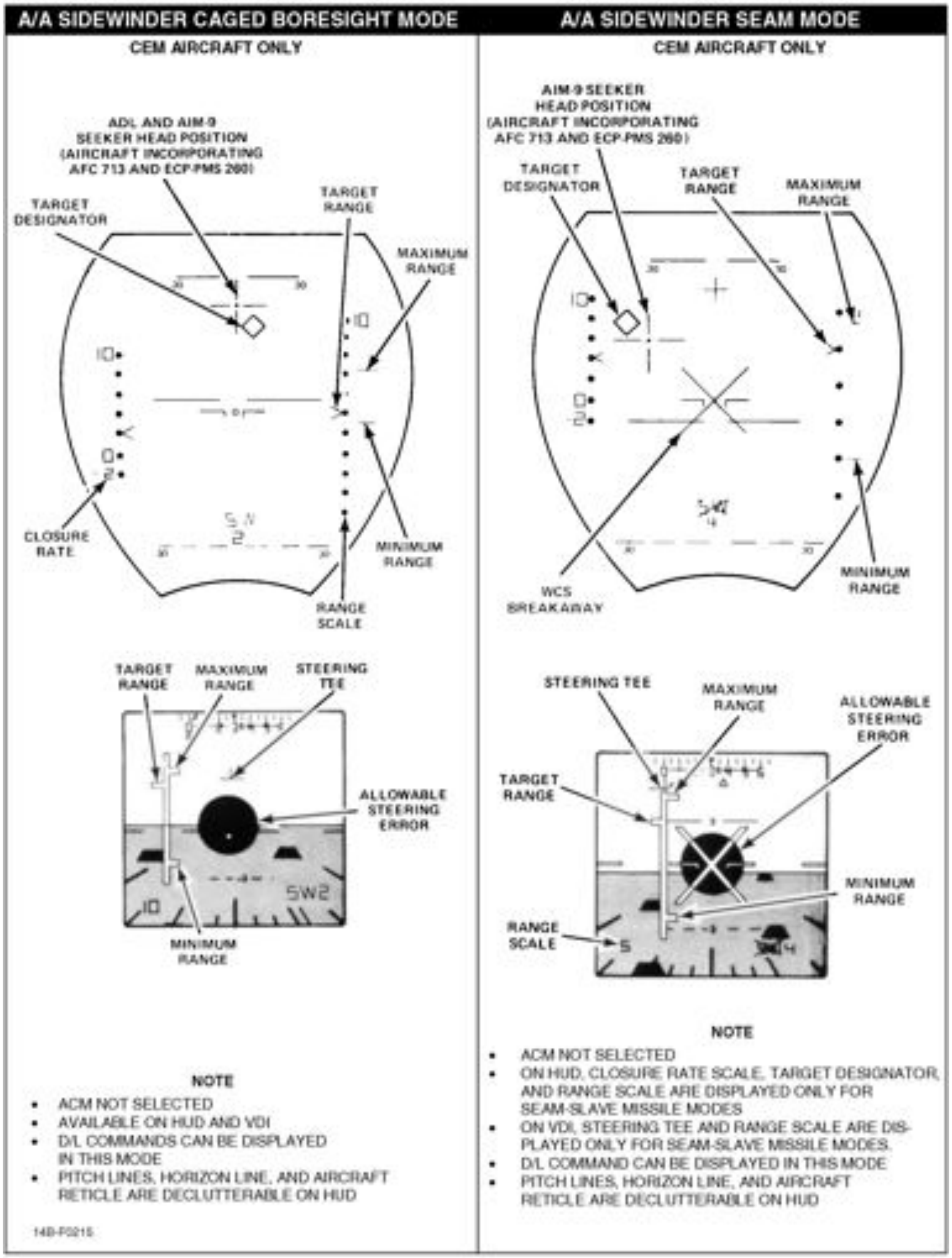


Figure 22-1. VDI and HUD Presentations (Sheet 12)

AIR-TO-AIR MODE		
WEAPON SELECT SWITCH	TARGET DESIGNATOR (DIAMOND)	MOVEABLE RETICLE (PIPPER) (STEERING T IS NOT AVAILABLE WHEN PIPPER IS DISPLAYED.)
SP/PH/OFF	Radar STT — radar LOS No radar STT — not displayed In the air-to-air TARPS mode with the weapon select switch OFF, and without radar STT, the target designator(diamond) overlays the last hooked reference point.	TCS track — TCS LOS TCS driven by HCU — TCS LOS
SW	Radar STT — radar LOS TCS track only (no radar STT) — TCS LOS No TCS track or radar STT — not displayed	The seeker head position is displayed on the HUD.
GUN 1/2, 1, or 2	PSTT — radar LOS reverts to BATR solution one bullet TOF (BTOF) after trigger squeeze. Blinks for 1/2, 1, or 2 seconds (based on selected burst length) when first bullet is at target range. No PSTT — fixed at 2,000 feet LCOS solution reverts to a fixed 1,000 foot BATR one BTOF after trigger squeeze. No PSTT fixed — 2,000 foot lead computing optical sight (LCOS) solution	PSTT — Solution reverts to in-range cue (forward quarter) or optimum range cue (aft quarter) when target is within maximum range or optimum range. Blinks for 0.5 seconds. No PSTT — fixed 1,000 foot LCOS solution.

Figure 22-2. Relationship of Weapon Select Switch to Movable Reticle (Pipper) and Target Designator (Diamond)

WARNING

- At certain pitch attitudes, the horizon line will not be displayed on the VDI. The remaining display will consist of background, pitch lines, and the roll pointer. When this occurs, the roll pointer should be referenced to assist in determining aircraft attitude. The actual attitude at which the horizon line is lost will depend on the VDI mode selected.
- During night and/or IFR conditions, the increased acceleration during use of afterburner will result in inner ear disturbances that may cause flightcrew confusion/ disorientation. The large amount of light generated by the afterburner exhaust reflecting around the aircraft will compound this condition. These factors may result in severe aircrew disorientation/ vertigo.

22.1.3.2 Flight Parameters. The flight parameters displayed include magnetic heading, data-link-command airspeed (Mach number), and altitude. Ground texture elements superimposed on the ground plane simulate both motion and simple perspective. Command information includes steering, breakaway, and air-to-air attack steering. The circle used to indicate allowable attack steering error is programmed to diminish continually in size as steering becomes progressively more critical during a maneuver. Tactical symbology provides such information target position, azimuth position, target range and armament types, and quantities for the air-to-air attack mode.

22.1.4 Heads-Up Display. The HUD is used for visual identification terminal approaches, short-range air-to-air (A/A) weapon attacks (predominantly Sidewinder and gun), air-to-ground (A/G) attacks, and ACL. The instrument is used primarily when the pilot can see the target or landing zone.

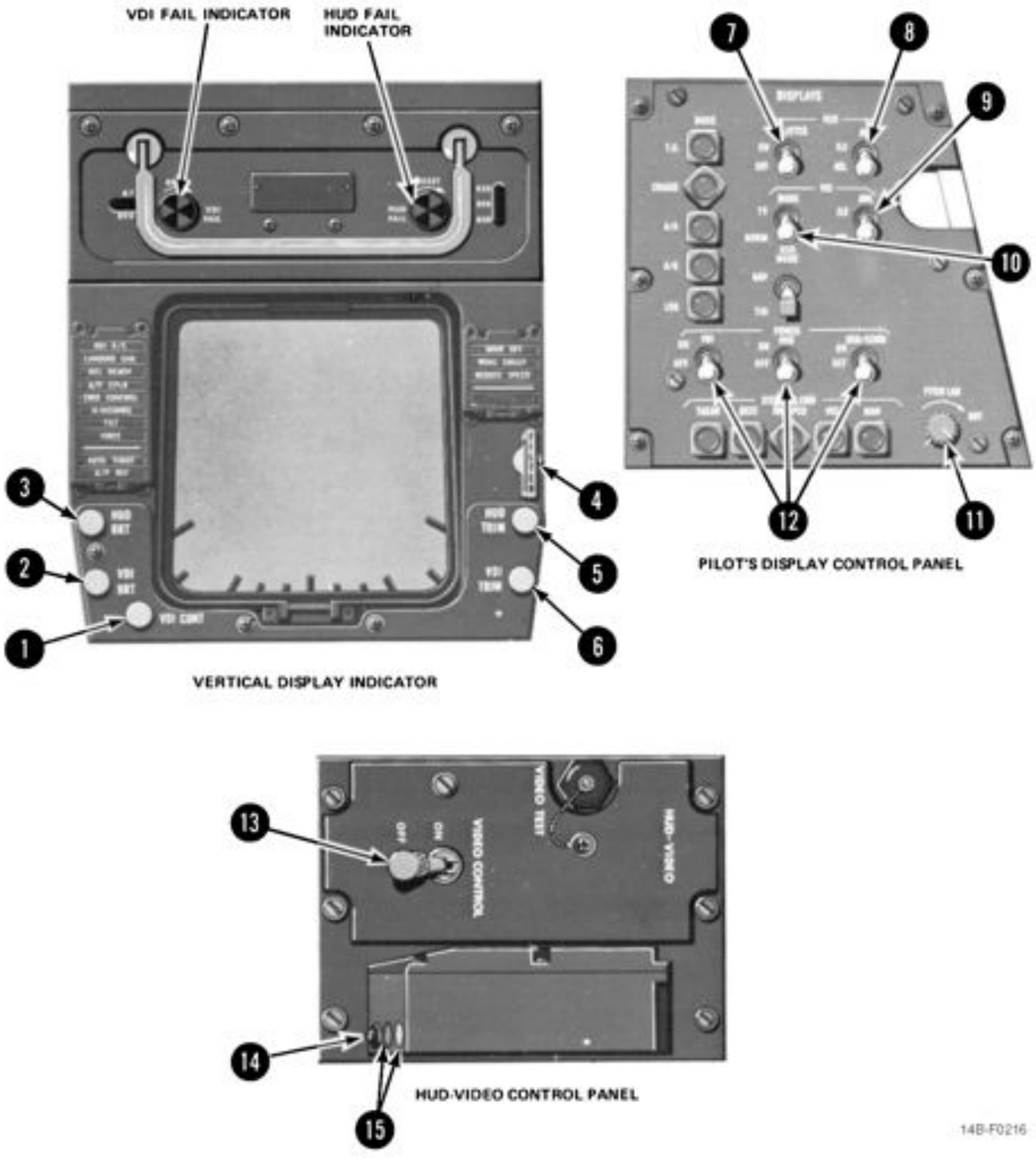


Figure 22-3. VDI and HUD Controls (Sheet 1 of 2)

NOMENCLATURE	FUNCTION
1 VDI CONT control	Allows pilot to vary VDI contrast on display.
2 VDI BRT control	Allows pilot to vary VDI brightness.
3 HUD BRT control	Allows pilot to vary HUD brightness.
4 FILTER handle	When extended, inserts filter on HUD for night flying.
5 HUD TRIM control	Allows pilot to adjust pitch lines on HUD display.
6 VDI TRIM control	Allows pilot to adjust pitch lines on VDI display.
7 HUD DECLUTTER switch	Placing the switch to ON reduces the amount of symbology on HUD.
8 HUD AWL switch	ILS — Selects ILS (AN/SPN-41) display presentation on HUD during landing phases. ACL — Selects ACL (AN/SPN-42) display presentation on HUD during landing phases. Normally left in ACL.
9 VDI AWL switch	ILS — Selects ILS (AN/SPN-41) displays on VDI. ACL — Selects ACL (AN/SPN-42) displays on VDI. Normally left in ACL.
10 VDI MODE switch	TV — Selects TCS display. NORM — VDI displays format selected by display MODE switch.
11 PITCH LAD control	Controls the intensity of pitch ladder on HUD.
12 POWER switches	Three separate switches are provided for ON-OFF power control of the VDI,HUD, and HSD/ECMD. All three switches must be set to ON to satisfy OBC. In the event of display loss caused by electrical power transients, display may be restored by cycling the appropriate ON-OFF switch.
13 VIDEO CONTROL switch	ON — Provides electrical power for operation of the control television sensor (CVS) camera. Camera is started and stopped by using the first detent of trigger switch. OFF — Turns off electrical power to the CTVS camera.
14 BIT button	Depressing and holding button activates an end-to-end BIT of the CTVS.
15 BIT lights	Amber light indicates degraded CTVS operation. Momentary illumination is normal when initiating CTVS BIT. Steady green light during CTVS BIT indicates successful BIT.

Figure 22-3. VDI and HUD Control (Sheet 2)

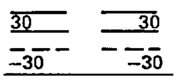
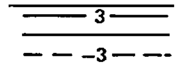
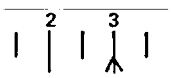
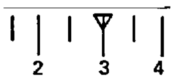
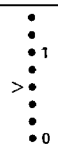
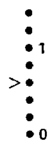
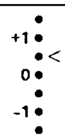
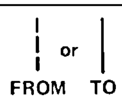
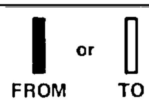
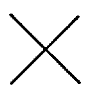
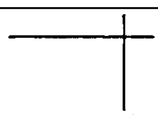
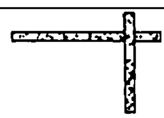
HUD SYMBOL	VDI SYMBOL	NAME	FUNCTION
		Aircraft reticle	Depicts own aircraft wings. When lined up with horizon, aircraft is in straight and level flight.
		Horizon	Demarcation point between ground and sky textures on VDI. Represents horizon with respect to aircraft, and changes orientation with change in aircraft pitch or roll.
		Pitch lines	Indicates with respect to aircraft reticle pitch attitude. In cruise and A/A mode, HUD pitch lines have a 4:1 compression ratio. Dotted lines indicate a negative pitch. Solid lines indicate positive pitch. Pitch lines above the magnetic heading scale are blanked.
		Magnetic heading (AHRS or WCS via CSDC)	Indicates magnetic heading with respect to index mark.
	N/A	Radar Altimeter Scale	Indicates altitude derived from radar altimeter. Scale from 0 to 1,400 feet in 200-foot increments and has a movable pointer. Only available in takeoff and landing modes.
	N/A	Barometric Altimeter Scale	Indicates altitude derived from CADC pressure altitude. Scale from 0 to 14,000 feet in 2,000-foot increments. Available in A/G and tarps modes. Altitude is referenced to 29.92 inches Hg.
	N/A	Vertical Speed Indicator	Indicates rate of altitude change. Scale is from –1,500 to +1,500 ft/min 500-foot increments. Appears on the left side of the HUD in takeoff and landing modes.
		Tacan Deviation Bar (tacan via ICSDC)	Indicates difference between bearing to tacan and selected tacan radial. Deviation limited to ±5.625° tacan deviation on the VDI, and ±3° tacan deviation on HUD. Never leaves field of view. Limit at edge nearest selected tacan radial.
		Breakaway	Appears as a flashing symbol at a 3-cycle per second rate in the center of field-of-view when range-to-go-to minimum or safe pullup point is zero. Symbol is commanded by the WCS computer or by D/L, depending on mode of operation.
		Precision course Vector	Consists of two independent vectors (vertical and horizontal), which form a cross pointer. Elevation glide slope information positions horizontal vectors, whereas vertical vector is positioned by azimuth glide slope information. Also used in D/L bombing modes.
	N/A	Velocity Vector	Indicates direction of ground track velocity vector (where aircraft is going, not where it is pointed).
	N/A	Angle of attack error (CADC via CSDC)	Position in relation to aircraft reticle indicates angle-of-attack error. Positioned by true AOA. Small center horizontal bar indicates zero error. When in line with aircraft reticle, AOA is 15 units (10.31°). If below aircraft reticle, AOA is too high; above aircraft reticle indicates AOA is too low. Displayed in landing mode only.
-ORD G, SW,- SP/PH 0, 1, 2, 3, 4, 5, 6 14B-F0217	SW, SP/PH only 0, 1, 2, 3, 4, 5, 6 (GUN and ORD are not displayed)	Armament Ready Legends	ORD — indicates bombs or rockets selected, or bombs and guns selected (A/G GUN switch on ACP set to MIXED) G — indicates gun is selected or gun and bombs are selected (A/G GUN switch on ACP 6 set to OFF). Number under G indicates rounds remaining in hundreds (6, 5, 4, 3, 2, 1, 0). In GSS with MASTER ARM OFF number indicates trigger squeeze count. In GSS with MASTER ARM ON or OFF, number 7 indicates bullets at target range. SW, SP/PH — indicates missile type selected (Sidewinder, Sparrow or Phoenix) and the numbers (0 to 6) indicates number of missiles ready for launch.

Figure 22-4. VDIG Symbology (Sheet 1 of 3)

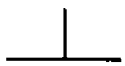
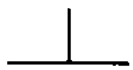
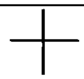
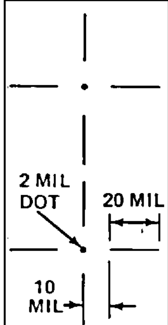
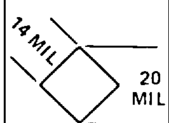
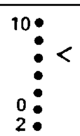
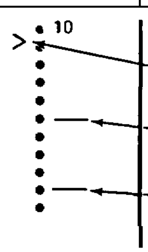
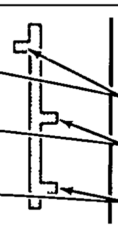
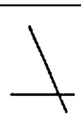
HUD SYMBOL	VDI SYMBOL	NAME	FUNCTION
		MASTER ARM switch off	An X symbol through armament ready legend indicates MASTER ARM switch on ACM panel is OFF. Disappears when MASTER ARM switch is set to ON.
		Steering Tee	Provides elevation and azimuth steering in the air-to-air modes when a single target track exists. Type of steering (pursuit, collision, etc.) is dependent on weapon selection and the mode selected on the PTID by the RIO. May also provide azimuth steering only on the VDI in TWS. Aircraft steering is accomplished by aligning and maintaining the vertical and horizontal bar of the inverted T with the aircraft reticle center dot. Steering sensitivity on the HUD is 26.5° per inch, on the VDI 25° per inch
	N/A	Boresight Reference	Symbol is a set of crosshairs fixed on the HUD and used to represent the armament data line (ADL) of the aircraft. Located 5.03° above aircraft reticle.
	N/A	Moveable Reticle (Impact Point)	Serves as an optical sight for A/A gunnery and A/G weapons delivery. In A/A gunnery, it can be positioned manually using the elevation lead control or automatically by the computer in the MMGS mode. In MMGS, indicates the director solution (with PSTT) or LCOS 1,000 foot solution (all other cases). Stadiametric ranging techniques can be employed during manual gun mode. With SW selected, indicates AIM-9 seekerhead position (aircraft with AFC 713 and ECP-PMS 260). With PH/SP or OFF selected, indicates TCS LOS. In A/G modes indicates instantaneous weapon impact point. Positioned by the computer in all modes except manual. In the manual mode, it is positioned by the elevation lead control. The computer positions the symbol based on the ballistics of the bomb, wind conditions, and various aircraft parameters. Must overlay the target at the moment of release.
	N/A	Target Designator	In A/A modes, indicates sensor LOS or optical sight for A/A gunnery. With PH/SP/GUN or OFF selected. Indicates radar STT LOS. With SW selected, indicates radar STT or TCS LOS. If target is not within HUD FOV, symbol is positioned at edge of target. In MMGS, indicates sensor LOS (or BATR) with a PSTT, or LCOS 2,000 foot solution without a PSTT. In A/G modes symbol is positioned by pilot via target designate switch to indicate desired target for weapon delivery computations.
	N/A	Closure Rate	Indicates closing velocity from –200 to +1,000 knots between aircraft and target.
		Target Range Scale (azimuth range bar) Target Range Mark Maximum Range Mark Minimum Range Mark	Appears on right side of HUD during A/A modes. Scaling determined by RIO selecting RANGE pushbuttons on the DDD panel. On VDI, range scaling is indicated in lower left corner of display. Limits are ± 35° in horizontal. Appears on left side of VDI during A/A modes, except in STT when it is located at target azimuth. Indicates range to target. Indicates maximum range for weapon launch. Indicates minimum range for weapon launch.
	N/A	Upper Solution Cue	Measure of instantaneous weapon range, constrained to motion on bomb fall line. Displayed with respect to velocity vector to indicate range to-go to weapon release. When it crosses the velocity vector symbol, computer commands a weapon release.
	N/A	Lower Solution Cue	Measure of maximum range of weapon calculated from instantaneous aircraft position, constrained to motion on the bomb fall line and used in conjunction with velocity vector to indicate range to-go-to in range. In range when cue crosses velocity vector and indicates weapon can reach target if plot executes a pullup. Appears after designate.

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Figure 22-4. VDIG Symbology (Sheet 2)

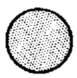
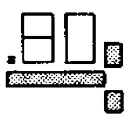
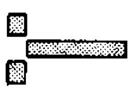
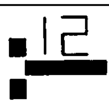
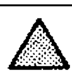
HUD SYMBOL	VDI SYMBOL	NAME	FUNCTION
	N/A	Pullup Cue	Measure of range at which a 4 g pullup is required to clear weapon fragmentation pattern or ground. Positioned directly below velocity vector. Used in conjunction with velocity vector to indicate range-to-go to minimum safe pullup point, when one cross the other.
	N/A	Bomb Fall Line (BFL)	Determined by velocity vector and weapon impact point used to acquire target in azimuth and present post designate steering in conjunction with velocity vector. Angle of line is an indication of wind direction and velocity.
N/A		Ground Texture	Simulated ground patterns to give better relationship between sky and ground. Consists of dark green trapezoids on a lighter background. Sky texture is a uniform light green. Size and spacing of ground texture are arranged to give perspective to the display. Ground texture remains parallel to the horizon line and provides a basic A/C attitude reference compatible with heading change. Ground texture moves toward the pilot and emanates from horizon to simulate motion.
N/A		Roll Pointer and Indices	Indicates roll position. Indices fixed at 0°, ±10°, ±20°, ±30°, ±45° and ±60° and are permanently fixed to VDI faces with opaque fluorescent red tape. Pointer is generated by VDIG and moves across the indices.
N/A		Allowable Steering Error (ASE)	Circle located around aircraft reticle indicates steering error allowed for launching a Sidewinder, Sparrow or Phoenix in the normal mode. Size of ASE circle is determined by the magnitude of the allowable error.
N/A		Target Symbol	IR tracked target. Symbol is a bright flashing square. Not used.
		DATA LINK SYMBOLS	
N/A		Reference	Continuously displayed symbol appears on each side of display opposite wings of A/C reticle. Used as a reference in determining errors in D/L commanded altitude and airspeed.
N/A		Commanded Airspeed Error	Positioned relative to reference. Two vertically movable reference squares indicate either Mach or knots error dependent on control station. Fly-to-type; if above reference indicates airspeed below commanded, airspeed should be increased to bring symbol back down. When bisected by referenced, the A/C is at commanded airspeed.
N/A		Commanded Mach Numeric	Numeric printed on display above reference. Indicates commanded Mach to nearest twentieth. Range is from 0.4 to 3.5 with 0.4 to 1.0 in increments of 0.05 and 1.0 to 3.5 in increments of 0.1. **Note** Will always differ from command Mach bug on the Mach/airspeed indicator by 0.2 or 0.3 because commanded Mach can only be transmitted by TDS in 0.05 increments starting at 0.38.
N/A		Commanded Altitude Error	Positioned relative to reference symbol. Fly-to type; if error below reference, it indicates A/C altitude is above commanded and A/C must be pointed down to bring the symbol back up reference.
N/A		Commanded Altitude Numeric	Numeric printed on display above references. Indicates commanded altitude from 0 to 99,000 feet. Only 2 digits are displayed (0 to 99 numerics).
N/A		Command Heading	Positioned relative to magnetic heading scale. Can be positioned by WCS computer or D/L depending on steering submode selected. For destination steering, indicates heading is beyond display scale limits, symbol is pegged at edge nearest commanded heading.
N/A		Time-To-Go	Positioned on range bar during D/L bombing to indicate time-to-go in seconds before weapon release. However target range is not displayed. Total length of the bar represents 32 seconds. Displayed at a fixed position 1.5 inches to left of center.

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Figure 22-4. VDIG Symbology (Sheet 3)

The HUD provides a combination of real-world cues and flight direction symbology projected directly on the windscreen. The display is focused at Infinity, thereby creating the illusion that the symbols are superimposed on the real world (and so that visual cues received from outside the aircraft re not obscured). The pilot usually steers based on his interpretation of the visually observed real world.

The HUD presentation is generated entirely by calligraphic means. The brightness of the symbols is set manually and automatically adjusted so that they are visible under any ambient condition. Symbology for the HUD is basically attack oriented, and includes symbols for steering, target, target range, minimum range, release range, closure rate, and armament legends. A moving reticle, bomb impact line, and velocity vector are included for air-to-ground attacks. The moving reticle symbol is aircraft stabilized in both manual and automatic weapon delivery modes. The HUD also displays attitude, flight situation, and command information, primarily for the landing mode.

The overall field of view of the HUD is 20°. The optics exit port is 8 inches in diameter. Parallax error has been minimized over the entire field of view in order to improve the accuracy of the gunnery and bombing modes.

22.1.4.1 HUD Circular-Polarized Filter. A circular-polarized filter is added to the windshield-projected HUD. The filter fits on top of the Fresnel wedge and is used to eliminate excessive sun reflections. However, installation of this filter does reduce HUD brightness somewhat and the HUD intensity must be set at a higher reading. Installation of the HUD filter will extend beyond the present outline of the indicator, but this will not affect over-the-nose visibility.

22.1.4.2 Pitch Ladder. The pitch ladder provides attitude reference for basic flight control. The symbol is driven by inputs from the inertial navigation system during normal operation and from the attitude heading and reference set if selected or when the inertial measurement unit fails. The pitch lines maintain an orientation parallel to the horizon. Scaling depends on the flight mode selected (see Figure 22-5) For takeoff, landing, and air-to-ground operations, the HUD has a 1:1 pitch line compression with a pitch line displayed every 5° up to ±30° and in 10° increments up to ±90°. The A/A and cruise HUD displays have a 1: 4 pitch compression with 30° increments up to ±90°. Pitch lines above the HUD magnetic heading scale are blanked. The VDI, on the other hand, has its pitch lines determined by the total amount of pitch attitude displayed on the VDI. For A/A and A/G, 130° of pitch is displayed with the pitch lines every 30°. Takeoff, cruise, and landing display a total of 65°. However, takeoff and cruise have pitch lines graduated every 10° between ±60°; the landing displays are also graduated every 5° between ±30°.

22.2 VDIG TEST MODES

The test modes are initiated by the pilot when he selects INST on the MASTER TEST panel. During his instrument checks, the VDIG is tested by observing various displays on the HUD and VDI. These displays are static and are conditional on the mode selected. Figure 22-6 shows each of the four test displays. Selecting T.O. or CRUISE (test display 1) gives a presentation indicative of whether the deflection or brightness circuits of the indicator are operating correctly. Each of the other three modes (A/A, A/G, or LDG) generate presentations that depict all the symbols that are available in that mode and its submodes and is a check of the converter unit.

If the VDI or HUD is blank, the pilot should cycle the POWER switches so that power is turned off and then back on. A blank screen may occur during a power interrupt and may last up to 20 seconds after a long interrupt.

22.2.1 VDIG System Checkout. When power is applied, the VDI and HUD converter and indicators continuously perform self-tests. If a failure is detected, the BIT indicator on the respective unit is turned on. In addition, results of the tests are applied to the CSDC. The CSDC formats the test data and, if a failure exists, routes the information to the weapons control system computer under on-board checkout program control for display of a vertical display indicator group acronym on the tactical information display and the HSD if PTID repeat is selected. The following table provides DIG acronym definitions:

DIG ACRONYM	DEFINITION
DIG C	VDI converter
DIG CH	HUD converter
DIG I	VDI indicator
DIG IH	HUD indicator

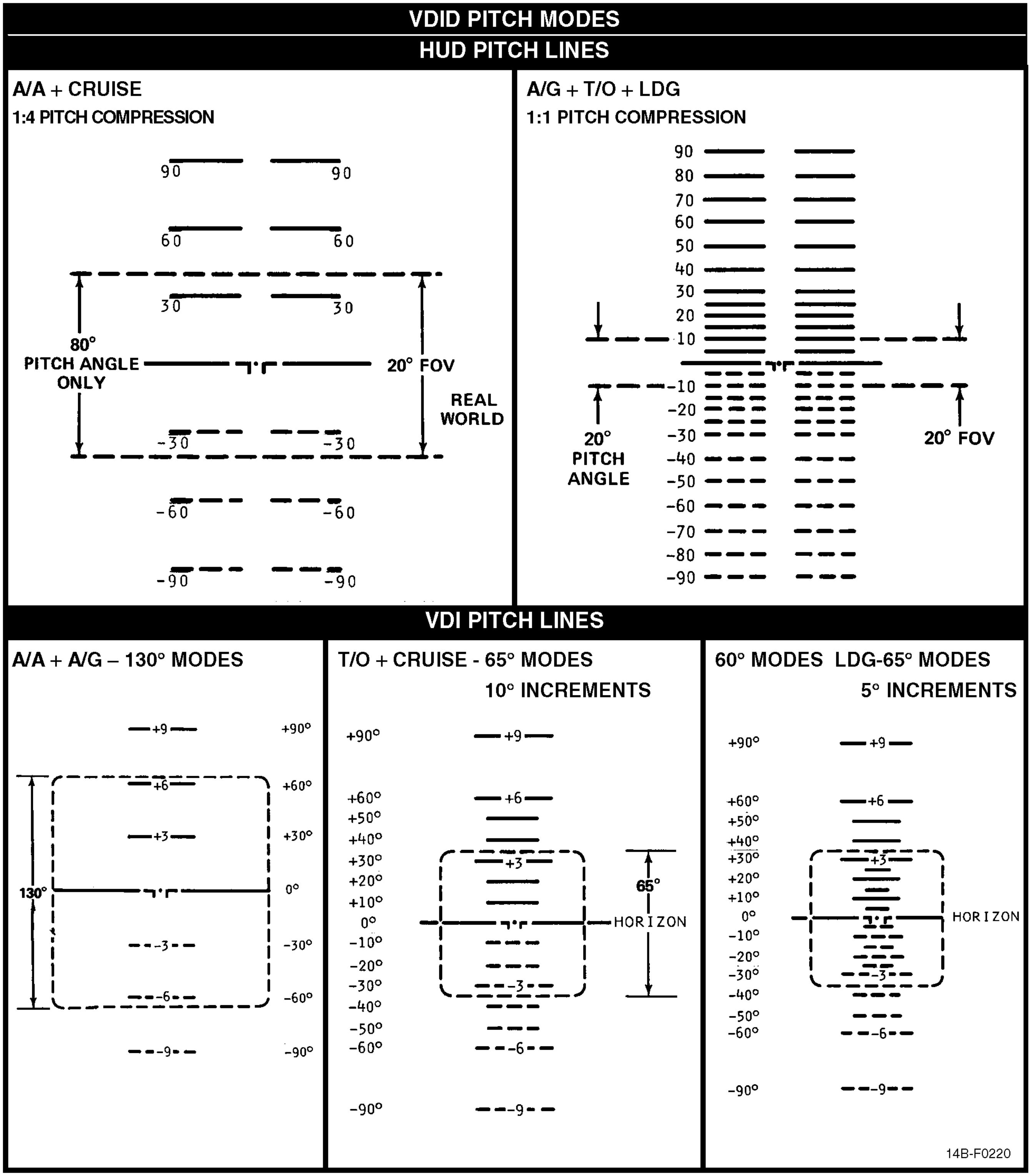


Figure 22-5. VDIG Pitch Modes

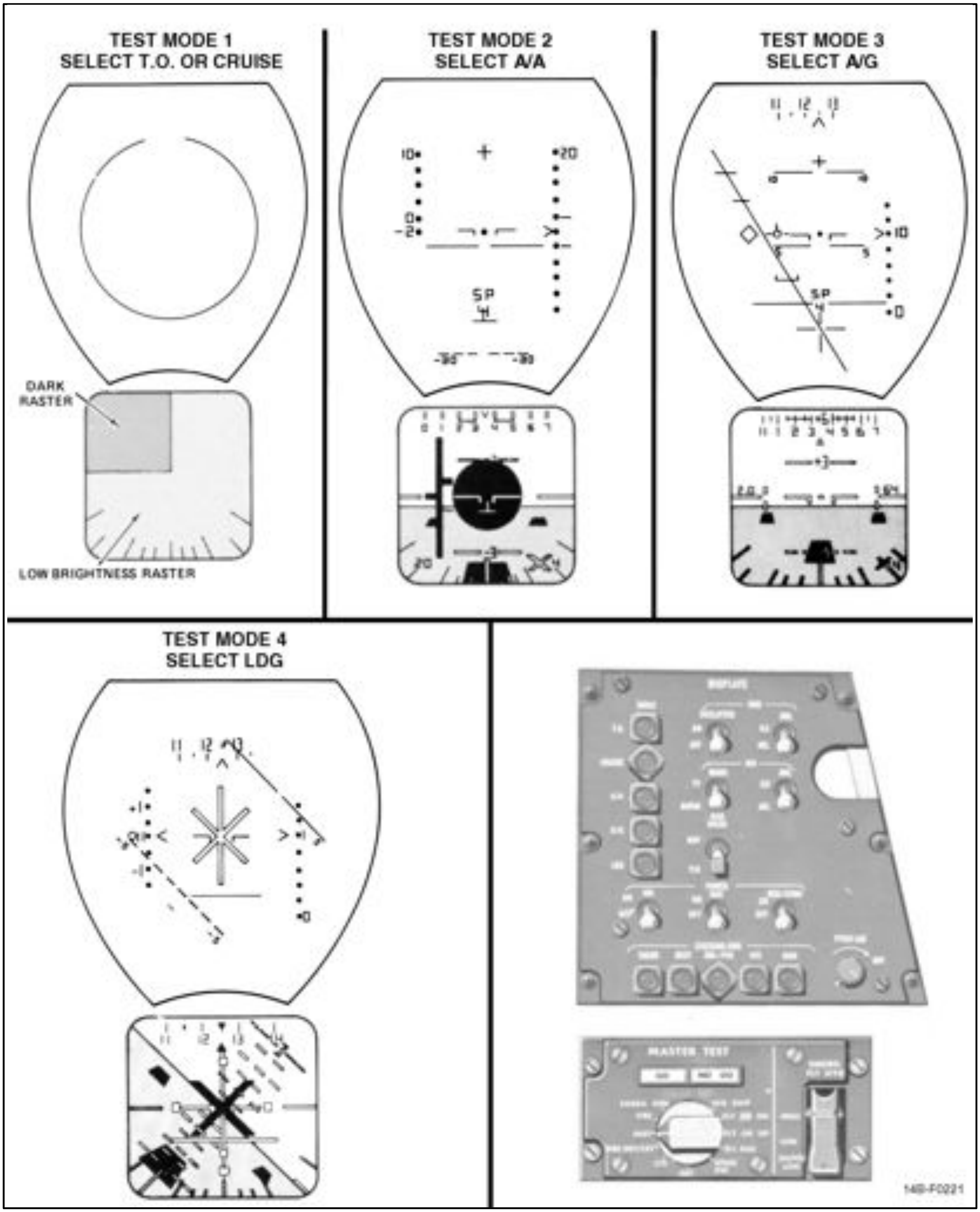


Figure 22-6. VDIG Test Displays

CHAPTER 23

Programmable Multiple Display Indicator Group

23.1 PROGRAMMABLE MULTIPLE DISPLAY INDICATOR GROUP (CP-2212B/ASA-79)

The PMDIG provides the pilot and RIO with navigation or tactical data in alphanumeric and symbolic form. The PMDIG is composed of the pilot horizontal situation display, the RIO multiple display indicator, and a processor. The horizontal situation display displays two types of data but the multiple display indicator is capable of displaying only navigation data. When both indicators operate in the navigation mode and any one of four submodes, they display data for the same submode. The PMDIG also has built-in-test capabilities for system checks on the ground and in flight.

The PMDIG presents the following navigation information: magnetic heading of the aircraft, command heading, command course, tacan bearing, automatic direction finder bearing, data block, and range readout. The data block presents alphanumerics of the aircraft's true airspeed, windspeed and direction, and groundspeed. Range to tacan station, a RIO-inserted destination, or a RIO manually set range is displayed on the HSD range readout. The aircraft heading (a compass rose read against a lubber line) is presented in all display modes.

23.1.1 Horizontal Situation Display. The HSD is the pilot's primary navigation display. The HSD is also capable of repeating the RIO tactical information display presentation.

The HSD indicator and the multiple display indicator are formatted in horizontal plan position indicator or in horizontal plane, depending on display mode. The HSD display consists of a cathode ray tube, providing a 5-inch diameter (approximate) display format. The display format is dependent on the position of the HSD MODE switch (NAV or PTID). The HSD provides line-written symbols that are internally generated for the navigation display and are received from associated systems as deflection and video signals during PTID modes.

23.1.2 PMDIG Processor. The PMDIG processor processes data inputs from other aircraft systems for display on the HSD and electronic countermeasures display. Based on the mode selected and navigation sub-mode selected, the processor sets the appropriate priority for each indicator.

Depending on the navigation submode selected, the unit processes data representative of tacan deviation and bearing, groundspeed, windspeed and direction, range to destination, tacan range, and true airspeed to enable display of alphanumerics, symbols, or both.

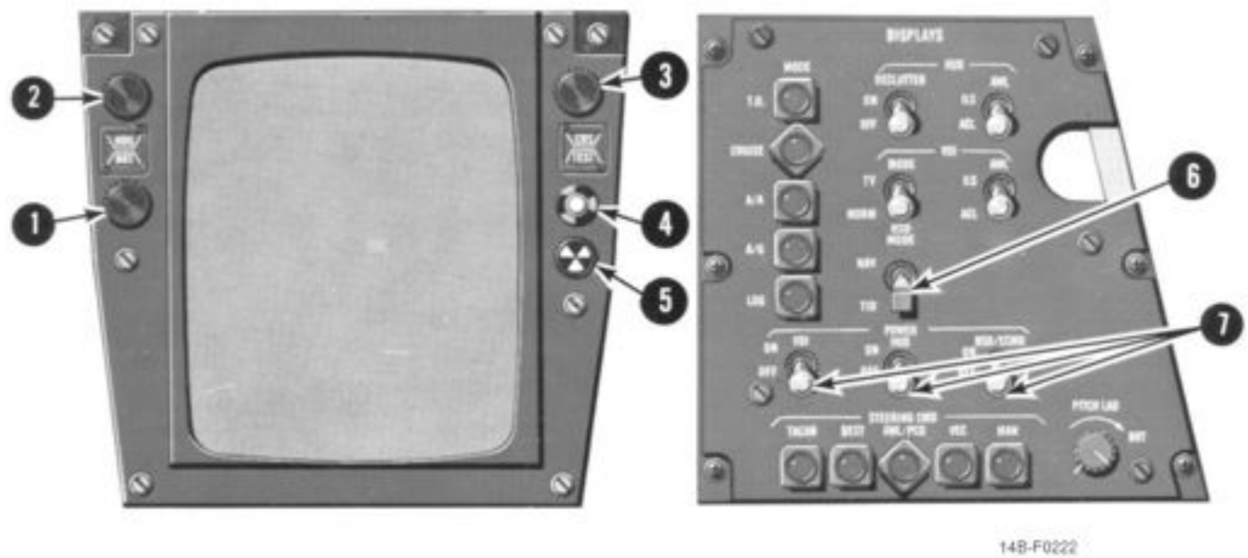
23.1.3 PMDIG Controls. Controls for the PMDIG are provided for the pilot and RIO to give each control of his respective indicator. The pilot controls for the HSD are on the pilot display control panel (see Figure 23-1). The display format depends on the position of the HSD MODE switch (NAV or PTID). Additional controls are on the panel surrounding the HSD tube face.

23.1.4 PMDIG Modes. The system operates in navigation or PTID repeat.

23.1.4.1 Navigation Mode. The navigation mode is selected by the pilot with the HSD MODE switch on the pilot display control panel. When the navigation mode is initiated, any one of four navigation submodes (tacan, destination, vector, or manual) can be selected. They are selected on the display control panel with STEER CMD pushbuttons.

Note

Refer to Chapter 20 for detailed description of navigation and steering modes.



NOMENCLATURE	FUNCTION
(1) BRT control	Allows pilot to vary brightness. Clockwise rotation increases brightness.
(2) HDG control	Enables pilot to rotate heading reference bug in tacan mode.
(3) CRS control	Enables pilot to set desired course in manual (MAN) and tacan mode.
(4) TEST pushbutton	Allows pilot to reset HSD power monitor when indicator goes blank due to overload and also enable HSD IR field test display.
(5) BIT indicator	Indicates component status. Solid black indicates system is normal. Failure is indicated by white flags. Indicator is reset by rotating it clockwise.
(6) HSD MODE switch	NAV — Presents navigation steering information associated with STEER CMD mode selected. PTID — Repeats information from PTID except when RIO selects TV on the PTID. The PTID attack symbology is then presented.
(7) HSD/ECMD POWER switch	Provides ON-OFF power control for both HSD and electronic countermeasures display (ECMD).

Figure 23-1. Horizontal Situation Display Controls

The navigation mode provides symbolic and alphanumeric display of navigation information for the selected submode (Figure 23-2). The DATA/ADF switch allows display of certain navigational information on both indicators.

23.1.4.2 PTID Repeat Mode. The PTID repeat mode provides display of the PTID presentations on the HSD (Figure 23-3) and is initiated with the MODE switch on the PDCP. If the RIO selects TV on the PTID, the HSD will continue to present PTID attack symbology while the PTID displays TV.

Note

During PTID repeat mode operation, the HSD may go blank in the course of any AWG-9 transients, recycles, etc. In this case, perform HSD reset by depressing the TEST pushbutton on the HSD front panel.

23.1.4.3 Test Mode. The HSD and electronic countermeasures indicator can be tested for an indication of whether its deflection or brightness circuits are operating correctly (see Figure 23-4). The test mode can be initiated by the pilot or RIO by depressing the TEST pushbutton on his indicator.

For the pilot, the HSD will display a typical infrared display (for the rear-looking IR system, which may be installed at a later date). This is a test pattern and is not indicative of whether the IR system is functioning properly.

23.1.5 PMDIG System Checkout. When power is applied to the PMDIG, both indicators and the processor perform individual self-tests. If a failure is detected, the self-contained BIT indicator of the failed assembly goes on. In addition, self-test results are applied to the computer signal data converter. The CSDC formats the data and, if a failure exists, routes the data to the weapons control system computer for display on the PTID.

23.1.6 PMDIG Symbology. Figure 23-5 (Sheets 1 through 3) shows a pictorial representation of the PMDIG-generated symbology for navigation modes as they appear on the pilot and the RIO indicators. Symbology generated during PTID repeat mode is discussed in the Confidential Supplement (NAVAIR 01-F14AAA-1A).

NOTE

PILOT HAS NO VISUAL INDICATION OF WHICH DESTINATION THE RIO HAS SELECTED.

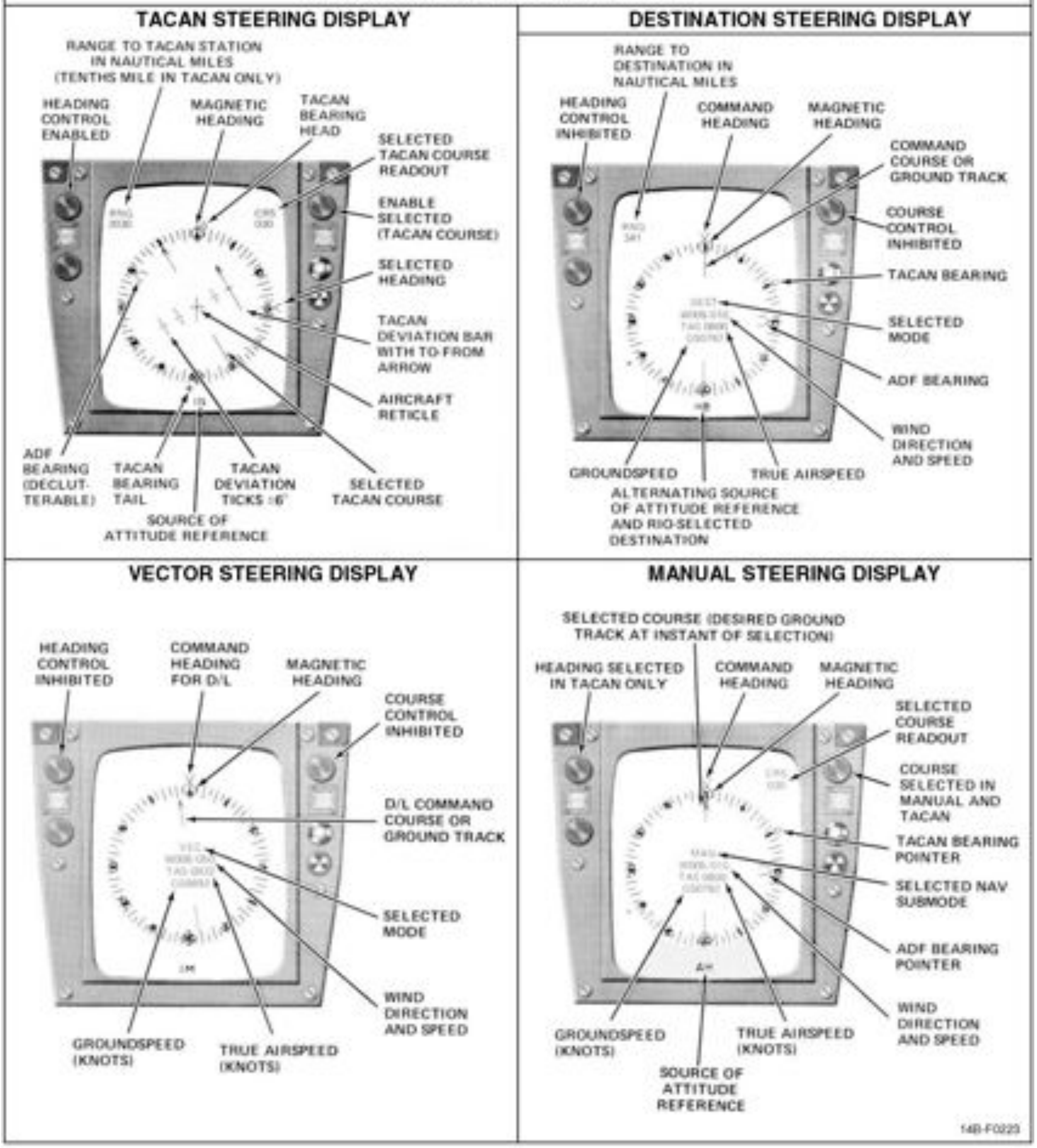


Figure 23-2. PMDIG Navigation Formats

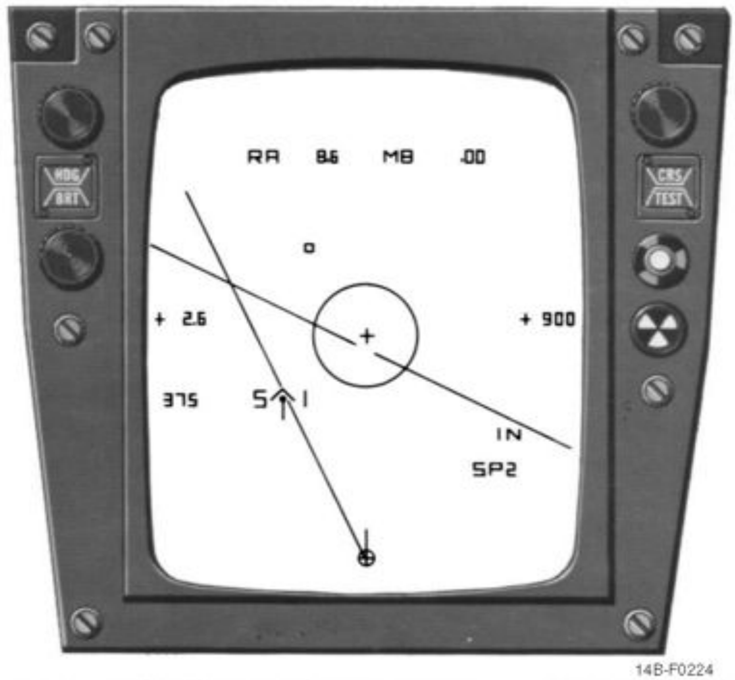


Figure 23-3. PTID Repeat Mode

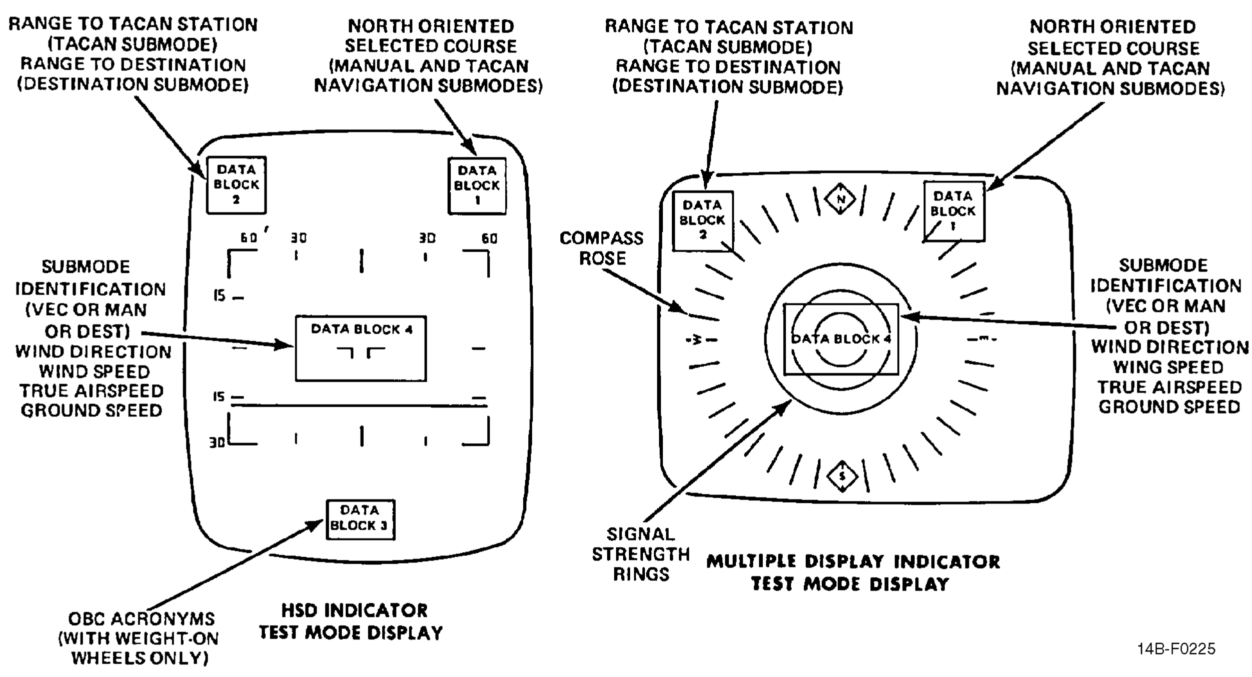
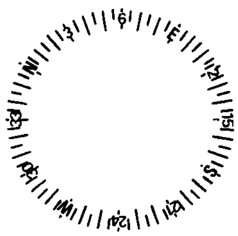
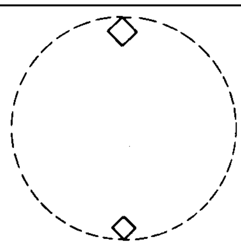
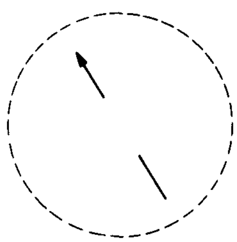
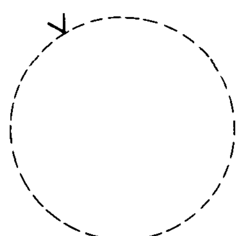
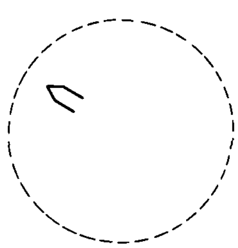


Figure 23-4. PMDIG Test Displays

NOTE

THIS FIGURE DEPICTS PMDIG GENERATED SYMBOLOGY ONLY. SYMBOLOGY GENERATED DURING PTID REPEAT MODE IS NOT ILLUSTRATED.

NAVIGATION SYMBOLOGY

SYMBOLOGY	NAME	FUNCTION
	NAVIGATION COMPASS ROSE	NAVIGATION COMPASS ROSE IN 5° INCREMENTS, NUMERIC SAT 30° INCREMENTS, AND CARDINAL POINTS AT 90° INCREMENTS. APPEARS IN ALL NAVIGATION MODES. COMPASS ROSE IS MODIFIED IN ECM MODES.
	NAVIGATION LUBBER LINE	AIRCRAFT NAVIGATION LUBBER LINE OR ECM LUBBER LINE (WITH NAVIGATION OR ECM COMPASS ROSE) REPRESENTING NOSE AND TAIL OF AIRCRAFT. SHOWS MAGNETIC HEADING OF AIRCRAFT WITH RESPECT TO COMPASS ROSE.
	NAVIGATION COURSE SYMBOL	HEAD AND TAIL SYMBOL DEPICTING AIRCRAFT GROUND TRACK OR COMMANDED COURSE DURING DEST STEERING; SELECTED TACAN COURSE DURING TACAN STEERING; DATA LINK COMMANDED COURSE OR GROUND TRACK DURING VECTOR STEERING; OR SELECTED COURSE USING COURSE CONTROL DURING MANUAL STEERING
	HEADING SYMBOL	SELECTED OR COMMAND HEADING IN ALL NAVIGATION DISPLAYS (MANUALLY CONTROLLED BY HEADING CONTROL OR AUTOMATICALLY CONTROLLED BY WCS COMPUTER OR DATA LINK).
	ADF BEARING SYMBOL	ADF BEARING SYMBOL SHOWS DIRECTION OF NEAREST AUTOMATIC DIRECTION FINDING STATION (ADF SYMBOL IS DECLUTTERABLE ON ECM DISPLAY PANEL).

14B-F0226

Figure 23-5. PMDIG Symbology (Sheet 1 of 3)

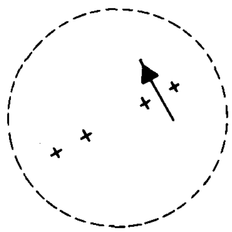
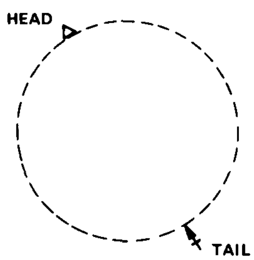
NAVIGATION SYMBOLOGY		
	FIXED AIRCRAFT SYMBOL	CENTERED IN NAVIGATION COMPASS ROSE AND DEPICTS AIRCRAFT WINGS AND ELEVATORS (ONLY IN TACAN MODE).
	TACAN DEVIATION BAR AND DEVIATION TICKS	DEVIATION BAR SYMBOL SHOWS TACAN STATION DIRECTION WITH DEVIATION TICKS (DEVIATION BAR MAY BE THE SAME DIRECTION AS THE COURSE ARROWHEAD TO STATION, OR 180° FROM THE ARROWHEAD FROM STATION). TICKS ARE 6° APART.
	TACAN BEARING SYMBOL	HEAD AND TAIL TACAN BEARING SYMBOL SHOWS DIRECTION OF SELECTED TACAN STATION. ARROWHEAD SHOWS COURSE TO STATION. 14B-F0227

Figure 23-5. PMDIG Symbology (Sheet 2)

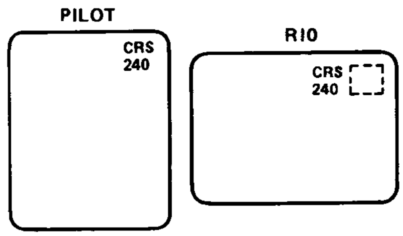
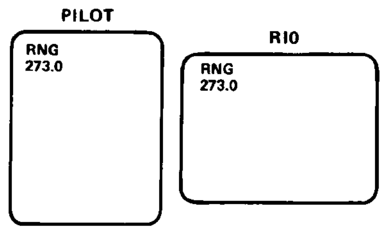
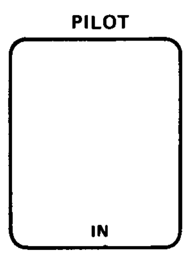
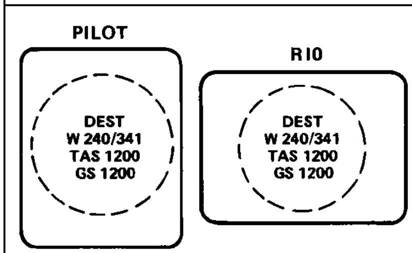
MULTIPLE DISPLAY INDICATOR GROUP PART BLOCKS		
SYMBOLOGY	**NAME**	**FUNCTION**
	DATA BLOCK 1	HSD MANUAL OR COMMANDED SELECTED COURSE. MD, (MAN AND TACAN MODE ONLY).
	DATA BLOCK 2	RANGE TO DESTINATION IN MILES OR RANGE TO TACAN STATION IN TENTHS OF MILES (TACAN AND DEST MODE ONLY).
	DATA BLOCK 3 (HSD ONLY)	PREFLIGHT ALTERNATING DISPLAY OF SYSTEM FAILURES AS DETERMINED BY OBC AND SOURCE OF ATTITUDE REFERENCE. THE SOURCE OF ATTITUDE REFERENCE REFERS TO SYSTEM ACTUALLY DRIVING DISPLAY, NOT THE SYSTEM SELECTED BY THE NAV MODE SWITCH. REFER TO SECTION IX OF THIS MANUAL FOR DESCRIPTION OF THE OBC ACRONYMS THAT MAY BE DISPLAYED. THE SOURCE OF ATTITUDE REFERENCE ACRONYM MAY BE: IN — INERTIAL NAVIGATION MODE IM — IMU/AIRMASS MODE AH — AHRS/AIRMASS MODE IN FLIGHT ALTERNATING DISPLAY (1-SECOND RATE) OF SOURCE OF ATTITUDE REFERENCE AND THE RIO-SELECTED DESTINATION STEERING. THE SOURCE OF ATTITUDE REFERENCE IS THE SAME AS PREFLIGHT. THE DISPLAY OF SELECTED DESTINATION STEERING IS DETERMINED BY THE POSITION OF DEST STEERING SWITCH ON THE NAVIGATION CONTROL AND DATA READOUT PANEL.
	DATA BLOCK 4	1st LINE — SELECTED MODE OF DEST, VEC, OR MAN 2nd LINE — WIND DIRECTION (TRUE) AND WIND SPEED (KNOTS) CK SPEED ON AND LINE 3rd LINE — TRUE AIRSPEED (KNOTS) 4th LINE — GROUNDSPEED (KNOTS) 14B-F0228

Figure 23-5. PMDIG Symbology (Sheet 3)

CHAPTER 24

TARPS Subsystem

24.1 TACTICAL AIR RECONNAISSANCE POD SYSTEM

The TARPS establishes the F-14 as a multisensor reconnaissance aircraft with the flexibility for a wide range of reconnaissance missions. Specific missions include target generation, prestrike and poststrike photography, order-of-battle maintenance, lines of communication coverage, and maritime surveillance.

The TARPS sensors and ancillary equipment are contained in the pod's four compartments (Figure 24-1). The sensors are: serial frame camera (KS-87D); low-/medium-altitude panoramic camera (KA-99), or long-range standoff frame camera (KS-153A with 24-inch lens) and infrared reconnaissance set (AN/AAD-5A).

24.1.1 TARPS Pod (LA-610). The TARPS pod (Figure 24-2) is 207.5 inches long with a maximum cross-section of 26.5 inches. Total weight is approximately 1,750 pounds including film and sensor equipment. It is attached to the aircraft by an integral adapter that provides the pod with sensor control signals, data annotation signals, electrical power, and ECS support from the aircraft. Circuit breaker protection is provided through the ac left and right main circuit breaker panels and the dc main circuit breaker panel. The nonjettisonable pod is mounted to the aircraft on the station 5 weapon rail with an integral pylon adapter. Doors on the adapter provide access to electrical and ECS power test systems and sensor system circuit breakers.

The pod is designed for carriage throughout the flight envelope of the F-14 and is easily integrated with the aircraft weapon system. The subsonic drag index of

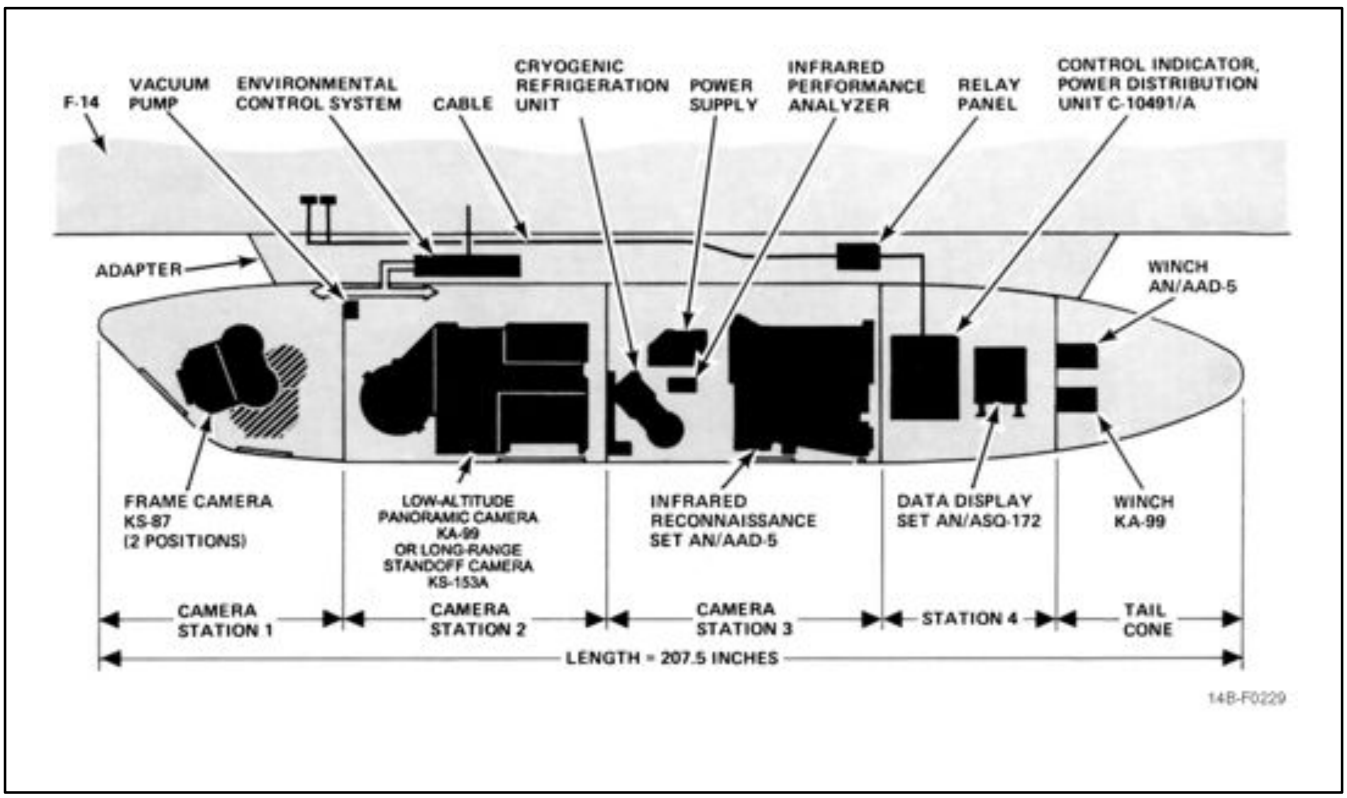


Figure 24-1. Tactical Air Reconnaissance Pod System

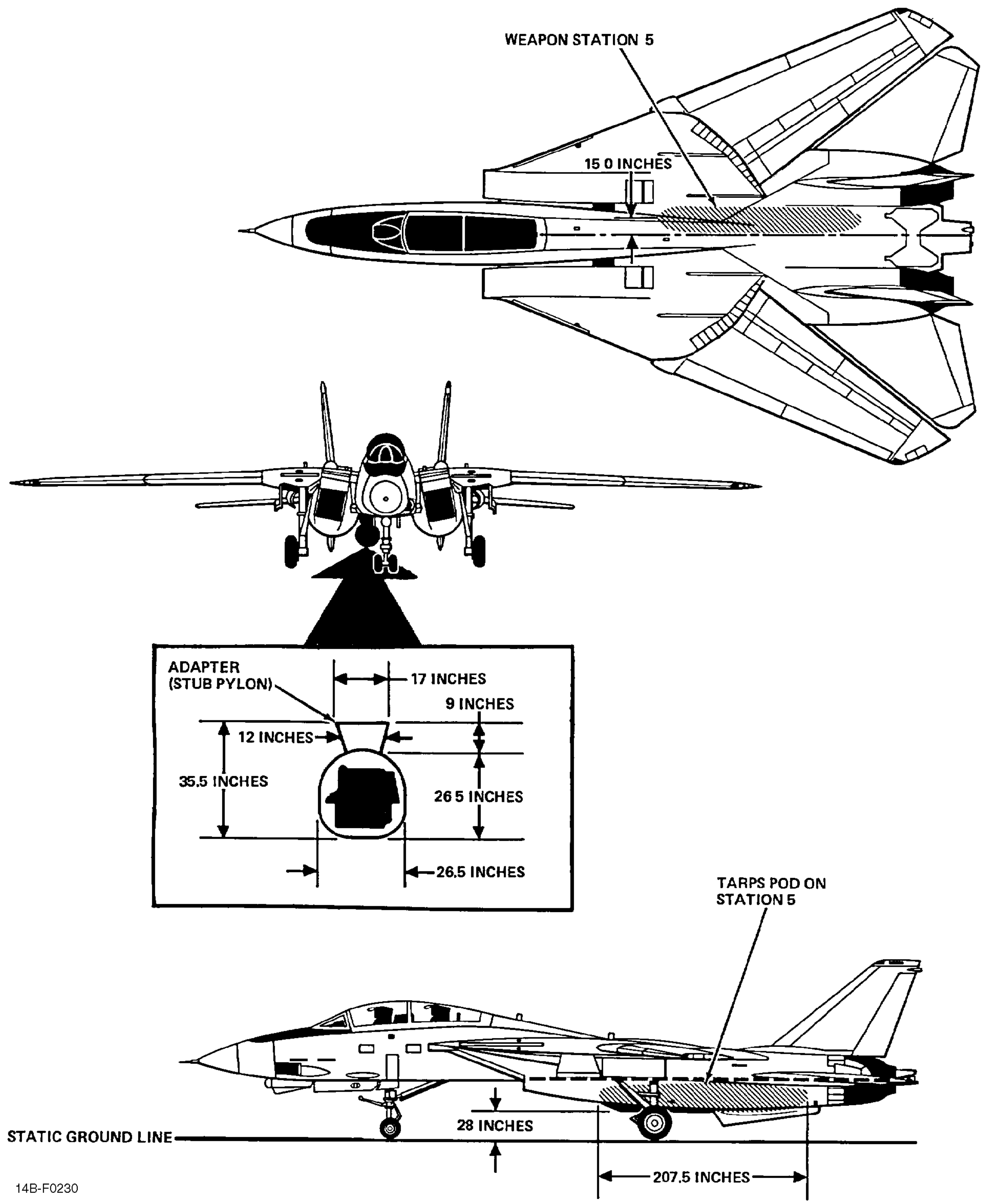


Figure 24-2. TARPS Pod General Arrangement

the pod with or without inert Sparrow ballast is 25 counts, which is congruous with all NATOPS performance charts and operating limitations.

The F-14/TARPS functional interface is shown in Figure 24-3 and Figure 24-4.

24.1.2 TARPS Equipment Circuit Breakers. The main power circuit breakers that control TARPS equipment are in the aft cockpit. FO–8 and FO–9 show their location. The circuit breakers are numbered and labeled as follows:

8D2 — COUNTING ACCEL/TARPS/FEMS

1F4 — RECON POD

2B1 — RECON HTR PWR PH A

2D1 — RECON HTR PWR PH B

2F1 — RECON HTR PWR PH C

2G4 — RECON ECS CONT AC

8F1 — RECON POD DC PWR NO. 2

8F2 — RECON POD DC PWR NO. 1

8F7 — RECON POD CONTR

8G7 — RECON ECS CONT DC.

24.1.3 Data Display System (AN/ASQ-172). The DDS performs three basic TARPS functions: (1) provides data to the recording head assembly (RHA) in all three sensors; (2) supplies necessary control signals to the individual sensors; and (3) provides the signal flow interface between the aircraft systems and the pod equipment.

24.1.4 TARPS Environmental Control System. The TARPS pod ECS supplies conditioned air for heating and cooling the pod interior and for defogging the camera windows. The aircraft ECS cooling air is piped into the pod adapter section, passes through a water separator that removes 75 percent of the moisture, then is routed through a heater and finally is ducted to each camera bay. The aircraft ECS-provided air is about 40 °F at sea level and about 0 °F above 30,000 feet. The pod ECS maintains the camera bay interiors between 70 to 90 °F. The ECS is initiated by the weight-on-wheels switch.

Warm air for defogging is routed to all three windows. The warm air is activated by a window sensor when the temperature falls below 65 °F. A shutoff valve stops the defogging air when the cameras are operating to avoid heat distortion of imagery.

24.1.5 Control Indicator Power Distribution Unit. The CIPDU consists of a sensor test module, three sensor control modules, an aircraft simulator module, and printed circuit boards. Located in bay 4, the CIPDU provides manually resettable fail indicators for each of the various pod sensors and major pod equipment to guide maintenance personnel in the identification of faulty WRAs. The CIPDU provides the capability of initiating and monitoring the BIT functions within the pod and a means of operating the sensors, individually or together, as a verification of proper operation following corrective maintenance or for preflight checkout. All pod equipment circuit breakers are on the front panel. The aircraft simulator module allows maintenance personnel to functionally check the pods components without activating the aircraft computer.

24.1.6 Controller Processor Signal Unit. The CPS cockpit displays provide the controls and information required by the RIO and pilot for operation and checkout of TARPS. The CPS is located in the aft cockpit left console (Figure 24-5) and contains the primary TARPS controls and indicators. Using the CPS with the tactical information display, the RIO has full control of TARPS except for circuit breakers. The controls and indicators on the CPS are described in Figure 24-5. Panel illumination of the CPS is accomplished with the rest of the cockpit lighting using the same controls.

24.1.7 Tactical Contingency Pod (AN/ALQ-167). The ALQ-167 provides TARPS aircraft electronic detection and deception jamming for self-defense from ground-to-air (G/A) and air-to-air (A/A) guided missiles. The pod is mounted on weapon rail 6 with a BRU-10/A bomb rack and a BRU-10 adapter. It is connected to the aircraft LAU-92 connector by an interface umbilical cable.

The control panel is in the RIO left outboard console and is the central controller for the pod. Circuit protection is provided through the STA 3/6 AIM-7/AIM-54 PUMP PH A, PH B, and PH C (1D1, 1D3, 1D7) and the LIQUID COOLING CONTR DC (8B4) circuit breakers. A weight-on-wheels interlock (right main landing gear) prevents radiation on deck.

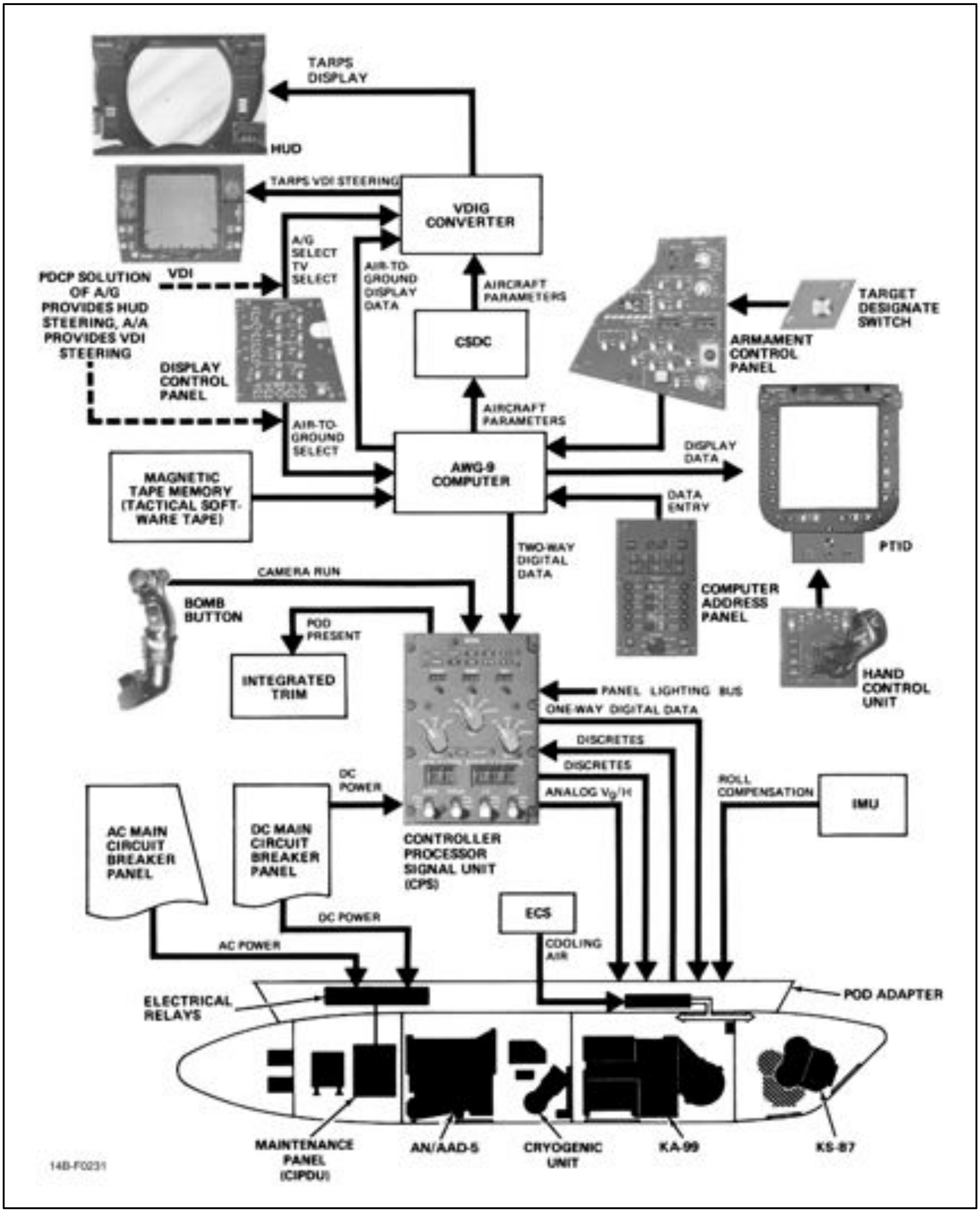


Figure 24-3. TARPS/F-14 Functional Interface

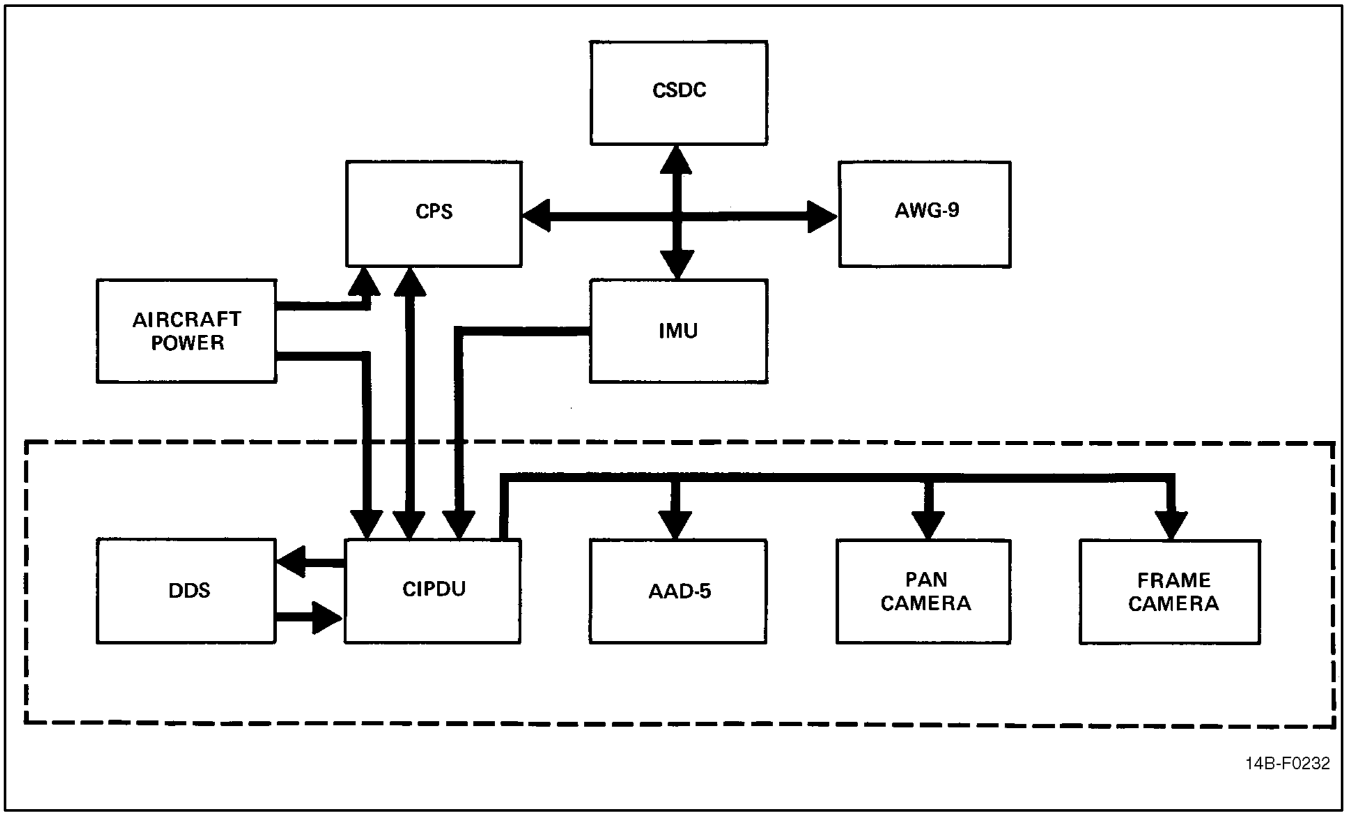


Figure 24-4. TARPS System Configuration

WARNING

Although the ALQ-167 is inhibited from radiating on deck by the weight-on-wheels switch, a malfunction could cause low-energy level radiation hazard to personnel. This radiation hazard area extends to 15 feet in front, 3 feet either side, and 3 feet above and below the transmit antenna.

24.2 TARPS TACTICAL INFORMATION DISPLAY SYMBOLOGY

The reconnaissance tactical situation is displayed for the RIO on the PTID using standard AWG-9 symbology. Additional TARPS alphanumerics are used to display time and range-to-go to the target, and range and time remaining to camera OFF. The PTID acronyms are unique to TARPS (see Figure 24-6). Figure 24-7 shows a typical PTID reconnaissance display.

24.3 TARPS MODE ENTRY

Upon reaching the target area, the flightcrew must perform the following steps to obtain the TARPS symbology.

24.3.1 Pilot

1. Selects either A/G (HUD steering) or A/A (VDI steering) on pilot display control panel.

2. Selects either destination or manual steering on the PDCP.

24.3.2 RIO

1. Hooks PTID menu select symbol.

2. Hooks REC on the full PTID menu.

Note

If TARPS and tactical air combat training system are required simultaneously, TACTS must be loaded from the MTM first. See NAVAIR 01-F14AAA-1A.

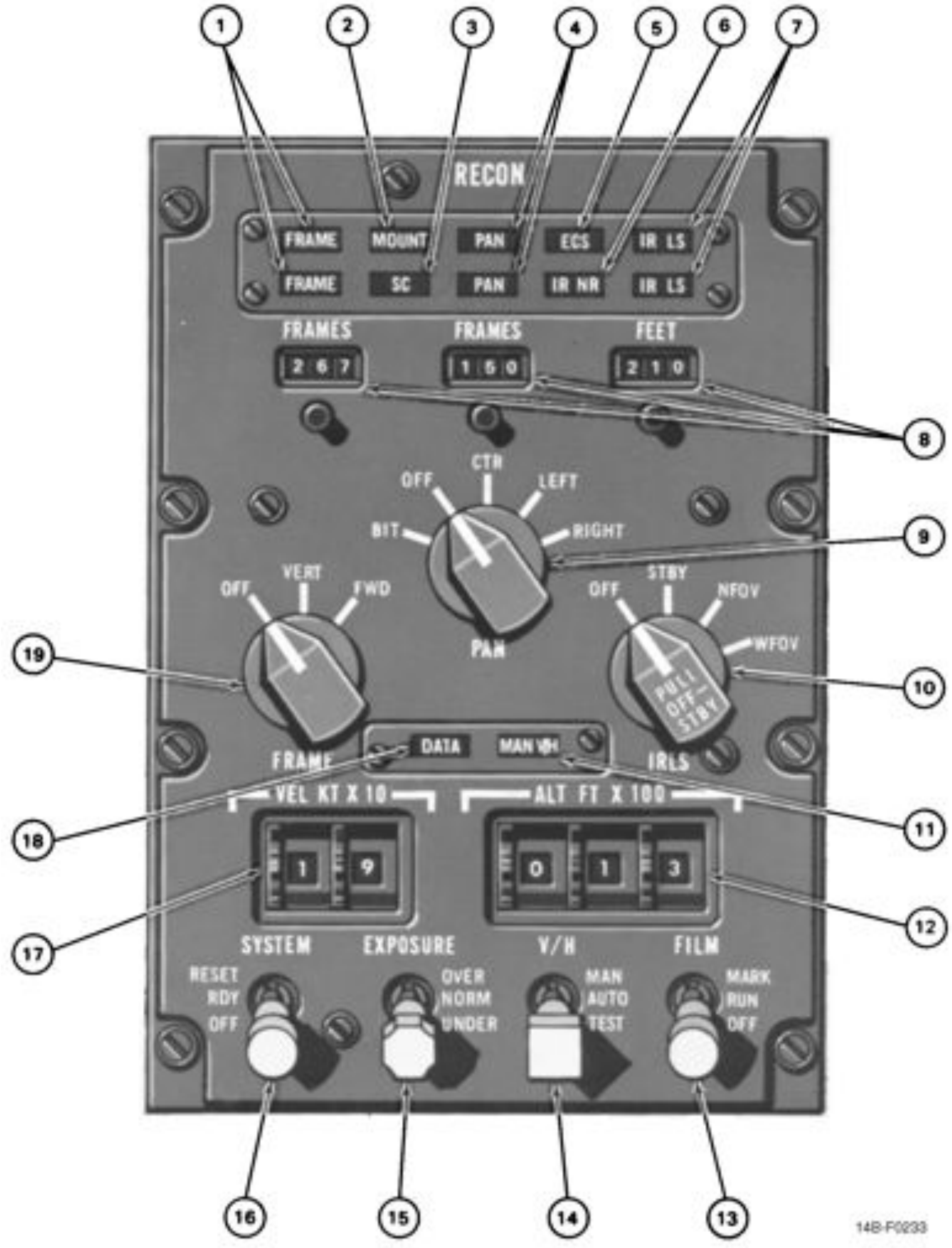


Figure 24-5. Controller Processor Signal Unit (Sheet 1 of 4)

NOMENCLATURE	FUNCTION
1 FRAME lights 1 Amber 1 Green	Green FRAME light flashes once per camera cycle when KS-87 is activated and no failure exists. Amber FRAME light illuminates if failure exist in KS-87 and green FRAME light goes off.
2 MOUNT light Amber	Illuminates indicating mount failure. This occurs when KS-87B fails to achieve directed position. (It may be firmly locked in position opposite to directed one.) CIPDU internal failure can also give mount failure indication.
3 SC (sensor control) light Amber	Illuminates when SC/DS has failed to furnish film motion compensation (FMC) or cycle commands to sensors. Failure to deliver formatted data on command to sensors will not show sensor control (SC) failure. Consequently, SC go indication can result in good sensor imagery operation but without data annotation.
4 PAN lights 1 Amber 1 Green	Green panoramic (PAN) light flashes once per camera cycle when KA-99A has been activated and no failure exists. Amber PAN light illuminates and green light goes out if failure occurs.
5 ECS (environmental control system light) Amber	Illuminates only under failure condition (compartment temperature below 0 °C or above 51 °C). ECS is automatically activated on takeoff by weight-on-wheels switch.
6 IR NR (IR not ready) light Amber	Illuminates when sensor is not sufficiently cooled. Cool down period is a maximum of 17 minutes. After cooldown is completed the IR NR light goes out for 25 seconds, then on for 80 seconds during BIT testing.
7 IR LS (R line scanner) light 1 Green 1 Amber	Green IR LS light illuminates when infrared sensor is activated. Green IR LS light flashes once per each foot of film exposed. Green IR LS indicator goes out and amber IR LS light illuminates if failure occurs in infrared sensor.
8 Frames and feet (indicators)	Display number of frames remaining in frame and pan cameras, and number of feet of film remaining in infrared sensor. Indicators are set initially as part of sensor servicing via reset knobs directly under indicators. Each frame or pan camera cycle decreases indication by 1. Each foot of film cycled through IR sensor decreases feet indication by 1.
9 Camera switch (KA-99)	BIT (momentary position) SYSTEM switch must be in RDY to get BIT. Applies power to pan camera. Initiates 12-second BIT. With FILM switch to RUN, BIT will not function. OFF — Pan camera is shut off. CTR — SYSTEM switch in RDY. Pan camera enabled. Awaiting operate command. FILM switch to RUN; pan camera cycling. Exposure, average of left and right light sensors. Camera set for 55% overlap at NADIR. FILM switch to RUN; pan camera cycling. Exposure, average of left and right light sensors. Camera set for 55% overlap at NADIR. LEFT — SYSTEM switch in RDY. Pan camera enabled. Awaiting operate command. FILM switch in RUN; pan came cycling. Exposure controlled by left light sensor. Camera set for 55 percent overlap at 30° below left horizon. RIGHT — SYSTEM switch in RDY. Pan camera enabled. Awaiting operate command. FILM switch in RUN; pan camera cycling. Exposure controlled by right light sensor. Camera set for 55 percent over lap at 30° below right horizon. **Note** LEFT or RIGHT should only be selected for high-altitude standoff or low sun angle photography. With LEFT or RIGHT selected, blurring of imagery at NADIR will occur at lower altitudes because focus is set 30° below horizon slant range. OFF — Pan camera is shut off.

Figure 24-5. Controller Processor Signal Unit (Sheet 2)

NOMENCLATURE	FUNCTION	
9 PAN camera switch (KS-153A/24 inch)	Selects 21.4° scan centered on preflight adjustable depression angles. To prevent interference in coverage by the external fuel tanks, the following preset values are recommended:	
	LEFT —	27° depression angle.
	CTR —	Vertical scan volume.
	RIGHT —	31° depression angle.
10 IRLS switch	OFF —	Sensor is shut off.
	STBY —	SYSTEM switch in RDY. Continuous monitor mode (CMM) is activated. Sensor begins cooldown (if cooldown is not achieved within 17.6 minutes, the IRLS fail light (amber) will illuminate. The IR door will remain closed during cooldown, BIT check, and while the landing gear handle is in DN.
	NFOV/WFOV —	SYSTEM switch in RDY. Sensor in ready mode. Sensor selects narrow (or wide) field of view in response to switch position. Mirror spin motor energized. Sensor is ready to cycle if cooldown has occurred. IR door will open if gear handle is UP FILM switch in RUN. Sensor starts moving film over exposure slit and IRLS flashes green (one flash per foot of film travel). If cool down is incomplete, the IR NR will be illuminated amber and the sensor will not respond.
11 MAN V/H light (amber)	Off —	Velocity/height (Vg/H) from aircraft computer within acceptable limits.
	On —	Illuminated. • V/H switch in TEST. With VEL set at 90 (900 Kts) and ALT set at .005 (500 ft), or to any equivalent 1.8 ratio, the thumbwheel circuitry has failed if light stays on. • V/H switch in AUTO. Computer failed or computer fail discrete received with or without TARPS pod on aircraft. Manual Vg/H being used. Set correct values to Vg/H in thumbwheels. Set V/H switch to MAN. If negative AGL or computed Vg/H = 0, and TARPS pod on aircraft, MAN Vg/H is being used. Set corrected values to Vg/H in thumbwheels. • V/H switch in MAN. Manual V/H intentionally selected. Values set in thumbwheels being used. Set correct values in thumbwheels. **Note** If negative AGL or computed Vg/H = 0, and TARPS pod not on aircraft, no MAN Vg/H advisory.
12 ALT FT × 100 thumbwheel	Used to set manual altitude inputs to pod. Counter range is from 000 to 999, read in multiples of 100 feet.	
13 FILM switch	MARK (momentary position) — Allows RIO to mark special interest frame with ↓ in data block.	
	RUN —	Activates selected sensor when SYSTEM switch is set to RDY
	OFF —	Stops TARPS sensor operation unless activated by pilot's bomb button, if sensors are selected to operate position on CPS.
14 V/H selector switch	MAN —	Selects manual thumbwheel inputs.
	AUTO —	Selects aircraft computer inputs.
	TEST (momentary position) —	Tests proper functioning of thumbwheels Vg/H circuitry.
15 EXPOSURE selector switch	UNDER —	–1 f-stop exposure for doubled S/C film setting.
	NORM —	Normal exposure for doubled S/C film setting.
	OVER —	+1 f-stop exposure for doubled S/C film setting.

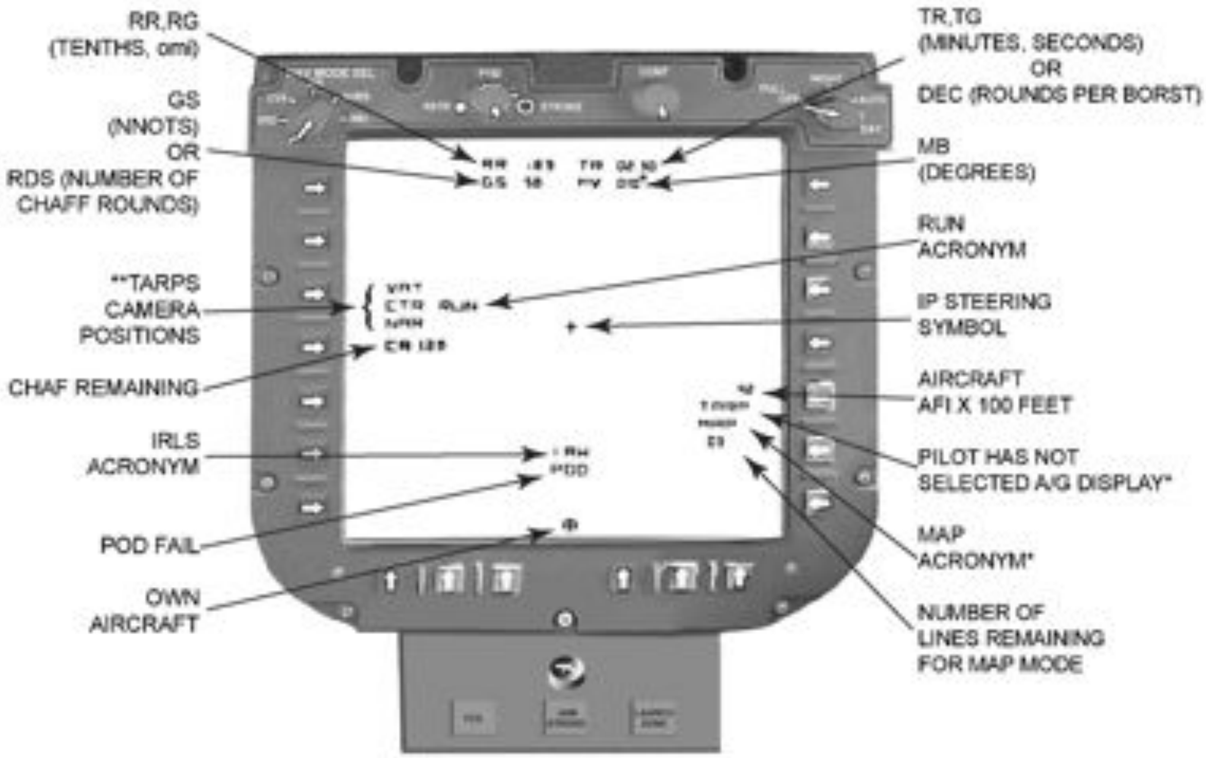
Figure 24-5. Controller Processor Signal Unit (Sheet 3)

NOMENCLATURE	FUNCTION	
16 SYSTEM switch	OFF —	Aircraft power denied to TARPS. No sensors can be operated.
	RDY —	Aircraft power available at sensor connectors. If respective sensor moved from OFF, sensor is placed in standby or ready mode. Pilot can cycle any sensor placed in ready mode by pressing bomb button.
17 VEL KT $\times$ 10 thumbwheels	Used to set manual ground speed inputs to pod. Counter range is from 00 to 99, read in multiples of 10 knots.	
18 DATA light (amber)	Off —	Data received from aircraft computer.
	Illuminated —	Data from aircraft computer failed.
19 FRAME camera switch	OFF —	Frame camera is shut off.
	VERT —	SYSTEM switch in RDY. Power applied to frame camera. Mount placed in vertical position. When FILM switch in RUN, camera is cycling.
	FWD —	SYSTEM switch in RDY; power is applied to frame camera. Mount placed in forward position (depressed 16°). When FILM switch in RUN, camera is cycling.
	Note Requires about 15 seconds to transition between FWD and VERT positions.	

Figure 24-5. Controller Processor Signal Unit (Sheet 4)

ACRONYM	DEFINITION	CREW ACTION
IRW	IRLS switch to NFOV and Vg/H exceeds 0.357.	Set IRLS switch to WFOV. NFOV is not adequate for Vg/H requirement.
POD	TARPS system failure. One or more failure (amber) lights illuminated on controller processor signal unit (CPS). If no TARPS pod on aircraft, acronym will flash for 60 seconds and then go dim.	Select RESET with SYSTEM switch on CPS to remove flashing POD acronym. Selecting reset will remove the flashing pod acronym but will not correct the system failure that caused the acronym to be displayed.
MAP X X	Normal indication when in mapping mode. Digits under acronym indicate lines remaining; number decreased by one as each line is completed.	None. To exit MAP mode, enter zero, value for either target length of run or IP, ALT (separation distance) or NBR (number of lines in MAP).
TARP	Pilot has not selected A/G display on PDCP.	Pilot must select A/G display on PDCP for HUD steering. Selection of A/A will provide VDI steering and TARP acronym will remain.
VRT FWD	CPS frame camera switch. VERT or FWD selected.	
CTR LFT RGT	CPS PAN camera switch. CTR, LEFT, or RIGHT selected.	
NAR WID	CPS IRLS camera switch. NFOV or WFOV selected, and RUN switch on.	
—	Camera not selected. Flashes for 10 seconds when the aircraft is located within 30 second radius of hooked reference point or TARPS target of opportunity.	Select camera to remove flashing dash marks.
RUN	When the acronym is steady and bright indicates RUN is selected. If film RUN is not selected, RUN will appear and flash when the aircraft is within a 30 second radius of hooked reference point or TARPS target of opportunity.	If RUN is flashing, RIO set FILM switch to RUN or pilot press bomb button on control stick.

Figure 24-6. TARPS PTID Acronyms



*MAP/TARP ACRONYM DISPLAY LOGIC		
SYSTEM STATUS	PILOT'S PDCP MODE SWITCH POSITION	
	A/G	OTHER
NOT IN MAP MODE	BLANK	TARP ACRONYM
IP HOOKED WITH VALID NL AND SD ENTRIES.	FLASHING MAP ACRONYM	ALTERNATING MAP/TARP ACRONYM
IN MAP MODE	MAP ACRONYM	MAP ACRONYM

** NOT PRESENT WHEN FIGHTER-TO-FIGHTER/DATA LINK CO-CHANNEL ADVISORY IS DISPLAYED.

14B-F0234

Figure 24-7. TARPS PTID Displays (Sheet 1 of 2)

ACRONYM	DESCRIPTION
RG	Range to go to target.
TG	Time to go to target.
RR	Range remaining to camera off (length of target run dependent) after camera on.
TR	Time remaining to camera off (length target run dependent) after camera on.
GS	Own aircraft ground speed.
MB	Magnetic bearing to hooked TARPS target.
POD	POD/CPS failure indication: Flashes bright for 60 seconds, then dims until reset on CPS.
IRW	Vg/H is above operational value (0.357) of IRLS narrow field of view; RIO selects WFOV on CPS.
IP	Dynamic steering point relative to target and own aircraft.
XXX	Own aircraft AGL to nearest 100 feet.
TARP	Pilot has not selected A/G on PDCP after RIO has selected TARPS mode. When MAP mode is entered, MAP acronym has priority.
MAP	Displayed steady when MAP mode is entered. Hooking IP and entering separation distance (ALT) and number of lines (NBR) provides flashing display. Display is steady after IP is deselected and desired NAV file is re-hooked.
VRT	FRAME camera switch at VERT. (Not present when fighter-to-fighter/data link co-channel advisory is displayed)
FWD	FRAME camera switch at FWD.
CTR	PAN camera switch at center. (Not present when fighter-to-fighter/data link co-channel advisory is displayed)
LFT	PAN camera switch at left.
RGT	PAN camera switch at right.
NAR	IR camera switch at NFOV. (Not present when fighter-to-fighter/data link co-channel advisory is displayed)
WID	IR camera switch at WFOV.
—	Camera not selected. Flashes for 10 seconds when the aircraft is within a 30 second radius of hooked reference point or TARPS target of opportunity.
RUN	Indicates RUN selected when the acronym is bright and steady. If film RUN is not selected, RUN appears and flashes when the aircraft is within a 30 second radius of TARPS hooked reference point or target of opportunity.
RNDS	Number of chaff rounds loaded in DECM adapter (displayed at lower left buffer during data entry).
DEC	Decrementer. Number rounds of chaff released per burst (displayed at lower right buffer during data entry).
CR	Number of remaining rounds of chaff at any given time.

Figure 24-7. TARPS PTID Displays (Sheet 2)

24.3.3 Reconnaissance Reference Point Entry. Reconnaissance reference points are entered into the AWG-9 computer memory bank by the RIO via the computer address panel with the CATEGORY switch in TAC DATA. They are displayed on the PTID for navigation and tactical evaluation. The maximum number of inserted reference points is eight: three waypoints, a fixed point, a surface target, home base hostile area, and a defended point. Initial point is used by the program for other purposes and therefore cannot be used as a reference point. Data entered includes latitude, longitude, target length, target altitude, and command heading. The heading entered is the desired target crossing angle used by the pilot for steering. The altitude entered is the target mean sea-level altitude. The target length is entered via the SPD push-tile in even tenths of a mile. Figure 24-8 shows the TARPS CAP entry matrix.

Note

Entries of odd tenths will be rounded to the next lowest even digit. If an odd tenth of target length is required, enter the next higher even tenth. (For example, LR desired 0.3 nm, enter 0.4 nm.)

24.3.3.1 In-Flight Entry of Reconnaissance Reference Points. In order for the RIO to enter reconnaissance reference point data in flight with TARPS selected and not disturb pilot steering on the HUD, the following procedures are required:

1. Hook target desired for pilot steering via CAP or hand control unit.
2. Select MAN position on PTID DEST switch and unhook target (step 1) using PTID cursor or CAP with following results:
    a. Horizontal situation display steering is caged.
    b. Pilot steering is still valid to target previously selected in step 1.
3. Hook target file desired for change and enter data. (IP cannot be used as a reference point)
4. Hook target previously unhooked in step 2.
5. PTID DEST switch — As Desired.

Note

If a change of heads-up display target steering is desired from step 1, MAN must be deselected and the desired steering point hooked.

24.3.4 FEMS/TARPS POD Configuration. To ensure that FEMS airframe structural stresses are properly computed when operating with a TARPS POD configured aircraft, the TARPS POD present I.D. must be recognized by the AWG-9 software prior to taxi. Since the AWG-9 software does not presently interrogate the TARPS POD present I.D. when the MASTER ARM switch is set to TNG, the procedure below must be followed to ensure the TARPS POD present I.D. is sent to the FEMS.

1. WCS switch — STBY.
2. MASTER ARM switch — OFF.
3. CPS system switch — RDY.

Once the I.D. is sent, FEMS recognizes the existence of the TARPS POD, and correct calculations can be obtained regardless of the MASTER ARM switch position. Should the AWG-9 have to be powered down in flight, the procedure above must be performed when the AWG-9 and the TARPS POD are powered up.

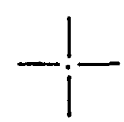
24.4 PILOT OPERATION OF SENSORS

A sensor operating button is provided on the pilot control stick. With SYSTEM switch ON, controller processor signal unit set to RDY, and any or all sensor selector switches in the ready position, the activated sensor can be cycled by the pilot pressing the bomb button on the control stick. This is the only TARPS control capability provided to the pilot. Each camera will cycle at its proper rate for velocity/height ratio and the infrared line scanner will run continuously at the proper speed until the pilot releases the bomb button.

Note

The bomb button will not initiate camera operation with the expanded chaff adapter installed.

24.4.1 TARPS HUD Symbology. TARPS HUD symbology (Figure 24-9) A/G selected on PDCP and changes from the current aircraft are summarized below:

1. Heading — Same.
2. Velocity vector — Same.
3. Steering reticle — Command error indicator (azimuth steering). 
4. Bomb fall line — Command ground track line. 
5. Pitch ladder — Same.
6. Diamond — Target designator. 
7. Aircraft reticle.

PREFIX	DISPLAY INDICATION	DESCRIPTION	RANGE OF VALUES	UNITS
*LAT/1	LN or LS	Target position north or south of equator.	00° 00.0° to 90°	0.1 minute
SPD/3	LR	Readout/update target length	0 to 409.4 nmi	even tenths of a nmi
ALT/4	AL	Readout/update target altitude	±97,216 feet	1 foot
RNG/5	Prior to target: RD TG After target: RR TR	• Great circle range from own ship to target. • Time remaining before target intercept. • After target, range and time to end of run.	0 to 2,048 nmi 0 to 512 minutes	0.1 nmi 1 second G (XXX XX) min sec
*LONG/6	LE or LW	Target longitude position east or west of prime meridian.	000° 00.0' to 180°	0.1 minute
HDG/8	MH/CH	Readout/update command ground track over target.	000° to 359°	1°
IP ALT/4 N+E IP ALT/4 S-W	SD	Readout/update separation distance between map lines preceded by a (+) for right or a (–) for left map lines.	±97,216 feet	1 foot
IP NBR/2	NL **Note** PTID readout limited to 1 through 99.	Readout/update number of lines for MAP mode.	1 to 99 lines	1 line
IP SPD/3	GS	Readout/update number of intended groundspeed on HUD.	0 to 4,096 knots	1 knot

* If the TARPS target of opportunity has been designated and no target is hooked, selection of either LAT and/or LONG CAP pushbutton(s) will provide PTID readout of target of opportunity LAT/LONG.

Figure 24-8. TARPS CAP Entry Matrix

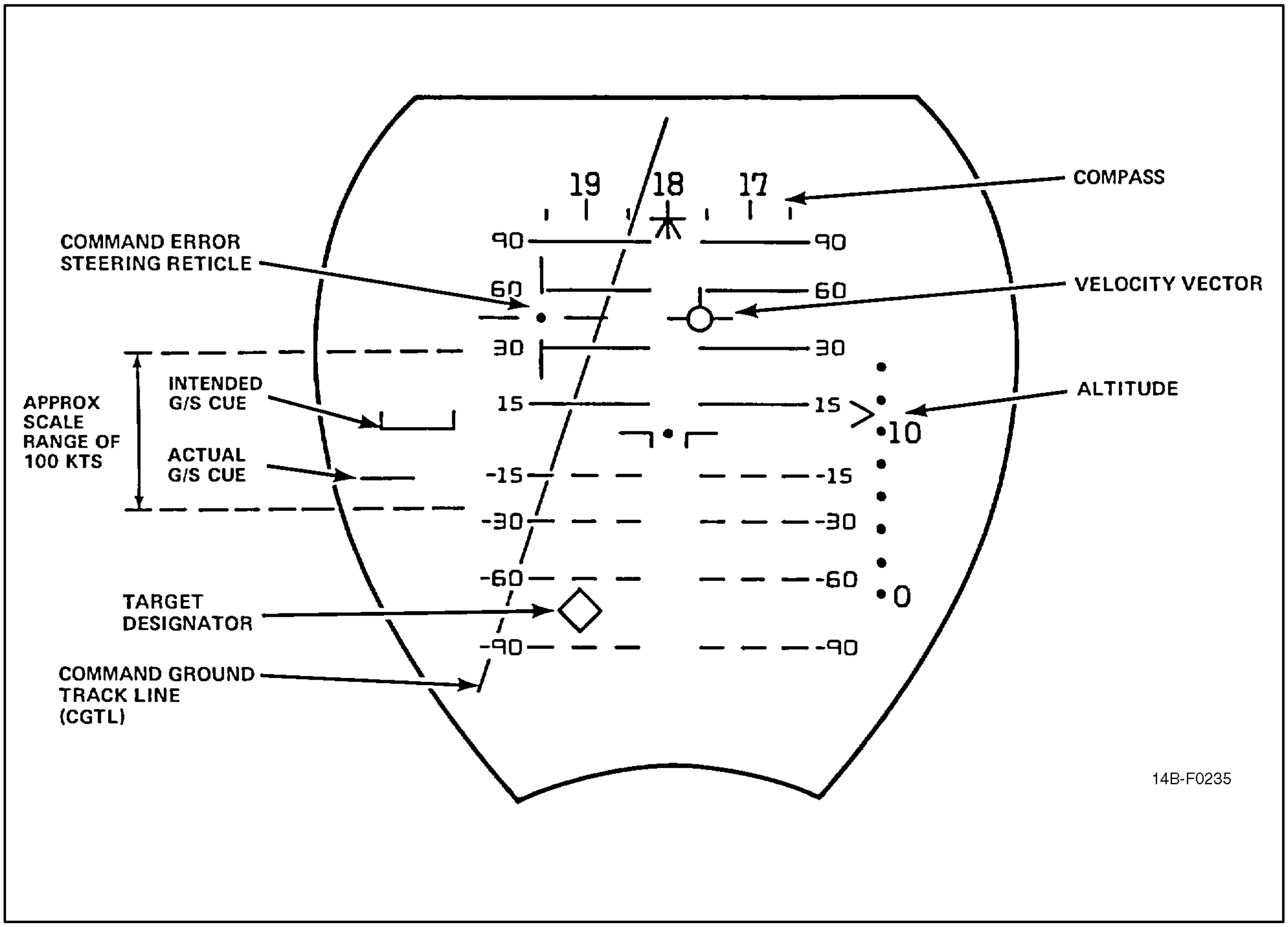


Figure 24-9. TARPS HUD Symbology

8. Altitude — Same

9. Intended groundspeed cue.

10. Actual groundspeed cue.

Additionally, the following symbols can be decluttered by the pilot as required during TARPS runs when the air-to-ground (A/G) mode is selected:

1. Heading.

2. Pitch ladder.

3. Aircraft reticle.

24.4.2 TARPS VDI Symbology. TARPS VDI symbology (A/A selected on PDCP) is shown in Figure 24-10.

24.4.3 TARPS Pilot Steering. TARPS aircraft steering is displayed on either the HUD or vertical display indicator because of pilot switch selection on the PDCP.

During visual flight conditions, HUD TARPS steering using TARPS symbology (Figure 24-11) is obtained by selecting A/G on the PDCP. When the target is hooked, the HUD designator diamond will move from its superimposed position on the velocity vector symbol to a position that indicates actual target location. Steering is accomplished by noting the direction that the command error steering reticle is displaced from the velocity vector. Banking the aircraft in the same direction to achieve and maintain alignment of the two symbols will produce the desired flightpath.

During instrument flight conditions, VDI TARPS steering using TARPS symbology (Figure 24-10) is obtained by selecting air-to-air (A/A) on the PDCP. With a hooked target, the HUD designator diamond will

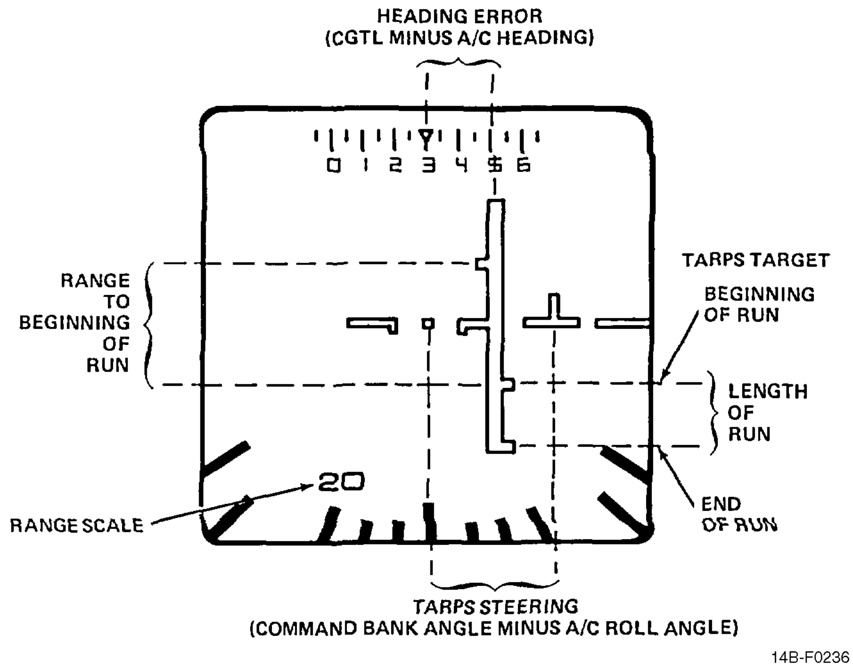


Figure 24-10. TARPS VDI Symbology

continue to indicate actual target location. VDI steering is accomplished by noting the direction that the steering tee is displaced from the own aircraft symbol. Banking the aircraft in the same direction to achieve and maintain alignment of the two symbols will produce the desired flightpath.

At the completion of a single target run, with either HUD or VDI steering selected, the RIO must unhook the currently hooked waypoint to terminate the current steering. In the MAP mode, the target will unhook and steering will terminate automatically after the last pass. In either case, steering to the next waypoint is obtained by hooking the desired point.

WARNING

Following steering too closely can result in pilot fixation to the exclusion of safe altitude control.

24.4.3.1 TARPS Pilot Steering With Expanded Chaff Adapter. TARP steering symbology is available to the pilot during chaff dispensing operations with the expanded chaff adapter when the RIO selects computer pilot (CMPTR PLT) attack mode on the armament control panel. If the RIO selects manual (MAN) attack mode on the ACP, TARPS steering symbology will not appear on the HUD or VDI.

24.4.3.2 Destination Steering. Selecting destination steering on the PDCP displays TARPS steering to the hooked target on either the HUD or VDI concurrently with the HSD/ECMD displaying steering information direct to the point selected on the RIO PTID DEST switch. For tactical situations where a particular ground track across the target is required, the RIO enters the desired ground track and length of run for that target. Then with the target hooked and destination steering selected on the PDCP TARPS steering will steer to a movable, displaced point that is represented by the IP symbol. This will permit establishment of the command ground track line prior to reaching the target. The CGTL is represented on the HUD by the bomb fall line and on the VDI by the azimuth range bar.

24.4.3.3 Direct Steering. Direct steering is provided to any hooked reference point by selecting manual steering on the PDCP. This will provide direct (point-to-point) steering from present own-aircraft

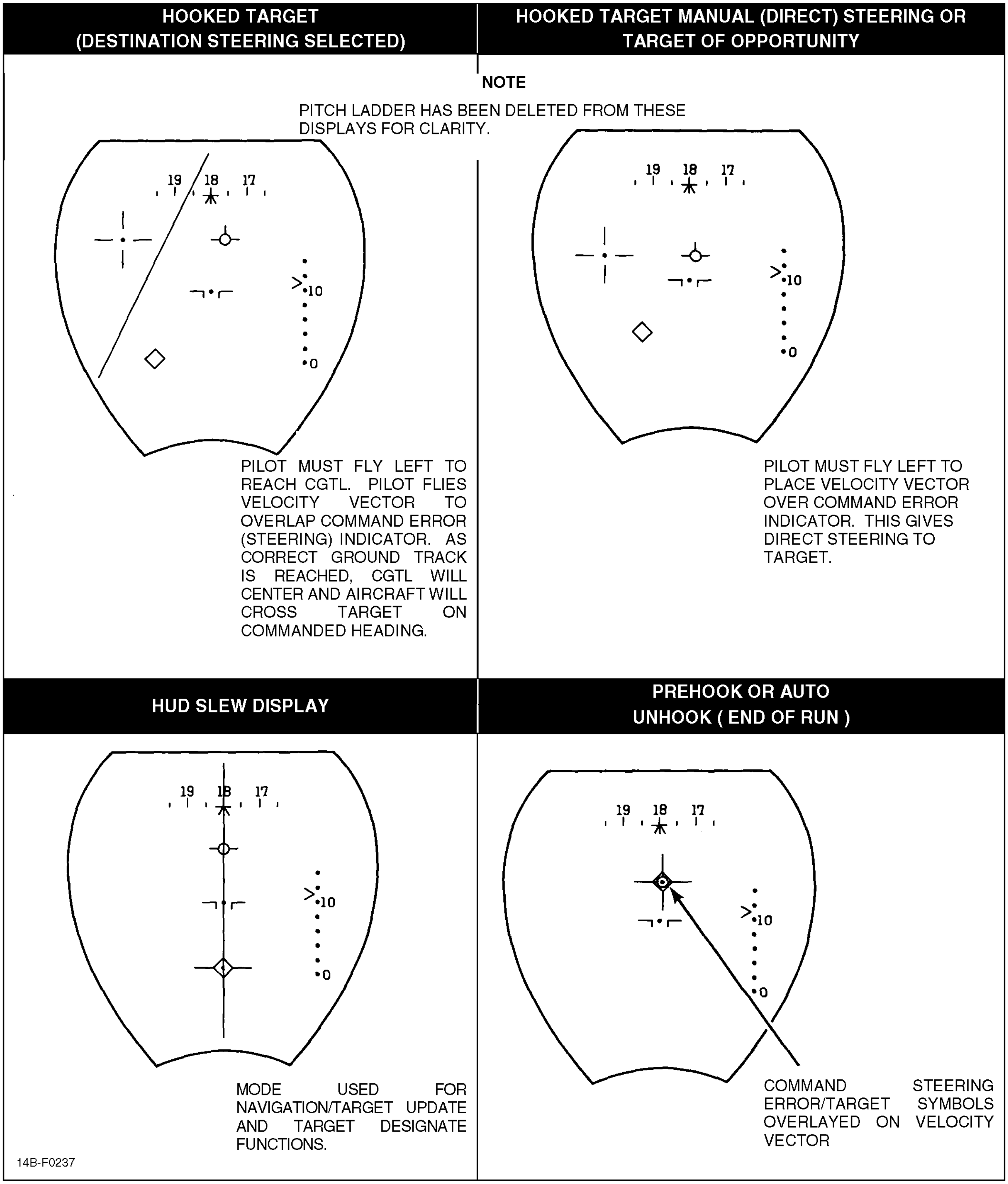


Figure 24-11. TARPS — HUD Displays

position to the selected target. However, selection of manual steering on the PDCP will result in loss of HSD/ECMD steering to the reference point selected on the destination switch. Direct TARPS steering can be obtained while retaining HSD/ECMD steering by remaining in destination steering on the PDCP and entering zero for length of run for the hooked TARPS target. To follow either type of steering, the velocity vector on the HUD must be flown to and maintained over the steering reticle or the steering tee maintained over the A/C symbol on the VDI.

24.4.3.4 Groundspeed. The actual groundspeed of own aircraft relative to an intended groundspeed entered by the RIO available for display on the HUD in TARPS mode. The intended groundspeed is entered by the following procedure:

1. Select TAC DATA category, function pushbutton No. 5 (IP) on the computer address panel.

2. Depress SPD/3 pushtile on CAP and enter intended groundspeed.

The CAP entered groundspeed is represented on the HUD by the intended groundspeed cue (a bracket that remains fixed). The actual aircraft groundspeed is represented by a horizontal line that moves vertically above or below the intended groundspeed cue (Figure 24-9). The separation between the two cues is proportional to the difference between the actual and intended groundspeeds. The actual groundspeed cue will be pegged if the difference between the actual and intended groundspeed exceeds ±50 knots.

24.4.4 Navigation System Updates. Navigation system updates can be performed via the three normal methods: VIS FIX, TACAN FIX, and RDR FIX. The TARPS mode provides an additional update capability via the HUD.

Note

SURF TGT file can be used for TARPS HUD updates, but not for VIS, TACAN, or RDR FIX updates.

If the navigation system is operating accurately, the HUD diamond will be superimposed over the hooked target. If the pilot determines that the system is not accurate (diamond significantly off hooked target), he moves the target designate switch (outboard of throttle quadrant) forward, undesignating the target. This action cages the CGTL in azimuth and positions the designate diamond on the CGTL midway between the center and bottom of the HUD FOV. The pilot can then fly the aircraft so as to align the CGTL with the target and slew the diamond via the designate switch up or down to superimpose it over the target. Moving the designate switch forward again will supply the system with the new updated position of the target. If the RIO selects NAV category on the CAP and presses function pushbutton 3 (not labeled), he can read delta latitude/longitude displayed on the PTID. If system update is desired, he presses FIX ENABLE.

Note

Accurate target altitude determines the quality of the HUD navigation update. Additionally, the quality of an update increases with greater lookdown angles. Low grazing angles may induce navigation error.

24.4.4.1 TARPS VDI Steering. TARPS steering is displayed on the VDI when the pilot selects A/A on the PDCP.

Note

Selecting A/A causes loss of HUD steering and the steering reticle, but the diamond will still represent target position (HUD and VDI steering displays do not coexist). A/G selected provides HUD steering or A/A selected provides VDI steering.

The steering tee reflects the commanded bank angle (maximum 45° bank angle) and the tee centers on the VDI when the proper bank is achieved. The azimuth range bar indicates heading error (CGTL minus own A/C heading, maximum ±30° heading error) and the bar centers on the VDI when the aircraft is on CGTL. Azimuth bar maximum launch range (R_{max}) tick mark represents start of run; the minimum launch range (R_{min}) tick mark represents the end of run; and the distance between them the length of run. Azimuth bar target range tick represents own aircraft in relation to beginning and end of run (Figure 24-11).

24.4.4.2 Targets of Opportunity. The pilot, using the target designate procedure, can selectively reconnoiter targets of opportunity. Direct (manual) steering will be provided to intercept the reconnoitered target. Before the pilot designates a target of opportunity, it is necessary for the RIO to be unhooked and have entered an estimated target altitude in the hostile area altitude file.

Selection of either LAT or LONG CAP button displays target of opportunity LAT/LONG coordinates on the PTID. The target designator is software limited in slewing to a maximum range of 48 nm. However, once designated, the target designator will indicate target location out to 96 nm.

24.4.4.3 Identification of Targets Using Television Camera Set. The pilot can enhance his ability to identify ground targets by using TCS; TCS is software slaved to the TARPS diamond line of sight based on entered target latitude, longitude, and altitude. The TCS is continuously slaved to the TARPS diamond when MAN is selected on the ACQ switch; TCS is selected on the SLAVE switch and wide field of view is selected.

24.4.4.4 Mapping Mode. Mapping mode software will be initialized when IP altitude and IP speed contain valid data (nonzero) and a target file is selected that has a command heading and target length entered. The following steps are required of the RIO to enter the mapping mode:

1. Select TAC data category on CAP.
2. Press IP function pushbutton.
3. Select NBR and enter the number of mapping lines required.
4. Select ALT and enter the offset distance between passes (in feet). If the map is to be to the right of the first line, press the N + E pushtile, then ENTER. If the map is to be to the left of the first line, press the S – W pushtile, then ENTER. With IP hooked and separation distance (ALT) and number of lines (NBR) entered, the MAP acronym will flash. If A/G is not selected on the pilot display control panel, the acronym will alternate with the TARP acronym.
5. Select reconnaissance reference point to be mapped by hooking it on CAP or the PTID. This stored target must have a command heading stored as well as target length. (Length of map legs is entered via the SPD pushtile in even tenths of a mile.)

   The MAP acronym will now appear steady with the associated number of lines requested on the PTID (lower right-hand corner). This number of lines will decrease by one as each pass is completed. Map steering is the same as for a single target with a stored CGTL. The primary difference is that steering commands a 90° and a 270° turn following each mapping line and then updates steering for each consecutive pass. At camera off (TR=00 on the PTID) completing the first leg (RIO must turn camera off with FILM switch), the target designator, steering reticle and velocity vector will coincide. After approximately 8 seconds, the HUD steering reticle will update, commanding the 90°/270° turn to set up for the next pass; the PTID MAP acronym will blink for 8 seconds and stop; the pass number will decrease by one; and the IP symbol will then move to the proper location for the next pass. On the last pass, the PTID MAP acronym will go off and the HUD symbology will freeze. At this time, IP altitude and speed entries will be zeroed by the computer and the MAP acronym will be removed.

Note

If TARPS mapping is terminated prior to completion of the last pass, the RIO must zero either offset distance (IP ALT) or number of lines (IP NBR) to exit the map mode.

24.4.4.5 Altitude (AGL) Mechanization. Above ground level information for initial F-14/TARPS software calculation of Vg/H uses the following sources in the order given below:

1. APN-194 radar altimeter — This altitude source is used whenever the F-14 is below 5,000 feet and the APN-194 is operating properly.
2. AWG-9 radar altitude — Altitude will be calculated using a 55° lookdown angle, Earth stabilized antenna (TARPS mode). This source will be used if above 5,000 feet or APN-194 is inoperative.
3. Ownship system altitude (hooked target) — Used whenever the APN-194 and AWG-9 derived altitude are not available. For target stored in file (hooked), AGL is calculated as system barometric altitude minus target altitude.
4. Ownship system altitude (no-hooked target) — For nonstored or no-hooked targets, AGL is calculated as barometric system altitude minus hostile area altitude. A hostile area altitude is chosen that represents the average terrain in the

area of interest and inserted into the hostile area altitude file before flight.

Note

- Computed AGL is presented on the right side, center of the PTID, in hundreds of feet, (i.e., 42 = 4,200 feet AGL). If computed AGL becomes a negative number, the MAN Vg/H advisory light on the CPS panel is lit. If the aircraft is not equipped with a TARPS pod, computed negative AGL does not cause the MAN Vg/H light to illuminate. However, a computer failure causes the MAN Vg/H light to illuminate, whether or not the aircraft is carrying a TARPS pod. The PTID AGL display is replaced by three dashes. Manual velocity altitude factor (V/H) values are then being used.
- If APN-194 radar altimeter is inoperative or malfunctioning, the unit should be secured to prevent invalid altitude inputs from entering the CPS.

The CPS provides a manual V/H analog output via the velocity and altitude thumbwheels for use by the TARPS sensors when primary sources of V/H (digital data from the aircraft computer) are not available or invalid. Manual V/H may be selected at any time by the RIO and should be used instead of steps 3 or 4 above when doubt exists as to the quality of the inputs.

The RIO can determine which altitude source is being used by selecting Flycatcher 7-00740. The following readouts will be displayed in the last four digits:

1. XXXX0000 — Radar altimeter
2. XXXX0001 — AWG-9
3. XXXX0002 — Barometric minus target altitude
4. XXXX0003 — Barometric minus hostile area altitude.

24.4.4.6 TARPS Pulse Search Enable. The AWG-9 antenna is normally positioned at zero azimuth, –55° elevation, while operating in TARPS. If desired, the pulse search radar mode is available without off-loading the TARPS program when the RIO selects the special (SPL) electronic counter-countermeasures pushtile on the detail data display control panel. The AWG-9 radar altitude source is not available when operating in this mode. Normal TARPS AWG-9 operation is regained by deselection of the SPL pushtile.

24.4.4.7 Ground Mapping. Ground mapping is provided by a short-pulse ground-map mode. Engaging GND MAP (target data category, function pushbutton 1) on the CAP in pulse search, short pulse is commanded in all low-pulse repetition frequency range scales and a GND MAP advisory is displayed on the PTID in the PARAMP location. Ground mapping is disengaged by deselecting target data category function 1 pushbutton (GND MAP) on the CAP or by depressing any DDD, WCS MODE pushtile.

Note

To engage the ground-mapping mode during TARPS operations, select the SPL CCM MODES pushtile on the DDD control panel prior to selecting GND MAP on the CAP.

24.5 SENSOR CAPABILITIES AND LIMITATIONS

24.5.1 Lineal Coverage. Total lineal coverage available for specific sensors depends on film load and altitude. Complete lineal coverage data for all sensors is provided in the F-14 Tactical Manual (NWP-55-5-F14, NAVAIR 01-F14AAA-1.1T) and Tactical Pocket Guide NWP-55-5-F14 PG (NAVAIR 01-F14AAA-1T-3).

24.5.2 Serial Frame Camera. The KS-87D has a fixed focus 6-inch focal-length lens, weighs about 79 pounds, and can hold up to 1,000 feet of 2.5-mil thick, 5-inch film. The fixed focus is set at a hyperfocal distance of 1,339 feet, which gives excellent imagery from about 750 feet to medium altitudes. Below 750 feet, the imagery is less sharp but still good down to about 500 feet. The KS-87D provides a 41° field of view with a 4.5 × 4.5 inch negative and a full 1,000-foot roll allows 2,400 exposures.

The recording head assembly exposes a data block on each frame. The data are encoded, binary code decimal, alphanumeric, or alternate BCD and A/N. The data block provides time, date, latitude, longitude, altitude, drift, heading pitch, roll, classification (if known in advance), and mission code. The RCD also provides Vg/H, which allows the aircraft velocity to be calculated.

The KS-87D's two position mount allows the RIO to select vertical (VERT) or forward (FWD). In the vertical position, the KS-87 backs up the pan camera and is also used for bomb damage assessment, route reconnaissance, and is the primary camera for mapping missions. The forward position instead of steps 3 or 4 above when doubt exists as to the quality of the input looks 16° down from the horizon and is very useful for pilot view flightpath tracing and ship surveillance photography. The mount requires about 16 seconds to change positions and will cause the mount fail indication if transition is not completed within 23 seconds. Frequent FWD-VERT switching can cause the mechanical drive to overheat and seize, resulting in a mount failure, as will cycling the switch under high g-loaded situations. The mount will automatically move to vertical when the SYSTEM switch is at RDY and the FRAME switch is turned OFF or if the landing gear handle is moved to DN.

The KS-87 can be reloaded or replaced in approximately 10 minutes and with the aircraft's engines turning if necessary.

Figure 24-12 summarizes some specific characteristics and information on the KS-87 serial frame camera.

24.5.3 Panoramic Camera. The KA-99A is a 9-inch focal length, f/4.0 lens panoramic camera that provides high-quality low- to medium-altitude imagery. Located in bay 2, the KA-99A offers full horizon-to-horizon imagery with 55-percent overlap up to a maximum of 1.06 Vg/H (8 cps). When external fuel tanks are installed, the field of view is reduced about 25° on the right and 17° on the left. The film cassette will hold a maximum of 2,000 feet of film. A single exposure measures 4.5 × 28 inches and a data code block appears between each frame. The camera will indicate FAIL when the film load is down to approximately 40 exposures, preventing the film bitter end from going through the high-speed drive gears and causing camera damage. The KA-99A will automatically focus down to approximately 500 feet, but will revert to a focus altitude of 6,000 if the TARPS program fails to input and there s no input from the CPS for manual V/H. The RIO may select center, left, or right for the KA-99A on the CPS. When left or right is selected, the camera will use only the light sensor on the side selected instead of averaging the two as it normally does. Also, the cycle rate and FMC is based on the slant range distance from the aircraft to the ground at a 30° below horizon depression angle. To avoid degraded imagery, do not use left or right settings below 1,500 feet altitude. The KA-99A can be set for air-to-air (focus set at infinity, no FMC, and one cycle per second) on the CIPDU and there is no cockpit indication of this setting. The KA-99A is favored by flightcrews on combat missions because its horizon-to-horizon lateral coverage allows it to be used with a considerable offset.

This capability increases the flightcrew's probability of successfully completing the mission in defended areas where evasive combat maneuvering will be necessary. Although it is not necessary for the aircraft to be flown wings level when photographing a target with the KA-99 camera, the lack of roll-rate stabilization dictates that an established angle of bank be maintained while the target is within the camera's field of view.

Figure 24-13 summarizes some specific characteristics and information on the KA-99 panoramic camera.

24.5.3.1 Long-Range Oblique Photography Camera (KS-153A With 610-MM Lens). The KS-153A still picture camera set is a modular, pulse-operated, sequential fame camera designed for oblique or vertical reconnaissance photography at medium to high altitude. Two configurations are available: (1) low altitude, high-speed photography (80-mm focal length Tri-Lens configuration); (2) medium-altitude standoff (610-mm/24-inch focal length standoff configuration). The 24 inch standoff configuration will be utilized to replace the KA-93C LOROP sensor and will be mounted in bay 2 of the TARPS pod replacing the KA-99.

The KS-153A features true angle corrected forward motion compensation across the entire film format for any oblique angle, automatic range focus from 1,000 feet to infinity and self-contained automatic temperature/pressure focus compensation, shutter priority automatic exposure control using preflight setting of aerial film speed and aircraft V/H signal, 12- or 56-percent preflight selectable overlap, roll compensation, and data annotation. The 4.5 × 9-inch film format provides sequential frames 10.7° along track and 21.4° across track coverage on 9.5-inch-wide film. This image format reduces processing time and allows direct stereo viewing without cutting the film.

The KS-153A can be programmed for any desired depression angle from horizon to horizon, limited in coverage only by the aircraft external fuel tanks (17° left, 25° right). Typically, the KS-153A will be pre-programmed for the following three depression angles: 27° left oblique, vertical, and 31° right oblique. These are selected using the LEFT, CTR, and RIGHT positions on the CPS pan camera control switch. When selected, a 21.4° scan will be utilized centered about the preset oblique angle.

Focal length	6 inches
Diaphragm range	f 2.8 to 6.7
Field of view	41° × 41°
Negative Format	4.5 × 4.5 inches
Vg/H Range*	0.01 to 1.18
Maximum Cycle Rate	6 cycles per second
Effective Shutter Speeds	1/60 to 1/3,000
Filters	Yellow, red, or none
Angle of View	Vertical or Forward (16° below horizon)
Hyperfocal Distance**	1339 feet (fixed focus)

* Vg/H is listed as a knots per foot of altitude ratio, (computed for vertical camera position only). The DDS is capable of generating a maximum of 1.42 Vg/H.

** The hyperfocal distance is the distance from the optical center of the lens to the nearest point of acceptable sharp focus, when focused at infinity. The sensor may be effectively used well below the hyperfocal distance, but will render increasingly soft imagery at lower altitudes.

The automatic exposure control (AEC) system uses an external light meter. The AEC can be overridden (plus-or-minus one F-stop) on the CPS.

The mount requires approximately 16 seconds to move the camera from vertical to forward, or back to vertical. The Cps will display a mount fail light if the transition is not completed within 23 seconds.

Optional 3 inch focal length lens available.

Figure 24-12. KS-87D Serial Frame Camera Characteristics

Focal Length	9 inches
Maximum Aperture	f/4.0
Field Of View	28° × 180°
Negative Format	4.5 × 28 inches
Vg/H Range	0.5 to 1.06
Maximum Cycle Rate	8 cycles per second
Effective Shutter Speeds	1/43 to 1/22,600
Filters	Yellow, red, or clear
Forward Overlap	CTR 55% at NADIR; L/R 55% at 30° below side horizon
Film Load	2,000 feet (2.5 mil) ; 800 exposures (750 usable)

Note

- The Automatic Exposure Control (AEC) system uses internally mounted light meters which average the scanned field. AEC can be overridden(±1 Fstop) in-flight with the CPS.
- Sensor does not have roll stabilization, thus aircraft rolling will alter angle of view and may blur imagery.
- Maximum listed Vg/H can be exceeded, but the imagery will be degraded by incorrect FMC and reduced overlap.

Figure 24-13. KA-99A Panoramic Camera Characteristics

Figure 24-14 summarizes some specific characteristics and information on the KS-153A standoff camera.

24.5.4 Photographic Film. Film can be separated by general type as follows:

1. Black and white film

   a. Aerial film speed

   b. Resolution

   c. Spectral sensitivity.

2. Color film

   a. Aerial film speed

   b. Negative reversal

   c. Camouflage detection infrared.

Film speed is a value assigned to a specific film to enable you to determine the correct exposure in various light conditions. High-speed films are required for low available light missions and for high-speed, low-level missions where very fast shutter speeds are required. High-resolution films provide greater detail, but require more light. A film's spectral sensitivity means some colors will reproduce on the film better than other colors. Most of the common black and white films are panchromatic, sensitive to all three primary colors (red, green, and blue) that are found in normal daylight. Since the red light does not scatter as much as blue, contrast filters are used to reduce the blue light. A yellow filter will pass the green and red light, eliminating the scattered blue light. A red filter will pass only the red light, eliminating the scattered blue light and also the green (which scatters less than the blue). However, a yellow filter will normally require one additional f/stop of exposure and the dark red filter will normally require two additional f/stops of exposure. Some black and white films have extra sensitivity to infrared light. This film is most helpful in producing contrast detail between some objects that would tend to blend with normal film. Most notable would be the difference between water and vegetation. Color films reproduce greater shadow detail than black and white films, and show color separation in some objects that would reproduce the same density on black and white film. But color film has less fine resolution to show very intricate detail in a target. Some color films are reversed in processing, so that they will reproduce the colors in the original scene without printing. These films are termed reversal or transparency film. Camouflage detection color film is used to show contrasts between live vegetation and camouflage material. This greatly increases the chances of locating difficult targets. Aerial color films require expensive, complex processing that is not generally available at sea.

24.5.5 Infrared Reconnaissance Set. The AAD-5 infrared line scanning detector is a passive detector of energy in the far infrared region. The most striking characteristic of the AAD-5 is its ability to detect thermal activity, such as the hot-water discharge of a powerplant, the heat from the boiler of a ship, or the thermal shadow left on a runway or ramp by a departed aircraft. This characteristic can be used for many purposes, such as determining the state of readiness of ships in a harbor, judging the traffic load of an airfield, determining the quantity of P-O-L in storage tanks, determining whether buildings are occupied, and separating recent bomb craters from old ones. Since the AAD-5 IR detector cannot determine the difference between the radiated energy generated by activity and infrared energy reflected from the sun, some types of activity cannot be reliably detected during the day.

The natural phenomenon of crossover will cause land and water bodies to have identical infrared signatures about 1 hour after sunrise and 1 hour after sunset. Missions flown to detect land and water contrast (such as bomb damage assessment on bridges) should avoid these times by at least 2 to 3 hours.

The AAD-5 IR detector is not an all-weather sensor. It cannot collect imagery through clouds or extremely heavy haze. It is relatively unaffected by smoke.

At low altitudes, the AAD-5 IR detector is a relatively good identification sensor. At higher altitudes, it may be adequate only for detection or general identification, depending on the type of target. A spatial ground resolution chart is included in Tactical Manual NWP-55-5-F14, Vol. II (NAVAIR 01-F14AAA-T-l).

The AAD-5 IR detector is fully roll and roll-rate stabilized from 0° to 20° angle of bank. Beyond 20°, a steady bank angle with no roll rate will not seriously degrade imagery. Because of varying scale at the outer edges, the target should be placed within the center 90° of the format.

Focal Length	24 inches/610mm
Angular Field Of View	21.4 across track, 10.7 along track
Film Format	4.5 × 9.5 inches
Image Frame Format	9.06 inches across track, 4.53 inches along track
Frame overlap (preflight selected)	12% or 56%
Film Capacity	200 feet of 2.5 mil/2.47 frames per foot (500 feet optional)
Aperture Range	f/4 to f/16 continuously
Maximum Cycle Rate	4 frames per second
Average Resolution	75 Lp/mm, EK 3412
Shutter Speed Range	1/150 to 1/2,000 sec
Film Speed (preflight setting)	AFS 0 to AFS 999
Linear Coverage (200 feet film @ 30K, 12 nmi standoff @ 56% overlap)	467 nm
Weigh (500 foot cassettes without film)	233 pounds
V/R Rate	0 – 0.196 knots/foot @ 56% 0 – 0.39 knots/foot @ 56% 1.25 knots/foot maximum
Camera Oblique Rotation (24 inch)	±86° of vertical
Angle of View (adjustable)	Vertical, left (27° below horizon), and right (31° below horizon)

Note

- Optional yellow, red, orange, or clear filters.
- Shutter priority automatic exposure control by preflight film speed setting and aircraft V/H signal, accuracy 1/2 f/stop.
- Sensor will automatically compensate for altitude pressure (sea level to 5,000 feet) and temperature (25 °C to 45 °C stable within ±2 °C).
- Sensor produces a LED matrix array data block with a 3-millisecond write time.

Figure 24-14. KS-153A Still Picture Camera Characteristics (610-MM Standoff Configuration)

The AAD-5 IR detector can be reloaded in approximately 10 minutes and with the aircraft's engines turning. The system is made up of several modular sections that can be replaced rapidly (in about 15 minutes). Replacement of the entire system requires in excess of 45 minutes.

24.5.6 Digital Data System. The reconnaissance pod carries a digital data system that interfaces with the aircraft's inertial navigation system, altimeters, computers, and altitude heading reference system to automatically control and integrate the reconnaissance systems.

Reconnaissance system control is accomplished by the data converter. Sensor stabilization signals and operating rate voltages are generated and routed to the sensors. Stabilization signals are provided from the inertial navigation system or, if it fails, from the AHRS. Operating rate signals are determined from inertial navigation and radar altimeter inputs. A semiautomatic backup method of generating Vg/H signals is available if the inertial navigation system fails. A fully manual option is available through the CPS if other components (including the data converter) fail. Maximum automatic Vg/H is 1.42 knots per foot.

If the aircraft is carrying a TARPS pod, negative AGL causes the MAN Vg/H advisory light on the CPS panel to be lit. This light is extinguished when AGL becomes positive. Without a TARPS pod onboard, negative AGL does not cause the MAN Vg/H advisory light to illuminate. If the CADC or CSDC computer fails, however, the AWG-9 causes the MAN Vg/H advisory to be lit, whether or not the aircraft is carrying a TARPS pod.

Note

Even with a subsequent recovery of CSDC function, the failure indication is retained in the OBC maintenance file and the system remains in the MAN Vg/H mode with the light lit. This failure indication can be cleared only by activating SPL category FB 10 (OBC DISP or OBC FILE CLEAR pushbutton) while on deck.

Reconnaissance system integration is accomplished through digital information from the data converter, which is translated into binary or alphanumeric form and added to preset information and real time which is adjusted prior to flight. Code matrix boxes are printed on all imagery in either binary or alphanumeric form. Integration information includes date, squadron and detachment, sortie, sensor identification, barometric altimeter, heading, roll, pitch, time, latitude, longitude, radar altitude, inertial navigation system status, relative drift to ground track, and Vg/H.

24.6 AIR-TO-AIR TARPS MODE

The air-to-air (A/A) TARPS mode provides simultaneous operation of TARPS reconnaissance and the A/A tactical mode. Full A/A capability and adequate TARPS functions for most reconnaissance missions are available. The following TARPS functions are provided in the A/A TARPS mode:

1. Complete control and full function operation of all TARPS sensors.
2. Normal function of all switches and indicators on the CPS unit.
3. Normal data annotation and Vg/H support the pod.
4. Modified camera status and control indicators on the PTID.
5. Target designator display on the HUD.
6. Pilot control of camera run via the bomb button.
7. Partial PTID TARPS data readouts.
8. The capability to transition to full TARPS in less than 1/4 second.

The following TARPS functions are not provided in A/A TARPS:

1. TARPS steering
2. Mapping mode
3. Target designate, undesignate, or designator slew
4. AWG-9 radar altitude
5. TARPS navigation fix
6. TARP acronym on PTID
7. AGL PTID display

24.6.1 Air-to-Air TARPS Mode Entry and Exit. The A/A TARPS mode is entered from the A/A mode by selecting the CPS SYSTEM switch to RDY. Conversely, mode exit back to A/A is accomplished by selecting the CPS SYSTEM switch to OFF. The A/A TARPS mode is normally entered from the TARPS mode by deselecting REC on the full or partial PTID menu or depressing any WCS MODE pushtile on the DDD after the CPS SYSTEM switch is in RDY. The transition from A/A TARPS back to TARPS is accomplished by hooking the PTID menu select symbol and then hooking REC on the full PTID menu (see Figure 24-15). This entry may also be made from full TARPS by selecting radar full action, any dogfight mode (PAL/MRL), or ACM guard up.

Note

While in the FF/DL mode, entering or exiting the TARPS mode causes initialization within the AWG-9 that in turn may cause the FF/DL N/9 advisories to be erroneously posted for participating members.

TRANSITION	CREW ACTION	TRANSITION TIME
A/A to A/A TARPS	CPS SYSTEM switch — RDY	Immediate (0.25 second)
A/A TARPS to A/A	CPS SYSTEM switch — OFF	Immediate (0.25 second)
TARPS to A/A TARPS	Deselect REC, from the partial PTID menu, or engage any WCS MODE pushtile, or select any ACM radar mode, or select full action on HCU (if DDD CCM MODES SPL pushtile selected).	
A/A TARPS to TARPS	Hook REC on the full PTID menu.	0.25 second or 12.5 seconds.

Note

- Transition from TARPS to A/A TARPS occurs with CPS SYSTEM switch RDY. If switch is OFF, transition is from TARPS to A/A.
- Any MTM tape read, unless caused by initiating restart, causes a transition to A/A TARPS with CPS SYSTEM switch in RDY. If CPS SYSTEM switch is OFF, A/A mode is entered. Depressing PRGM RESTART pushtile TARPS mode reinitializes TARPS.
- If the TARPS mode was previously entered and none of the following has occurred since the last exit from TARPS mode, transition occurs in approximately 0.25 second:

  — CPS SYSTEM switch OFF

  — BIT select

  — OBC select

  — A/G mode selected

  — PRGM RESTART pushtile

  — SPL function pushbutton selected

  — IFT selected

Figure 24-15. Air-to-Air TARPS Mode Transitions

24.6.2 Air-to-Air TARPS PTID Display. The camera-status acronyms used in the TARPS mode are abbreviated to one letter each for A/A TARPS. A single-letter camera-status acronym for each sensor is used to form a three-letter camera-status acronym that is displayed in the lower left portion of the PTID (see Figure 24-16 and Figure 24-17). The first letter of the camera status acronym represents the frame camera, the second letter represents the PAN camera, and the third letter represents the IR camera. The POD and IRW acronyms are provided in the same PTID location as the camera status advisory. When either acronym appears, it overrides the camera-status acronym. The camera RUN acronym is displayed using the same logic as in the TARPS mode. The TARPS data readouts RG, TG, GS, and MB are available for display; however, data readouts RR and TR, AGL displays, and the TARP acronym are not available in A/A TARPS. The NAV GRID display is available in A/A TARPS.

24.6.3 Air-to-Air TARPS HUD and VDI Symbology. TARPS-related symbology is not displayed on the VDI in TARPS. The only TARPS symbology displayed on the HUD is the target designator (diamond). The target designator overlays the last reference point hooked only when the pilot weapon select switch is OFF and no radar STT exists. If this reference point is subsequently unhooked, the diamond continues to overlay the reference point and a pointer appears on the PTID adjacent to the appropriate reference point. The pointer appears on the PTID only when the diamond overlays the reference point. If a new reference point is hooked, the diamond overlays the new reference point and no pointer is displayed unless the new reference point is unhooked.

Note

While PLM is selected, the HUD A/A TARPS diamond is suppressed. Upon deselection of PLM, the A/A TARPS diamond reappears. However, if a radar STT is established from PLM, the diamond becomes the radar STT target designator and the A/A TARPS diamond is no longer displayed.

24.6.4 Air-to-Air TARPS Steering. TARPS steering is not provided in the A/A TARPS mode. However, the HUD target designator is available as an orientation cue. Normal A/A steering modes on the HSD or ECMD are unaffected by the A/A TARPS mode. After transitioning from the TARPS mode to the A/A TARPS mode, the IP loses its dynamic steering function and becomes a stationary reference point.

Note

If TARPS steering is utilizing a CGTL or executing a TARPS map run, transitioning from TARPS mode to the A/A TARPS mode while overflying the IP during A/A TARPS operation may invalidate TARPS steering upon reentry to the TARPS mode.

ACRONYM	DESCRIPTION
RG	Range to go to hooked reference point.
TG	Time to go to hooked reference point.
GS	Own aircraft ground speed.
MB	Magnetic bearing to hooked reference point.
POD	POD/CPS failure indication: flashes continuously. Overrides camera status acronym in A/A TARPS only.
IRW	Vg/H is above operational value (0.0357) of IRLS narrow field of view; RIO selects WFOV on CPS. Flashes continuously, overrides camera status acronym in A/A TARPS.
V	Frame camera switch at VERT, first character of camera status acronym.
F	Frame camera switch at FWD, first character of camera status acronym.
C	Pan camera switch at CTR, second character of camera status acronym.
L	PAN camera switch at LEFT, second character of camera status acronym.
R	PAN camera switch at RIGHT, second character of camera status acronym.
N	IR camera switch at NFOV, third character of camera status acronym.
W	IR camera switch at WFOV, third character of camera status acronym.
—	Camera not selected. Entire camera status acronym flashes for 10 seconds when the aircraft is within a 30 second radius of the last hooked reference point. Symbol can occupy first, second and/or third character of camera status acronym.
RUN	Indicates RUN selected when the acronym is bright and steady. If film RUN is not selected, RUN appears and flashes continuously when the aircraft is within a 30 second radius of the last hooked reference point.

Figure 24-16. Air-to-Air TARPS PTID Displays

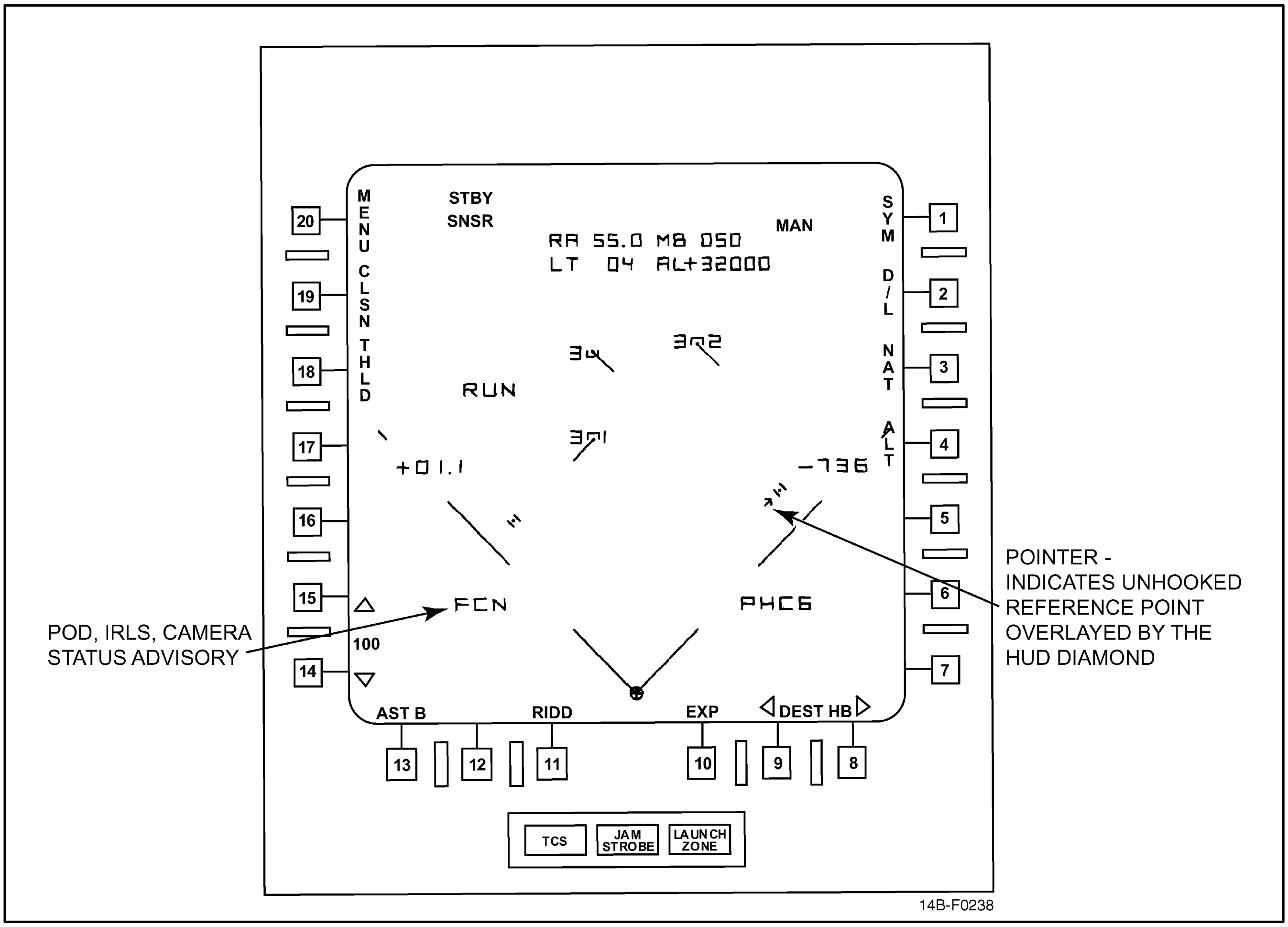


Figure 24-17. Air-to-Air TARPS Displays

CHAPTER 25

Navigation Command and Control Grid

25.1 NAVIGATION COMMAND AND CONTROL GRID

Navigation command and control grid (NAV GRID) enhances fleet air defense by providing navigation and command/control information during combat air patrol operations and for fleet defense of a specific fixed position. NAV GRID has two major advantages: it provides aircraft position relative to a geographic reference point (YY) common to all fleet defense units and eliminates dependence on navigation aids such as tacan during antiair warfare operations. F-14 combat air patrols using NAV GRID can report target contacts using grid coordinates or range and bearing relative to YY in addition to normal reports referenced to own aircraft position. NAV GRID is selected by the RIO and displayed on the tactical information display (Figure 25-1).

25.1.1 NAV GRID Display. NAV GRID is displayed in the tactical and training modes with all range scales and GND STAB selected on the PTID (Figure 25-1). It consists of certain data readouts and a maximum of six subsectors emanating from YY. Grid coverage up to 180° is available. The NAV GRID display is available during air-to-air TARPS operations, but not for TARPS.

NAV GRID is available in in-flight training (simulated scenarios and live target). IFT exercise number is not displayed while NAV GRID is displayed. Upon deselection of NAV GRID, IFT exercise number is again displayed. NAV GRID display is inhibited while IFT option menu or postexercise display is on the PTID.

Without PTID offset, YY is positioned on the PTID perimeter and oriented with the threat axis (grid heading) passing through PTID center. Each grid strobe has short and long tic marks representing 50- and 100-nm increments respectively from 50 to 350 nm. When six subsectors (seven strobes) are selected, range tics are not displayed on the center strobe. Own aircraft and all NAV GRID symbology is displayed in reference to YY. When PTID offset is selected, portions of the grid display may be positioned off the PTID. Offset positioning can be cancelled by momentarily cycling the PTID MODE switch out of GND STAB (Figure 25-2). When NAV GRID display is selected or deselected, any PTID offset or PTID expansion is retained. With a hook (including own aircraft), displayed range and bearing is from YY to hooked symbol. With ALT NUM selected, NAV GRID sector voice codes are displayed next to hooked target alternating with altitude numeric (Figure 25-3). With no hook, displayed range and bearing is from own aircraft to YY. Once NAV GRID is entered, NAV GRID readouts are available in all CAP category positions as long as there are no track file hooks or position hooks in effect. Figure 25-4 depicts NAV GRID display priorities.

With GND STAB not selected, NAV GRID sector voice codes are displayed to the left of own aircraft symbol on the PTID. If a target is hooked, NAV GRID sector voice code alternates with the altitude numeric or data-link modifier of the hooked target. The voice codes will not be displayed if the PTID buffer space is over-loaded. However, the altitude numeric will continue to blink at a 2-second rate.

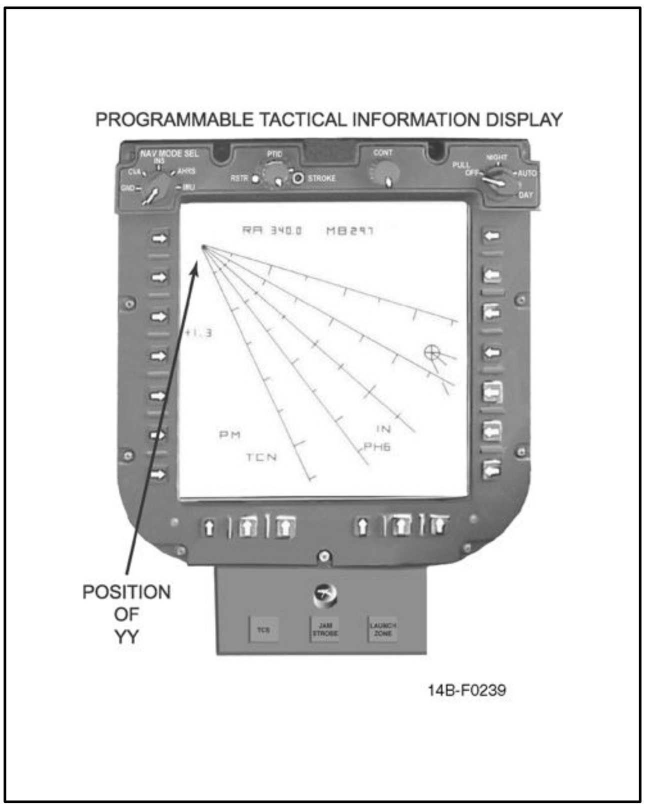


Figure 25-1. NAV GRID Controls

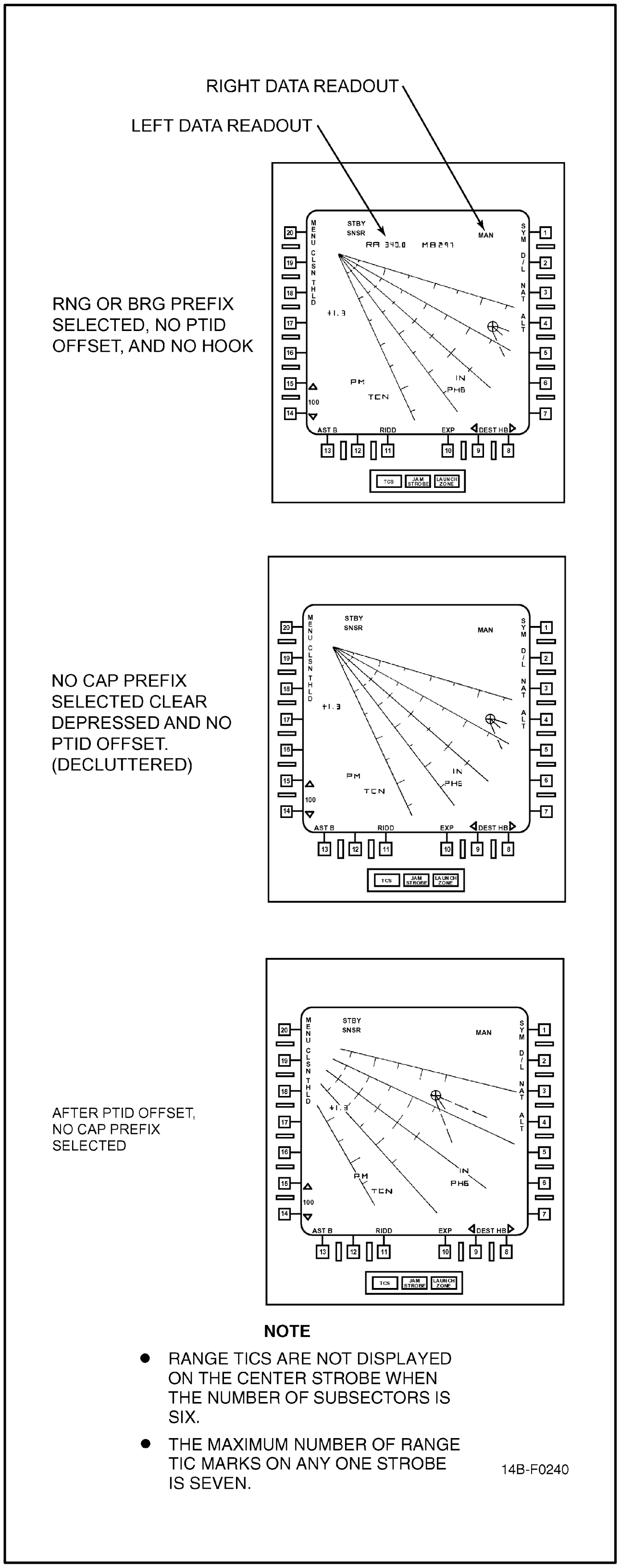


Figure 25-2. NAV GRID Displays (Typical)

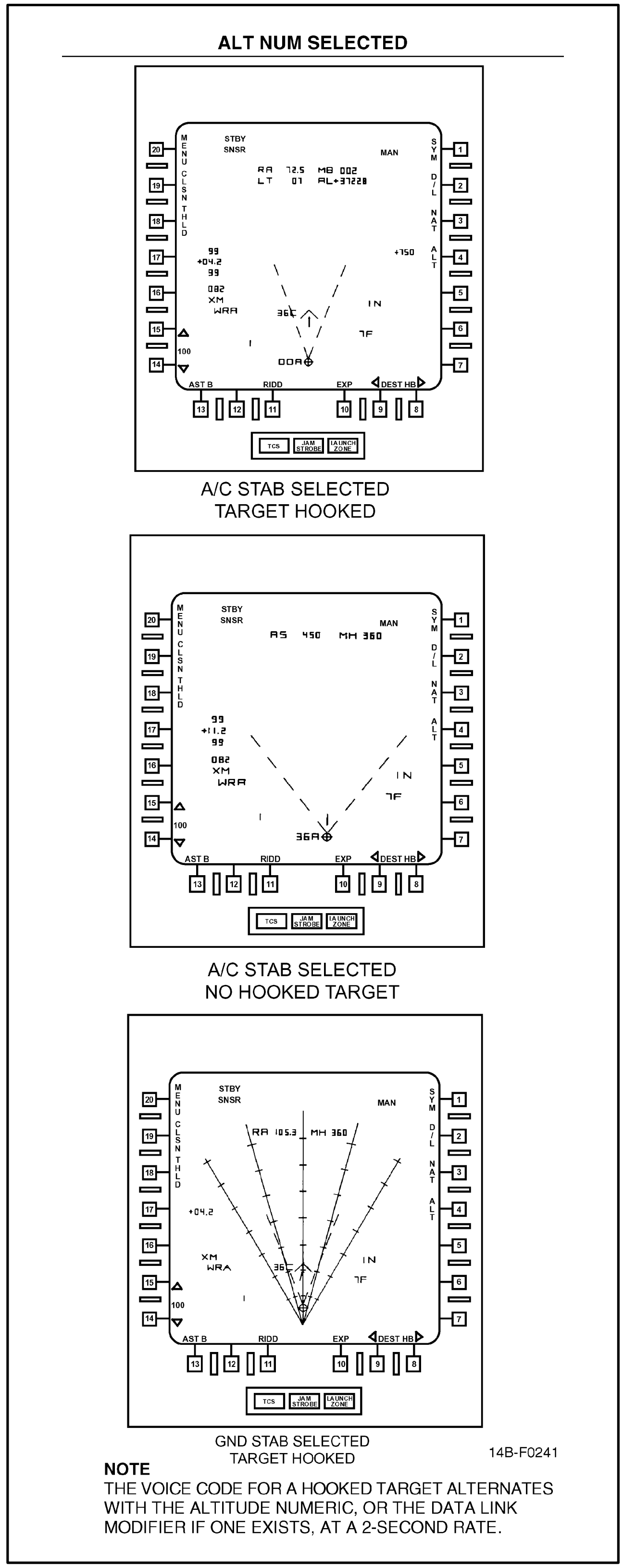


Figure 25-3. NAV GRID Sector Voice Code Displays (Typical)

SELECT / POSTED	LAR CONTOUR	NAV GRID	ACS MENU
LAR CONTOUR		SUPPRESS LAR CONTOUR	SUPPRESS LAR CONTOUR
NAV GRID	*DESELECT NAV GRID		SUPPRESS NAV GRID
ACS MENU	DESELECT ACS MENU	DESELECT ACS MENU	
*GND STAB only			

Figure 25-4. NAV GRID Display Priorities

Note

Depressing CLEAR pushbutton clears PTID upper left and right readouts (decluttered).

CAP sequences and keyboard data selection readouts available in NAV GRID are shown in Figure 25-5. The following PTID functions are disabled during NAV GRID display:

1. Lower left and right data readouts
2. Flycatcher
3. PA OFF advisory
4. Closure rate
5. Frame counter
6. Antenna altitude scan coverage
7. IFT exercise number.

Note

The antenna elevation readout is not displayed during CAP data entry. Upon completion of data entry, the display is reenabled.

25.1.1.1 NAV GRID Display Priorities. When NAV GRID is selected, the LAR CONTOUR (GROUND STAB mode only) is suppressed and the automatic channel select (ACS) MENU is deselected. After NAV GRID is displayed and LAR CONTOUR subsequently selected (LAUNCH ZONE pushtile depressed and target hooked and PTID mode switch in GROUND STAB), NAV GRID is deselected. When NAV GRID is deselected, it can only be displayed by hooking NG on the full PTID menu. After NAV GRID is displayed and ACS MENU subsequently selected, NAV GRID is suppressed. When NAV GRID is suppressed, it can be redisplayed by deselecting ACS MENU or by hooking NG on the full PTID menu. The logic provides the operator's last requested display on the PTID and suppresses or deselects the previously requested display. If a display is suppressed, it is redisplayed upon deselection of the operator's last requested display. If a display is deselected, it must be reselected to be restored.

25.1.2 NAV GRID Entry

Note

NAV GRID can be entered in the tactical or training modes. Do not enter NAV GRID parameters during alignment.

1. Select NVD on PTID Menu.
2. Select GRD from submenu.
3. Under the ACTIVE legend, select NG.
4. Select GSTB on PTID MODE selection pushtile.
5. Select MENU on PTID.
6. Select NG on PTID Full Menu.

25.1.3 NAV GRID Parameter Entry

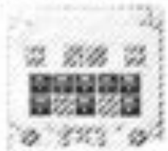
1. ALT — Enter grid coverage angle (up to 180°).
2. NBR — Enter number of grid sectors (up to six).
3. LAT/LONG — Enter latitude and longitude of YY;

   or

   RNG/BRG — Enter range and bearing of YY from own aircraft.
4. HDG — Enter threat axis (grid heading).

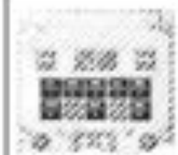
Note

NAV GRID display is automatically updated approximately every 5 minutes to compensate for changes in MAG VAR.

NAV GRID				
ACTION			INDICATION	REMARKS
PTID MENU FUNCTION	 PREFIX	 NUMERICS	DATA READOUT 	COMPUTER RESPONSE
NG....HOOK	LAT 1		LN or LS LE or LW	DISPLAY YY CONTROL POINT (NAV GRID ORIGIN) OR HOOKED SYMBOL LATITUDE AND LONGITUDE. SELECTING NAV GRID SUPPRESSES LAR CONTOUR AND DESELECTS ACS MENU.
	LAT 1	NEW LATITUDE	LN or LS LE or LW	UPDATE YY CONTROL POINT (NAV GRID ORIGIN) LATITUDE
	LON 6		LN or LS LE or LW	DISPLAY YY CONTROL POINT (NAV GRID ORIGIN) OR HOOKED SYMBOL LATITUDE AND LONGITUDE
	LON 6	NEW LONGITUDE	LN or LS LE or LW	UPDATE YY CONTROL POINT (NAV GRID ORIGIN) LONGITUDE
	HDG 8		AL MH	DISPLAY OF GRID COVERAGE ANGLE AND NAV GRID SECTOR (THREAT AXIS).
	HDG 8	NEW NAV GRID SECTOR HDG	AL MH	UPDATES NAV GRID SECTOR HDG (THREAT AXIS)
	RNG 5		RA MB	WITH NO HOOK, DISPLAY OF RNG AND BRG FROM OWN A/C TO YY CONTROL POINT. WITH HOOK (INCL. OWN A/C), DISPLAY OF AND BRG FROM YY CONTROL POINT TO HOOKED SYMBOL.
	RNG 5	NEW RANGE	RA MB	UPDATES RNG FROM OWN A/C TO YY CONTROL POINT.

14B-F0242

Figure 25-5. Computer Address Panel Sequences (Sheet 1 of 2)

NAV GRID					
ACTION				INDICATION	REMARKS
		 PREFIX	 NUMERICS	DATA READOUT 	COMPUTER RESPONSE
		BRG 0		RA MB	WITH NO HOOK, DISPLAY OF RNG AND BRG FROM OWN A/C TO YY CONTROL POINT WITH HOOK (INCL. OWN A/C), DISPLAY OF RNG AND BRG FROM YY CONTROL POINT TO HOOKED SYMBOL.
		BRG 0	NEW BEARING	RA MB	UPDATES BRG FROM OWN A/C TO YY CONTROL POINT.
		ALT 4		AL MH	DISPLAY OF NAV GRID COVERAGE ANGLE AND NAV GRID SECTOR HDG (THREAT AXIS).
		ALT 4	NEW NAV GRID COVERAGE ANGLE	AL MH	UPDATES NAV GRID COVERAGE ANGLE
		NBR 2		NB	BUFFER REGISTER DISPLAYS NUMBER OF SUBSECTORS INCORPORATED IN NAV GRID DURING ENTRY ONLY.
		NBR 2	NEW NUMBER OF NAV GRID SUBSECTORS	NB	UPDATES NUMBER OF SUBSECTORS

14B-F0243

Figure 25-5. Computer Address Panel Sequences (Sheet 2)

25.1.3.1 On Deck NAV GRID Entry

Note

Because of magnetic disturbances on deck, the following procedures are required for accurate entry of grid heading.

1. NAV MODE switch — AHRS/AM.
2. Grid area MAG VAR ENTERMAG VAR must be entered regardless of displayed value.
3. Grid magnetic heading (HDG) — ENTER.
4. NAV MODE switch — INS.
5. Local MAG VAR — ENTER.
6. Enter only if displayed MAN MAG VAR is incorrect.

25.1.3.2 NAV GRID Exit. NAV GRID can be exited by any of the following actions:

1. Deselect GSTB. Reselecting GSTB will not retain previous offset. With ALT NUM selected, a NAV GRID sector voice code appears to the left of own aircraft symbol on the PTID. If a target is hooked (before or after deselecting GSTB, a sector voice code appears alternating with the hooked target altitude numeric.

   or

2. NG on partial PTID menu — Unhook

   or

3. NG on full PTID menu — Unhook

   or

4. PRGM RESTRT pushtile — Depress

   or

5. Change to a nontactical mode.

   or

6. Deselect NG from Grid Data page.

   or

7. Select BE from Grid Data page.

25.2 BULLSEYE GRID

The Bullseye Grid provides F-14 aircrews with a means to quickly and accurately locate the position of airborne or ground targets based on position data from a fixed geographical point. The Bullseye mode provides a digital readout of range and bearing from a designated pseudo file (Bullseye Reference Point) to any hooked symbol, an active PTID cursor, or PTID cursor spot hook. Bullseye Grid is selected by the RIO and displayed using any of the three PTID tactical display formats. Figure 25-6 shows the Bullseye Grid Display with range and bearing from the designated reference point to a hooked symbol.

25.2.1 Bullseye Grid Display. Bullseye Grid is displayed in the tactical and training modes in all range scales with the PTID in GND STAB, A/C STAB or ATTK. It consists of data readouts for range and bearing from the Bullseye Reference Point to a hooked symbol, an active PTID cursor, or PTID cursor spot hook. The Bullseye display is available during air-to-air, air-to-ground**,** air-to-air TARPS, or TARPS operations. Bullseye Grid is also available during in-flight training exercises but is inhibited while the IFT option menu or postexercise display is posted.

When the Bullseye Grid mode is active, the “BE” acronym in the partial menu is brightened. The Bullseye Grid displays consist of a bearing and range readout which is displayed in the upper right submenu area of the PTID and is mutually exclusive from the VEC mode time-to-go displays. The bearing display is located to the left of the range readout and consists of a three-digit readout ranging from 001 to 360° accompanied by a dimmed degree symbol.

The range display is a three-digit readout from 000 to 999 nm. If there is no active cursor, spot hook, or hooked symbol, dashes will be displayed for the bearing and range readouts. Figure 25-7 depicts the Bullseye displays without an active cursor, spot hook, or hooked symbol.

Immediately below the bearing and range readout the alphanumeric identifier for the Bullseye Reference Point is posted. The Bullseye Reference Point is selected from the Grid Data (GRD) Page which is a submenu of the NVD page.

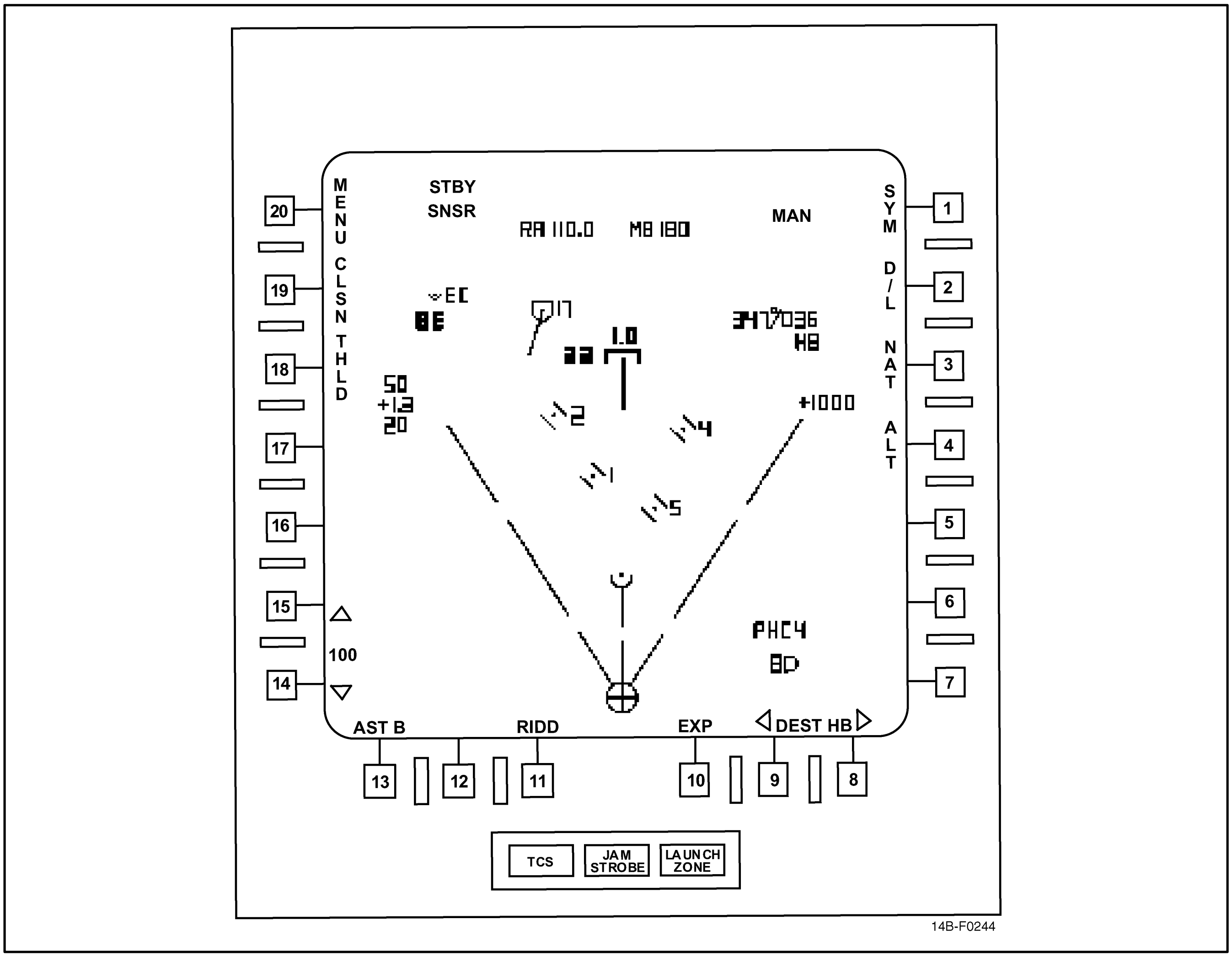


Figure 25-6. Bullseye Range and Bearing with Hooked Symbol

Note

Display of Bullseye Grid data will have no impact on LAR contour or closure rate displays.

The Bullseye Reference Point has a “North Spike” emanating from the symbol center. The “North Spike” is a fixed length of 0.6 inches and is always referenced to magnetic north. This “North Spike” will replace the velocity vector normally associated with the designated pseudo file. Upon selection of another valid pseudo file as the Bullseye Reference Point, the previous reference point will have its velocity vector restored.

While in the Bullseye Grid mode tactical display, the Bullseye Reference Point can be redesignated by hooking another pseudo file and by depressing CAP category Data Link function button 4. If no pseudo file is selected or the selected pseudo file is inactive (LAT/LON data not entered) when the Data Link function button 4 is depressed, the Bullseye Reference Point will remain unchanged. The function button does not illuminate as a result of redesignating the Bullseye reference point.

25.2.2 Bullseye Grid Parameter Entry. The Grid Data page is used for designating the reference point for the Bullseye range and bearing computations presented on the tactical display. The Bullseye Reference Point is indicated on the Grid Data page in the REF PT rotary display window (the selected pseudo file will be displayed between the arrow symbols “<” and “>”). The Bullseye Reference Point can be changed by hooking the centroid dot of the left or right arrows. The pseudo files will be displayed in the rotary in the same order as displayed on the Way Point (WP) page. The right arrow will increment through the pseudo files and the left arrow will decrement through the pseudo files.

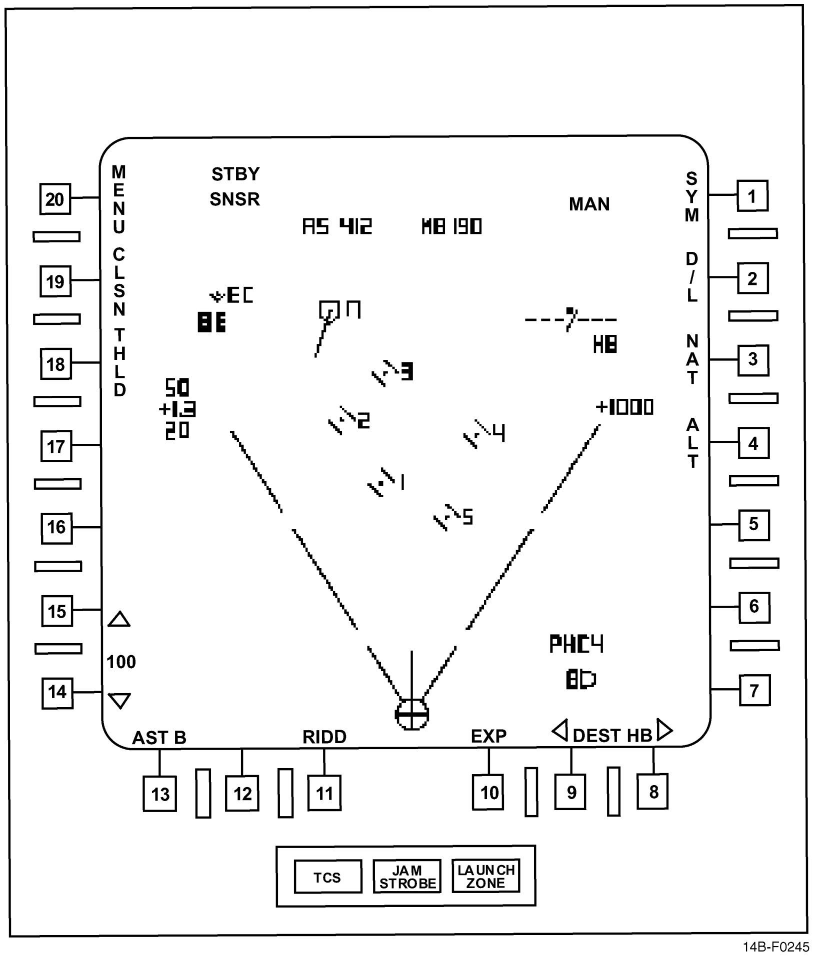


Figure 25-7. Bullseye Range and Bearing with No Spot Hook, No Hooked Symbol, and Not Half Action on HCU

The rotary display will wrap around (first to last/last to first) as pseudo files are decremented or incremented. An "X" will be superimposed over any pseudo file display that does not have a latitude or longitude entry. If no valid Bullseye Reference Point has been selected since power-up, waypoint 1 (1) will be the default pseudo file. Otherwise, the pseudo file displayed will be the most recent Bullseye Reference Point.

Immediately below the Bullseye Reference Point selection line, the latitude and longitude of the Bullseye Reference Point will be presented adjacent to LAT and LON labels, respectively. Immediately below the latitude and longitude readouts, the aircrew assigned numeric of the pseudo file designated as the Bullseye Reference Point will be displayed. If no number has been assigned by the aircrew to the pseudo file then the numeric indicator will be zero.

Note

The LAT/LON and NBR values of the selected Bullseye Reference Point can only be changed while the GRD page is displayed if that pseudo file was hooked (cursor or CAP) prior to GRD page selection or CAP hooked during GRD page display.

25.2.3 Bullseye Grid Entry

1. On the full PTID Menu, shown in Figure 25-8, select NVD to transition to the Navigation Data page. Figure 25-9 shows the Navigation Data (NVD) page.
2. On the Navigation Data page, cursor hook the centroid dot of the "G" on the "GRD" acronym in the submenu to transition to the Grid Data page. Figure 25-10 shows the Grid Data (GRD) page.

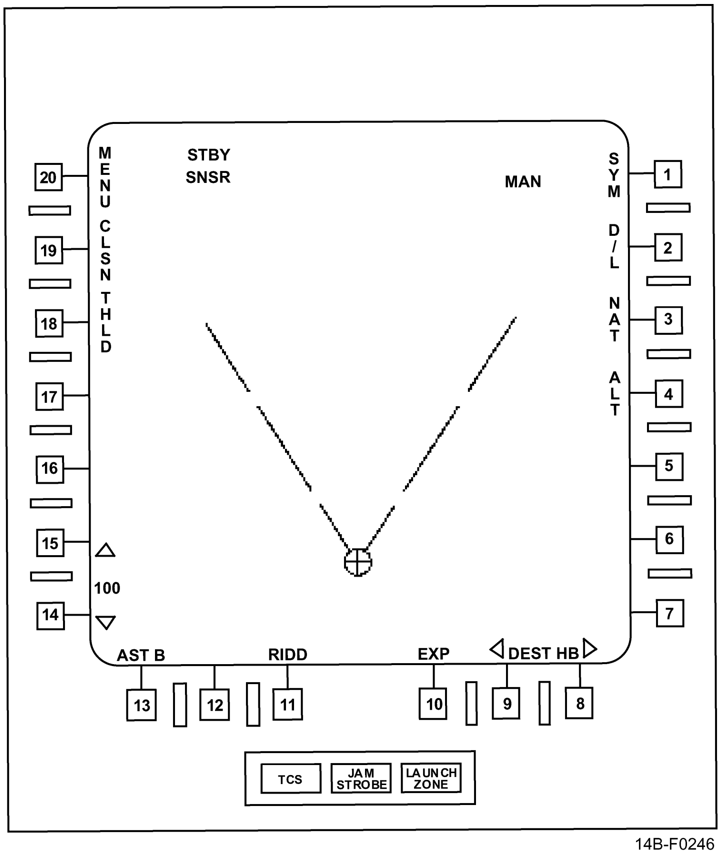


Figure 25-8. PTID Full Menu Page

3. Select the desired pseudo file on the Grid Data page Reference Point (REF PT) rotary display window.

4. On the Grid Data page, hook the centroid dot of the “B” in the dimmed “BE” acronym. The “BE” acronym will brighten if an active pseudo file has been selected as the Bullseye Reference Point.

5. Once the “BE” acronym is brightened on the Grid Data page, select MENU on the Grid Data page to return to the full PTID Menu.

6. On the full PTID Menu, select NG.

Note

If neither “NG” nor “BE” is active on the Grid Data page then NG on the full PTID Menu will not be selectable.

25.2.4 Bullseye Grid Mode Exit. Bullseye Grid can be exited by any of the following actions:

1. With the Bullseye Grid Mode active on the tactical display (“BE” acronym is brightened in the partial PTID menu), hook the centroid dot of the “B” in the brightened “BE” acronym, the Bullseye Grid Mode will be de-activated and the “BE” acronym will change from bright to dim. The Bullseye Grid Mode can be restored by hooking the dim “BE” acronym in the partial menu.

2. With the Bullseye Grid Mode active, select MENU. On the full PTID Menu, deselect NG. This will deactivate the Bullseye Grid mode and cause the “BE” acronym to be removed from the partial menu. The Bullseye Grid Mode can be restored by re-selecting NG on the full PTID Menu.

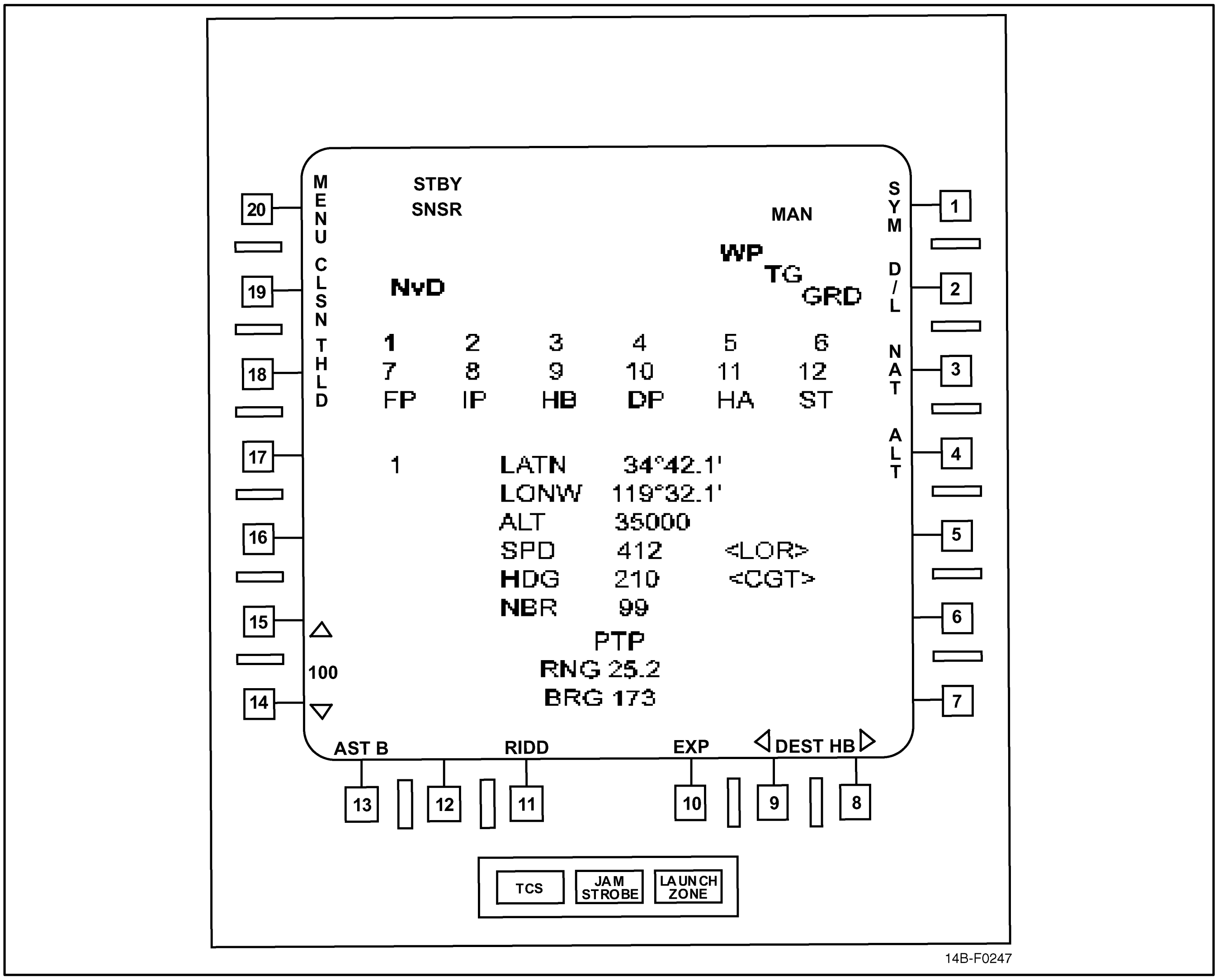


Figure 25-9. Navigation Data (NVD) Page — Defaults to Waypoint

Note

The “north spike” will remain with the Bullseye Reference Point until “BE” is de-selected from the Grid Data page.

3. With the Bullseye Grid Mode active, on the Grid Data page, hook the centroid dot of the “B” of the brightened “BE” acronym under the active menu. The “BE” acronym will become dim and the BE mode will be deselected. The Bullseye Grid Mode can be re-selected by hooking the centroid dot of the “B” in the same dim “BE” acronym and reselecting NG from the full PTID menu.

Note

De-selecting “BE” on the Grid Data page to deactivate the Bullseye Grid Mode (both the “NG” and “BE” acronyms are dim) will result in the NG on the full PTID Menu not being selectable.

4. With the Bullseye Grid Mode active, on the Grid Data page, hook the centroid dot of the “N” of the dim “NG” acronym. This will result in dimming the “BE” acronym and brightening the “NG” acronym.

Note

Selecting “NG” on the Grid Data page to deactivate the Bullseye Grid Mode will result in the Nav Grid display if NG is subsequently selected from the full PTID menu.

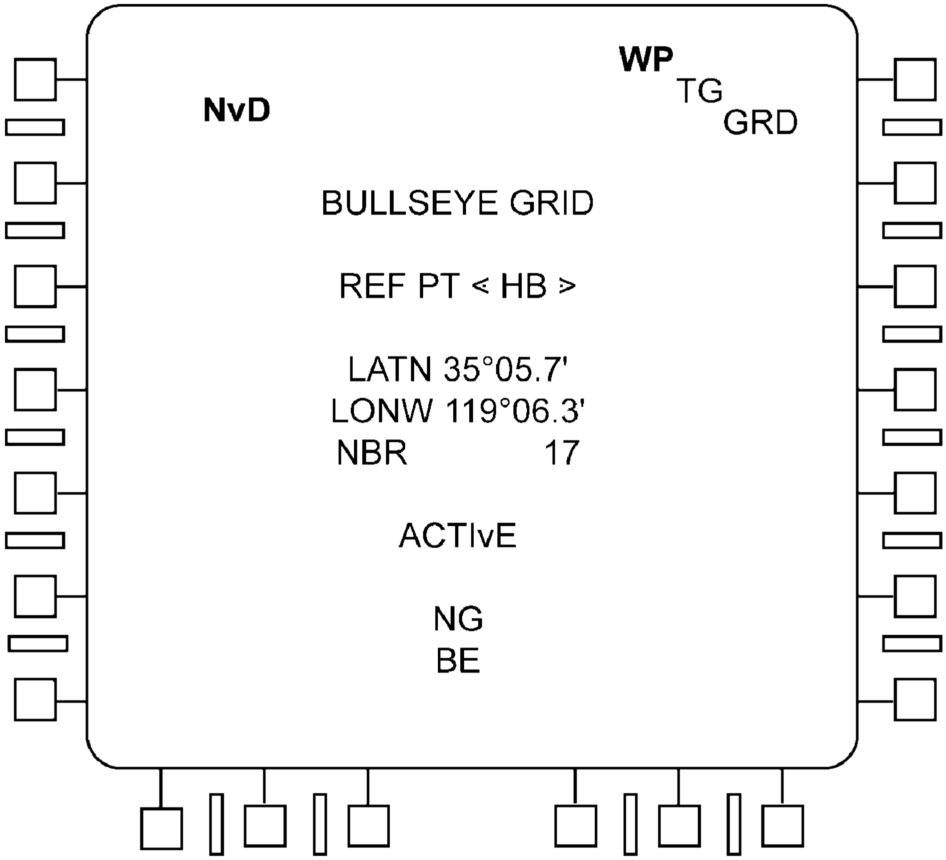


Figure 25-10. Grid Data (GRD) Page

PART IX

Flightcrew Coordination

CHAPTER 40

Flightcrew Coordination

40.1 INTRODUCTION

The duties of the pilot/RIO team are necessarily integrated and contribute to the performance of the other. Successful crew interaction can provide cockpit synergism that significantly improves mission success. However, a pilot/RIO team that does not interact successfully can be a major detriment to mission success. In this chapter, specific responsibilities are delineated for each phase of flight. Specific mission flightcrew responsibilities are also delineated.

40.2 PILOT AND RIO RESPONSIBILITIES

40.2.1 Aircrew Coordination. Aircrew coordination is the flightcrew's use and integration of all available skills and resources in order to collectively achieve and maintain crew efficiency, situational awareness, and mission effectiveness. Integration of flightcrew activities will provide error protection through human redundancy. Crew coordination is one of the most significant factors towards mission success.

40.2.2 Pilot Responsibilities. The pilot is the aircraft commander and is responsible for the safe and orderly flight of the aircraft and the wellbeing of the crew. In the absence of direct orders from higher authority cognizant of the mission, responsibility for starting or continuing a mission with respect to the weather, mission environment, or any other condition affecting the safety of the aircraft, rests with the pilot.

40.2.3 RIO Responsibilities. The RIO will constitute an extension of the pilot observation facilities. By intercommunication, the RIO should anticipate rather than await developments in flight. The RIO will be a safety backup for the pilot. In this capacity, he shall offer constructive comments and recommendations, as necessary, throughout the mission in order to maintain the safest and most effective flight environment. The RIO will be responsible for the reading of the checklists utilizing a challenge and reply system. The RIO will normally be responsible for all communications except in tactical situations.

40.2.4 Mission Commander. The mission commander may be either a pilot or a RIO. He shall be qualified in all phases of the assigned mission and be designated by the unit commanding officer. When the assigned mission commander is a RIO, he shall be responsible for all phases of the assigned mission except those aspects of safety of flight that are directly related to the physical control of the aircraft. The mission commander shall direct a coordinated plan of action and shall be responsible for the effective execution of that plan.

40.2.5 Specific Responsibilities

40.2.5.1 Flight Planning

40.2.5.1.1 Pilot. The pilot is responsible for the preparation of required charts, flight logs, and navigation computations including fuel planning, checking weather and notices to airmen (NOTAMs), and for filing required flight plans.

40.2.5.1.2 RIO. The RIO is responsible for the preparation of charts, flight logs, navigation computations including fuel planning, checking NOTAMs, obtaining weather for filing purposes, and for completing required flight plans.

40.2.5.2 Briefing. Accomplish those tasks delineated in the preceding paragraph.

40.2.5.2.1 Mission Commander. The mission commander, pilot or RIO, is responsible for briefing all crewmembers on all aspects of the mission to be flown. Refer to Chapter 6 of this manual for specific items.

40.2.5.3 Preflight

40.2.5.3.1 Pilot. The pilot is responsible for accepting and preflighting the aircraft assigned and coordinating preflight operational checks in accordance with this manual and appropriate preflight checklists contained in the NATOPS Pocket Checklist.

40.2.5.3.2 RIO. The RIO will be capable of and proficient in performing a complete aircraft preflight, including all armament, in accordance with this manual and appropriate preflight checklists contained in the NATOPS PCL.

40.2.5.4 Prestart

40.2.5.4.1 Pilot. The pilot will execute prestart checks prescribed in the NATOPS PCL and, when external power is applied and checks requiring external power are completed, will inform the RIO, "Prestart checks completed — ready to start."

40.2.5.4.2 RIO. The RIO will execute prestart checks prescribed in the NATOPS PCL and, when external power is applied, will inform the pilot, "Prestart checks completed."

40.2.5.5 Starting

40.2.5.5.1 Pilot. The pilot will start engines as prescribed in engine start-pilot in paragraph 7.4.3 and will keep the RIO informed of any unusual occurrences.

40.2.5.5.2 RIO. The RIO will remain alert for any emergency signal from the groundcrew and will inform the pilot if such signals are observed.

40.2.5.6 Poststart

40.2.5.6.1 Pilot. At completion of the emergency generator check, the pilot will inform the RIO, "Emergency generator check completed." The pilot will complete all poststart checks prescribed in the NATOPS PCL and coordinate with the RIO the initiation of OBC.

40.2.5.6.2 RIO. At completion of the emergency generator check, the RIO will perform the poststart checks prescribed in the NATOPS PCL. When OBC is completed and the inertial navigation system aligned, RIO informs the pilot, "Ready to taxi."

40.2.5.7 Taxi/Pretakeoff

40.2.5.7.1 Pilot. The pilot will follow the prescribed procedures for arming the aircraft and ensure that the aircraft is clear of all obstacles prior to taxiing. Prior to entering the taxiway, he will ensure that taxi clearance has been received and observe local traffic to ensure adequate separation to avoid ingestion of FOD. The pilot shall execute Pretakeoff, Instrument, and Takeoff Checklists prescribed in the NATOPS PCL. The pilot shall report to the RIO takeoff checklist items, using the challenge-reply method. The pilot will receive the "Ready for takeoff" report from the RIO and advise him of type and configuration takeoff planned prior to rolling or entering the shuttle. Additionally, the pilot will verbally acknowledge the takeoff weight accepted by the RIO from the catapult weight board during shipboard operations. The pilot shall report "Rolling" or "Saluting," as appropriate, to the RIO.

40.2.5.7.2 RIO. The RIO shall execute pretakeoff checklists prescribed in the NATOPS PCL and will assist the pilot, ensuring that the aircraft is clear of all obstacles before taxiing. The RIO shall initiate the challenge-reply Takeoff Checklist stipulated in the NATOPS PCL and, at the completion of the Takeoff Checklist, inform the pilot, "Ready for takeoff." Aboard ship, the RIO has the additional responsibilities to "roger" the weight board and report the weight to the pilot as well as ensuring that those caution and advisory lights that can be readily seen from the back seat are extinguished (BRAKES, NWS ENGA) and the desired trim is set for the aircraft configuration.

40.2.5.8 Takeoff and Departure

40.2.5.8.1 Pilot. The pilot shall ensure that the intercom remains in HOT MIKE for normal flight operations and will report, "Gear up" and "Flaps up" to the RIO insofar as safety permits. The RIO should be advised of any unusual occurrences during takeoff that may affect safety of flight. The pilot or RIO will request, copy, and acknowledge all clearances.

40.2.5.8.2 RIO. Where departures are made in actual instrument conditions, the RIO will monitor the published clearance departure procedures and inform the pilot of any deviation from the prescribed flightpath. The RIO will copy all clearances received and at all times be prepared to provide the pilot with clearance information of navigational information derived from these instruments. Built-in-test checks will not be conducted during instrument climbouts.

40.2.5.9 In Flight (General)

40.2.5.9.1 Pilot. The pilot will inform the RIO of any unusual occurrences and will ensure that the aircraft is operated within prescribed operating limitations at all times. The pilot or RIO will normally request, copy, and acknowledge all clearances.

40.2.5.9.2 RIO. The RIO will assist the pilot in normal or emergency situations, including navigation, communication, and visual lookout. The RIO will inform the pilot of the weapon system status. During ascent or descent, the RIO will inform the pilot 1,000 feet prior to the intended level off altitude.

40.2.5.10 Intercept

40.2.5.10.1 Pilot. The pilot will maneuver or coordinate aircraft maneuvers with or as directed by the RIO, observing normal operating limitations. The pilot will inform the RIO of weapons status, weapons selected and armed, and when the target is sighted visually. The pilot will monitor aircraft position from initial vector through breakaway by pigeons information or navigational display.

40.2.5.10.2 RIO. The RIO will handle all communications from initial vector through breakaway (excluding missile-away transmissions), provide the pilot with descriptive commentary (including weapon status and target aspect), if available, and direct and coordinate aircraft maneuvers with the pilot, as necessary, to complete the intercept.

40.2.5.11 Instrument Approaches

40.2.5.11.1 Pilot. The pilot is responsible for the safe control of the aircraft, the decision to commence the approach with the existing weather, and the selection of the type of approach to be made. The pilot before commencing any penetration will report to the RIO the completion of each item of the Instrument Checklist. In addition, the pilot will challenge the RIO Instrument Penetration Checklist as to approach plate availability and corrected altimeter setting.

40.2.5.11.2 RIO. The RIO will monitor aircraft instruments and appropriate approach plate during holding, penetration, and approach and shall be ready to provide the pilot with any required information. He shall be particularly alert to advise the pilot of deviations from the course of minimum altitudes prescribed on the approach plate. Built-in-test checks will not be conducted in actual instrument conditions. The RIO will inform the pilot of the status of the radar and will do nothing to cause the display to be lost. During penetrations and/or descents (VFR or IFR), the RIO will report to the pilot the aircraft descent through each 5,000 feet of altitude above 5,000 feet and each 1,000 feet of altitude loss below 5,000 feet until, on reaching the desired altitude, the RIO will report when altitude error exceeds 10 percent of actual altitude or ±300 feet.

40.2.5.12 Landing

40.2.5.12.1 Pilot. The pilot will utilize the Landing Checklist and report each item to the RIO prior to reporting, “Gear down, hook down” to the final controller, tower, or PriFly.

40.2.5.12.2 RIO. In the landing pattern, the pilot shall read and the RIO shall acknowledge the Landing Checklist. The RIO shall visually check the flap position and landing gear position by looking through the opening on the left side of the instrument panel. Built-in-test checks shall not be conducted while in the landing pattern.

40.2.5.13 Postflight

40.2.5.13.1 Pilot. The pilot will inform the RIO of any unusual occurrences on the landing roll or arrestment. The pilot will report flap and wing position to the RIO when clear of the runway or landing area, and report when the wing is actuated. The pilot will inform the RIO when shutting down engines. The pilot will conduct a postflight inspection of the aircraft.

40.2.5.13.2 RIO. The RIO will challenge the pilot on flap position if the report is not received. When informed by the pilot that the wing has been actuated, the RIO will visually verify wing and spoiler positioning. The RIO will complete the built-in-test checks remaining and secure the rear cockpit for shutdown, then notify the pilot, “Ready for shutdown.” The RIO will assist the pilot in conducting a postflight inspection of the aircraft.

Note

The RIO will vacate the aircraft first and after he is on the ground, flight deck, or hangar deck, the pilot will exit. This is particularly important during shipboard operations.

40.2.5.14 Debriefing. The pilot and RIO will complete the Yellow Sheet and all required debriefing forms.

40.2.5.14.1 Maintenance. The pilot and RIO will complete the Maintenance Action Form, BER card, and all other required maintenance debrief forms. The crew will ensure a complete debrief is provided for all maintenance discrepancies.

40.2.5.14.2 Mission. The mission commander will be responsible for conducting a thorough mission debrief to include the accomplishments of mission goals, adherence to SOP/ROE/NATOPS, intercockpit and flight communication, and conflict resolution.

40.3 SPECIAL CONSIDERATIONS

40.3.1 Functional Checkflights. The pilot and RIO shall brief with maintenance to determine the discrepancies that were corrected and the intentions of the functional checklist.

40.3.1.1 Pilot. The pilot is responsible for adherence to all FCF procedures as described in Chapter 10 of this manual.

40.3.1.2 RIO. The RIO is responsible for monitoring the FCF procedures and the completion of his specific tasking outlined in Chapter 10 of this manual.

40.3.2 Formation Flights

40.3.2.1 Formation Leader. A pilot will be designated the formation leader. The status of each member of the formation shall be briefed and clearly understood prior to takeoff. As a minimum, formation brief items shall include loss of sight, lost communication, inadvertent IMC, and formation integrity. The formation leader is responsible for the safe and orderly conduct of the formation. This includes visual lookout, the separation between the aircraft within the formation and during transition periods, breakups, and rendezvous.

40.3.2.2 Pilot. The pilot is responsible for the safe separation of his aircraft and the other aircraft in the formation. Lead changes will include a positive acknowledgment by both pilots.

40.3.2.3 RIO. The RIO will monitor formation separation and closure during joinup and advise the pilot when an unsafe situation exists.

40.3.3 Training

40.3.3.1 Instructors. All instructors will be designated in formal directives by unit commanding officers. In FRS's, the instructors will be charged with authority and responsibility to provide proper direction to pilot and RIO replacements to ensure safe and successful completion of each training mission. On those training missions where a pilot under instruction is the pilot in command, the instructor's guidance shall be advisory in nature and under no circumstance shall the pilot in command be relieved of his authority and responsibility as aircraft commander. Termination of the training or evaluation portions of the flight for reasons of safety, unsatisfactory performance, or material discrepancy shall be the instructor's prerogative.

40.3.4 SAR. The mission commander or senior member of the flight, should the mission commander be unavailable, shall assume responsibility for the rescue operation until relieved on scene or fuel dictates a return to base. The primary responsibility of the on-scene commander will be communication of the downed crew's position and condition to potential rescue aircraft or vessels. Additionally, the on-scene commander will ensure search coordination, traffic control on the scene, and provide communication with the downed crews if feasible.

40.4 PROCEDURES, TECHNIQUES, AND CHECKLISTS

40.4.1 General. Even though some of the procedures, techniques, and checklists are specifically designed for the pilot or RIO, the entire contents of the flight manual and the pocket checklist should be thoroughly read, understood, discussed, and agreed upon collectively by the pilot-RIO team. Discrepancies in procedures or the need for additional procedures should be brought to the attention of the NATOPS evaluator and/or instructor. Most of the procedures (individual and coordinated) are covered in this manual and are grouped under flight phases and/or categories. Aircraft systems description, with their individual operating criteria, is covered in Chapter 2. Classified system descriptions and procedures, and some limitations information, are covered in the NATOPS classified supplement (NAVAIR 01-F14AAA-lA).

The NATOPS PCL (NAVAIR 01-F14AAA-1B) contains the pilot and RIO checklist items for preflight, prestart, start, poststart, takeoff, built-in-test, instrument and descent, and postflight procedures. Improper crew coordination is usually the attributable factor to improper emergency procedure.

40.4.2 Pilot. The pilot should relate to the RIO all indications relevant to the ongoing emergency. The pilot should assess the situation, prioritize the emergencies, and direct the RIO to effectively assist him.

40.4.3 RIO. The RIO should monitor all critical flight parameters and read all applicable checklists in a challenge and reply system. He should assist in navigation, communication, and coordinate with outside agencies and aircraft, but not to the detriment of the resolution of the emergency.

CHAPTER 41

Aircraft Self-Test

41.1 SELF-TEST

There are six self-test procedures in the weapon system: four in the airframe and avionic systems and two that deal specifically with the AN/AWG-9. The self-test procedures are presented in the following table.

NAME	ORIGINATOR	PURPOSE
MASTER TEST checks	PILOT	Selectable tests of instruments, fuel system, warning system (lights), wing sweep, and angle of attack (AOA).
Onboard checkout (OBC)	PILOT and RIO	Tests various avionics, flight controls, FEMS, actuators, AICS, and computers. (Does not check AICS anti-ice)
Onboard checkout continuous monitor (CM)	AUTOMATIC	Monitors various avionics functions for in-flight or on-deck failures. Works on 2-second cycle time.
AWG-9 continuous monitor	AUTOMATIC	Monitors various AWG-9 functions for in-flight or on-deck failures. Operates on 2-second cycle time.
AWG-9 BIT	RIO and AUTOMATIC	Tests AWG-9 and BIT missile functions.
Unit self-test	PILOT, RIO, and AUTOMATIC	Test incorporated in various components independent of other tests.

41.2 MASTER TEST CHECKS

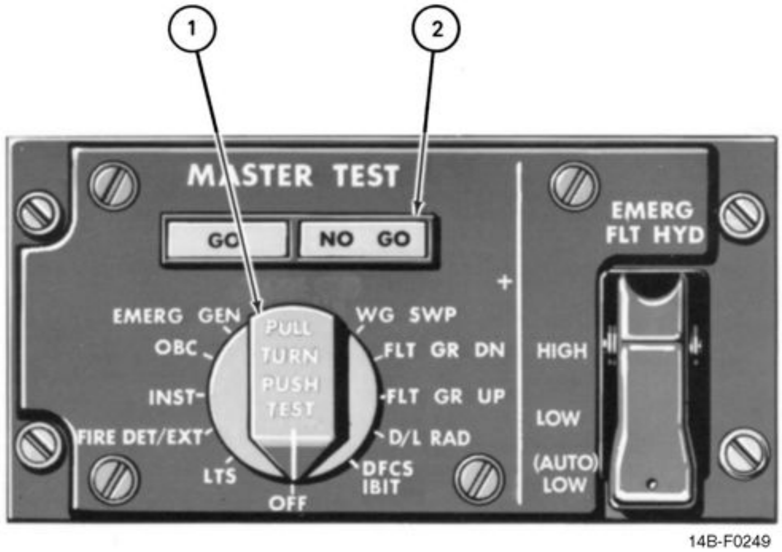
MASTER TEST checks are initiated by the pilot through the MASTER TEST panel (Figure 41-1) on the right outboard console. These tests check the operational status of specific aircraft systems basic to safety of flight and mission success. The OBC, WG SWP, FLT GR UP, and FLT GR DN positions are used on the deck only and are prevented from inadvertent use in flight by the weight-on-wheels safety switches. The remaining tests, except for emergency generator, which also requires combined hydraulic pressure can be done whenever electrical power and cooling air are available. For details of specific aircraft system tests, refer to the applicable system description.

WARNING

During ground operations, once the OBC position is selected, do not deselect OBC until the program has completed the entire cycle. When the disable signal that inhibits throttle movement is removed, the approach power compensator will run through its BIT and advance the throttles greater than 80 percent.

Note

- Before starting the test, the MASTER RESET button on the left vertical console must be depressed to turn off any caution or advisory lights associated with the air data computer.
- Cycling CSDC circuit breakers while the MASTER TEST switch is in the OBC position can cause uncommanded DFCS and/or AICS OBC.
- In LTS, the MASTER CAUTION light will flash unless there is a circuit failure within the caution advisory indicator, in which case, the light will remain on.



NOMENCLATURE	FUNCTION		
1 MASTER TEST switch	OFF —	Disables test functions.	
	LTS —	Turns on caution, warning, and advisory lights; emergency stores jettison button; GO and NO GO lights; landing gear and hook transition lights; approach indexer; FIRE warning lights; L and R STALL lights; and air combat maneuver (ACM) panel lights. Data link (D/L) power switch must be ON the check digital data indicator (DDI) lights.	
	FIRE DET/EXT — (before engine start)	L and R FIRE warning lights illuminate. If a circuit problem (before engine exists, the corresponding FIRE light will not illuminate. Simultaneously, the fire extinguishing system initiates a self-test. If tests pass, the GO light illuminates, if the NO-GO light illuminates or if both or neither GO or NO-GO lights illuminate, a failure exists in the system.	
Note L STALL and R STALL warning lights flash, the 10 second audio alarm goes on, and TIT reads 940 °C. If EIG fails self test the BIT segment to the left of the EGT legend remains illuminated.	INST —	Lights the FUEL LOW and OXY LOW caution lights in both cockpits, and displays the following pilot cockpit indications. Before engine start (after 5 seconds):	
		RPM	96%
		TIT	960° ±10 °C (initiates engine over temperature alarm)
		FF	10,500 pounds per hour
		FUEL QTY	2,000±200 pounds (both cockpits)
		LOX	2 liters
		WING SWEEP	45° ±2.5°
		AOA	18±0.5 units
		L and R OVSP/VALVE	ON
		BINGO	ON (if Bingo set > 2,000)

Figure 41-1. Master Test Panel (Sheet 1 of 2)

NOMENCLATURE	FUNCTION	
	INST —	After engine start: Symbology on the vertical display indicator group (VDIG) and horizontal situation display (HSD) are determined by display mode selected.
	OBC — (after engine start)	Enables class IIA checks during AUTO SAT mode or (after engine through selection of SPL by RIO on computer address panel (CAP) and initiation of OBC BIT. Test acronyms available on HSD and programmable tactical information display (PTID) for AICS, control air data computer (CADC), and auto throttle, through the computer signal data converter. FEM acronym displayed on PTID until successful completion of FEM's BIT.
	EMERG GEN —	Activates automatic transfer feature of generator and checks tie contactors. GO lights indicate satisfactory start) check. If the NO GO light remains illuminated, a malfunction is indicated.
	WG SWP — (after engine start)	Air data computer simulates that circuit to the wing (after engine sweep, system (wings do not move). Requires wings in oversweep and wing sweep button in AUTO.
	FLT GR DN —	Initiates ground check of auto throttle interlocks. Requires throttles in AUTO throttle region and enables ground selection of AUTO throttles. Engines will respond to stick movement and nozzles remain closed.
	FLT GR UP — (after engine start)	Permits checking external fuel tank pressurization. GO (light indicates required pressure. WING/EXT TRANS switch must be in AUTO position and DUMP switch set to OFF. Engine rpm above idle (approximately 75%) may be required to provide sufficient bleed air pressure for satisfactory check.
	D/L RAD — (after engine start)	Tests the data link converter. Test is displayed on DDI indicators, the multiple display indicator group (PMDIG), HSD, and VDIG. Inhibits tactical control messages during test sequence. Symbology displayed is determined by the display mode selected.
	DFCS BIT — (after engine start)	Permits running DFCS IBIT independently of the rest of OBC.
2 GO-NO GO lights	GO —	Indicates a valid test. Indicates a satisfactory test of the alpha computer in INST test.
Note Functional only in LTS, FIRE DET/EXT, INST, EMER GEN, FLT GR UP, and DFCS BIT.	NO GO —	Indicates unsatisfactory test. Indicates an unsatisfactory test of the alpha computer in INST test. With the alpha computer circuit breaker (7C8) pulled there will be no indication.

Figure 41-1. Master Test Panel (Sheet 2)

41.2.1 MASTER TEST Switch Operation. The MASTER TEST check is made by pulling the knob up, rotating to the desired position, and depressing it. After the test is completed, the MASTER TEST switch must be pulled up to deenergize the system.

System status and test results are indicated on the cockpit instruments: GO-NO GO lights on the MASTER TEST panel; warning, caution, and advisory lights in both cockpits; and displays on the HSD, vertical display indicator, heads-up display, and PTID.

The GO-NO GO indicator lights on the MASTER TEST panel will illuminate only in LTS, FIRE DET/EXT, EMER GEN, and FLT GR UP. In the LTS test position, only the bulbs in the GO-NO GO indicators are checked. In EMER GEN, FIRE DET/EXT, and FLT GR UP, a GO light indicates a valid test and a NO GO light indicates an unsatisfactory test.

Electrical power for the MASTER TEST panel comes from the left main DC bus through the MASTER TEST circuit breaker (8H5) on the main DC circuit breaker panel. When operating on aircraft power or when external electrical power is connected to the aircraft, cooling air must be supplied to all avionic equipment before a test is initiated.

41.3 ON-BOARD CHECK

The OBC system checks the operational status of non-AWG-9 avionics equipment. It provides fault isolation to the weapon replaceable assembly without the use of ground support equipment. The system is capable of monitoring various avionic systems to detect failures or to initiate test signals that simulate a response that the OBC system monitors. The OBC system uses the AWG-9 computer and the computer signal data converter (Figure 41-2) to process test information, maintain a record of all failures, and display test information on the PTID and HSD (PTID repeat).

The record of failures is maintained during the course of the flight and may be displayed at any time, including postflight operations, by maintenance personnel. The record, however, must be erased prior to the next mission by the flightcrew. However, if OBC is run, systems that have passed will clear previous fail acronyms from the maintenance file, except the computer signal data converter (CSD) and SSI failure (CSI) acronyms. These acronyms are retained in the maintenance readout file to maintain a history of intermittent CSDC(R) failures while airborne. The CSD and CSI acronyms can be cleared only by selecting the OBC FILE CLEAR pushbutton while on deck. Systems that have not passed will display any existing acronyms that are in the maintenance file.

The type of test information displayed is dependent on which OBC test routine is selected. The command activated BIT and maintenance readout routines are stored on the magnetic tape module, and the continuous monitoring is permanently stored in computer expanded memory.

Note

> In flight, the maintenance function (OBC FILE CLEAR pushbutton) does not function.

Some of the avionic equipment that the OBC does not check are the EGI, CDNU, PTID, MDL, PMDIG, ADF, UHF, VHF/UHF, auxiliary UHF receiver, speech security system/KY-58, barometric altimeter, vertical velocity indicator, standby compass, parts of the electrical power supply, intercommunications, and antenna assemblies.

The Upgrade aircraft can display multiple (up to three) OBC Maintenance Display pages if the failure list exceeds one page. Each time the MAINT DISPL push-button on the CAP is depressed, a new page of acronyms will appear until all have been displayed. At that time TEST COMP is displayed at the bottom of the acronym list. The final page showing the TEST COMP acronym must be displayed to obtain an OBC File Clear.

41.3.1 Onboard Checkout Built-In Test. To facilitate fault detection and isolation, the avionic equipment has BIT features, associated output lines that provide GO-NO GO indications, and both continuous and command-initiated BIT features. The OBC program under the control of the weapons control processor (WCP) sends BIT commands to the avionic equipment under test and subsequently monitors the response from the BIT GO-NO GO features of the equipment. This equipment, upon completion of a particular test, outputs GO-NO GO voltage levels and an equipment identification code on its BIT lines. The CSDC(R) converts this raw data into digitally formatted data words for the WCP. A history file of all NO GO responses is maintained by the WCP and all NO GO

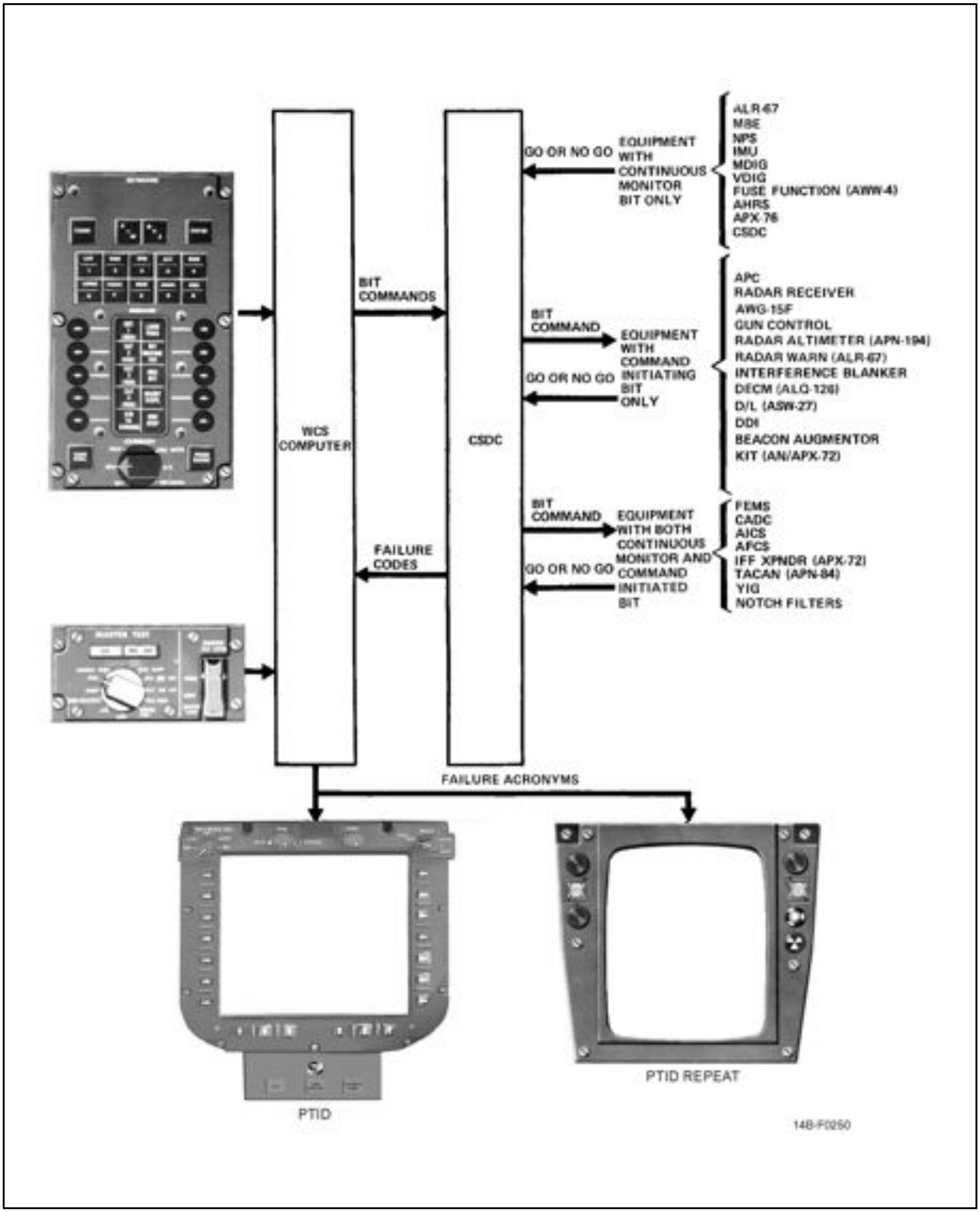


Figure 41-2. OBC Block Diagram

responses are displayed to the WRA level on the PTID. (See Figure 41-3 and Figure 41-4).

Because of hardware inhibits, DLS tests are not valid with the data link MODE switch in CAINS/ WAYPT. DLS tests can only be accomplished in a non-SAT mode with data link MODE switch in TAC.

There are two ways to complete OBC: automatically and manually. The differences between the two are in the methods for entering and exiting the routines. The systems under test in OBC are presented on the PTID under their respective classes: Class I (in flight only), Class IIA and Class IIB (preflight only), and Class III (in flight and preflight). (See Figure 41-5.) Automatic OBC can only be performed on the ground when preflight systems are checked. Systems not tested glow bright and steady. Systems under test are flashing and those which have been tested are dim and steady.

Lifting the ACM guard results in an exit from OBC to air-to-air (A/A) mode unless an automatic alignment is in progress. When an automatic OBC is in progress, the system remains in test.

Note

Weight-on-wheels or TAS <70 knots inhibits tests that radiate power on the deck.

41.3.2 Automatic OBC. An automatic OBC normally occurs at system startup at the same time as an alignment. The method of entry requires the RIO to set the NAV MODE switch to ALIGN prior to the completion of the auto BIT sequence 2. At the completion of the auto BIT sequence 2, OBC will automatically begin (the alignment will begin independently at the same time — see Chapter 20). If BIT sequence 2 is degraded or failed, automatic OBC will not be entered. OBC will not run unless manually selected since auto OBC requires a successful completion of auto BIT 2.

Note

A successful auto BIT 2 is necessary to initialize certain radar constants. If an “X” appears above the S2 in the SAT displays, another power up auto BIT 2 is necessary.

41.3.3 Manual OBC. A manual OBC can be run by the pilot selecting OBC on the MASTER TEST panel and the RIO selecting OBC BIT in SPL category. This initiates the OBC routine only. If the pilot does not select OBC, only a Class IIB and III will run and POBC DIS will appear on the PTID (Figure 41-4).

Once initialization is completed, approximately 65 seconds later (after the BITs have been completed), the acronyms of the aircraft systems that have not passed their BIT tests appear on the PTID followed by a TEST COMP legend. Also, a DIS POBC legend will appear when the OBC BIT testing is completed. The DIS POBC legend is deleted when the pilot deselects OBC with the MASTER TEST switch. Additionally, a CHAL IFF legend appears during OBC testing. This legend requires that the RIO challenge the APX-76 by depressing the IFF DISPLAY pushbutton on the detail data display panel. When challenged, the legend will be deleted from the display.

Class IIA is enabled by the pilot via the MASTER TEST panel with WOW, TAS <70 knots, pilot’s OBC discrete, throttles at IDLE, and handbrake set. Class IIB is enabled by WOW only. The WOW BITS are constantly checked for change in status to ensure proper class testing. Class I tests are performed in flight only because they radiate power. Class II tests are designated for preflight because a failure of these systems constitutes a flight safety hazard. Class III tests do not radiate energy and are not considered safety-of-flight components.

The fault display following Class I OBC contains a CIA acronym followed by a four-digit number representing the time, in milliseconds, that the AWG-15 was in self-test. If an AWG-15 failure was detected, the appropriate WRA acronyms will be displayed following the test time display. AWG-15 self-test is terminated if a failure is detected in the control indicator or the power switching unit. A CI or PSU acronym and the test time can be used to perform a limited degraded mode assessment of remaining system capabilities.

WARNING

Inadvertent jettison of external stores may result during Class I OBC.

Note

After completion of the last test cycle, the MASTER TEST switch must be set to OFF. If left in OBC, the weight-on-wheels interlock prevents the CSDC from commanding AFCS, APC, AICS, and CADC self-test.

ACRONYM	SUBSYSTEM WRA LEVEL
ADA	Airborne data acquisition computer
AFC AM*	Auto flight control system yaw accelerometer
AFC PA*	Auto flight control system pitch actuator
AFC PC*	Auto flight control system pitch computer
AFC PS*	Auto flight control system pitch sensor
AFC RA*	Auto flight control system roll actuator
AFC RC*	Auto flight control system roll computer
AFC RS*	Auto flight control system roll sensor
AFC YA*	Auto flight control system yaw actuator
AFC YC*	Auto flight control system yaw computer
AFC YS*	Auto flight control system yaw sensor
AGD	Target designate switch
AHR	AHRS heading and vertical failure
AICL A1	No. 1 AICS left inlet actuator
AICL A2	No. 2 AICS left inlet actuator
AICL A3	No. 3 AICS left inlet actuator
AICL A4	AICS left MCB relay
AICL P	AICS left inlet programmer
AICL S1	AICS left inlet sensor (static pressure)
AICL S2	AICS left inlet sensor (total pressure)
AICL S3	AICS left inlet sensor (total temperature)
AICL S4	AICS left inlet sensor (angle of attack)

ACRONYM	SUBSYSTEM WRA LEVEL
AICR A1	No. 1 AICS right inlet actuator
AICR A3	No. 3 AICS right inlet actuator
AICR A4	AICR right MCB relay
AICR P	AICS right inlet programmer
AICR S1	AICS right inlet sensor (static pressure)
AICR S2	AICS right inlet sensor (total pressure)
AICR S3	AICS right inlet sensor (total temperature)
AICR S4	AICS right inlet sensor (angle of attack)
ALR	Radar warning receiver (ALR-67)
ALQ	ALQ-126B defensive ECM
APC A	Approach power controller accelerometer
APC C	Approach power controller computer
ARB	Armament bus
AVB	Avionics bus
BAG	Beacon augmenter
CAD	Central air data computer (CADC)
CAL	IMU calibration data fail
CDN	Control display navigation unit (CDNU)
CFD	Chaff/flare dispenser
CIA A1	CIACS A decoder station No. 1 rails
CIA A3	CIACS A decoder station No. 3 rails
CIA A4	CIACS A decoder station No. 4 rails
CIA A5	CIACS A decoder station No. 5 rails
CIA A6	CIACS A decoder station No. 6 rails

*NOTE: These acronyms do not unambiguously isolate a failure at the WRA level. Combinations of lights and acronyms will identify specific degradation, but reference to DCP codes is required to identify specific WRAs.

Figure 41-3. OBC and Maintenance Readout Display Acronyms (Sheet 1 of 2)

ACRONYM	SUBSYSTEM WRA LEVEL
CIA A8	CIACS A decoder station No. 8 rails
CIA B2	CIACS B decoder station No. 2
CIA B3	CIACS B decoder station No. 3 and 6
CIA B4	CIACS B decoder station No. 4 and 5
CIA B7	CIACS B decoder station No. 7
CIA C1	CIACS control indicator
CIA CPA	CIACS power A
CIA CPB	CIACS power B
CIA PSU	CIACS PWR switching unit
CSD	CSDC failure
CSI	SSI failure (synchronizer 3, 4, or 5)
DDI	Digital data indicator
DIG C	VDIG converter — VDI
DIG CH	VDIG converter — HUD
DIG IH	VDIG indicator — HUD
DIG I	VDIG indicator — VDI
DLS	UHF D/L transceiver AN/ASW-27B
DMS AVB	PMDIG AVBUS Remote Terminal
DSM E	PMDIG-ECM indicator failure
DSM H	HSD indicator failure
DSM P	MIDG processor failure
FEM ADA	FEMS data acquisition computer
FEM DSS	FEMS digital storage set
FEM EMS	FEMS engine monitoring signal processor
FSE	Fuse function
GPS	EGI global positioning system receiver

ACRONYM	SUBSYSTEM WRA LEVEL
GCS	Gun control system
IFA	Computer IFF (APX-72)
IFB	Interference blanker
IFI CH	IFF challenge (APX-76)
IFI RT	IFF interrogator AN/APX-76 RT
IFI SW	IFF interrogator AN/APX-76 SW/AMP
IFI SY	IFF interrogator AN/APX-76 synchronizer
IFN	Computer IFF (APX-76)
IFX	IFF transponder AN/APX-72
IMU	EGI inertial measurement unit
MDB	Mission data loader blank
MDL AVB	Mission data loader AVBUS RT
MDL ML	Mission data loader
NPS	Navigation system power supply
RAMP	Air inlet control system
RAW ALR	Radar warning receiver (AN/ALR-67)
RAW AVB	ALR-67 AVBUS RT
RAW NFL	Notch filter left
RAW NFR	Notch filter right
RAW PCI	ALR-67 platform configuration
RDA	Radar altimeter control
TCN	Tacan continuous monitor/ commanded
PTID AVB	PTID AVBUS RT
WOW	Weight-on-wheels failure
WRA	Illegal failed BIT
YIG	ALQ-126 PD filter failure

Figure 41-3. OBC and Maintenance Readout Display Acronyms (Sheet 2)

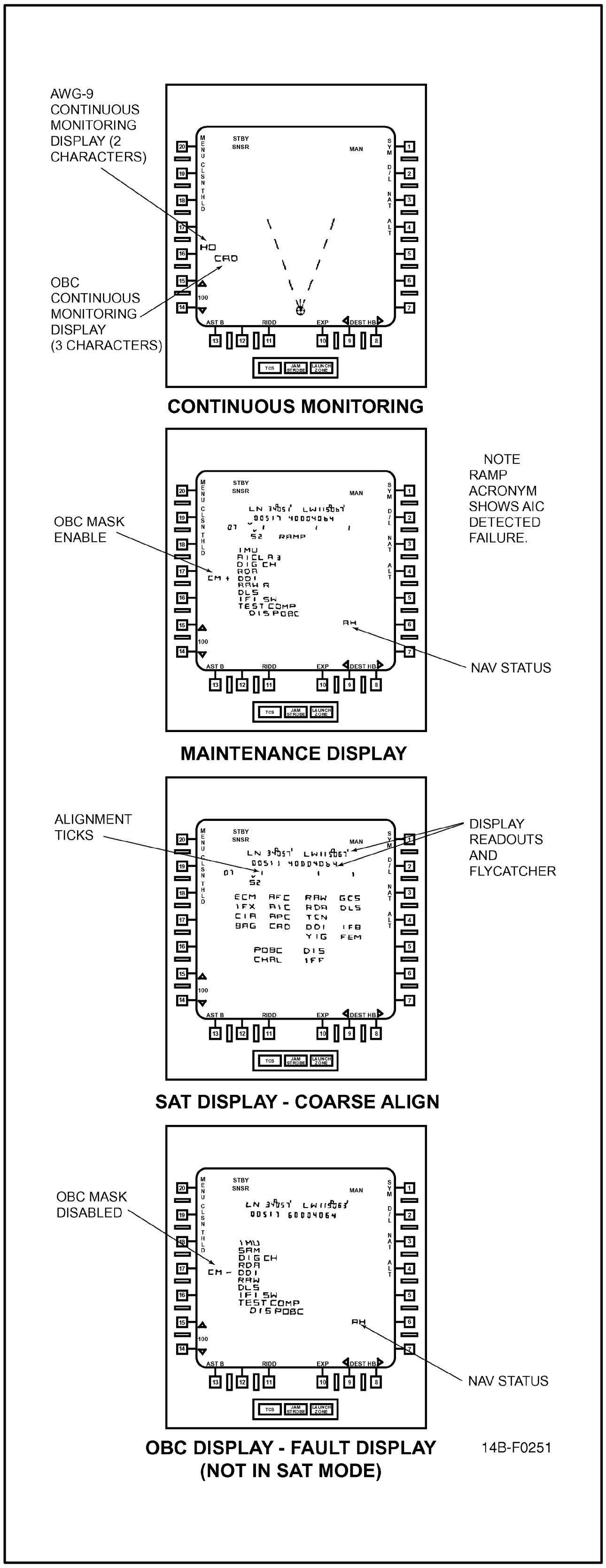


Figure 41-4. OBC Display

41.3.4 Maintenance Readout. When the CAP CATEGORY switch is in SPL, the OBC BIT sequencing (in the air only) can be terminated by pressing the MAINT DISPL pushbutton. The PTID displays any failed WRAs for the avionics that were completely tested before OBC BIT termination. This feature allows quick determination of AWG-15 test results. AWG-15 tests are completed in the first 4 seconds of airborne OBC.

The maintenance readout routine cycles through the failure history file and displays failure acronyms at the WRA level on the PTID, two-thirds page format. Upon depression of the MAINT DISPL pushbutton on the CAP, the routine will brand directly to the MR routine. When the routine is completed, the words TEST COMP are displayed under the last acronym and the routine terminates.

The MR routine has the capability to clear the WCS computer and the CSDC(R) failure history file upon command from the RIO. This feature is enabled on the ground only. To clear the file, the RIO calls up MAINT DISPL, as before, and then depresses the OBC DISPL function pushbutton. The word CLEARED is then displayed below the MR display (Figure 41-4).

41.3.5 OBC Masking. Masking is the AWG-9 software method of inhibiting known WRA faults from producing OBC system acronyms in CM (except the CSI and CSD acronyms).

Note

Pilot must select OBC on MASTER TEST panel to enable OBC masking.

To set the OBC fault mask:

1. Perform OBC BIT or OBC maintenance readout display and wait until TEST COMP is displayed on the PTID.
2. Enter CLEAR 7 ENTER on the AWG-9 keyboard.

Note

To enable CM mask during automatic OBC, SPL category must be selected.

3. The PTID will display CM+ at the 9-o'clock position and acronyms will be masked from CM display.

CLASS	FLIGHT STATUS	EQUIPMENT MONITORED
I	In-flight (weight-off-wheels, TAS >70 knots).	DECM (AN/ALQ-126), IFF transponder (AN/APX-72), CIACS, and beacon augmenter.
IIA	Preflight only (weight-on-wheels, hand brake set, TAS <70 knots, and pilot's OBC discrete) throttle at idle.	AICS, DFCS, CADC, and APC.
IIB	Preflight only (weight-on-wheels).	Radar warning receiver (ALR-67), and radar altimeter (APN-194), TACAN (ARN-84), DDI, and ALQ-126 PD filter (YIG).
III	Preflight or in-flight.	Gun control unit, D/L (ASW-27), radar receiver (ALR-67), and interference blanker.

Figure 41-5. OBC Classifications

To clear OBC fault mask:

1. Perform OBC BIT or OBC MR and wait until TEST COMP is displayed on the PTID.
2. Enter CLEAR 77 ENTER on the AWG-9 keyboard.
3. The display CM– will appear on the PTID in the 9-o'clock position, indicating the CM mask is cleared.
4. Mask will be cleared by running OBC or by initiating AWG-9 OBC file clear.

41.3.6 OBC Continuous Monitoring. The CM routine is an integral part of the weapon system tactical program. It displays system failure information on the PTID during normal tactical processing. The routine is permanently stored in the computer and is cycled every 2 seconds.

If an aircraft failure occurs, the appropriate three-letter acronym (Figure 41-6) for this failure is displayed on the lower left quadrant of the PTID below the two-letter AWG-9 acronym (Figure 41-4) and is also stored in the maintenance file. If multiple failures occur, the appropriate acronyms are automatically displayed at a 2-second rate.

ACRONYM	DEFINITION	EXPLANATION
BASIC (Top level system fault acronym shown in CM, and on PTID OBC and Maintenance Display pages) MODIFIER (Subsystem fault information. Displayed following the basic acronym on PTID OBC and Maintenance Display pages only)		
2BC	Dual Bus Controller (Displayed in CM only)	WCP detected dual bus controller (MDP and AWG-15H) condition. System operation unpredictable. Attempt to clear using System Reset or WCS power OFF — ON.
AFC	Automatic Flight Control	With caution lights — See PCL
AM	Accelerometer	Yaw accelerometer fail.
PA	Pitch Actuator	Pitch actuator position does not agree with command.
PC	Pitch Computer	Pitch computer — Ignore PC without associated autopilot caution light. Caution lights indicate valid failures.
PS	Pitch sensor	Pitch sensor failure.
RA	Roll Actuator	Roll actuator position does not agree with command.
RC	Roll Computer	Roll computer.
RS	Roll Sensor	Roll sensor rate failure.

Figure 41-6. Upgrade CM, OBC, and Maintenance Display Readout Acronyms (Sheet 1 of 6)

ACRONYM	DEFINITION	EXPLANATION
YA	Yaw Actuator	Yaw series servo actuator failure.
YC	Yaw Computer	Yaw computer — check that ALPHA COMP/PEDAL SHAKER cb (7C8) is engaged.
YS	Yaw Sensor	Yaw sensor failure.
AGD	Air-to-Ground Designate	Target designate switch failure.
AHR	Attitude Heading Reference System	AHRS failure. Computer will select best NAV mode available. Select COMP mode for flux valve MAG HDG.
AICL or AICR	Air Inlet Control Left or Right	Air INLET RAMPS switch in stow without other acronyms. With other acronyms call up maintenance file.
P	Programmer	Programmer fail. Without INLET light, computer uses nominal values. Operational mode, no flight restriction.
A1	Actuator No. 1	No. 1 ramp actuator position does not agree with command.
A2	Actuator No. 2	No. 2 ramp actuator position does not agree with command.
A3	Actuator No. 3	No. 3 ramp actuator position does not agree with command.
A4	Not Used	N/A
S1	Static Pressure Sensor	Static Pressure. With INLET light, fail safe mode. Without INLET light, fail operational. No flight restriction.
S2	Total Pressure Sensor	Total pressure. With INLET light, fail safe mode.
S3	Not Used	None.
S4	Angle-of-Attack or Engine Fan Speed Sensor	Angle-of-Attack (AOA) or engine fan speed (F110 engine, AFTC may be in secondary mode) **CAUTION** S4 indicates the AICS programmer is operating with a fixed value for AOA and RPM. As a result, below 25,000 feet at speeds greater than 1.1 IMN, unloading the aircraft to less than 1g will reduce inlet stability and may result in inlet buzz and possibly an engine stall. Cycling AICS cbs at constant subsonic air speed should eliminate the S4 acronym and reset the programmer to the full Rev. 5 schedule.
ALQ	ALQ-126B Defensive ECM (Replaces DSM acronym)	ALQ-126B failure. Defensive ECM may not be available. Run manual BIT.
APC	Approach Power Compensator	Auto throttle inoperative. System will shift to BOOST automatically.
A	APC Accelerometer	APC accelerometer. No associated light. Auto throttle inoperative. APC not authorized for landing.
C	APC Computer	APC computer fail. Auto throttle inoperative.

Figure 41-6. Upgrade CM, OBC, and Maintenance Display Readout Acronyms (Sheet 2)

ACRONYM	DEFINITION	EXPLANATION
ARnn	Anomaly Recovery Code (Displayed in CM only) nn Meaning 50 Warm Start without Saved Return 51 False PTI 52 4.718 sec Interval Timer Overflow 53 Program Restart Interrupt 54 Cell Zero Executed 55 8 ms Sync Overflow 56 Trace Error from 8/128/2048 ms & EOF loops 57 Illegal Loop Exit 60 MC/VF Checksum Bad 61 Compatibility Fail Bypass	Transient failure (system automatically initiates soft purge) visible for approximately 8 seconds. Expect MTM read acronym, “M” while system performs self recovery. Sensor files should be retained. System may return to Tactical if in A/G, BIT, etc., when anomaly occurred. No further action if system recovers. Report code to maintenance if able (check postflight PTID video recording if available).
ARB	Armament Bus Failure	Armament Bus failure.
AVB	Avionics Bus Failure	Avionics Bus failure.
BAG	Beacon Augmenter	System not on. Run manual BIT. Degraded precision approach on automatic carrier landing (ACL) and/or ground vectoring.
BBC	AWG-15H Back-Up Bus Controller	AWG-15H BBC failure detected
AVB	AWG-15H AVBUS RT	MDP detected AWG-15H AVBUS RT failure
P	Processor	AWG-15 BBC processor failure
SS8	SSI SYNC 8	SSI SYNC 8 failure.
CAD	Central Air Data Computer	Check caution/advisory light. Run CADC flycatchers.
CDN	CDNU Failure	Degraded navigation capability. Depending on the type of failure, partial or total loss of navigation system function may result. Check CDNU Status and Test Page
CIA	AWG-15 Coded Integrated Armament System.	If displayed in CM prior to Class I OBC, indicates AWG-15H CI (Z-80) processor failure: AIM-9, and Gun modes limited. EMER JETT is available. AIM-7 and AIM-54 modes are not available. If CIA displayed after Class I OBC, see Maintenance File. See TPG AWG-15 BIT .
A1, A3, A4, A5, A6, A8, B3 and B4	Decoder Type and Station ID	Station decoder failure. Degraded station operation. Note: B3 and B4 acronyms are displayed respectively for B6 and B5 failures (combined decoders).
B2 and B7	Decoder Type and Station ID	Station decoder failure. Valid only if MXU-611 (tank rack) is installed. No operational impact if tanks/ CADS not installed.
CI	Control Indicator	Control indicator failure. Call up maintenance file. Possible failure of LAU-7 detent solenoid. Refer to AWG-15 acronyms in TPG Troubleshooting section.

Figure 41-6. Upgrade CM, OBC, and Maintenance Display Readout Acronyms (Sheet 3)

ACRONYM	DEFINITION	EXPLANATION
CPA	CIACS Power Supply A	Gun and EMER JETT available. AIM-7, AIM-9, AIM-54 not available.
CPB	CIACS Power Supply B	All weapon, firing, and jettison modes are available. Indicates backup power supply failure.
PSU	Power Switching Unit	Power Switching Unit failure. Call up Maintenance File. Possible failure of LAU-7 detent solenoid. Refer to AWG-15 acronyms in TPG Troubleshooting section.
nnnn	COATS Fail Time	See F-14B NATOPS, Ch. 41, Figure 41-33 or TPG Special Procedures, Critical Failure Time Testing Matrix.
CSD	Computer Signal Data Converter	See CSD in TPG Troubleshooting Guide.
CSI	CSDC Standard Serial Interface Failure (SYNC 3, 4, 5)	See CSDC Problems in TPG Troubleshooting Guide.
DDI	Digital Data Indicator	Data link not on. Run manual BIT
DIG	Vertical Display Indicator Group	Evaluate displays for flight. Acronyms indicate degrade detected. Display may be fully functional. Reset BIT indicators.
C	Vertical Display Converter	Evaluate display
CH	HUD Converter	Evaluate display
I	Vertical Display Indicator	Evaluate display
IH	HUD Indicator	Evaluate display
DLS	Data Link System (AN/ASW-27)	Data link off. Run manual test. Run D/L Rad test.
DSM	Multiple Display Group (PMDIG)	Evaluate display usability for mission requirements
AVB	PMDIG AVBUS Remote Terminal	MDP detected PMDIG AVBUS RT failure. Possible loss of 1553 communication with MDP. ECMD/HSD ECM mode degraded/unavailable. NAV and PTID Repeat modes may operate.
E	ECMD (RIO)	ECMD may be degraded. Evaluate display.
H	HSD (Pilot)	HSD may be degraded. Evaluate display.
P	PMDIG Processor	PMDIG functions (ECMD, HSD, video switching) may not be available. Evaluate operation.
EWB	Electronic Warfare Bus Failure	EW bus failure. ALR-67 and ALQ-126 bus communication degraded/inoperative. Possible degraded ALQ-126 response.
FEM	Fatigue Engine Monitoring System	Failure in one of the FEMS components
ADA	Airborne Data Acquisition Computer	ADAC failure. FEMS data recording degraded/inoperative.
DSS	Digital Storage Set	DSS failure. FEMS data recording degraded/inoperative.
EMS	Engine Monitoring Signal Processor	EMSP failure. FEMS engine data recording degraded/inoperative.
FSE	Electrical Fuzes	Electric bomb fuzes cannot be set.
GPS	EGI GPS Module Failure	Loss of GPS function. Degraded navigation capability

Figure 41-6. Upgrade CM, OBC, and Maintenance Display Readout Acronyms (Sheet 4)

ACRONYM	DEFINITION	EXPLANATION
GCS	Gun Control System	Gun control system failure. See TPG AWG-15 BIT. Normal immediately after trigger activation.
IFA	IFF Computer APX-72	IFF failure. Run IFF manual test.
IFB	Interference Blanker	Possible interference between AWG-9, DECM, IFF, Radar Altimeter, TACAN.
IFI	Air to Air Interrogator APX-76	APX-76 not on/installed. APX-76 failure.
CH	Challenge	Air-to-Air Interrogate BIT failure. APX-76 degraded/ not available.
RT	Receiver Transmitter	Air-to-Air Interrogate BIT failure. APX-76 degraded/ not available.
SW	Switch Amplifier	Air-to-Air Interrogate BIT failure. APX-76 degraded/ not available.
SY	Synchronizer Unit	Air-to-Air Interrogate BIT failure. APX-76 degraded/ not available.
IFN	APX-76 Computer	APX-76 KIR computer failure/not installed.
IFX	IFF Transponder APX-72	IFF failure. Master switch to NORM. Select test for each mode and observe test light.
IMU	EGI Inertial Measurement Unit	IMU failure. Degraded missile and navigation capability. (If GPS is still operating, position information will be reliable.)
MDB	Mission Data Loader Blank	MDL cartridge blank.
MDL	Mission Data Loader	Mission data loader failure
AVB	MDL AVBUS RT	MDP detected MDL AVBUS RT failure. Bus communication degraded/inoperative
ML	Loader	Loader failure, MDL unusable.
MDP	Mission Data Processor	Mission Data Processor failure detected
MR1	Missile Relay Switching Assembly—Station 1	MRSA station 1 failure.
MR8	Missile Relay Switching Assembly—Station 8	MRSA station 8 failure.
NSI	Navigation System Interface	CSDC(R) has lost communication with Navigation System. Check CDNU Status Pages. Run CDNU BIT.
NPS	Navigation Power Supply	Possible EGI power failure
NPT	NPS Transient	Power transient, possible IMU degrade
OFS	Operational Flight Software	OFS incompatibility detected, check OFS page.
RAW	Radar Warning (ALR-67)	Verify system on/installed. Run BIT.
ALR	ALR-67 Computer	ALR-67 computer failure. Expect loss of all ECM displays (HSD/ECMD, ADU, audio, lights)
AVB	ALR-67 AVBUS RT	MDP detected ALR-67 AVBUS RT failure. AVBUS communication degraded/inoperative. ECMD/HSD ECM mode degraded/inoperative. If only RT failed; ALR-67 audio, lights, and ADU display should be available.
NFL	Notch Filter Left	Left notch filter failure. ALR-67 subject to own aircraft EMI.

Figure 41-6. Upgrade CM, OBC, and Maintenance Display Readout Acronyms (Sheet 5)

ACRONYM	DEFINITION	EXPLANATION
NFR	Notch Filter Right	Right notch filter failure. ALR-67 subject to own aircraft EMI.
PCI	Platform Configuration	ALR-67 hardware detected aircraft configuration incompatibility. NOT affected by aircraft software configuration.
RDA	Radar Altimeter	Verify system on. Run manual test.
TCN	TACAN	Verify system on. Run manual test. Evaluate TACAN display on bearing distance heading indicator (BDHI).
PTID	Programmable Tactical Information Display (PTID)	PTID failure
AVB	PTID AVBUS RT	MDP detected PTID AVBUS RT failure. Some functions (tactical display, non-Menu items) may be available. Attempt to clear by selecting System Reset.
TD	PTID Display Processor	PTID internal display processor detected failure, evaluate PTID displays
WOW	Weight On/Off Wheels	Failure of weight on/off wheels switches. Refer to WOW in emergency section.
XXX	Invalid Failure ID	OBC/CM program has attempted to reference an invalid area in acronym table (i.e., unused location). Indicates hardware/software error, notify maintenance.
YIG	ALQ-126 PD Filter	If YIG acronym persists, ALQ-126 and/or AWG-9 PD performance may be degraded. Attempt to reset by cycling ALQ-126 DECM cb (6C1). A YIG acronym/failure will not affect ALQ-126 performance when the AWG-9 is in a pulse mode or non-radiating status (SNIFF, STANDBY).
NOTE Before correcting a malfunction, ensure available flycatcher/CM data recorded.		

Figure 41-6. Upgrade CM, OBC, and Maintenance Display Readout Acronyms (Sheet 6)

Note

A CSD acronym appearing on the PTID may indicate failure of the primary attitude reference. When an acronym appears, the VDI and the standby attitude indicator should be cross-checked to determine if the primary reference system is degraded. If the VDI is erroneous, the standby attitude indicator should be used as the primary reference instrument and instrument flight should be avoided.

41.3.7 DFCS IBIT

41.3.7.1 IBIT Initiation. DFCS IBIT is initiated automatically when OBC is initiated. It can also be initiated independently through the DFCS position on the MASTER TEST switch. IBIT can be initiated with the wings forward and the flaps down, or with the wings aft of 62°. Additional interlocks which must be satisfied include the PITCH, ROLL, and YAW STUB AUG switches must be ON, ANTISKID SPOILER BK switch must be OFF, the CADC must be operating properly, and the aircraft must have weight-on-wheels. If it is desired to test autopilot WRAs during IBIT, the AUTOPILOT switch must be ENGAGED while DFCS IBIT is armed. The aircraft must not be in motion during IBIT operation or IBIT failures will result.

The DFCS BIT position allows the independent execution of DFCS IBIT. DFCS IBIT is armed by raising the MASTER TEST switch and rotating it to the DFCS BIT position. Depressing the MASTER TEST switch while DFCS IBIT is armed will initiate DFCS IBIT. Results of this test are displayed through the caution/advisory lights, acronyms on the PTID and HSD, and fault codes on the DCP.

Note

The DCP fault codes cannot be cleared while DFCS IBIT is armed. This condition will occur if the MASTER TEST switch is not rotated out of the DFCS BIT position following completion of a DFCS IBIT.

41.3.7.2 IBIT Tests. The DFCS IBIT performs tests designed to detect faults within the DFCCs, the DFCC inputs and outputs, the various sensors and the actuators which are driven by the DFCCs. Sensor tests include stimulation of the rate gyros and lateral accelerometers and reasonableness checks for the air data sensors. The actuators which are tested are the pedal shaker motor, the electro-mechanical actuators, and the electro-hydraulic actuators. The electro-hydraulic actuators are exercised if either combined or flight hydraulic pressure is present. In the absence of hydraulic pressure, the electrical circuits which drive the actuators are tested, but the actuators themselves are not exercised.

41.3.7.3 IBIT Indications. IBIT status and results are displayed to the aircrew through a combination of caution/advisory lights, PTID acronyms, and DCP codes as shown in Figure 41-7 and Figure 41-8.

41.3.7.4 IBIT Armed. When IBIT is armed by raising the MASTER TEST switch and rotating it to the DFCS BIT position, and all interlocks are satisfied, the DCP will alternately flash the codes IBIT and ARM at a rate of 1 Hz.

41.3.7.5 IBIT Run. While IBIT is running, the ACL mode caution light, and the AP mode reference light will flash at a rate of 1 Hz. Additionally, the DCP will alternately flash the codes IBIT and RUN. All other DFCS related caution/advisory lights will be illuminated, and all DFCS related PTID acronyms will be displayed. During the last three seconds of IBIT, the DCP will display a test pattern which will allow the pilot to determine if all the display segments are operating properly.

41.3.7.6 Premature Termination. If any interlocks are broken while IBIT is running, IBIT will be aborted. This state will be indicated by extinguishing of the ACL mode caution, and AP mode reference lights, and illumination of all other DFCS related caution/advisory lights. The AUTOPILOT switch will revert to the OFF position. Additionally, the DCP will display the ABRT codes. Depressing pilot MASTER RESET will reengage the DFCS and extinguish the ABRT DCP code.

FAILED COMPONENT	LIGHT	ACRONYM
Pitch Rate Gyro (1)	FCS CAUTION	PS
Pitch Rate Gyro (2)	FCS CAUTION PITCH SAS	PS
Roll Rate Gyro (1)	FCS CAUTION	RS
Roll Rate Gyro (2)	FCS CAUTION ROLL DGR ARI DGR ARI/SAS OUT	RS
Yaw Rate Gyro (1)	FCS CAUTION	YS
Yaw Rate Gyro (2, 3)	FCS CAUTION ARI DGR YAW DGR ARI/SAS OUT	YS
Lateral Accel (1)	FCS CAUTION	AM
Lateral Accel (2, 3)	FCS CAUTION ARI DGR YAW DGR ARI/SAS OUT	AM

Figure 41-7. DFCS Caution Lights and Acronyms (Sheet 1 of 2)

FAILED COMPONENT	LIGHT	ACRONYM
Pitch Series Actuator (1, 2)	PITCH SAS	PA
Roll Series Actuator (1)	ROLL DGR ARI DGR	RA
Roll Series Actuator (2)	ROLL DGR ARI DGR ARI/SAS OUT	RA
Yaw Series Actuator (1)	ARI DGR YAW DGR	YA
Yaw Series Actuator (2)	ARI DGR YAW DGR ARI/SAS OUT	YA
Spoilers (Any Inboard)	SPOILER	RA
Spoilers (Any Outboard)	SPOILER	PA
Pitch Parallel Actuator	ACLS/AP AUTOPILOT	PA
DLC Trim Actuator	—	PA
Pitch Autotrim Actuator	AUTOPILOT	PA
Mach Trim Actuator	MACH TRIM	—
Lateral Authority Actuator	HZ TAIL AUTH	—
Rudder Authority Actuator	RUDDER AUTH	—
Right AICS Static Pressure	FCS CAUTION ARI DGR	PS
Left AICS Static Pressure	FCS CAUTION ARI DGR	PS
Right AICS Total Pressure	FCS CAUTION ARI DGR	PS
Left AICS Total Pressure	FCS CAUTION ARI DGR	PS
Right AICS AOA	FCS CAUTION	PS
Left AICS AOA	FCS CAUTION	PS
ADD (AOA side-probe) AOA	FCS CAUTION	PS
ARI (alpha nose-probe) AOA	FCS CAUTION	PS
Two or more of L/R AICS AOA, ADD side-probe AOA, or ARI alpha nose-probe AOA	FCS CAUTION ARI DGR	PS
Any Internal DFCC Test	PITCH SAS FCS CAUTION ROLL DGR ARI DGR YAW DGR ARI/SAS OUT	PC, RC, YC (as applicable)

Figure 41-7. DFCS Caution Lights and Acronyms (Sheet 2)

DCP	IBIT	OFP	Meaning
115V	I		Aircraft 115 V_{AC} power supply out of tolerance fault.
28DC	I		Aircraft 28 V_{DC} power supply out of tolerance fault.
AC28	I	O	Alpha computer/pedal shaker 28 V_{DC} power supply input fault.
AD01		O	Air data computer (CADC) general fault.
AD02	I		Mach schedule (pitch) signal from CADC fault.
AD03		O	Air data computer valid input (pitch) fault.
AD04		O	Air data computer valid input (roll) fault.
AD05		O	Air data computer valid input (yaw) fault.
AD06		O	Mach trim schedule input fault.
AD07		O	Lateral authority schedule input fault.
AD08		O	Rudder authority schedule input fault.
AD09	I		Autopilot altitude error signal from CADC fault.
AD10	I		Autopilot altitude rate signal from CADC fault.
AD11	I		Mach trim schedule 1 signal from CADC fault.
AD12	I		Mach trim schedule 2 signal from CADC fault.
AD13	I		Lateral authority schedule 1 signal from CADC fault.
AD14	I		Lateral authority schedule 2 signal from CADC fault.
AD15	I		Rudder authority schedule 1 signal from CADC fault.
AD16	I		Rudder authority schedule 2 signal from CADC fault.
AHR1		O	Attitude and heading reference system invalid input fault.
AHR2		O	Attitude and heading reference system pitch synchro input fault.
AHR3		O	Attitude and heading reference system roll synchro input fault.
AICX		O	Disagreement between left and right AICS fault.
AOAC	I	O	ARI angle of attack sensor fault.
AOAL		O	Left AICS angle of attack sensor fault.
AOAR		O	Right AICS angle of attack sensor fault.
AOAT	I	O	ADD angle of attack sensor fault.
APCA	I		Normal accelerometer sensor fault.
APCS	I		Scheduled outputs to approach power compensator fault.
CA28	I	O	Flight controls authority 28 V_{DC} power supply input fault.
CSDC	I		Steering error signal from CSDC fault.
DCP1		O	DFCS control panel Pitch SAS switch fault.
DCP2		O	DFCS control panel Roll SAS switch fault.
DCP3		O	DFCS control panel Yaw SAS switch fault.
DCP4	I	O	DFCS control panel Autopilot switch fault.
DLCT	I		DLC thumb-wheel sensor fault.
DLT1	I	O	DLC trim servo fault.
DLT2		O	DLC trim servo isolation fault.
DPSL	I		Left AICS delta pressure (angle of attack) sensor fault.

Figure 41-8. DFCS Fault Codes (Sheet 1 of 6)

DCP	IBIT	OFP	Meaning
DPSR	I		Right AICS delta pressure (angle of attack) sensor fault.
EDPS		O	Emergency disengage paddle switch discrete input fault.
FLAP		O	Flaps down discrete input fault.
GRBS		O	Ground roll braking system discrete input fault.
HT28		O	Lateral authority actuator 28 V_{DC} power input fault.
HZTA	I	O	Lateral authority actuator fault.
IMU1		O	Inertial measurement unit INS invalid input fault.
IMU2		O	Inertial measurement unit pitch synchro input fault.
IMU3		O	Inertial measurement unit roll synchro input fault.
IMU4		O	Inertial measurement unit PQVM fault.
LAT1	I	O	Lateral accelerometer channel A fault.
LAT2	I	O	Lateral accelerometer channel B fault.
LAT3	I	O	Lateral accelerometer channel M fault.
LDG1		O	Main landing gear input 1 fault.
LDG2		O	Main landing gear input 2 fault.
LDG3		O	Main landing gear input 3 fault.
MACL		O	SCADC to AICS Mach miscompare while left AICS was selected.
MACR		O	SCADC to AICS Mach miscompare while right AICS was selected.
MRS1		O	Master reset switch input 1 fault.
MRS2		O	Master reset switch input 2 fault.
MRS3		O	Master reset switch input 3 fault.
MT28	I	O	Mach trim 28 V_{DC} power supply input fault.
MTRM	I	O	Mach trim actuator fault.
PC01		O	Pitch A computer 115 V_{AC} export power supply fault.
PC02		O	Pitch B computer 115 V_{AC} export power supply fault.
PC03	1		Pitch A computer 28 V_{DC} power supply monitor fault.
PC04	I		Pitch B computer 28 V_{DC} power supply monitor fault.
PC05		O	Pitch A computer general fault.
PC06		O	Pitch B computer general fault.
PC07	I		Pitch A computer general fault.
PC08	I		Pitch B computer general fault.
PC09	I		Probable Pitch A computer isolation fault.
PC10	I		Probable Pitch B computer isolation fault.
PC11		O	Pitch A from Pitch B computer CCDL fault.
PC12		O	Pitch B from Pitch A computer CCDL fault.
PC13		O	Pitch A from Roll B computer CCDL fault.
PC14		O	Pitch B from Yaw A computer CCDL fault.
PC15		O	Pitch A from Yaw B computer CCDL fault.
PC16		O	Pitch B from Roll A computer CCDL fault.

Figure 41-8. DFCS Fault Codes (Sheet 2)

DCP	IBIT	OFP	Meaning
PC17	I		Pitch A computer ±12 V_{DC} exported power supply fault.
PC18	I		Pitch B computer ±12 V_{DC} exported power supply fault.
PC19	I		Pitch computer consolidated exported power supply fault.
PC20	I		Servo isolation in Pitch A computer fault.
PC21	I		Servo isolation in Pitch B computer fault.
PC22	I		Pitch A computer ground test input fault.
PC23	I		Pitch B computer spoiler servo amplifier fault.
PC24	I		Pitch computer gyro input fault.
PC26	I		Pitch computer autotrim command monitor fault.
PC35	I		Pitch A computer consolidated exported power supply monitor fault.
PC36	I		Pitch B computer consolidated exported power supply monitor fault.
PC37	I		Pitch A computer 115 V_{AC} power supply monitor fault.
PC38	I		Pitch B computer 115 V_{AC} power supply monitor fault.
PC39	I		Probable Pitch A computer interface BIT circuit fault.
PC40	I		Probable Pitch B computer interface BIT circuit fault.
PC41	I		Pitch A computer AC analogue input interface fault.
PC42	I		Pitch B computer AC analogue input interface fault.
PC45		O	Pitch computer consolidated exported power supply fault.
PGY1	I	O	Pitch gyro channel A fault.
PGY2	I	O	Pitch gyro channel B fault.
PGY4	I	O	Pitch gyro channel A SMRD fault.
PGY5	I	O	Pitch gyro channel B SMRD fault.
PGY7	I		Pitch gyro common mode fault.
POR	NA	NA	In-flight power on reset.
PPA	I	O	Pitch parallel actuator fault.
PSA1	I	O	Pitch series servo channel A fault.
PSA2	I	O	Pitch series servo channel B fault.
PSA3		O	Pitch series servo channel A isolation fault.
PSA4		O	Pitch series servo channel B isolation fault.
PTRM	I	O	Pitch auto-trim actuator fault.
RC01		1	Roll A computer 115 V_{AC} export power supply fault.
RC02		1	Roll B computer 115 V_{AC} export power supply fault.
RC03	I		Roll A computer 28 V_{DC} power supply monitor fault.
RC04	I		Roll B computer 28 V_{DC} power supply monitor fault.
RC05		O	Roll A computer general fault.
RC06		O	Roll B computer general fault.
RC07	I		Roll A computer general fault.
RC08	I		Roll B computer general fault.
RC09	I		Probable Roll A computer isolation fault.

Figure 41-8. DFCS Fault Codes (Sheet 3)

DCP	IBIT	OFP	Meaning
RC10	I		Probable Roll B computer isolation fault.
RC11		O	Roll A from Roll B computer CCDL fault.
RC12		O	Roll B from Roll A computer CCDL fault.
RC13		O	Roll A from Yaw B computer CCDL fault.
RC14		O	Roll B from Pitch A computer CCDL fault.
RC15		O	Roll A from Pitch B computer CCDL fault.
RC16		O	Roll B from Yaw A computer CCDL fault.
RC17	I		Roll A computer internal power supply fault.
RC18	I		Roll B computer ±12 V_{DC} exported power supply fault.
RC19	I		Roll computer consolidated exported power supply fault.
RC20	I		Servo isolation in Roll A computer fault.
RC21	I		Servo isolation in Roll B computer fault.
RC22	I		Roll A computer ground test input fault.
RC23	I		Roll A computer spoiler servo amplifier fault.
RC24	I		Roll computer gyro input fault.
RC27	I		Roll computer Mach trim actuator isolation fault.
RC28	I		Roll computer Mach trim current monitor fault.
RC35	I		Roll A computer consolidated exported power supply monitor fault.
RC36	I		Roll B computer consolidated exported power supply monitor fault.
RC37	I		Roll A computer 115 V_{AC} power supply monitor fault.
RC38	I		Roll B computer 115 V_{AC} power supply monitor fault.
RC39	I		Probable Roll A computer interface BIT circuit fault.
RC40	I		Probable Roll B computer interface BIT circuit fault.
RC41	I		Roll A computer AC analogue input interface fault.
RC42	I		Roll B computer AC analogue input interface fault.
RC45		O	Roll computer consolidated exported power supply fault.
RCP1		O	Roll stick position input 1 fault.
RCP2		O	Roll stick position input 2 fault.
RCP3		O	Roll stick position input 3 fault.
RD28		O	Rudder authority 28 V_{DC} power input fault.
RGY1	I	O	Roll gyro channel A fault.
RGY2	I	O	Roll gyro channel B fault.
RGY4	I	O	Roll gyro channel A SMRD fault.
RGY5	I	O	Roll gyro channel B SMRD fault.
RGY7	I		Roll gyro common mode fault.
RPP1		O	Rudder pedal position sensor input 1 fault.
RPP2		O	Rudder pedal position sensor input 2 fault.
RPP3		O	Rudder pedal position sensor input 3 fault.
RSA1	I	O	Roll series servo channel A fault.

Figure 41-8. DFCS Fault Codes (Sheet 4)

DCP	IBIT	OFP	Meaning
RSA2	I	O	Roll series servo channel B fault.
RSA3		O	Roll series servo channel A isolation fault.
RSA4		O	Roll series servo channel B isolation fault.
RUDA	I	O	Rudder authority actuator fault.
SHKR		O	Rudder pedal shaker fault.
SP1L	I	O	No. 1 left spoiler actuator fault.
SP1R	I	O	No. 1 right spoiler actuator fault.
SP2L	I	O	No. 2 left spoiler actuator fault.
SP2R	I	O	No. 2 right spoiler actuator fault.
SP3L	I	O	No. 3 left spoiler actuator fault.
SP3R	I	O	No. 3 right spoiler actuator fault.
SP4L	I	O	No. 4 left spoiler actuator fault.
SP4R	I	O	No. 4 right spoiler actuator fault.
SPSL	I		Left AICS static pressure sensor fault.
SPSR	I		Right AICS static pressure sensor fault.
TPSL	I		Left AICS total pressure sensor fault.
TPSR	I		Right AICS total pressure sensor fault.
WOW1		O	Weight-on-wheels input 1 fault.
WOW2		O	Weight-on-wheels input 2 fault.
WOW3		O	Weight-on-wheels input 3 fault.
WSP1		O	Wingsweep input to Roll computer fault.
WSP2		O	Wingsweep input to Pitch computer fault.
YC01		O	Yaw A computer 115 V_{AC} export power supply fault.
YC02		O	Yaw B computer 115 V_{AC} export power supply fault.
YC03	I		Yaw A computer 28 V_{DC} power supply monitor fault.
YC04	I		Yaw B computer 28 V_{DC} power supply monitor fault.
YC05		O	Yaw A computer general fault.
YC06		O	Yaw B computer general fault.
YC07	I		Yaw A computer general fault.
YC08	I		Yaw B computer general fault.
YC09	I		Probable Yaw A computer isolation fault.
YC10	I		Probable Yaw B computer isolation fault.
YC11		O	Yaw A from Yaw B computer CCDL fault.
YC12		O	Yaw B from Yaw A computer CCDL fault.
YC13		O	Yaw A from Pitch B computer CCDL fault.
YC14		O	Yaw B from Roll A computer CCDL fault.
YC15		O	Yaw A from Roll B computer CCDL fault.
YC16		O	Yaw B from Pitch A computer CCDL fault.
YC17	I		Yaw A computer ±12 V_{DC} exported power supply fault.

Figure 41-8. DFCS Fault Codes (Sheet 5)

DCP	IBIT	OFP	Meaning
YC18	I		Yaw B computer ±12 V_{DC} exported power supply fault.
YC19	I		Yaw computer exported ‘M’ channel power supply fault.
YC20	I		Servo isolation in Yaw A computer fault.
YC21	I		Servo isolation in Yaw B computer fault.
YC22	I		Yaw B computer ground test input fault.
YC24	I		Yaw computer gyro input fault.
YC25	I		Yaw computer accelerometer input fault.
YC29	I		Yaw computer rudder authority actuator isolation fault.
YC30	I		Yaw computer rudder authority current monitor fault.
YC31	I		Yaw computer lateral authority actuator isolation fault.
YC32	I		Yaw computer lateral authority actuator current monitor fault.
YC33	I		Yaw computer 28 V_{DC} power supply discrete input fault.
YC34	I		Yaw computer pedal shaker fault.
YC35	I		Yaw A computer exported ‘M’ channel power supply monitor fault.
YC36	I		Yaw B computer exported ‘M’ channel power supply monitor fault.
YC37	I		Yaw A computer 115 V_{AC} power supply monitor fault.
YC38	I		Yaw B computer 115 V_{AC} power supply monitor fault.
YC39	I		Probable Yaw A computer interface BIT circuit fault.
YC40	I		Probable Yaw B computer interface BIT circuit fault.
YC41	I		Yaw A computer AC analogue input interface fault.
YC42	I		Yaw B computer AC analogue input interface fault.
YC43		O	Yaw M AC export power supply fault.
YC44		O	Yaw M AC power supply monitor fault.
YC45		O	Yaw computer consolidated exported power supply fault.
YGY1	I	O	Yaw gyro channel A fault.
YGY2	I	O	Yaw gyro channel B fault.
YGY3	I	O	Yaw gyro channel M fault.
YGY4	I	O	Yaw gyro channel A SMRD fault.
YGY5	I	O	Yaw gyro channel B SMRD fault.
YGY6	I	O	Yaw gyro channel M SMRD fault.
YSA1	I	O	Yaw series servo channel A fault.
YSA2	I	O	Yaw series servo channel B fault.
YSA3		O	Yaw series servo channel A isolation fault.
YSA4		O	Yaw series servo channel B isolation fault.

Figure 41-8. DFCS Fault Codes (Sheet 6)

41.3.7.7 Completion without Faults. Upon completion of IBIT without any faults being detected, all DFCS related caution/advisory lights, and acronyms will be returned to the state that existed prior to IBIT initiation, and CADC must be operating properly, and the aircraft must the AUTOPILOT switch will revert to the OFF position. The DCP will display a PASS code which can be extinguished by depressing MASTER RESET. At that point the display will either be blanked or the IBIT ARM message will be displayed, depending on MASTER TEST switch position, and the DFCS will enter OFF.

41.3.7.8 Completion with Faults. If faults are detected during IBIT, they will be indicated to the aircrew through the caution/advisory lights and PTID acronyms as indicated in Figure 41-7 along with any caution/advisory indications which existed before IBIT was initiated. Additionally, the DCP will show a NOGO code. Depressing the INC button will display the IBIT code followed by specific WRA codes for failures detected during IBIT. Depressing MASTER RESET will clear the IBIT failure indications along with any previously existing resettable indications, but does not indicate that the detected failures have been resolved. The DCP display will either be blanked, or return to the IBIT ARM indication, depending on MASTER TEST switch position, and the DFCS will enter OFP. IBIT failure codes will still be stored in the DCP display and can be recalled with the INC/DEC buttons until another IBIT is run or aircraft power is secured.

CAUTION

Following an IBIT, MASTER RESET will clear the IBIT caution/advisory light failure indications, but will not clear the FAULT DISPLAY IBIT codes. This does not indicate that the failures detected during IBIT are resolved. The DFCS should not be considered fully operational. Only the successful completion of another IBIT can verify proper system operation.

Note

AFC acronyms following OBC are invalid because DFCS IBIT lasts longer than the rest of the OBC tests. Acronyms present following stand alone IBIT are generally valid.

41.4 WEAPON SYSTEM BUILT-IN TEST

The BIT is designed to assist the flightcrew in determining if the AWG-9 WCS in operational and capable of performing an assigned mission.

41.4.1 BIT Capabilities. The BIT has the following four major capabilities:

1. Fault detection — Uses eight computer-controlled and RIO-initiated test sequences to detect system failures in flight or on the deck.
2. Fault isolation — Enables the operator to isolate a detected system failure by indicating decision points and suspect WRAs.
3. Degraded modes assessment — Provides a pass, fail, or degraded evaluation of the operational modes at the completion of sequence BIT 3. BIT 2 sequence will also post the DMA of the last computed sequence BIT 3 if one has been run since the AWG-9 power-up.
4. Continuous monitoring — Automatically provides the RIO with a warning when system failures occur during tactical modes.

41.4.2 Types of Tests. These BIT capabilities are incorporated into the five types of tests within BIT: computer operability test, confidence test, detailed radar tests, continuous monitoring tests, and special tests. The computer operability test is performed at power-up of the AWG-9 system. The confidence tests and the detailed radar tests include keyboard digital entries to enable partial or complete rerun of the tests. BIT sequence 1 uses digital entry to perform the dynamic portions of the display tests without the need for read-ins. BIT sequence 3 does not have this digital entry capability. BIT sequence 2 and 4 read in from the MTM with digital entries. BIT sequence 5, 6, 7, and 8 can be partially or completely rerun by digital entry without additional MTM tape read-in.

At power-up of the AWG-9, the new built-in self-test program residing in the ROM performs an operability test. This consists of an instruction test, a ROM checksum test, a state management test, and a partial memory test. This test evaluates the ability of the central processor portion of the 451 WRA to properly execute the instructions contained within the ROM memory. If the CP catastrophically fails the operability test, a blinking CP FAILED will be displayed on the PTID and no memory integrity test will be performed. However, PRGM RESTART may initiate the memory integrity test (Figure 41-9).

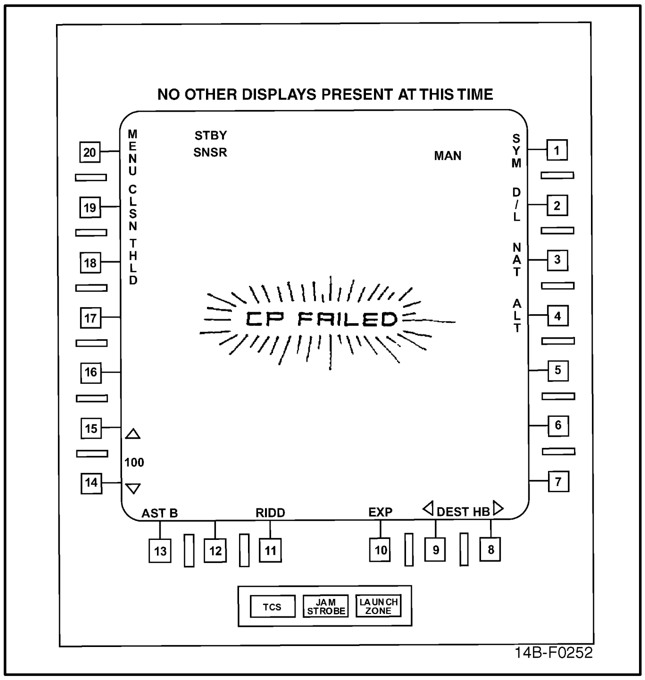


Figure 41-9. Catastrophic BIT Failure Indicator

If the CP passes the ROM operability test, the ROM memory confidence test computes a checksum of the existing program in memory. If it fails, the tactical program (copy 3 of the MTM) will be reloaded into the weapon program memory and a blinking N will be displayed on the PTID. If copy 3 is missing or the load function errs, a blinking E will be displayed on the PTID (Figure 41-10). If a particular MTM block of data transferred to memory does not properly checksum or if the entire 24K WPM load does not properly checksum, a blinking MEMORY FAILED will be displayed on the PTID (Figure 41-11).

If a reload has been mandated by the ROM MCT test, a several minute delay will be encountered for loading WPM from the MTM before commencing a power-up sequence 2.

If the checksum computation performed by the ROM MCT test yields the correct checksum results, a copy 3 load from MTM will not be required.

After copy 3 has been loaded and properly checksummed, a normal power-up sequence 2 will ensue, including loading of copy 1 (or copy 2) into memory with M or B sent to the PTID. Of course, no legends will be displayed on the PTID until the 30-second timeout has elapsed.

The legend CP FAILED, MEMORY FAILED, N, or E will blink when displayed. These failures can be occluded by the PTID Power-up BIT Page. Exiting the page enables display of operability test legends.

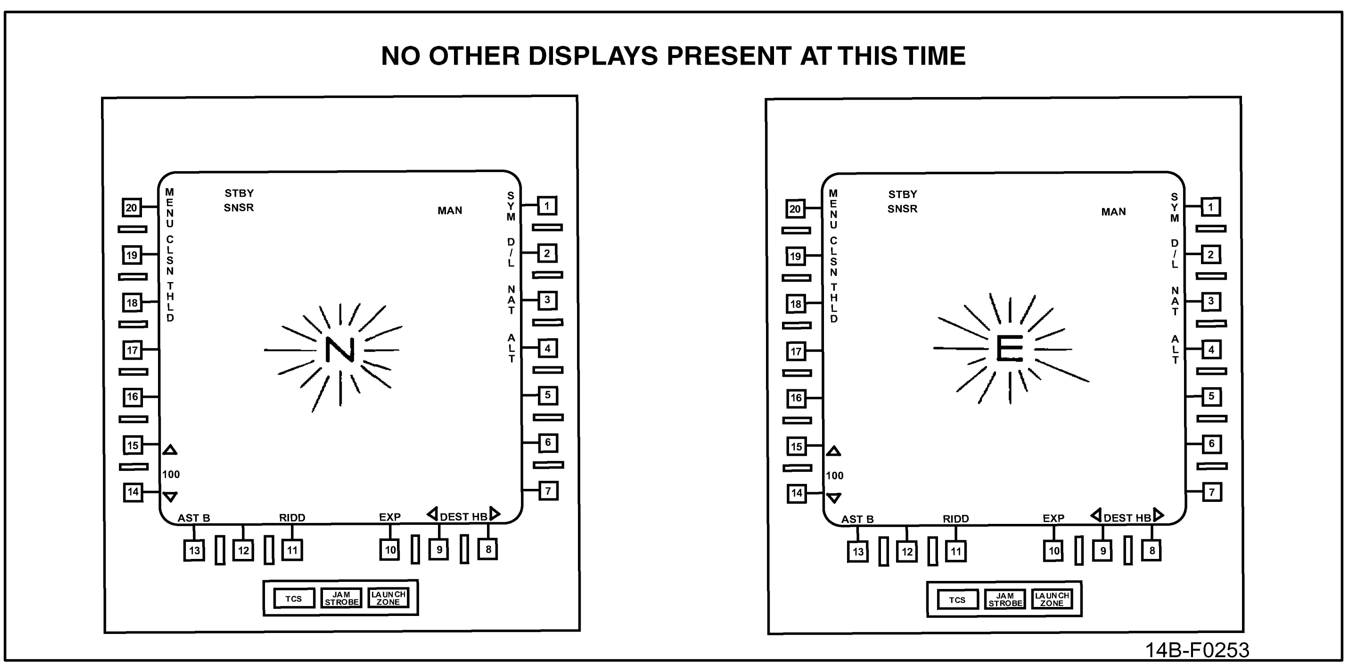


Figure 41-10. Copy 3 Loading

41.4.2.1 Summary of PTID Displays

LEGEND	MEANING
CP FAILED	Hard failure of the central processor as detected by the ROM BIST.
MEMORY	MTM block checksum failed or, tactical
FAILED	Memory checksum failed.
N	Displayed when copy 3 is being normally loaded.
E	Displayed when the loading process has erred (for example, nocopy 3 on the MTM; or a specific MTM block cannot be found; or loader function has failed).
Legends will blink when displayed.	

41.4.2.2 Confidence Tests. The confidence tests provide the RIO with a rapid check of all essential system functions utilizing the fault detection, fault isolation, and degraded mode assessment capabilities of the system. The confidence tests provide a subsystem-by-subsystem check of the AWG-9. The RIO may perform these tests before takeoff in order to verify that the system is capable of performing the assigned mission. After a mission, the confidence tests may be repeated by the RIO to determine if the WCS is still operating properly and can be scheduled for another mission. These postflight confidence tests may be performed before or after landing. The confidence tests consist of four test sequences:

1. Sequence 1 — Displays test (DISPL 1).
2. Sequence 2 — Computer test (COMPTR 2).
3. Sequence 3 — AWG-9 confidence test (AMCS CONF 3).
4. Sequence 4 — Missile auxiliaries subsystem and missile-on-aircraft test (MAS-MOAT).

These tests are initiated when the RIO selects the BIT mode, using the CATEGORY select switch on the CAP, and depresses the appropriate MESSAGE select pushbutton. These four test sequences can be run in any order convenient to the RIO, but sequence 2 and sequence 3 should be run before sequences 5 through 8. Refer to the following section on MTM for the optimum sequence to perform BIT.

41.4.2.3 Detailed Radar Tests. The detailed radar tests provide the RIO with an extensive test of the radar subsystem. The RIO may choose to perform these tests based on the results of the confidence tests. Sequence 3 of the confidence tests performs a rapid check of the radar subsystem. If a fault is detected during this rapid check but cannot be isolated, the sequence 3 display may recommend detailed radar tests be performed. The detailed radar tests consist of four test sequences:

1. Sequence 5 — Receiver test (RCVR 5).
2. Sequence 6 — Transmitter test (XMTR 6).
3. Sequence 7 — Radar antenna servo test (ANT).
4. 8 — Single target track test (STT 8).

41.4.2.4 Continuous Monitoring Tests. The CM fault display is in the lower left quadrant of the PTID and consists of two alpha symbols for a radar or MAS function that failed. Each CM fault detected is displayed for 2 seconds, and then the CM program is continued. Basic weapon system related CM symbology is shown in Figure 41-12.

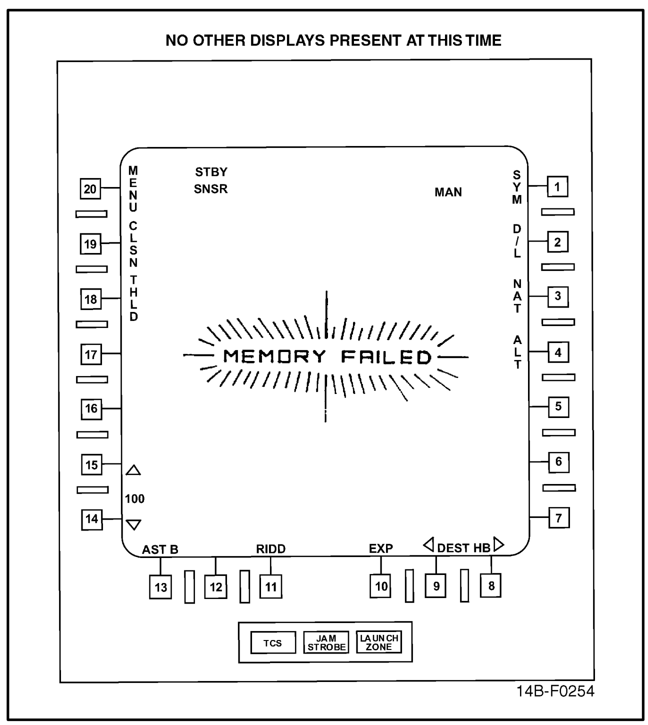


Figure 41-11. MCT Checksum Failure Indication

CONTINUOUS MONITOR DISPLAY	FAULT DESCRIPTION
HO	Clutter term saturated. Degraded or no doppler processing capability.
MA	Indicates missile launch may be degraded. Missile Auxiliary malfunction fault is displayed continuously. Missile irreversibles not in normal ready-to-launch state if displayed for 2 out of 6 seconds (normal with TNG selected).
MM	Occurs during AIM-54C LTE. Indicates that the AIM-54C has not received one or more prelaunch missile messages. Missile performance may be degraded.
MX	MDP checksum error indicating faulty load or computer memory failure.
OX	Overlay checksum error indicating faulty load or computer memory failure.
PM	Low flow in the AWG-9 coolant loop to the transmitter.
RP	Radar power fault indication.
SA	Radar master oscillator failed to tune semiactive channel because of decoder circuit failure.
T	BIT radome horn target turned on.
WX	WCP checksum error indicating faulty load or computer memory failure.
XM	Transmitter peak power below minimum acceptable level or transmitter is not selected on.
XO	No phase lock on transmitter channel selected. No receive capability.

Figure 41-12. Upgrade AWG-9 Acronyms

In the program, a test monitors missile-separated and missile-not-separated flags with a display of MA on the PTID if both flags are not the same except during the LTE cycle.

Note

When performing BIT sequences, refer to Chapter 7 for standard operating procedures.

41.4.2.5 Special Tests. Special tests are provided in the program primarily to aid the maintenance and crew. All special tests are entered via the SPL TEST selection of the BIT category, then NBR XX, then ENTER. The special tests provide the operational interface with AIM-7 and AIM-9 armament test sets, individual processing of computer inputs and outputs, and computer memory address inspection. Tests 31 and 32 may be entered on the deck or airborne. Tests 90, 91, 94, 95, 97, 98, and 99 cannot be entered when airborne. Test 101 will function the same as 100, if airborne. Special tests are as follows:

1. NBR-31 — BIT sequence 3 mission essential tests for alert launches.
2. NBR-32 — Tests radar channel phase-lock and transmitter leakage.
3. NBR-90 (SPAM) — SIP-SOP, PIP-POP, AI-AO, and memory inspection.
4. NBR-91 AWM-71 test set — Tests CWI noise and modulation.
5. NBR-94 — MATS/MITS interface test set.
6. NBR-95 — MITS (–150) interface test set.
7. NBR-97 (AIM-7 SMTS) — AIM-7 missile station test set (GAC).
8. NBR-98 (AIM-9 SEAM) — AIM-9 SEAM test set.
9. NBR-99 (AIM-7 MSTS) — AIM-7 missile station test set (Navy).
10. NBR-100 — Recalls three most recent transmitter overloads and/or power faults.
11. NBR-101 — Clears SPL TEST 100 on the deck (WOW).

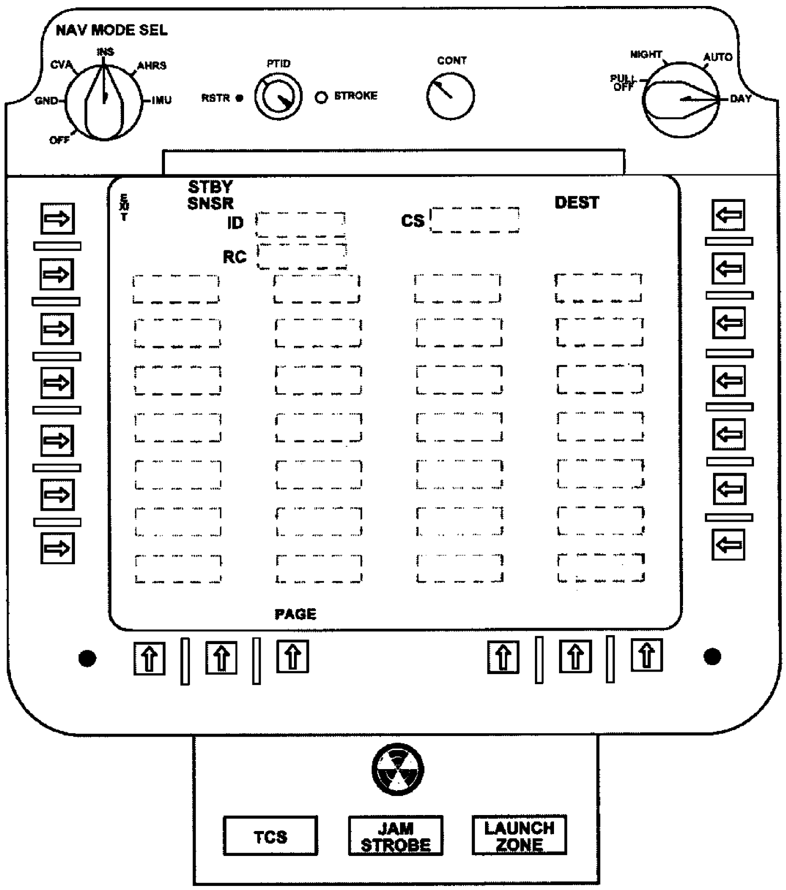


Figure 41-13. PTID Power-Up BIT Page

Note

Sacred cells are cleared upon entering special test 101 on the deck; displays remain until next entry.

If a radar transmitter fault is detected, the CM routine stores the transmitter status in three sacred cells that maintenance personnel can read using special test 100 (ST 100).

Transmitter fault monitoring is called at and 8-msec rate. When a new transmitter fault is detected, the fault is stored in the first sacred cell and any previous faults are moved to the next two sacred cells. This ensures that the three most recent transmitter faults are displayed

41.4.2.6 PTID Power-Up BIT. At power-up, an internal PTID BIT is performed. If failures are detected the PTID Power-Up BIT Page (Figure 41-13) is displayed. The PTID OFS identification (ID), PTID OFS load checksum (CS), and the last recurring reset code (RC) are displayed in the area at the top of the CRT.

Beneath is space for 28 lines (2 pages) of 4-digit hexadecimal codes for maintenance troubleshooting. The Power-Up BIT Page is cleared by selecting EXIT with the pushtile or HCU cursor.

41.5 MAGNETIC TAPE MEMORY FAILURE INDICATION

If the magnetic tape unit fails to run and respond with an enabled signal when commanded to run, and E will be displayed instead of a +, M, N, or I. The E can be hooked to call up the full PTID menu to select or deselect the non-MTM-related menu functions. To provide the proper perspective for the display of the different acronyms, the operational logic for each is briefly described.

The MTM is a long, single strip, with two identical copies of the data on the tape. As shown in Figure 41-14 the individual program files are sequentially located on each copy. Data cannot be used directly from the tape; it must be loaded into the non-write-protected memory first. This is done by running the tape through a tape read head similar to a home recorder. While the tape is searching for the right file and loading the file into the NWPM, it displays an M regardless of which copy is being used.

Depending on where maintenance left the tape, either copy may be used by the system and will continue to be used until a problem is encountered. After a block of data are read in, the program checks the sum and, if it is wrong (such as might be caused by a weak recording or loss of oxide from the tape surface), it tries again. If after five tries it still gets the wrong sum, it assumes the copy is defective and runs to the other copy. When it does this, it displays the letter of the new copy and runs the data in. If a problem is encountered with the new copy, it will go back to the original copy and try (it does not remember that a copy is defective).

If, when commanded to run, the MTM fails to run, an E will be displayed on the PTID. This means that: (1) no new data can be run in; (2) the MTM is still being commanded to run and, if the trouble is of a transitory nature, may recover; and (3) the present system status can be maintained if power is not recycled. The E can be hooked to call up the full PTID menu to select or deselect the non-MTM related PTID menu functions. If an E appears, even momentarily, it should be reported to maintenance.

Separate computer programs are loaded into the various F-14 Upgrade computers. Their programs must be compatible. Since these memories are loaded into multiple units, there is a possibility of having an incompatible tape configuration in one or more units. The incompatibilities may be few or many; they might show up in the displays or subtly interfere with a missile

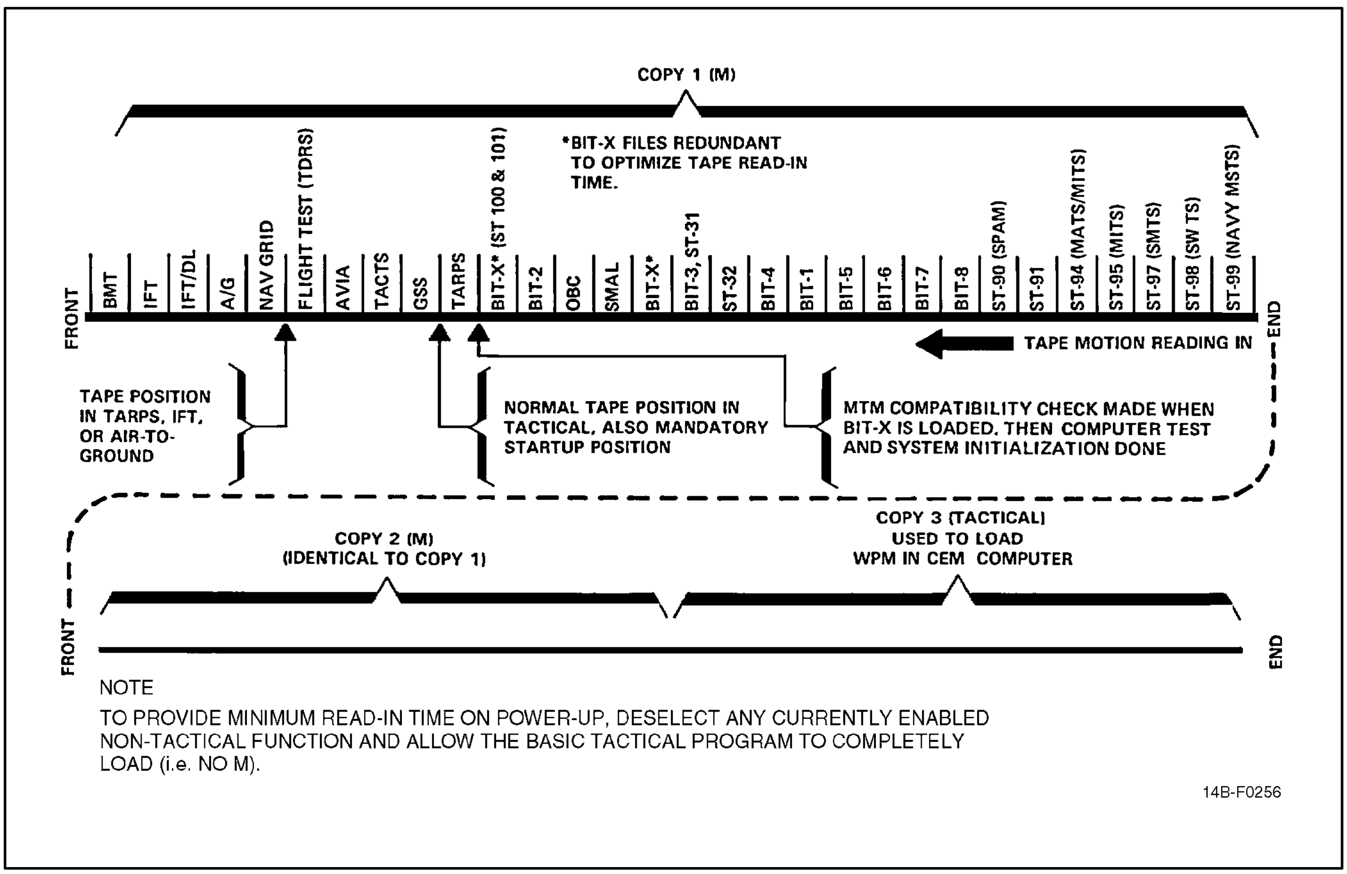


Figure 41-14. Magnetic Tape Memory

launch. The WCP does a compatibility test when the software is loaded at startup. If an incompatibility exists, the PTID BYPASS page will appear (see section 41.6.2).

Upgrade Tapes 317A and 320A replace the Tape 116A “W”, “Y”, and “Z” acronyms associated with BC, CSDC, and CI software incompatibilities with the PTID OFS display “BYPASS” legend. Beginning with Tape 317A, multiple MTM loads will be present in the fleet on a continuous basis. Extra care must be exercised by aircrew and maintenance personnel to ensure incompatible aircraft software configurations do not result.

WARNING

If an MTM containing a Tape 116A or earlier load is installed in an Upgrade aircraft, the proper load in the WCP can be overwritten. The BYPASS indication may not be displayed. If abnormal indications are observed during startup (N, X, W, Y, or Z acronyms) the OFS page must be checked to verify correct loading. The system may appear to function normally with incompatible loads, however further operation is unpredictable and potentially hazardous, especially due to the incompatibility of the EGI-based navigation system with Tape 116A. Flight with software load configurations not specifically authorized by NAVAIR written flight clearance is PROHIBITED.

When the flight test instrumentation routine is activated, an “I” is displayed on the lower left corner of the PTID.

Note

With the reordered BIT sequence 1 through 4, the complete set of confidence checks should be run in the following order to minimize time; 2, 3, 4, and 1.

41.6 PTID OPERATIONAL FLIGHT SOFTWARE (OFS) PAGE

The PTID OFS page (Figure 41-15) is selected from the PTID full menu display by selecting OFS. Processor IDs (PID) are displayed for the WCP, CSDC(R), MDP, PTID, CI, BC, PMDIG, EGI, CDNU, and MDL processors. It also provides the version number (VERS) and checksum (CS) for each of these processors.

Note

Checksums displayed on the OFS page are calculated only at system power-up. A subsequent memory error/failure indicated by a WX, MX, or OX acronym will not update OFS page checksums. If the checksum acronym cannot be cleared, the affected WRA must be reloaded.

The OFS page is exited by hooking the “EXIT” legend.

41.6.1 Upgrade PTID Configuration (CONFIG) Page. The CONFIG page (Figure 41-16) is selected by hooking the OFS legend on the OFS page. If the subsystem processor load is compatible with the WCP load, a check mark is displayed in the REQ column. An incompatible processor load will cause the required program ID for that processor to be displayed in the REQ column.

An “X” over a processor acronym indicates either the processor is not on, the processor has an invalid software load, the particular processor failed to report when polled (1553 bus problem), or the processor is failed. The exception is the MDL; if cartridge is removed, the required software load will appear in the REQ column, but no “X” will appear.

The AVAIL column is a provision for future capability to indicate processor software loads available on the MDL cartridge.

41.6.2 PTID BYPASS Page. The BYPASS page is provided to alert the aircrew of a software incompatibility. If any of the conditions that cause an “X” to appear over a processor acronym in the CONFIG page occur during start-up, the BYPASS page will be automatically displayed (Figure 41-17). To continue, the operator must hook the BYPASS legend, select the CONFIG page and verify all subsystem processor switches are ON. If a processor remains “Xed” out, the “CONF” acronym is hooked to verify checksums on the OFS page.

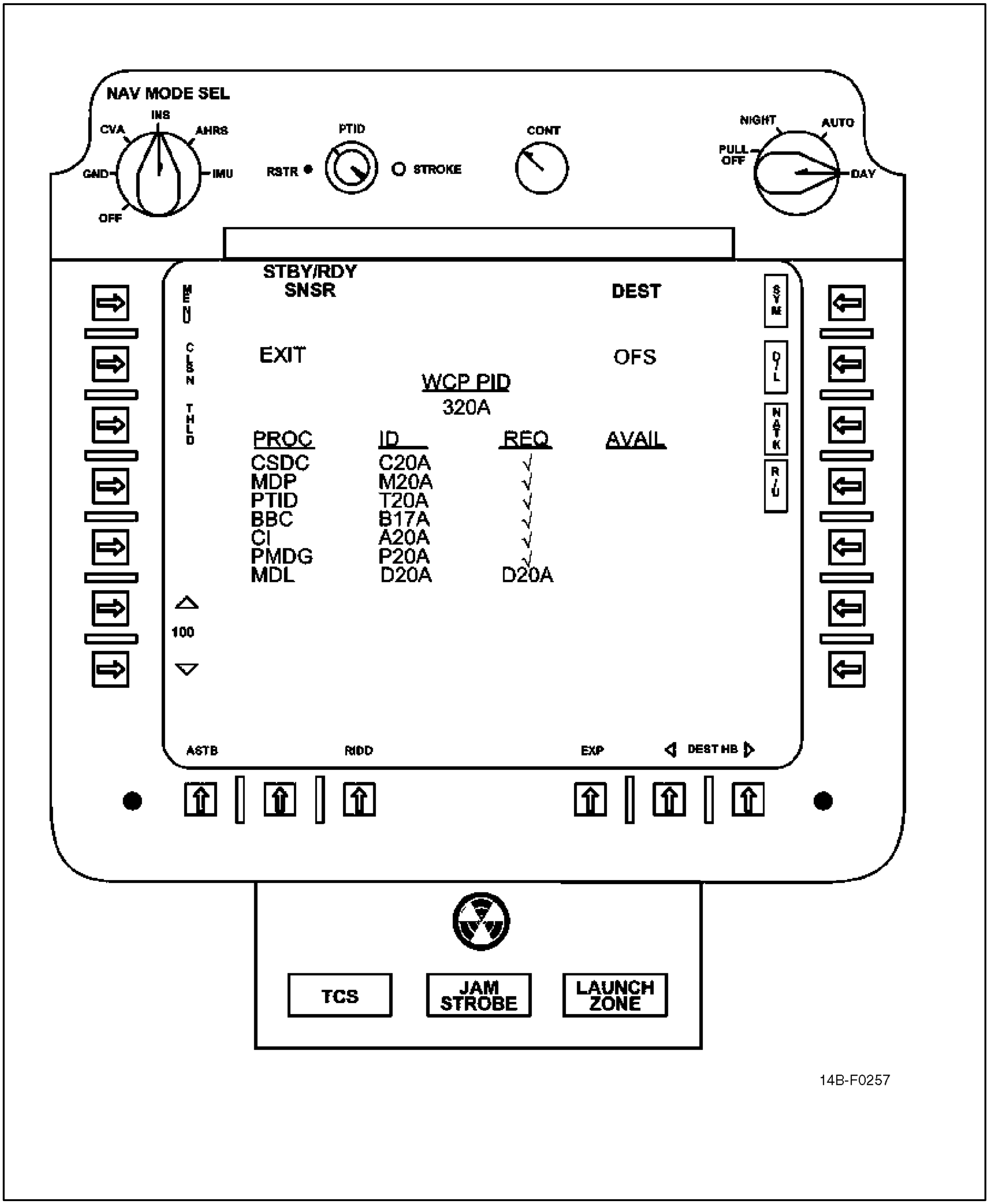


Figure 41-15. PTID OFS Page

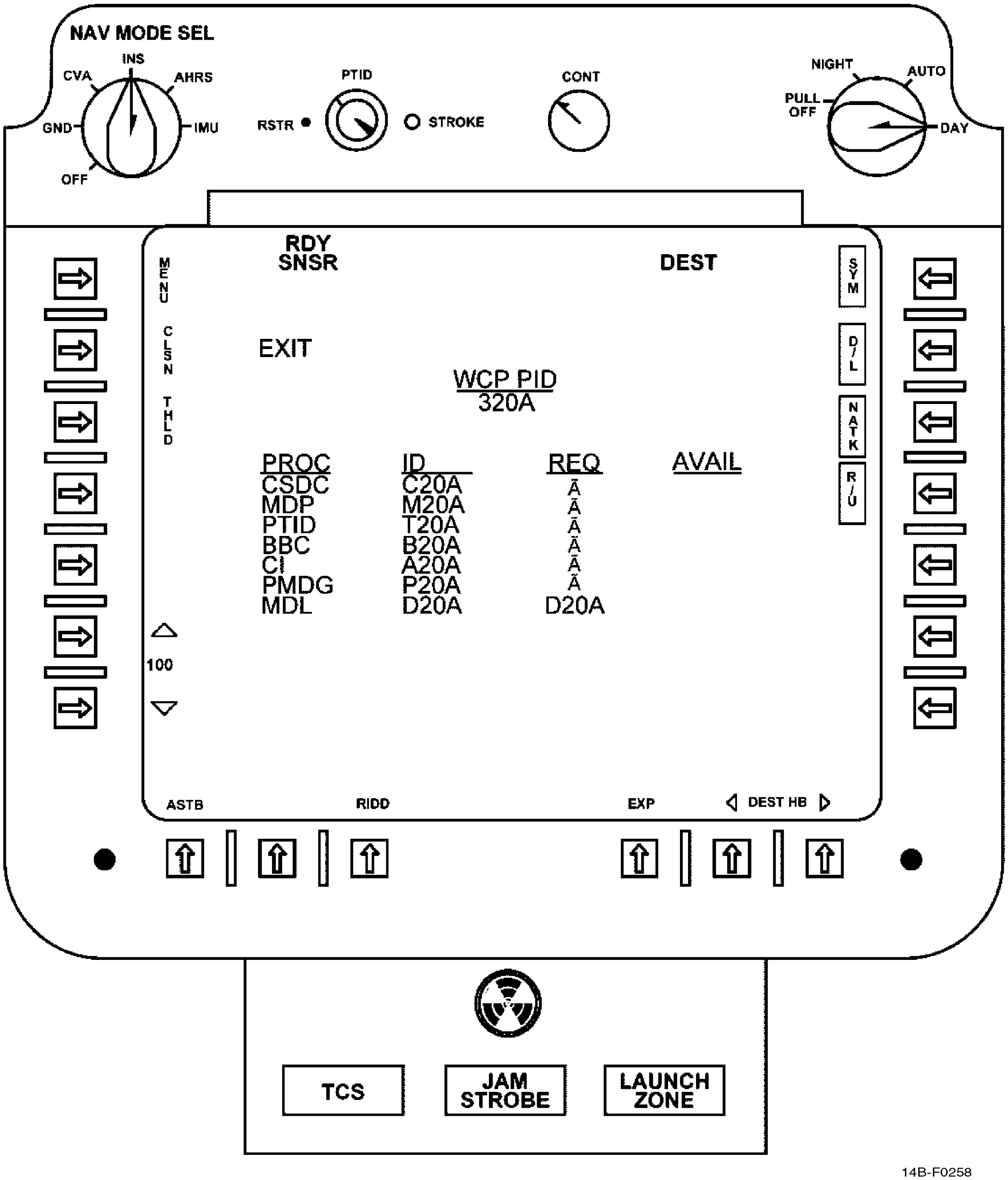


Figure 41-16. PTID CONFIG Page

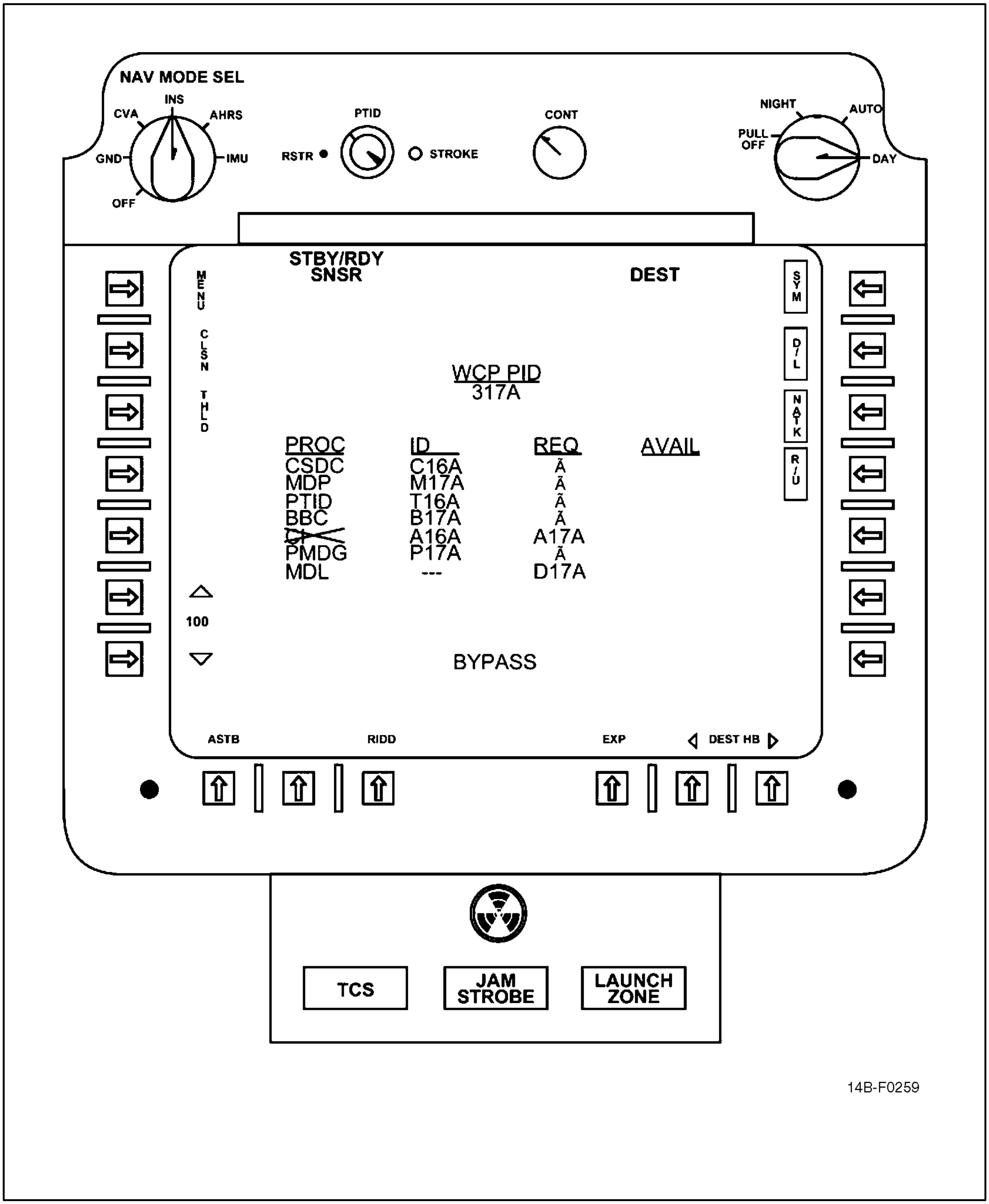


Figure 41-17. PTID BYPASS Page

WARNING

It is possible to load incompatible software versions into the Upgrade system processors. Use of the BYPASS function or PRGM RSTRT to continue system operation may cause unpredictable results. Flight with software load configurations not specifically authorized by NAVAIR written flight clearance is PROHIBITED. Stores released using cartridge activated devices (CAD) should not be carried with a non-cleared software configuration due to the increased possibility of inadvertent release or jettison.

41.7 FLYCATCHER

Flycatcher is a computer routine that allows the RIO to examine the contents of specific CADC, CSDC, or WCP memory locations. The difference between CADC, CSDC(R), or WCP is the numerical designation of the different memory locations (Figure 41-18). The flycatcher routine is entered using the computer address panel. The specific memory location and its contents, which are in octal numbers, are displayed on the PTID (see Figure 41-19). Figure 41-20 shows the interpretation of the displayed flycatcher data.

41.7.1 CSDC(R) Flycatcher. The CSDC(R) flycatcher routine is selected by entering 71 and then entering a five-digit octal number. The five-digit number is the octal address of a specific memory location under interrogation. Once entered, the PTID displays the contents of the memory location in octal form as the WCP interrogates the CSDC(R) memory location. Refer to NATOPS PCL for pertinent CSDC(R) flycatcher locations.

41.7.2 CADC Flycatcher. The CADC flycatcher routine provides a rapid in-flight and flight line identification of CADC-related malfunctions. Use of CADC flycatcher will allow sounder judgments to be made following CADC failures. CADC flycatcher routines are selected in the same manner as the CSDC(R) flycatcher routine. Figure 41-21 shows the major failure functions for each of the three words that can be called up. Refer to NATOPS PCL for details indicated in the CADC flycatcher locations.

Note

If the CADC failure flag is reset, the flycatcher will not retain the failure indications.

41.7.3 WCP Flycatcher. The WCP flycatcher routine is selected in the same manner as for CSDC(R) except the access code is 7 followed by the five-digit octal address. Entering a 9 will incrementally advance the address one location.

Entering 9X will decrement the address by one location. Multiple depressions of the ENTER button following 9 or 9X will increment or decrement the address location, once for each depression.

41.7.4 Flycatcher Exit. To exit a flycatcher routine, depress the following keys:

1. CLEAR
2. 7
3. 0
4. ENTER.

41.8 KEYBOARD DIGITAL ENTRY TESTS

The capability is provided to rerun all or selected portions of a sequence (1, 2, 4, 5, 6, 7, and 8) only after the test sequence has been run to its completion. This capability has been incorporated to aid the maintenance crews. Digital entry tests are initiated by the following sequence.

On computer address panel:

1. CLEAR pushbutton — Depress and Release.
2. NBR pushbutton — Depress and Release.
3. Enter number via digit pushbuttons — Depress and Release.
4. ENTER pushbutton — Depress and Release.

LOCATION	DATA IN LOCATION
7-00107	Transmitter Power
7-00157	Radar Overloads
7-00166	Transmitter Overloads (When difficulty is encountered entering Special Test 100 or 101)
7-00426	MSL Directional Problems
7-00427	MSL Type and Station Loading
7-00434	Missile Select and AIM-9 Scan and Slave Data
7-00435	MSL Power and Tuning AIM-54 and AIM-7
7-00444	MSL Parameters
7-00445	MSL MOAT Parameters
7-00504	Navigation Alignment Data
7-00507	BIT Lift Accelerometer
7-00517	Navigation Modes
7-00537	INS Wander Angle
7-00555	Weight-on-Wheels Check
7-00646	Missile Station Select Indicators
7-00647	Rapid Lock-on Problems, Missile Gate Aspect Select, and Weapon Type Select
7-00650	AIM-54 Ready, AIM-7 Tuned ACM Launch, Training Select, and SEAM LOCK indicators
7-16735	Should read XXXXXXX1
7-17530	Automatic Sequence 2 and DMA Initialization problems (Should read 7XX77777)
7-57776	AWG-9 Checksum
71-00101	CSDC(R) Self Test Loop
71-00750	CSDC(R) Fail Word
71-13757	CSDC(R) Checksum

Figure 41-18. Typical Flycatcher Locations

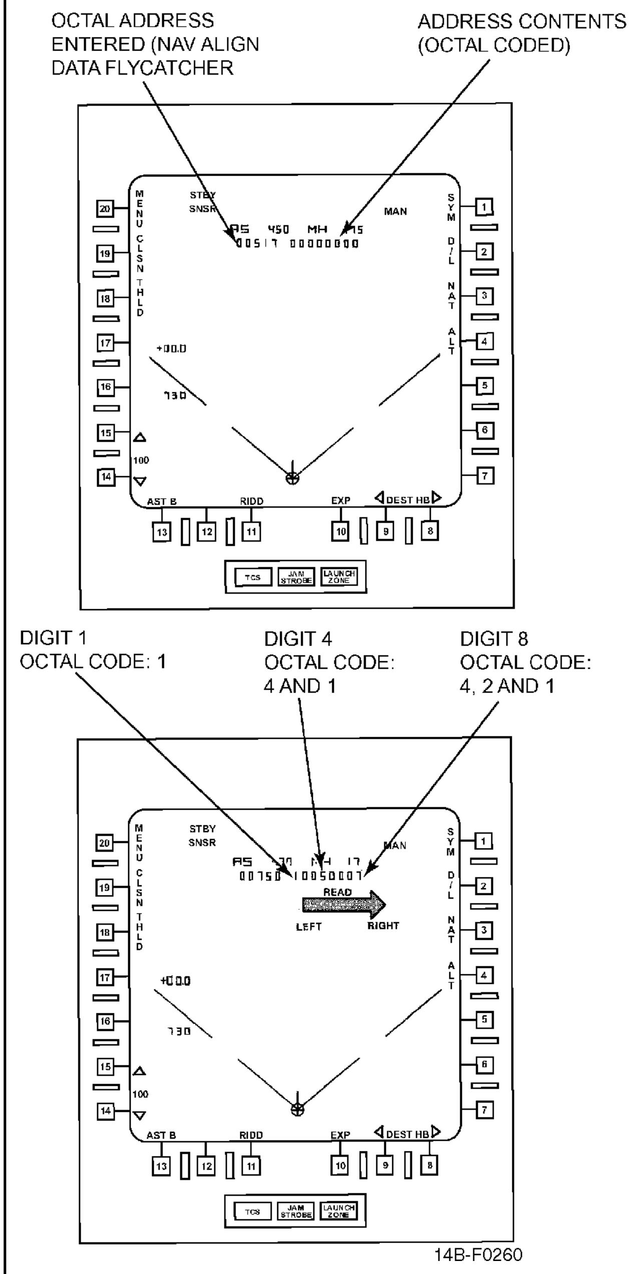


Figure 41-19. Flycatcher Display

OCTAL DISPLAYED	INTERPRETATION
1	Indicates condition for 1 exists.
2	Indicates condition for 2 exists.
3	Indicates condition for 1 and 2 exists.
4	Indicates condition for 4 exists.
5	Indicates condition for 1 and 4 exists.
6	Indicates condition for 2 and 4 exists.
7	Indicates condition for 1, 2, and 4 exists.
Note The octal numbers describe the existence of three possible situations or some composite of the three.	

Figure 41-20. Decoding Flycatcher

WARNING/ CAUTION/ ADVISORY	CAP ADDRESS	MAJOR FAILURE FUNCTION
CADC	7100037	ECS, Input Discretes, Sum Check
CADC, WING SWEEP	7100027	Wing Sweep, Tail Auth, ECS, RIO Altimeter, Total Temperature, CSDC Output
CADC, FLAP, MACH TRIM	7100025	Flaps, Autopilot, Pilot Altitude, Angle of Attack, Qc Monitor

Figure 41-21. CADC Flycatcher

NBR 63, 71, 81, and 86 digital entry tests may be terminated by the following sequence:

On computer address panel:

1. CLEAR pushbutton — Depress and Release.
2. ENTER pushbutton — Depress and Release.

41.8.1 Sequence 1

1. NBR-11 — Dynamic displays test.

41.8.2 Sequence 2 (NAV MODE Switch OFF). The provision for digital entries (DE 2X) in sequence 2 is made for the benefit of maintenance personnel and is intended for use only on the deck.

41.8.3 Sequence 4

1. NBR-40 — Repeat sequence 4 MAS only.
2. NBR-41 — Station 1 MOAT*.
3. NBR-43 — Station 3 MOAT*.
4. NBR-44 — Station 4 MOAT*.
5. NBR-45 — Station 5 MOAT*.
6. NBR-46 — Station 6 MOAT*.
7. NBR-48 — Station 8 MOAT*.
8. NBR-49 — MOAT all stations with AIM-54 IDs.

*With AIM-54 ID present

41.8.4 Sequence 5

1. NBR-50 — Repeat sequence 5.
2. NBR-51 — Doppler filter display with FMR off.
3. NBR-52 — Doppler filter display with FMR on.

41.8.5 Sequence 6

1. NBR-60 — Repeat sequence 6.
2. NBR-61 — Repeats all sequence 6 tests affected by channel selection on the operator-selected channel. The noise plot and the pulse Doppler

power test are performed at one-third transmitter duty cycle.

3. NBR-62 — Repeats all sequence 6 tests affected by channel selection on the operator-selected channel. The noise plot and the pulse Doppler power test are performed at one-half transmitter duty cycle.

4. NBR-63 — Displays transmitter peak power on the RIO-selected mode pulse Doppler search or pulse search (PDS or PS) and selected channel. Channel may be changed without reentering NBR-63.

5. NBR-64 — Decodes CM detected transmitter problem. Displays DPs and faulty WRA (applied fault isolation to octal (XM) display at ST 100).

41.8.6 Sequence 7

1. NBR-70 — Repeat sequence 7.

2. NBR-71 — Radar antenna scan pattern display with STAB IN or STAB OUT.

41.8.7 Sequence 8

1. NBR-80 — Repeat sequence 8.

2. NBR-81 — Radome target horn calibration tests (BIT adjustment).

3. NBR-82 — Track loop test on lobing frequency 1 only.

4. NBR-83 — Track loop test on lobing frequency 2 only.

5. NBR-84 — Track loop test on lobing frequency 3 only.

6. NBR-85 — Repeat pulse single-target track (PSTT) tests only.

7. NBR-86 — Transmitter oscillator leakage test.

Note

The continuous iterations of NBRs 63,71, 81, and 86 may be stopped by pressing CLEAR and then ENTER on the computer address panel.

41.9 BIT OPERATION

The BIT (Figure 41-22) can be exercised by the RIO while in flight or on the ground. The confidence tests, with the exception of MOAT, take approximately 5 minutes and provide a good indication of system condition. An additional 30 seconds is required for each AIM-54 missile on board.

Note

When a higher priority mode such as dog-fight mode is selected, BIT is automatically exited.

41.9.1 BIT Readout. BIT results are displayed on the PTID. Each of the confidence test sequences and each of the detailed radar test sequences has two basic displays: a fault-detection display and a fault-isolation display. Continuous monitoring displays appear only when a failure occurs during tactical modes.

To initialize the desired BIT, RIO selects the appropriate sequence and enters it via the CAP. Tape read-in on the PTID is indicated by the appearance of an M. At the completion of read-in, the BIT test result box will appear with a blinking sequence number. During the sequence test, the number will appear in the upper left-hand corner of the BIT test result box. The sequence number will blink until the test is completed.

41.9.2 BIT Fault Detection Displays. A typical BIT fault detection display is shown in Figure 41-23. In all the BIT fault detection displays (except BIT sequence 4), the square BIT box appears at the top center of the PTID. The sequence number appears in the upper left-hand corner of the BIT box.

When the sequence number is blinking, the test is in progress. If the test cannot proceed because a manual switch or control setting is required, a symbol blinking above the BIT box (below the box in BIT sequence 4) indicates which switch is not properly set. Proper settings are as defined in the test procedure for each sequence.

The WCP has been designed to require a minimum number of these manual switch settings while executing the confidence tests. If the required switch setting is not made within 28 seconds, the computer may continue and execute and abbreviated version of the test sequence. At the completion of the BIT sequence, the test sequence number remains steady and the test

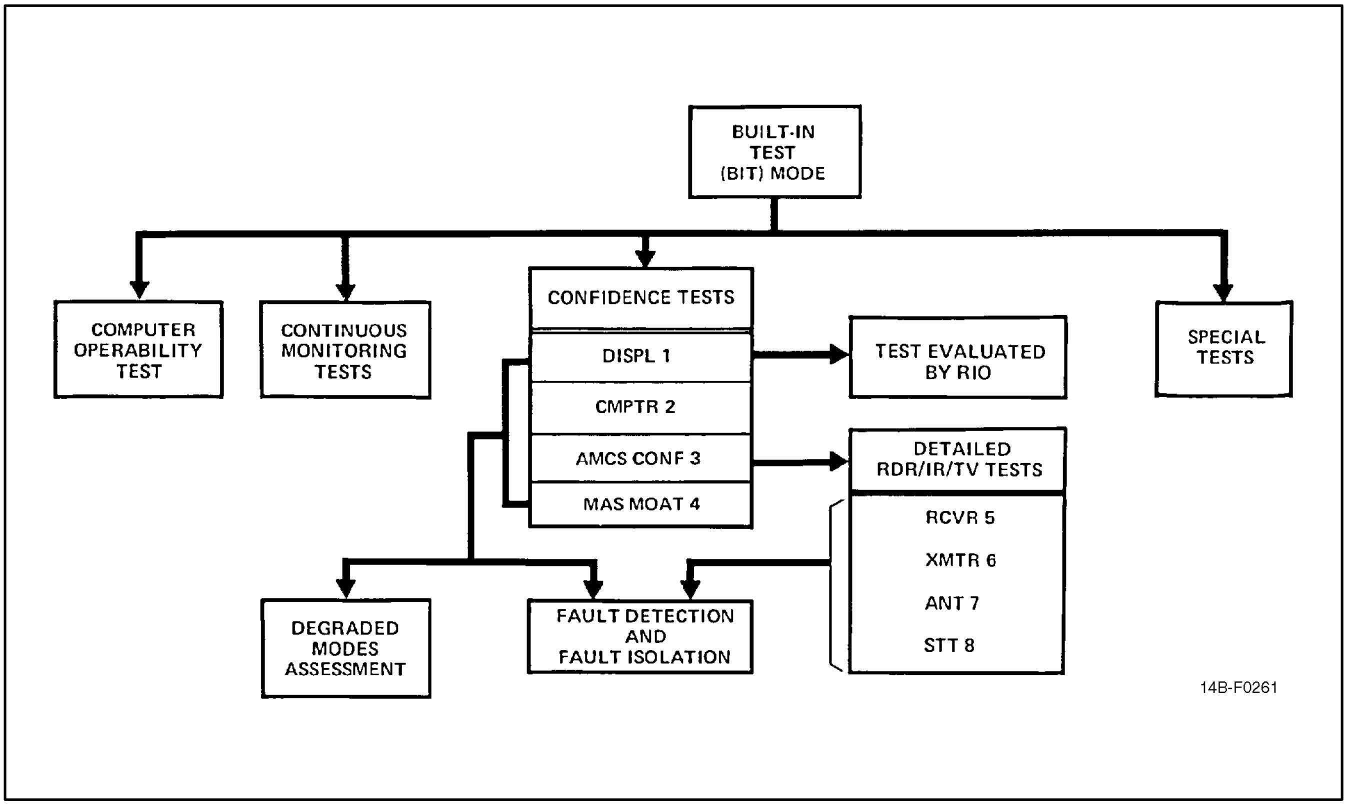


Figure 41-22. BIT Organization

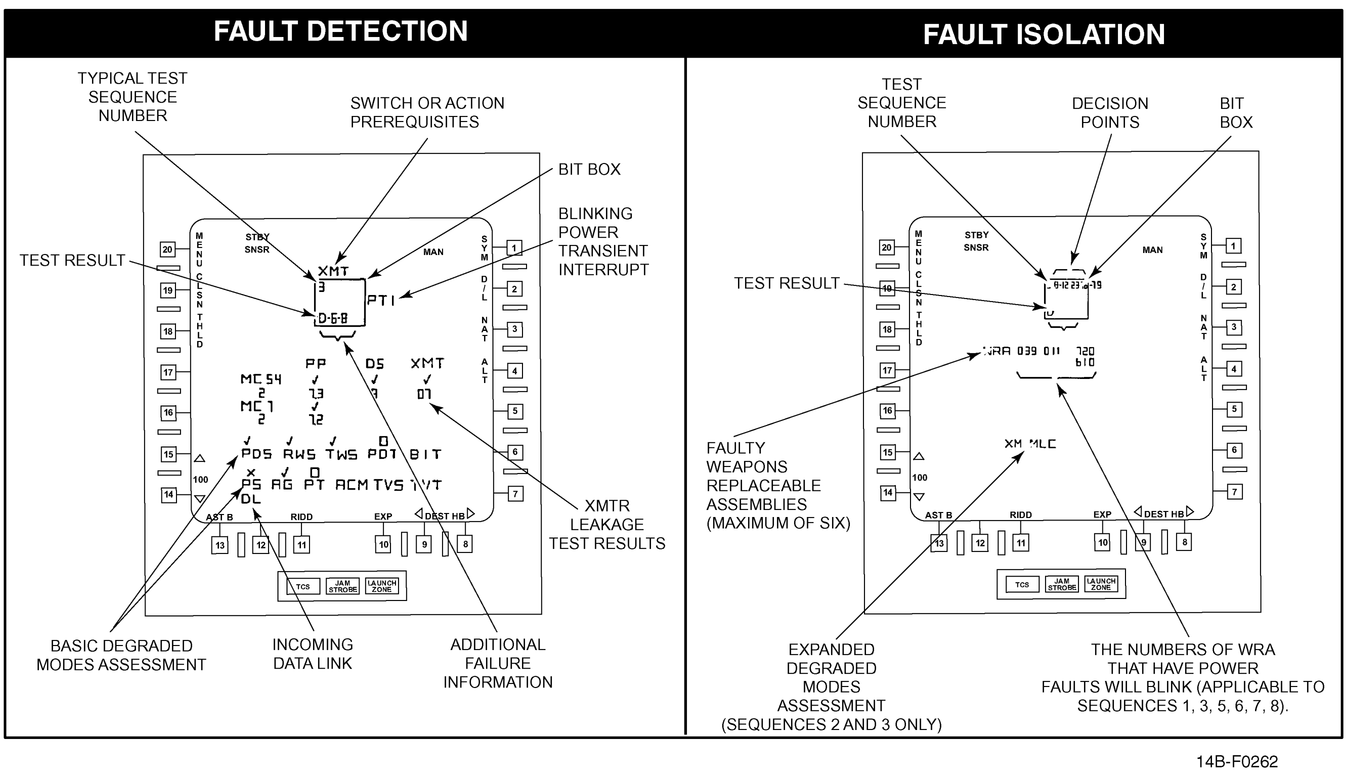


Figure 41-23. BIT Displays

sequence is evaluated by a symbol in the lower left corner of the BIT box (left center of the box in BIT sequence 4). A pass (✓) or a discrepancy (D) symbol will appear. An exception is sequence 1, the displays test, in which no (✓) will appear because it is evaluated by the RIO. The discrepancy (D) symbol may appear if there is a C and power fault. When the test sequence number goes steady, the RIO knows the fault detection test is completed and progression to the next test or fault isolation is possible. The RIO will note the discrepancies prior to the start of the next sequence.

If at anytime during execution of a BIT sequence (except auto sequence 2) incoming data link is detected, the blinking DL acronym will appear at the lower left portion of the PTID. At this time, the RIO may elect to exit BIT and receive data link. If a power transient should occur during the execution of a BIT sequence, the blinking symbol PTI (power transient interrupt) will be displayed to the right of the BIT box. This advises the RIO that a power transient has occurred and that the data displayed may not be entirely correct.

Note

If the aircraft was in motion (pitch or roll) during sequence 3, sequence 4 (MAS or MOAT), or sequence 8 tests, and aircraft-in-motion symbol (⊗) may appear in the BIT box. When this happens, it indicates portions of the test were either affected by the motion and/or were bypassed. The test should be rerun, with the aircraft stabilized, to perform a complete test.

41.9.3 Degraded Mode Assessment. The fault displays associated with sequences 2 and 3 also include the basic degraded modes assessment. An acronym for the basic degraded modes assessment. An acronym for each mode is displayed on the PTID and a pass (✓), fail (X), or degraded (□) evaluation is presented with each acronym when sufficient information becomes available to the computer. The basic DMA is cumulative and carries and updates evaluation throughout sequences. Sequence 1 display test consists of operator-evaluated patterns and contains no DMA display. Sequence 4 has an abbreviated DMA for AWG-9 modes related to missile launch capability.

Note

A mode with no fault detected but not fully evaluated will have no evaluation associated with it. In other words, a pass will be inhibited.

The operator may at any time call up the latest evaluated basic DMA display by depressing the SPL TEST pushbutton. The symbols that appear on the displays and the corresponding modes or function named for the basic DMA are listed as follows.

1. PDS — Pulse Doppler search
2. RWS — Range while search
3. TWS — Track while scan
4. PDT — Pulse Doppler single-target track
5. BIT — Built-in test
6. PS — Pulse search
7. AG — Air-to-ground
8. PT — Pulse single-target track
9. ACM — Pulse dogfight modes
10. TVS — Television search
11. TVT — Television track.

41.9.4 4BIT Fault Isolation Displays. A typical BIT fault-isolation display is shown in Figure 41-23. The fault-isolation display for a test sequence is initiated by depressing the FAULT DISPL pushbutton on the CAP when a fault has been detected. The fault-isolation displays contain a BIT box near the top of the PTID. The sequence number is in the upper left corner of the BIT box, and the test evaluation is in the lower left corner. In the BIT box and immediately to the right of the test sequence number, a list of decision points (DPs) will appear. These DPs represent the specific locations of failed decisions within the computer program of the test sequence. Displayed to the right of the acronym WRA are the unit numbers responsible for the failure of the test sequence. The relationship of unit number to unit common name is shown in Figure 41-24. Sequence 4 is an exception to this description. Refer to the sequence 4 detailed discussion for locations information.

SIMPLIFIED WRA NUMBER	COMMON NAME
001	Radar master oscillator
006	Transmitter oscillator waveguide
007	CWI oscillator waveguide
010	Synchronizer
011	Radar transmitter
012	Radar output waveguide
013	Collector power supply
014	Beam power supply
015	Solenoid power supply
021	Radar input waveguide
022	Radar receiver
025	Radar test horn
026	MOAT forward horn
027	Aft wing horn
028	Aft belly horn
029	Aft hook fairing horn
030	Aft center channel horn
031	Radar antenna
039	Doppler processor
042A or B	Doppler filter

SIMPLIFIED WRA NUMBER	COMMON NAME
081	Antenna and test controller
083	Low PRF processor
451	Arithmetic and control/DRO
452	NDRO memory
461	Input-output interface unit (IFU)
462	Computer power supply/Bulk storage memory (MTM)
501	Sensor control panel
505	Computer address panel (CAP)
541	Detail data display (DDD)
560	Hand control unit
580	Programmable tactical information display (PTID)
590	Mission recorder
601	Semi-regulated power supply
610	Regulated power supply
710	Missile signal data converter
720	Missile logic timing controller
730	Missile power supply
805	CSDC(R)
818	Television camera set (TCS) Control Power Supply (CPS)

Figure 41-24. AN/AWG-9 WRAs

The fault isolation display for sequence 4 MAS/MOAT is the only exception to the above display description. A typical sequence and fault isolation display is shown in Figure 41-33. The fault display is called up in the same way as all other BIT sequences. The sequence and fault isolation display contain a BIT box near the bottom of the PTID. The sequence number is to the left of the BIT box, the test evaluation is in the center, and degraded weapon status is to the right. Weapon stations affected by MAS/MOAT fault are displayed vertically on the left side of the display. First through fourth maintenance action choices are displayed horizontally from left to right beside the affected weapon station, if applicable. Test failures are on the right side in the form of acronyms and maintenance DP numbers. An R in front of a DP number indicates a MOAT readiness failure, while S indicates a WCS system failure affecting MOAT. When MAS/MOAT is repeated through a digital entry and a horizontal line appears across the PTID, real failures are displayed above the line while indeterminate failures will be displayed below.

41.9.5 Expanded Degraded Mode Assessment. Also included in sequence 2 and 3 fault-isolation displays is and expanded DMA presentation. The expanded DMA presentation is a list of acronyms near the bottom of the display that represents submodes or specific functions that are degraded or have failed. This expanded DMA display does not evaluate the functions with pass, fail, or degraded symbols; it displays only the acronyms corresponding to the failed or degraded submodes or functions. The expanded DMA symbols that may appear are as follows.

41.9.5.1 Sequence 2

1. DL — Data-link IFU failure

2. IFF — Identification friend or foe IFU failure

3. R/R — Range and range rate in the IFU failure

4. SAL — Semi-active launch

5. SSI — Standard series interface.

41.9.5.2 Sequence 3

1. ANT — Antenna failed two-bar and four-bar tests or antenna has failed the ±5° pointing test.

2. ANT 2 — Antenna failed two-bar test.

3. ANT 4 — Antenna failed four-bar test.

4. CWI — Continuous-wave illuminator power is below acceptable level to support AIM-7 in flight, the transmitter flood antenna switch was not enabled, or the CW transmitter dumped.

5. JET — Jam exceeds threshold interrupt failed.

6. MLC — Main lobe clutter notch fails to take out clutter.

7. MRL — Manual rapid lock-on (indicates the antenna failed to reverse scan direction within 300 milliseconds during ±10° scan).

8. PA — Paramp failure.

9. PC — Pulse compression failure.

10. SAL — Semiactive launch decoder command was true on a search channel or false for a semiactive channel.

11. VSL — Vertical scan locked-on antenna switching test failed.

12. XM — Transmitter was enabled but failed to come on, the XMTR position was not selected by the RIO, or no RF was detected.

41.9.6 Special Test 31. Special test 31 performs a subset of sequence 3 tests to detect 80 percent of mission essential faults and nominally saves 50 seconds. ST31 identifies failed or degraded modes. No check marks are displayed. ST31 consists of the following tests:

1. Standard serial interface and power fault
2. Side and main lobe clutter frequencies
3. Transmitter dummy load and flood antenna
4. Transmitter oscillator phase lock
5. PD range rate, range, and MLC filter
6. PD detection sensitivity
7. Antenna pointing and gyro torque
8. Antenna 10° scan and receiver open shutter
9. PD target acquisition
10. PD transmitter peak power
11. ACM threshold calibrate
12. Pulse target acquisition and tracking
13. ACM target acquisition and range
14. Pulse transmitter peak power and CWI
15. Pulse and PC zero range bias calibration
16. ALQ-126 YIG filter.

The results of these tests are displaced in the usual DMA and fault isolation formats.

41.9.7 Special Test 32. Special test 32 performs a transmitter leakage test and a radar channel phase-lock test. The fault isolation display for ST32 is shown in Figure 41-25.

41.9.8 Special Tests 100 and 101. Special test 100 allows ground maintenance personnel to check for the most recent power faults and transmitter problems that may have occurred on the previous flight. During the time CM is operating, if a power fault is indicated from any unit listed below or if a transmitter fault is detected in an operate mode, the status of power faults and/or BIT transmitter operate mode are stored in sacred cells.

FAULT DETECTION

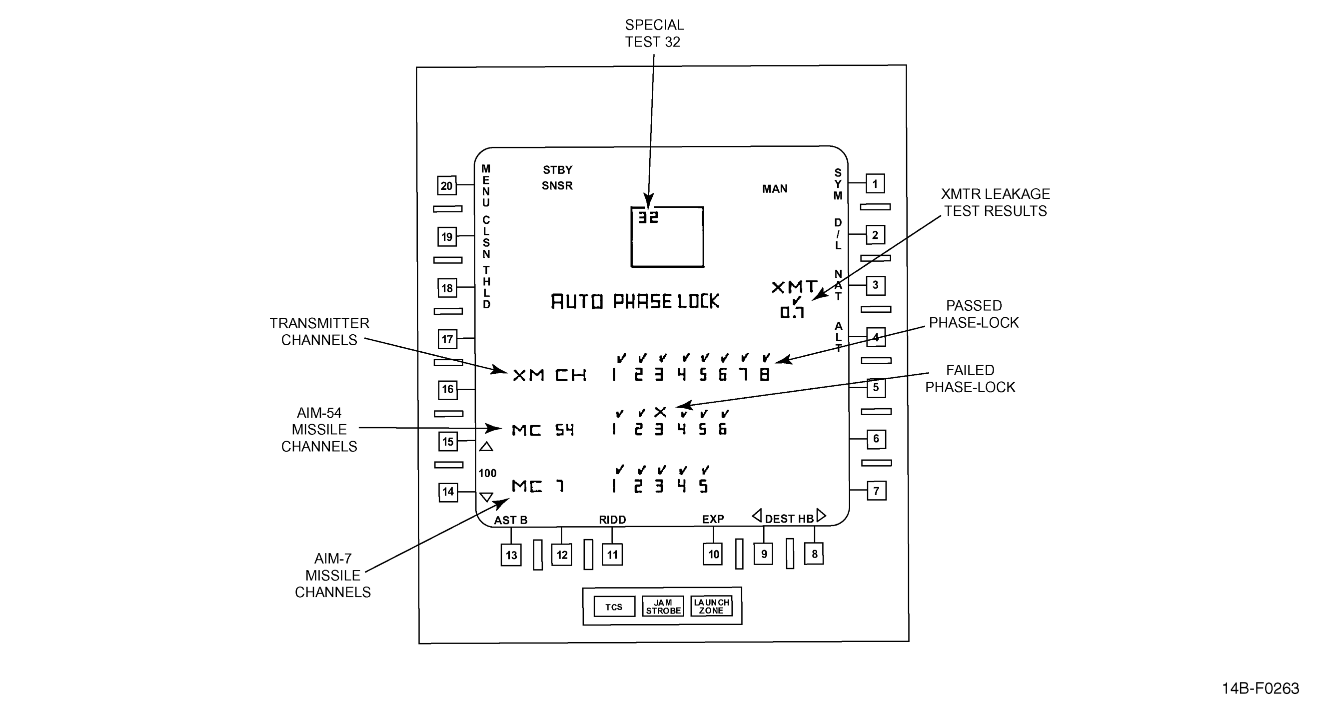


Figure 41-25. Special Test 32 Display

710/610	001	505
720/610	010	541
730/610	011	580
039	022	501
042A	31E	083
042B	081	610

When a new transmitter fault is detected, the fault is stored in the first sacred cell and any previous faults are moved to the next two sacred cells. This ensures that the three most recent transmitter faults are displayed. Special test 100 decodes the contents of those sacred cells and displays under the PF (Figure 41-26) the WRA number of the unit causing the power fault. If the conditions for a transmitter problem exist, the octal contents of location 00166 are displayed under the XM.

The three most recent transmitter faults are displayed with the most recent fault on top. The symbols WRA, PF, and XM will always be displayed with or without associated data.

Special test 101 is the same as special test 100 except the sacred cells are cleared if the aircraft is on the ground. If the sacred cells are not cleared after every flight, there is no way of knowing how long ago the data were stored.

To initiate special test 100 or 101, select BIT, then SPL TEST (NBR), then NBR followed by the digits 100 or 101, and then ENTER. Sacred cells are cleared upon entering special test 101 on the ground; displays remain until next entry.

41.10 BIT SEQUENCES

41.10.1 PTID BIT Sequence 1. The PTID first displays an internally generated PTID test pattern prior to the WCS BIT Sequence 1 display. This display incorporates a dynamic element that runs a full cycle within 15 seconds (Figure 41-27). The PTID display test pattern provides the aircrew with a visual test of the display drive components. A PRESS legend is displayed adjacent to each pushtile except for pushtile 20 which displays EXIT. Selecting or deselecting each pushtile will box and unbox the legend next to the pushtile. Selection of the EXIT pushtile returns to the WCS BIT sequence 1 test pattern. Upgrade Tapes 317A and 320A do not display the OFS ID on the WCS BIT

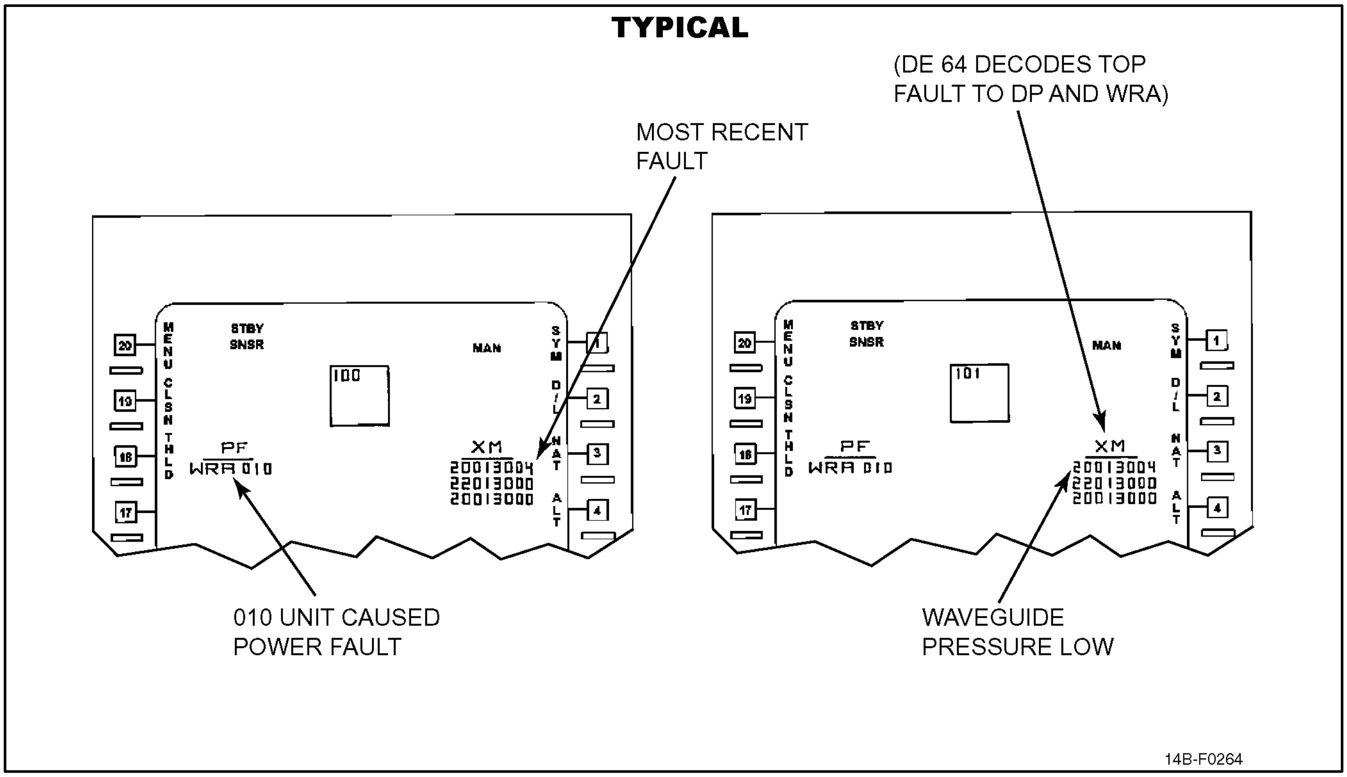


Figure 41-26. Special Test 100 and 101 Displays

1 page. This information is now displayed on the PTID OFS page.

41.10.2 Sequence 1 Display Tests. The display tests present the RIO with standard test patterns on the PTID and DDD for evaluation. Sequence 1 is initiated by selecting BIT with the CATEGORY switch and depressing the DISPL 1 pushbutton on the CAP. The display tests are divided into three tests: direct, static, and dynamic. Holding the DISPL 1 pushbutton in results in the direct display test, which consists of a 45° diagonal line across the PTID screen and a display of decreasing shades of intensity of the DDD video (DDD screen) (Figure 41-28, Sheets 1 and 2). Release of the DISPL 1 pushbutton initiates the static display test. The normal sequence 1 displays are obtained with the PTID MODE pushtile set to GND STAB or A/C STAB. At the same time, the DDD displays a two-bar, ±40°, scan pattern. In addition, the following lights on the DDD, PTID, CAP, and hand control are illuminated.

1. DDD
   a. CCM MODES
   b. ANT TRK
   c. RDROT
   d. JAT
   e. IROT
   f. RDR
   g. All WCS MODES.
2. Hand control
   a. One of four function lights
3. PTID
   a. LAUNCH ZONE.
4. CAP
   a. ALL MESSAGE pushbuttons (10).

Eight range-rate video targets are also displayed on the DDD as equally spaced horizontal lines. If the MASTER ARM switch is in TNG, the in-flight training target video appears two-thirds of the way down from the center of the DDD, aligned horizontally with the zero closing rate, each mark on the right side of the DDD.

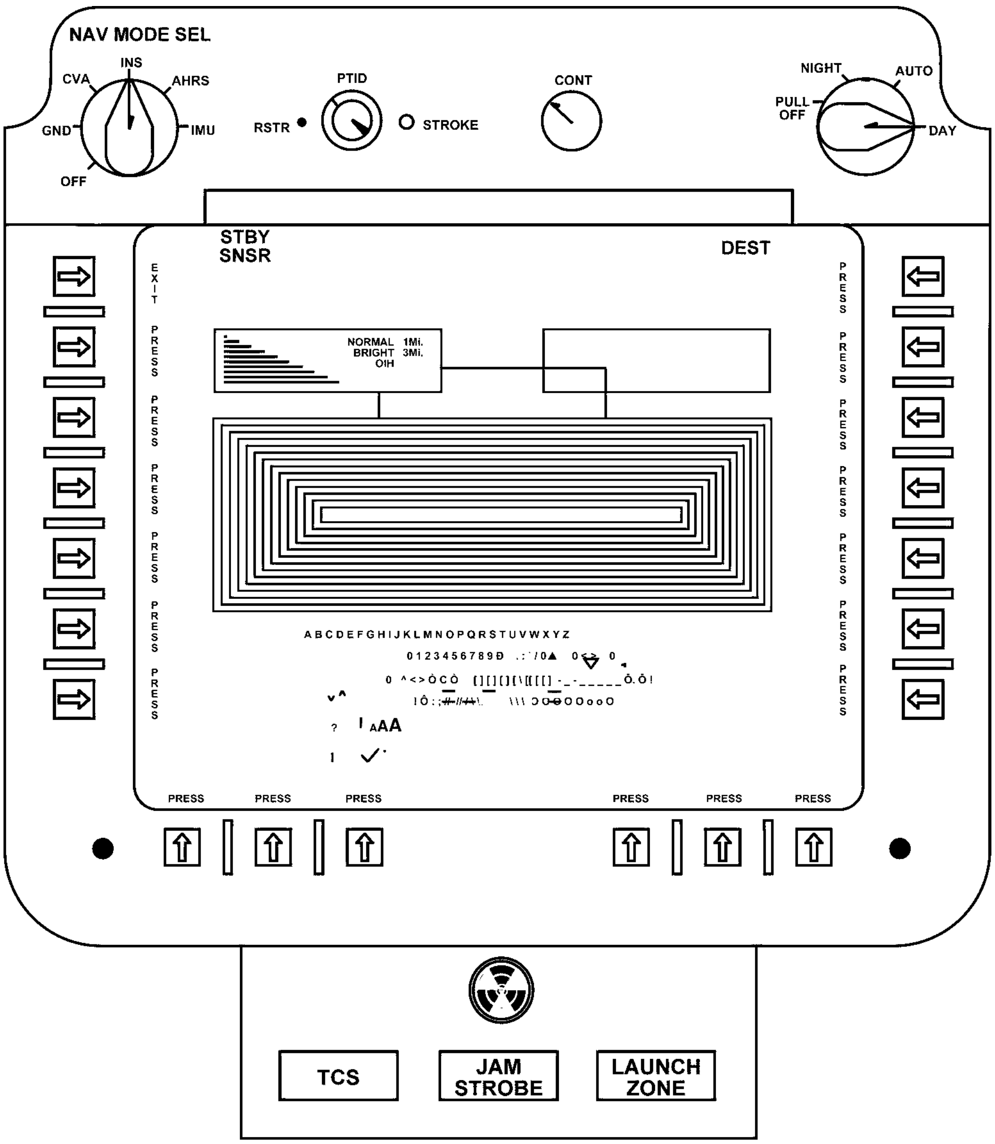


Figure 41-27. PTID BIT Sequence 1 Page

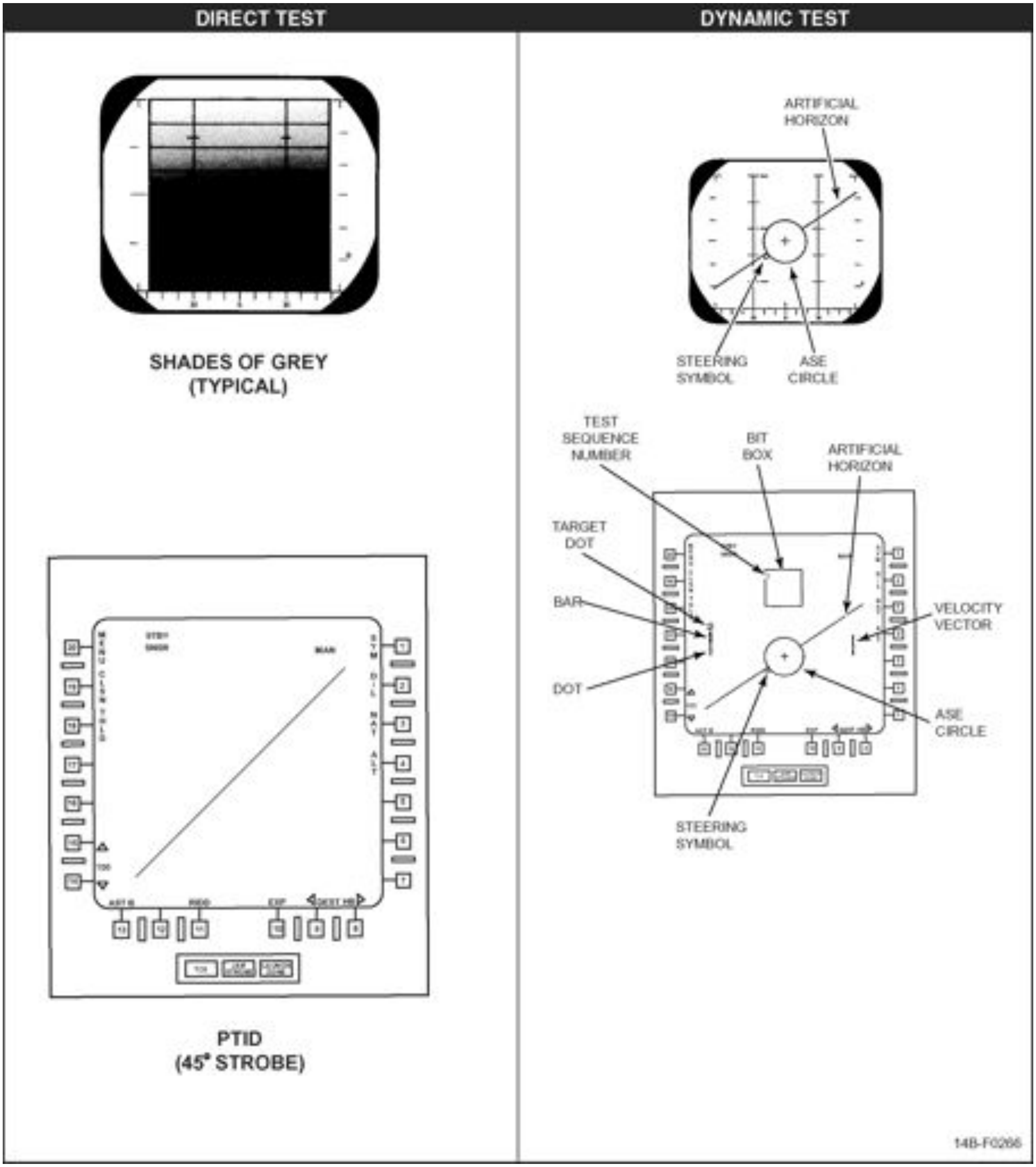


Figure 41-28. Sequence 1 Displays (Sheet 1 of 2)

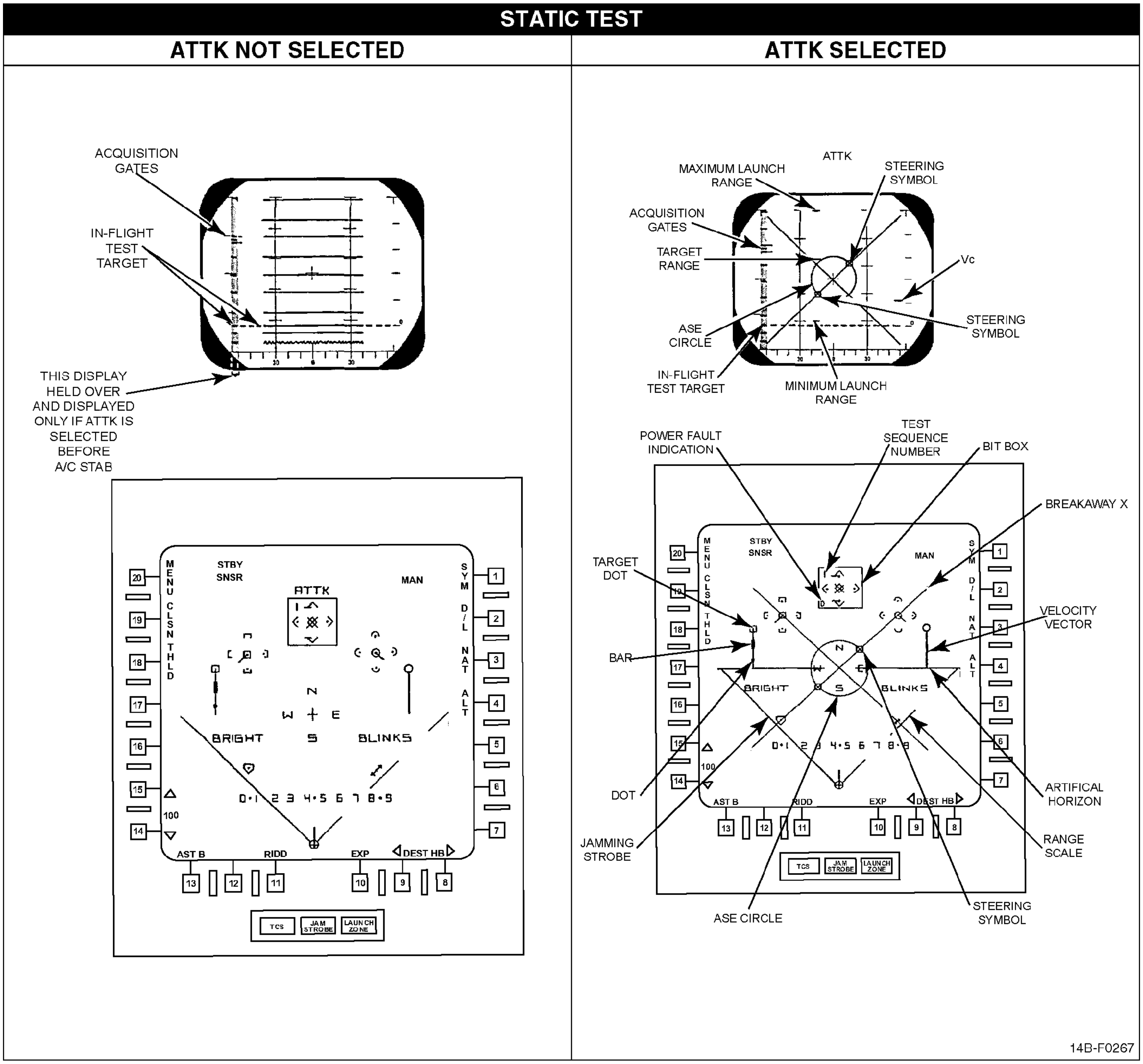


Figure 41-28. Sequence 1 Displays (Sheet 2)

When ATTK is selected with pushbutton 13 on the PTID, the only lights that illuminate are the PDSTT and RDR pushbuttons. The range readout drum (window) indicates 5 nm. The two-bar, ±40° scan pattern is replaced by a 0° B-scan positioned in azimuth by the AZ CTR control on the sensor control panel. The B-scan shows the minimum launch range marker (R_{min}) at 1 nm, the target range at 3 nm, and the maximum launch range (R_{max}) marker at 5 nm. The closing velocity symbol (V_c) is positioned at approximately +220 knots. The eight range-rate video targets are displayed at the left side of the DDD. The acquisition gates are over the target one-third of the way from the top.

These test patterns should be examined by the RIO for the absence of any symbols, for symbol intensity, and for symbol position. During the running of the static test, the RIO should also select HALF ACTION or FULL ACTION on the hand control. Then, moving the hand control, the RIO should ensure that the PTID CURSOR can be moved throughout the range of the

PTID. Upon release of the ACTION switch, the cursor symbols should return to the original position.

The static portion of the displays test indicates that the computer does or does not have the capability of displaying each of the indicated symbols. It is, therefore, more than a display test because it also tests the computer's ability to generate the symbols it would need in a tactical situation. It should also be pointed out that the computer assists the RIO in the static portion of the displays test by monitoring power failures that may have occurred in the controls and displays.

The presence of a power failure is indicated by the acronym "D" (indicating a discrepancy) in the BIT box. If the RIO wishes to know which control and display subunits have suffered a power failure, he depresses the FAULT DISPL pushbutton. This will cause the computer to display the numbers of the WRA that suffered a power failure.

The dynamic test consists of a visual evaluation of the movement of the artificial horizon, allowable steering error circle, steering symbol, launch zone symbols, and the velocity vectors. To enter the dynamic test, the RIO selects CLEAR, NBR, 1, 1, ENTER and selects ATTK using pushbutton 13 of the PTID. Throughout the dynamic test, the displays on the PTID and DDD go through the following movements at a rate of one step per second.

41.10.2.1 DDD. On the DDD, the following occurs simultaneously:

1. The artificial horizon moves in pitch from zero to +15°, +30°, +45°, 0°, –15°, –30°, –45°, and back to 00.

2. The artificial horizon steps in roll from 0° to 15° right wing down, 30°, 45°, back to 0°, 15° left wing down, 30°, 45°, and back to 0°.

3. The ASE circle steps from 0.8 inch in diameter to 0.1, 0.3, 0.56, then back to 0.8.

4. The steering symbol steps around the ASE circle in a clockwise direction in steps from its position in the upper right quadrant to the lower right, lower left, upper left, and back to the upper right quadrant.

41.10.2.2 PTID. On the PTID, the following occur simultaneously:

1. The bar marker steps from 1.5 inches above the artificial horizon to 1.0, 0.5, 0, and back to 1.5 inches.

2. The dot marker steps from above the artificial horizon to 0.5, 1.0, 1.5 inches, and back to the artificial horizon.

3. The artificial horizon, ASE, and steering symbol move on the PTID at the same rate as on the DDD.

4. The ASE circle steps from 2-inch diameter to 0.2, 0.8, 1.4, back to 2-inches diameter.

Note

The events occurring during the dynamic portion of the test are repeated until the flight officer selects and other BIT sequence test or until he rotates the CATEGORY switch to a new position.

41.10.3 Sequence 2 Computer Test. The check of the digital computer includes the basic elements of the computer subsystem and the interface to other subsystems. Four WRAs are checked in sequence 2: the computer power supply storer (WRA 462), the computer interface unit (WRA 461), and the computer itself (WRA 451 and 452). The computer power supply is not specifically tested by the sequence because, if the unit were faulty, the sequence could not have been initiated. The computer test is performed automatically after the WCS switch has been set to STBY or XMT or can be initiated manually by selecting BIT with the CATEGORY switch and depressing the CMPTR 2 pushbutton. Sequence 2 displays are shown in Figure 41-29.

The automatic sequence 2 normally requires about 25 seconds to run; however, because of a possible delay in tape read-in, the test might still be in progress when the displays have been timed in. In this case, the BIT box will appear on the PTID with a flashing 2 in the upper left corner until completion of the sequence 2 test. When sequence 2 testing concludes and the system shows a pass, the symbol S2 with a check mark over it appears on the left side just above center on the PTID. This symbol remains displayed for approximately 15 seconds, after which the system switches to a tactical display. If alignment or OBC is selected, the PTID will switch to the appropriate display. If the test fails, the

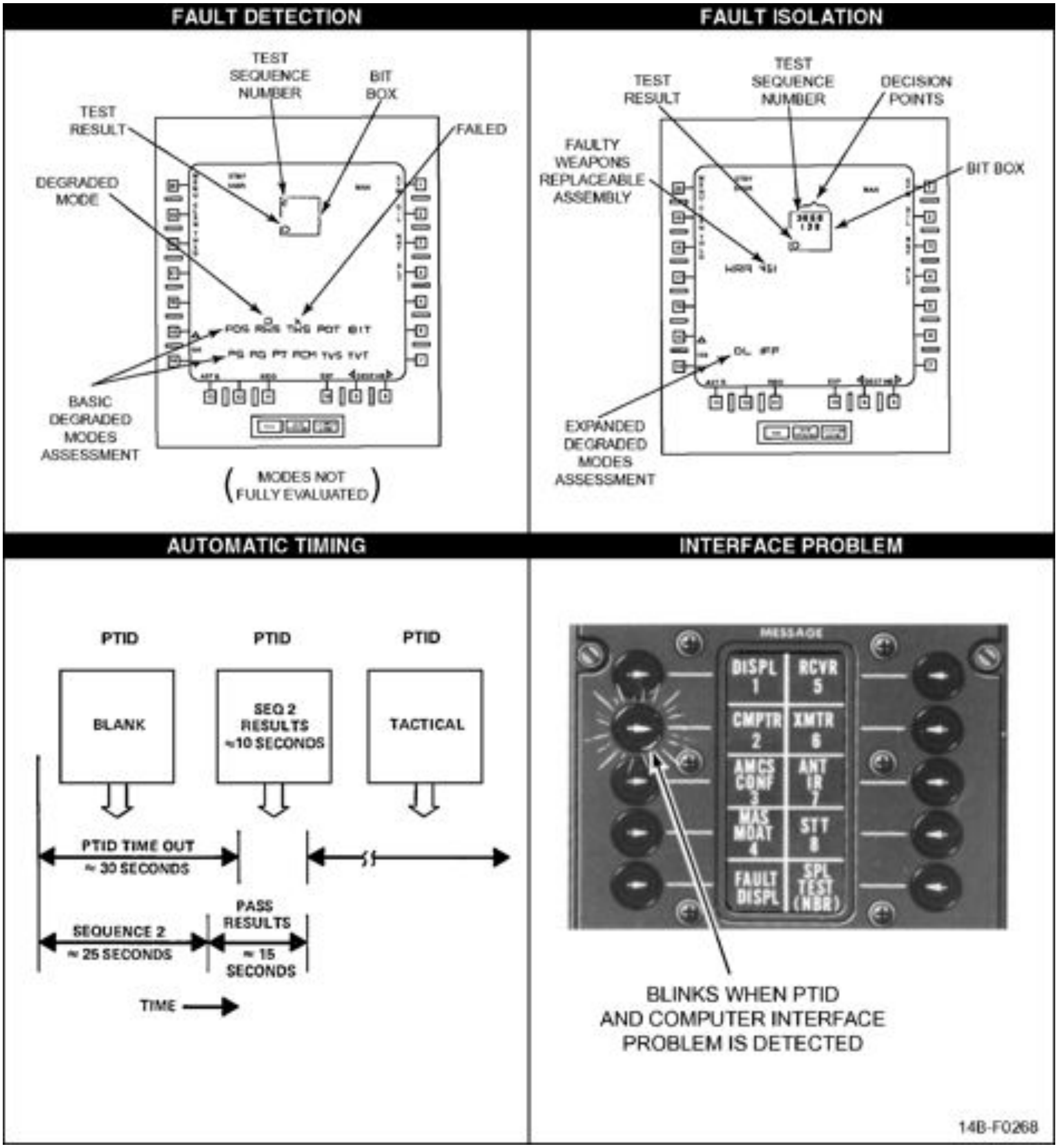


Figure 41-29. Sequence 2 Displays

fault-isolation display is automatically displayed and held until the RIO depresses the PRGM RESTRT pushbutton on the computer address panel. After auto sequence 2 has run and passed, the RIO can continue running BIT. If sequence 2 failed, however, the results of the other tests are likely to be invalid.

During an auto sequence 2 if only the M or B is displayed (prior to BIT box), depressing any CAP function switch in any CAP category will result in a skipped auto sequence 2. This will be indicated by an X displayed over S2 in the SAT mode. A power down for greater than 6 seconds and then reselecting standby is required to reinstate auto sequence 2. If power up sequence 2 passes and the system is running automatic OBC, a check will be displayed over S2 for approximately 15 seconds, then the program will return to tactical. If sequence 2 CAP function switch is depressed during this 15 seconds, an additional auto sequence 2 will be performed.

After reading in the program, sequence 2 (manually initiated) is executed and a flashing 2 appears in the upper left corner of the BIT box. During the first routine when performing the central processor test, the mode shown on the DDD is pulse Doppler search (PD SRCH pushbutton is illuminated, RDR DISPLAY pushbutton is illuminated, and PD is indicated on the mode readout window). The antenna scan pattern indicated on the DDD and EL meter is a two-bar, ±40°, as established by the BIT executive program (081 indication only). The antenna remains off during the test.

At the completion of the central processor test, the mode readout window indicates XXX. (RDR DISPLAY and PD SRCH mode remain illuminated.) The next four routines contain the interface unit tests and evaluation of the test results. Routine changes may be verified by watching the display of an M or B in the lower left quadrant of the PTID. Each time an M or a B appears during sequence 2, a new routine is being read in from the magnetic tape memory.

Completion of the sequence is indicated when the number 2 stops flashing. A pass (✓) or fail (D) is displayed in the lower left corner of the BIT box. A typical fault detection display is shown in Figure 41-29. If a D appears, the decision point numbers may be displayed in the BIT box by pressing the FAULT DISPL pushbutton on the computer address panel.

At the end of sequence 2, the program determines whether the test was run during power-up or manually selected as part of BIT. If the test was run during powerup, control is returned to the tactical program (if the test passed). If the test failed, the program enters an idle loop and waits for a program restart (the test results remain displayed during the idle loop). If sequence 2 was manually selected, control is transferred to the BIT executive program and the test results displayed while the program waits for another sequence command. If the CATEGORY switch is moved to a position other than BIT after sequence 2 is initiated manually, control is taken away from the BIT executive program.

41.10.4 Automatic Sequence 2 Initialization. Automatic sequence 2 performs certain weapon system initializations that are not performed by a manual sequence 2. This initialization does the following tasks: Nominal values are stored for pulse and PC mode zero range bias, a nominal ACM threshold of 2 volts is stored, AIM-7 and AIM-54 aerodynamic launch order is established, missile active frequency IDs are cleared, and AWG-9 DMA is initialized. If automatic sequence 2 fails or is exited while in progress, the above initializations may not occur.

If sequence 3 is then performed, computed pulse and PC zero range bias will be stored in lieu of the nominal. Similarly, a computed ACM threshold based on a calibrated target will be stored. If sequence 4 is performed, AIM-7 and AIM-54 launch orders will be established and AIM-54 active frequency identifications stored as well as MOAT status by mode. Thus if sequence 3 and sequence 4 are performed following an incomplete power-up sequence 2 initialization, all the missed initialization will be compensated for except DMA initialization. Lack of DMA initialization will prevent passes from being displayed over any mode in the AWG-9 DMA display. Degraded or failed modes, however, would be identified.

Power-up sequence 2 initialization can be verified by observing the check over S2 following power-up or by observing DMA storage location 7-17530 with the flycatcher. In the right half of this location 7777 indicates initialization has been performed. If power-up sequence 2 initialization has not occurred, a WCS power-down and backup may restore the initialization.

Note

DMA assessment will be incomplete if auto sequence 2 does not run at power up.

41.10.5 Sequence 3 AWG-9 Confidence Test. During the running of sequence 3, the computer program tests all the WCS subsystems sufficiently to ensure a high confidence of operation. Some of the tests for RADAR confidence include transmitter peak power and receiver detection sensitivity during both pulse and pulse Doppler operation. Readout of each individual mode and the test results for that mode will be displayed at the bottom of the PTID. The test results will be indicated on a fault detection format (Figure 41-30) with a check (✓) indicating the mode is operative, an X indicating the mode failed the BIT check, or a square (□) indicating the mode is degraded. Additionally, based on what modes are degraded, the computer recommends which other sequences should be executed to get explicit fault isolation information.

Sequence 3 is initiated by selecting BIT with the CATEGORY switch and depressing the AMCS CONF 3 pushbutton on the computer address panel. After sequence 3 has been read into the computer from the magnetic tape memory, a flashing 3 is displayed in the BIT box while the program is being executed. An M or B is displayed throughout much of the sequence because sequence 3 consists of three routines. The program loads a routine following the execution of each preceding routine. The modes that are being evaluated for a level of confidence are displayed at the lower center of the PTID.

Figure 41-30 shows the information displayed following the completion of sequence 3.

The AIM-7 channel tested will be the AIM-7 CWI channel that the AIM-7 was prepped on. If prep was not selected, then CWI is tested on the missile channel displayed. The AIM-54 channel tested will be on the computer selected channels.

As the test progresses, values for detection sensitivity (DS), peak power (PP), and transmitter leakage (XMT) are displayed on the PTID along with the AIM-54 or AIM-7 channel being tested. At the same time, a pass, degrade, or fail assessment is made as shown in Figure 41-30. As the mode evaluations are performed, the MODE pushbuttons on the DDD illuminate according to the mode being evaluated. For each mode evaluated, the antenna scan patterns, gate positioning, and lock-ons that occur change in accordance with mode being tested and are displayed on the DDD. The sequence of the mode evaluation, with an explanation of the events taking place during the test are discussed in the following paragraphs.

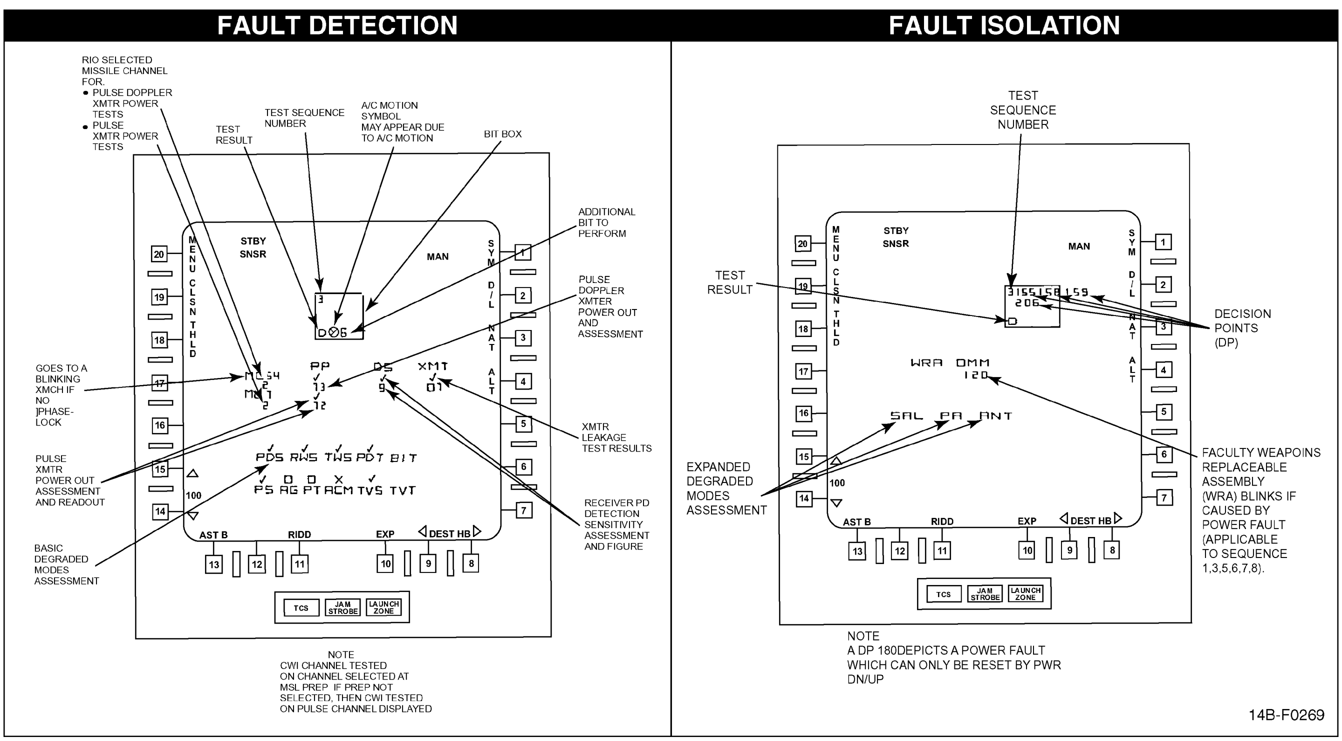


Figure 41-30. Sequence 3 Display

Note

If sequence 3 is not run following initial turn-on or y power-down sequence, a backup ACM threshold will be employed.

41.10.5.1 Pulse Doppler Search. The initial sequence 3 mode is PDS. The PD SRCH pushbutton is illuminated and PD is initiated on the mode drum. The DDD scan indication is two bar, ±40°. The antenna now moves to 0° in azimuth and elevation with a 0° B-sweep displayed while the main lobe and side lobe and modulation target levels are measured. A one-bar, ±65° scan (centered at 0° azimuth and elevation) is then commanded and displayed with JAM intensity noise displayed on the bottom of the DDD. The antenna ±65° scan tests are performed here.

41.10.5.2 Range While Search. The RWS mode is then commanded (RWS legend on the PTID, RWS mode pushbutton illuminates on the DDD, and a 0° antenna scan is displayed). Master oscillator phase-lock is checked on the semi-active channel selected by the flight officer. If this channel fails, up to four channels are tried. If phase-lock passes to an alternate search channel, XMCH and the channel number are displayed on the PTID in place of MC54. In this event, the RIO should select a different MC54 channel and rerun the test if AIM-54 missiles are loaded. AIM-54 phase-lock is required to perform sequence 4 MOAT. If no channels pass, XMCH is displayed blinking on the PTID. The DDD B-scan shows darkness in subbands 3 and 4 as the automatic gain control noise tests with the paramp are performed. Subband areas 1 and 2 then darken when the BIT JAM intensity tests are performed. Range-rate words now appear in the B-scan as many horizontal lines, while the program is testing for reception of range-rate words. Zero Doppler will appear as a lightly shaded square in the middle of the B-scan. The B-scan will then show a sweep up and down during the performance of the pulse Doppler sensitivity test in which the target aspect is switching between tail and nose aspects. (A dark sweep down indicates nose; sweep up indicates tail.) At the end of this test, the detection sensitivity is displayed under the DS acronym on the PTID.

41.10.5.3 Track-While-Scan Automatic. The antenna is positioned to 17° in azimuth and elevation. The mode indication on the DDD is TWS AUTO. The speed tracker tests are performed at this time followed by the antenna pointing tests unless the antenna hydraulics are open, in which case, the program will proceed directly to the transmitter test. The antenna gimbal angle position remains at 17°.

41.10.5.4 Track-While-Scan Manual. The antenna begins to scan in a two-bar, ±40° pattern, and the mode indications are switched to TWS MAN. JAM noise is displayed at the bottom of the DDD. The antenna two-bar scan rate, bar spacing, and frame time is tested at this time. The antenna is then switched to a four-bar, ±20° pattern and the four-bar scan rate, bar spacing, and frame time are tested. The antenna next is switched to scan in a one-bar, ±10° supersearch pattern. The supersearch scan time and scan reversal time is verified. The antenna is then commanded to scan 0° and the receiver shutter is checked to verify that it opened with the check of each operating channel for RF interference (SNIFF) command.

41.10.5.5 Pulse Doppler Single-Target Track. The mode is switched to PDSTT (PDSTT push button illuminated and PD indicated on the mode drum). The antenna attempts to track the horn target at an elevation angle of –5.2° centered at 0° azimuth. The DDD video shows a B-scan-type display with the range-rate gates positioning and then searching repeatedly as the BIT horn target is turned on and off. After antenna on target is true, the horn target remains on and the speed tracker is positioned and the gyros caged. The program then samples for fast frequency on target and delayed velocity on target. If FFOT is true, the ANT TRK indicator illuminates and if DVOT is true, the radar on target (RDROT) indicator illuminates. Both DDD indicators should illuminate to indicate lock-on. The antenna gyros are then uncaged and the velocity tracker and range-rate gate commands are disabled. A test to verify that the antenna does not drift more than 3° within 3 seconds is performed (RDROT and ANT TRK lights will go out).

41.10.5.6 Transmitter Test. The mode indications during the transmitter test remain as PDSTT indications and the antenna azimuth scan pattern 0°. The speed tracker voltage controlled oscillator frequency is set to a predetermined Doppler frequency, at which time a darkening of the B-sweep occurs and BIT LOG DC is measured. The transmitter then turns on and a momentary darkening at zero Doppler can be observed. The transmitter central line power at one-third, one-half, and two-thirds duty with transmitter peak power for one-third duty is determined. If the mode immediately changes to pulse search and a flash is observed on the DDD, the antenna hydraulics are open.

The PDSTT test was bypassed, and the sequence has proceeded to the CWI, low-PRF, and pulse compression tests.

41.10.5.7 Receiver Unblanking Test. The receiver unblanking test checks for degraded receiver blanking. The receiver blanking, which is controlled by the synchronizer, cuts off the return signal path between the antenna and the receiver to prevent damage to the receiver or interference with signal processing when the transmitter is being pulsed. If the blanking is degraded, DP 139 will be displayed in the BIT box and a DMA degrade symbol (**Y**) will be displayed over PDS, RWS, TWS, PDT, PS, AG, PT, and ACM. If one or more of the above modes has failed for another reason, a fail symbol (X) will be displayed over that mode instead of the degrade symbol.

41.10.5.8 Pulse Single-Target Track. The antenna is commanded to scan in one-bar, ±10° and the BIT low-PRF polar error is measured. The horn target is enabled, and the antenna is positioned to –5.2° in elevation and 0° azimuth. The program then monitors for low-PRF antenna on target for 1 second, maximum. When LAOT is true, radar full action is commanded and the antenna gyros are caged. When range on target (ROT) goes true, the RDROT indicator illuminates and the gyros are uncaged for 2 seconds to verify that the antenna does not drift more than 2°. RDROT goes off and when delayed range on target goes true, the ANT TRK indicator illuminates. The target along with the range gates appears at the top of the DDD. The RDROT and ANT TRK indicators then go out and a one-bar, 0° scan is commanded. The azimuth scan center shifts to about 0° left on the DDD and the elevation meter scan 35° up and then back down. During this time period, the program performs a dogfight-mode lock-on, but there is no external indication that it has occurred. The DDD now will go blank. PSTT, pulse, and pulse compression tests are performed on the MC7 channel selected. If this channel does not phase-lock, these sections are bypassed and DP 140 will be displayed.

41.10.5.9 CWI, Low-PRF and Pulse Compression Test. The mode switches to pulse search (PULSE legend on the PTID and PULSE SRCH pushbutton illuminates on the DDD). A flash on the DDD is observed when CWI is enabled. Gates are then seen at the bottom of the B-sweep, indicating that the low-PRF tests are being performed. The test then proceeds to measure the pulse compression peak power and ratio. The CWI channel tested in sequence 3 will be the one that the AIM-7 missiles tune to after PREP if the PREP switch was turned on.

41.10.5.10 TCS Interface and Slaving. TCS BIT consists of four major functions: TCS switch operations, slaving operations, search pattern verification, and TCS rate accuracy. The TCS switch operations portion of BIT checks the IR/TV, SLAVE, ACQ (AUTO SRCH), and field-of-view switch functions. The slaving operations test checks the TCS pointing accuracy for TCS slaved to radar and radar slaved to TCS. The TCS rate accuracy test checks the slewing rate of the TCS seekerhead with the RIO moving the hand control to a fixed position. The DMA will assess TCS search (TVS) but not TCS track (TVT).

During the TCS portion of BIT sequence 3, switch action prompts will be displayed on the PTID (Figure 41-31). The RIO has 15 seconds to respond to proper switch action to satisfy that test. If the switch is faulty or the response is not made, the prompt will stay on for 15 seconds and parts of the TCS BIT will be bypassed.

Note

- The TCS portion of BIT sequence 3 will not be performed unless TCS is installed and the IR/TV power switch is in IR/TV.
- Switch action prompt will not be displayed if that switch setting or action has previously been met.
- With weight on wheels, all modes will indicate failures in DMA and no peak power will be displayed if the ground cooling switch is in the CABIN/OBC position.
- If BIT sequence 3 is performed on a cold system, a few 039 WRA may fail the MLC and SLC translation tests. This results in any or all of the following DP: Nos. 4, 5, 6, 7, 8, and 9. Therefore, to preclude unnecessary maintenance, the tests should be rerun 5 minutes after system turn-on.

BIT SEQ 3 PROMPT DISPLAY ON PTID	RIO RESPONSE	
	UNIT	ACTION
IRTV HC	Hand control unit	Depress IR/TV pushtile
MAN ACQ	Sensor control panel	Select MAN on ACQ switch
TVSL	Sensor control panel	Select TCS on SLAVE switch
RTS	Hand control unit	Select half action and release
WIDE FOV	Sensor control panel	Select WIDE on FOV switch
AUTO SRCH	Sensor control panel	Select AUTO SRCH on ACQ switch
INDEP	Sensor control panel	Select INDEP on SLAVE switch
RSTV	Sensor control panel	Select RDR on SLAVE switch
HC FWD RT	Hand control unit	Position hand control to upper right comer
HC FWD RT WITH HA	Hand control unit	Select half action for at least 0.5 seconds while maintaining HCU in upper right corner

Figure 41-31. TCS BIT Switch Actions

41.10.6 Sequence 4 Missile Auxiliaries Subsystem (MAS) and Missile on Aircraft Test (MOAT)

41.10.6.1 MAS. Sequence 4 (Figure 41-32) is initiated by selecting BIT with the CATEGORY switch and depressing the MAS MOAT 4 pushbutton on the computer address panel. After sequence 4 has been read in from the MTM, a flashing 4 is displayed in the BIT box while the program is running.

Note

If sequence 4 is run with the MASTER ARM switch in TNG, DP 090 and TNG will be displayed.

41.10.6.1.1 Functions Tested Include

1. MAS BIT missile signal data converter
2. Missile logic timing controller
3. Missile power supply fault indicator
4. SSI loop between the MAS and computer subsystems.
5. MAS-MOAT digital test report lines
6. Irreversible safe signal
7. Active-frequency ID
8. Launch-initiate flag output
9. Miscellaneous AIM-54, AIM-7, and AIM-9 missile parameters, true airspeed, and range at launch
10. English bias pitch and yaw outputs
11. AIM-7 video injection signal output
12. AIM-54 parameters
13. Missile seekerhead positioning
14. Sequence programmer launch cycle
15. Missile separated flag
16. Launch-cycle output enable
17. SEAM test for Sidewinder missile
18. Roll and pitch initial conditions
19. AIM-7 sweep control.

The AIM-7 firing order is resequenced after MAS BIT is run so that passes are selected first. Failures are placed at the end of the firing order in sequence.

The test circuits use by MAS BIT are cleared at the end of the test, the sequence number stops blinking, and fault-detection test results are displayed on the PTID. A MAS BIT pass-fail indication and missile-type failures, if they occur, are displayed in the BIT box. Control will remain in the MAS BIT program until MOAT prerequisites have been met, BIT deselection or dogfight selections return control to tactical or a function pushbutton other than FAULT DISPL pushbutton is selected and depressed. After the test is completed, the program will idle in a monitoring loop if the WCS switch is in STBY, or the MSL PREP switch is OFF. Setting the WCS switch to XMIT and the MSL PREP switch to ON would cause a MOAT read-in from magnetic tape.

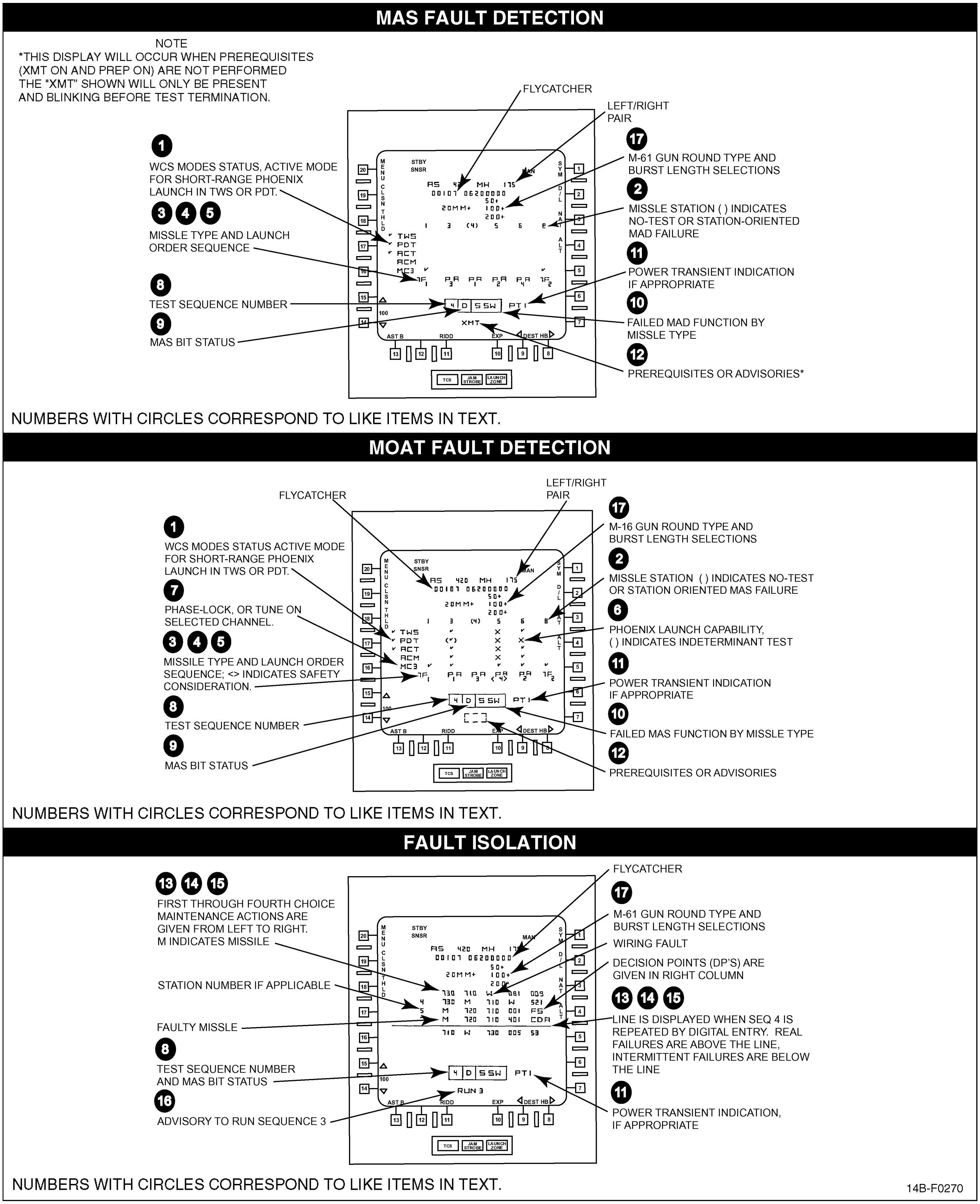


Figure 41-32. BIT Sequence 4 Displays

WARNING

When BIT sequence 4 detects the irreversible missile launch sequence is unsafe to test, the BIT box will flash. This indicates a failure in the WRA 720 sequence programmer that controls all missile timing and other information required by the AIM-7 during the launch sequence. With MSL PREP selected and a blinking BIT box, the WRA 720 can initiate. On the deck with a missile station selected, low probability exists for missile ejection or rocket motor ignition because of multiple aircraft interlocks. It is possible to activate the missile battery that will overvoltage the missile gyros causing an AIM-7 misfire condition. This could overheat the missile gyros and create a danger of fire. Airborne, with a missile station selected, a greater probability exists for missile ejection and/or activation of the missile battery. On deck or airborne, deselect MSL PREP and do not rerun BIT sequence 4. Continue the mission only if operational necessity dictates.

41.10.6.2 MOAT. MOAT functions tested are prelaunch phase-lock and velocity slaving, rear receiver and command decoder, transmitter PA output, velocity update-search-acquisition, velocity track, active and ACM mode logic, angle track, and autopilot.

The AIM-54C MOAT is functionally different from the AIM-54A MOAT, and neither missile will pass a MOAT intended for the other. The WCS will automatically run the MOAT that matches the type of AIM-54 identified in the identification test on each station. The MOAT display does not indicate to the RIO whether the MOAT run was an AIM-54C or an AIM-54A, but, if the identification test incorrectly identifies the missile type, the wrong MOAT will run and result in erroneous failure indications.

41.10.6.2.1 Sequence 4 Fault Detection and Fault Isolation Display Features

1. To validate the tests to be run in MOAT, certain tests are run to assure that all related WCS functions are proper. This is referred to as “MOAT readiness.”
2. To reduce MOAT failures caused by aircraft motion, adaptive thresholds are used for certain tests. These thresholds are increased progressively up to certain limits to allow greater test tolerance when aircraft motion is a factor.
3. Statistical data reduction technique is used in that failures formerly caused by external disturbances, or noise are identified.
4. The lift accelerometer itself is checked to eliminate it as a cause of MOAT failures.
5. Missile phase-lock is checked on all six missile channels, and the results stored in memory. At launch time, any missiles that failed phase-lock on the channel selected are put last in the launch selection order.
6. Also, the RIO can check which missiles failed which channel and the corresponding launch order sequence by dialing the channels with the thumbwheel at the end of MOAT.
7. AIM-7 missiles are checked for missile tuning on the channel selected at the time of the MOAT and the results displayed.
8. Certain missile messages are sent a second time to reduce missed message failures.
9. MAS seeker-pointing commands and transmitter-on commands are monitored to separate these from actual missile failures.
10. Test results will be analyzed by comparing the pattern of failures (former DPs) with data stored in the program. This will enable the display of failures by function, WCS modes, station, missile type, and MAS function.
11. MAS test and MOAT readiness results are included in the analysis to allow separation of missile failures from WCS failures.
12. When MOAT is rerun by digital entry, the results of the previous tests are saved and used to separate intermittent failures from hard failures.
13. The BIT box and test advisories have been moved to the lower half of the PTID.
14. MOAT results are displayed by overall WCS mode capability, missile launch capability, WCS mode, missile type, station phase-lock by channel (AIM-54), missile tune by station (AIM-7), MAS status, and launch sequence.
15. In the fault isolation display, MAS results are displayed in the form of prioritized maintenance

actions and DPs. MOAT results are displayed below the MAS display by station number, prioritized WRAs, an M signifying missile fault or W for wiring fault, and an acronym indicating the fault type. When applicable, an advisory is displayed at the bottom of the display recommending another BIT to run for additional data.

41.10.6.3 BIT Sequence 4 Displays. The following item numbers relate to the appropriate number on the MOAT illustrations (Figure 41-32):

1. WCS mode status

   a. Display data — Three-state status for three WCS MODES displayed. Status displayed:

      (1) ✓ = Pass

      (2) X = Fail

      (3) (Blank) = Unevaluated.

Note

The ACM mode applies to AIM-54 missiles only and not to the AWG-9 ACM mode. AWG-9 mode status is not indicated.

2. Missile Type.

   a. Displays.

      (1) Station number for weapon stations having a missile ID. Maximum stations displayed = 6. Station numbers for maximum load are 1, 3, 4, 5, 6, and 8. Station number will blink during missile test (MOAT).

      (2) MAS station fail indicated by parentheses enclosing station ID number.

      (3) MOAT no-test indicated by parentheses enclosing station ID in the same manner as a MAS station failure.

      (4) Excessive aircraft motion beyond the capability of the adaptive threshold is indicated by motion symbol displayed above the station number.

      (5) Excessive noise that is sensed by the program and precludes successful test evaluation is indicated by an external disturbance symbol above the station number.

3. Missile type

   a. Display data.

      (1) One missile type symbol for each station with a missile ID (maximum of 6).

      (2) The required symbols are:

PA	=	AIM-54A
PC	=	AIM-54C
S	=	Sparrow (PREP OFF)
7F	=	Sparrow 7F ID
7M	=	Sparrow 7M ID
7H	=	Sparrow 7M (H-build) ID.

Note

- If Phoenix missile is misidentified, hooking the station will change PA to PC. Sequence 4 MOAT should then be rerun to properly test missile.
- Enter — 7H or F IDs by hooking the appropriate station number with the PTID cursor. The missile type display will change from 7M to 7H, to 7F, then back to 7M. Rehooking the station will restore the 7F ID.

4. Launch priority

   a. Display data.

      (1) Subscript numbers for each missile ID to indicate computer-selected launch sequence for Phoenix and Sparrow missiles on board.

      (2) Brackets enclosing a Phoenix missile ID and launch number (for example, [P_1]) indicate that missile power cannot be deselected on that station. The launch priority will be number 1, and higher number stations loaded with Phoenix missiles will indicate no test (i.e., parentheses enclosing station numbers). The condition of latched missile power prohibits selection and, thus, testing of other stations; however, a missile on a station indicating latched power may be successfully prepared and launched.

CAUTION

If a MOAT latch condition exists [P1], do not attempt to rerun MOAT as equipment damage may occur.

5. Launch safety

   a. Display data — A missile that may not be safe to launch will be indicated by enclosing the missile ID (including launch number) with carats (< >).

WARNING

- Launching a missile with an indicated launch safety hazard (carats) could cause the missile to hit the aircraft.
- Certain MOAT station failures that indicate a possible launch safety hazard will not be identified with carats. FAULT DISPL must be selected to display these failures with the following acronyms.

   (1) ISU — Inertial sensor assembly failed (AIM-54C only)

   (2) DEU — Digital electronics unit failed (AIM-54C only)

   (3) APT — Autopilot timer failed

   (4) FS — Flipper servo failed

   (5) AP — Autopilot failed electronic servo control amplifier (ESCA) (AIM-54C only)

   (6) HG — Horizontal vertical G bias failed

   (7) APL — Autopilot lateral failed (AIM-54A only)

   (8) APR — Autopilot roll failed (AIM-54A only)

   (9) (FAULT DISP) GMP — General MSL processor (DEW) (AIM-54C).

6. Phoenix launch capability

   a. Display data — Missile mode status of four missile modes up to six stations. Status of modes displayed are as follows:

      (1) ✓ = Pass

      (2) X = Fail

      (3) (✓) = Indeterminate

      (4) Blank = Unevaluated.

7. Phoenix Phase Lock/Sparrow Tune

   a. Display data — Upon completion of MOAT, the RIO has the capability of checking Phoenix phase-lock on all MC54 channels by thumbing through each channel on the DDD. All Phoenix missiles will be evaluated for each channel change. The Sparrow missiles will be evaluated only on the continuous wave channel that they had tuned to if they were tuned prior to MOAT.

8. Test sequence number

   a. Display — Number 4 blinking indicates MAS BIT is in progress.

9. MAS BIT status

   a. Display — Pass or degrade symbol.

      (1) ✓ = Pass

      (2) D = Degrade (DPs).

10. Failed MAS function

   a. Display — Symbol indicates if MAS failures affect Phoenix, Sparrow, or Sidewinder functions. Symbols required are:

      (1) P = Phoenix

      (2) S = Sparrow

      (3) SW = Sidewinder.

11. Power transient interrupt indicator

   a. Display — PTI symbol is displayed whenever the power transient monitor routine detects a power transient except when display inhibit is requested by the resident program.

12. Prerequisites and advisories

a. Display.

(1) Prerequisites — The following control setting symbols are used to request operator action:

(a) XMT = AWG-9 transmitter on

(b) PREP = AIM-54 prep.

13. MAS DP/WRA display

a. Display.

(1) MAS DPs are displayed on the right-hand side of the PTID following depression of the FAULT DSPL button as indicated in Figure 41-32. Up to four maintenance choices are displayed horizontally across the PTID on line with the related DP. If more than seven failures occur, seven failures are displayed on the PTID initially. Any additional failures stored by the computer can be displayed by redepressing the FAULT DSPL button until all faults have been displayed as indicated by return to aircrew display.

(2) Any MAS DPs stored as intermittent DPs are displayed beneath a horizontal bar across the PTID as indicated in Figure 41-32. The vertical position of the horizontal bar is variable and its position determined by the number of hard DPs or MOAT failures displayed. If there are no intermittent failures, the bar will not be displayed.

14. MOAT station failures

a. Display — MOAT station-oriented failures and prioritized maintenance actions are displayed in the same manner as MAS failures in item 13 except failure acronyms are displayed in the right-hand position in lieu of DPs. Additionally, the station number of the failed station is displayed to the left of the maintenance actions. If two different missile functions fail requiring two fail acronyms, two lines of actions are displayed and the station number is repeated. Intermittent MOAT failures are indicated in the same manner as defined for intermittent MAS failures.

15. MOAT detected AWG-9 failures

a. Display — MOAT-detected AWG-9 failures are displayed in the same manner as MOAT missile failures described above except that and AWG-9 system failure number (SXX) is displayed on the right in lieu of missile failure acronyms.

16. Multiple mode gunsight options

a. Display — The MMGS options are presented in the upper center of the PTID in each of the BIT sequence 4 fault displays. The two options are:

(1)	20-mm +	=	M-61 gun round type on-board selection (M-56 or PGU).
(2)	50 + 100 + 200 +	=	Bullet at target range computation

The first option allows the RIO to select which round type is loaded in the M-61 gun. Hooking the + of the 20-mm acronym alternates the selection between the M-56 round and the new improved round for the M-61 gun bullet (PGU) round. When the 20-mm acronym is bright, the PGU round is selected; when the 20-mm acronym is normal intensity, then the M-56 round is selected.

CAUTION

It is important that the correct round type is selected since MMGS adjusts the weapons ballistics accordingly.

The second option allows the RIO to select one of the four following GCU burst length settings:

1. 50 rounds
2. 100 rounds
3. 200 rounds
4. Unlimited (burst length based on duration of trigger squeeze).

Based on the GCU setting, the burst length is selected on the PTID by hooking the + next to the appropriate number (number brightens). The previous selection is automatically deselected when a new burst length is hooked and the associated burst length number returns to its normal brightness. MMGS uses the selected burst length to determine the duration of the BATR display.

Note

- The unlimited GCU setting should be entered as the 200-round burst length option.
- PTID selection of burst length does not alter actual burst length set on the GCU.
- The bullet type and burst length selections are not cleared at power-up and are permanently maintained in the computer memory. They are initialized only when the tactical software is reloaded from the MTM because of a new fleet release tape or checksum error. The bullet type is initialized to M-56 and the burst length is initialized to 50 rounds.

41.10.6.3.1 Advisories. The following symbols are used for information only, no operator action is required:

DISPLAYED ADVISORY	WHEN DISPLAYED	CAUSE
DMLD	MOAT readiness or MOAT	Dummy load not in
XMT(1)	MOAT readiness or MOA	XMTR PP below 1.0 kw
PF(2)	MAS, MOAT readiness or MOAT	Power fault
SSI	MAS	SSI failure
TIME	MOAT readiness	PREP on but 128 seconds timer not timed out
ANALYSIS	Pattern analysis fault isolation	Test has terminated and results are being analyzed
RUN 3	Displays	Detected MOAT readiness failure needs further definition/ confirmation by sequence 3

Notes:

(1) Also a prerequisite during MOAT readiness.

(2) When test is completed, reset power and rerun sequence 4.

41.10.6.4 Digital Entries for MOAT Rerun. Digital entries for repeat of MOAT are as follows:

1. NBR-40 — Repeat sequence 4 MAS only.
2. NBR-41 — Station 1 MOAT*
3. NBR-42 — MATS/MITS
4. NBR-43 — Station 3 MOAT*
5. NBR-44 — Station 4 MOAT*
6. NBR-45 — Station 5 MOAT*
7. NBR-46 — Station 6 MOAT*
8. NBR-48 — Station 8 MOAT*
9. NBR-49 — MOAT on all stations with AIM-54A ID.

*Station with AIM-54A ID.

41.10.7 General MOAT Utilization Summary. MOAT tests the AIM-54 missile, but since all the weapons system must function correctly to test the missile, MOAT is a very good weapons system test. However, because the entire weapons system is involved, there are a number of problems other than a bad missile that can cause the weapons system to fail a MOAT.

The following guidelines are not in any particular order of importance and are not mandatory, but should be followed whenever time and/or conditions permit.

1. Radio frequency interference can cause the weapons system to fail MOAT. Separate missile channels should be assigned to each aircraft in a briefing if several aircraft are operating in the same area. A SNIFF check with the AWG-9 or the desired missile channel can be made to look for RFI.

2. There are several causes of occasional failures to pass MOAT other than real problems that usually will exist on successive MOATs such as RFI, aircraft maneuvers, or other transient events.

3. There are several modes of failures that are unique to a certain missile channel, so a missile may fail MOAT on one channel and pass on another channel.

41.10.8 Sequence 5 Receiver Test. This test sequence verifies the performance and detects and isolates faults to a WRA within the receiving subsystem. BIT sequence 5 consists of the following tests:

1. SSI test

2. Overloads/power faults
3. Main lobe and sidelobe clutter tests
4. T.O. channel lock and Doppler filter tests
5. Doppler processor test
6. Receiver gain/processing tests
7. Doppler processor/clutter processor tests
8. Channel switching test
9. Detection sensitivity test.

Note

The XMTR shall be OFF when running sequence 5 or erroneous DPs will occur.

41.10.8.1 Sequence 5 Displays. Test results are displayed on the PTID during and after the sequence (Figure 41-33). These displays indicate the full range of receiving subsystem operability from and overall pass (✓) or degrade (D) through the individual subtest (pass, degrade, or fail (X)). BIT sequence 5 is primarily intended to be a maintenance tool, but it is often used for system verification by the RIO.

41.10.8.2 Sequence 5 Initiation. Sequence 5 is initiated by selecting BIT category on the computer address panel and depressing the RCVR 5 message pushbutton. After the sequence has been read into DRO or non-write-protected memory from the MTM, a BIT box is displayed at the top of the PTID with a blinking 5 in its upper left corner.

Upon initiation of sequence 5, an M appears in the lower left corner of the PTID. The BIT box then appears after a short time delay that depends upon the point the MTM tape was situated prior to sequence 5 selection. Approximately 15 seconds after the appearance of the BIT box, the remainder of the sequence 5 PTID display appears. The selected missile channel appears under the MC 54. Throughout sequence 5, the DDD indicates PD SRCH mode and shows a vertical bar about 3/8-inch wide on the CRT. The next PTID indications are the assessment in sequence of XM CH 1 through 8, MC 54 1 through 6, and MC 7 1 through 5, followed by the PA and DS assessments and value. Finally, the overall sequence 5 assessment appears in the lower left comer of the BIT box. If the sequence 5 assessment was a pass

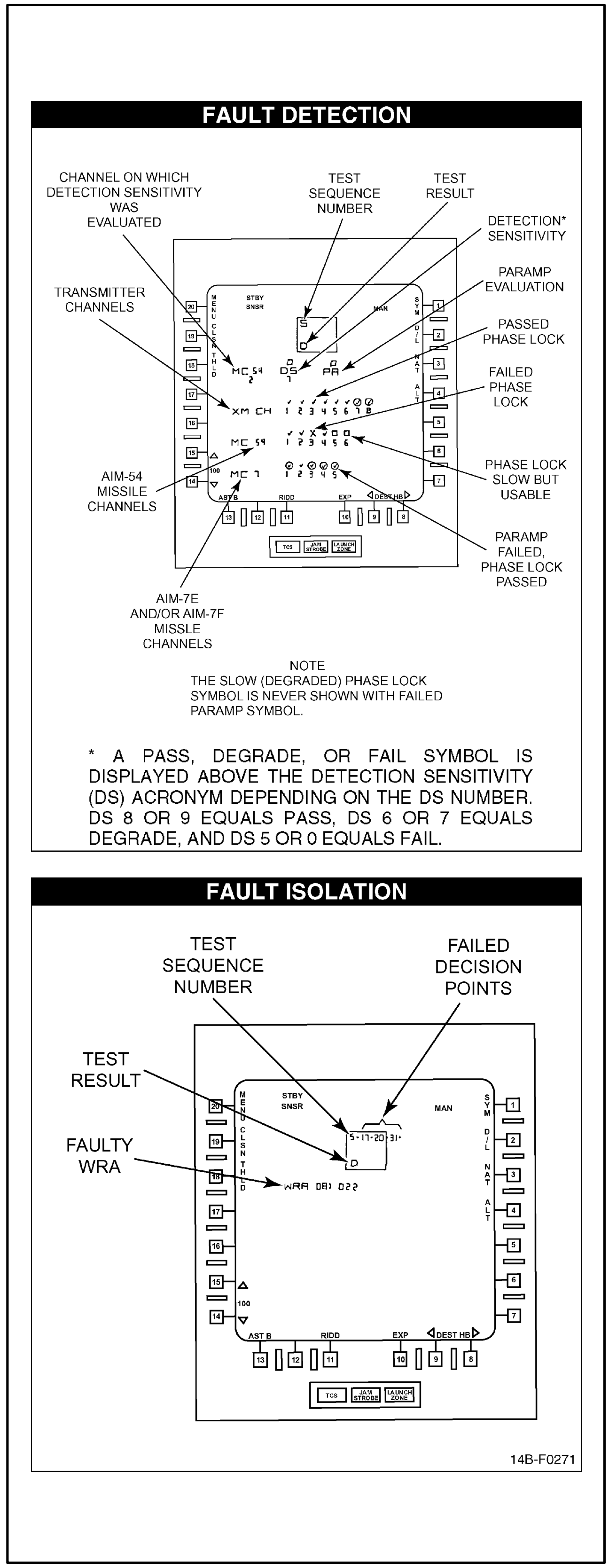


Figure 41-33. Sequence 5 Display

(✓), that test is concluded and the program remains in and idle loop waiting for operator action. If the assessment was a degrade (D), the program also enters an idle loop waiting for operator action such as depression of FAULT DISPL, digital entries, or running and other sequence. Depressing FAULT DISPL will display the DPs/WRAs involved, but will not pull the program out of the idle loop.

41.10.8.3 SSI and Overload/Power Faults Tests. Initial prerequisite testing is accomplished prior to actual receiving system tests. These tests include the SSI test and the overload/power fault test, which ensure that a set of system performance baselines have been met. If these tests are failed, the sequence is terminated.

41.10.8.4 Main-Lobe and Side-Lobe Clutter Tests. When the prerequisites are passed, the main-lobe clutter and side-lobe clutter tests are initialized. The MLC and SLC VCOs are varied across their frequency spectrum to three distinct points and measured in each of the frequency modulation ranging phases.

41.10.8.5 BIT T.O. Channel Lock and Doppler Filter Tests. When a T.O. phase-lock on a selected channel is attempted and fails, the testing jumps to the channel switching test. Next, a target aspect indication is checked. Reference levels for subbands 1 through 4 AGC are established and the false alarm rate thresholds are checked. Comparisons are then made between fast and slow AGC levels. The data processing capability is checked using range rate data. Finally, the subband amplifier gain is measured.

41.10.8.6 Doppler Processor Test. The Doppler processor test phase is conducted with a range processing test and clutter processor gain checks. The range processing test is run with FMR enabled and the SLC verified. The FMR phases jitter SLC to simulate a target in range and that range is then checked and compared. The clutter processor gain is tested with each subband filter by comparing subband AGC to a 3.2 MHz target.

41.10.8.7 Receiver Gain and Processing Tests. The receiver gain and receiver processing tests are then conducted. Unblanking in SNIFF mode is verified using an RF target. A blanking test and an inhibiting diode blanking loss test are run by varying the BIT target level by 18 dB and making comparisons. The paramp operation is then verified by varying receiver gain and series attenuation to compare target levels.

41.10.8.8 Doppler Processor and Filter Processor Tests. The subband filters are checked in TAIL aspect (subbands I through 4) and NOSE aspect (subbands 5 and 6) to respond to the SLC sweep test. At least 121 out of 128 filters in each subband must respond to a pass. AGC readings are taken and averaged to test the filter ripple.

41.10.8.9 Channel Switching. The channel switching tests are then conducted with T.O. phase-lock tests and paramp tests conducted on each channel. If the MC 54 channel and an appropriate missile channel is selected (determined by a channel decoder check) then the AGC is measured for reference. The paramp is then enabled and the AGC is compared to determine a pass or fail. The results of the paramp test on every channel are then tabulated to determined overall paramp condition. A zero or 1 channel fail equals a pass, 2 to 10 channel failures equal a degrade, and 11 or more channel failures equal a fail.

41.10.8.10 Detection Sensitivity Tests. The detection sensitivity tests are run to establish overall receiver sensitivity. If the paramp fails on the selected missile channel, it is turned off, detection sensitivity reduced by one, target level increased, and then tested. If the paramp passes on the selected missile channel, it is turned on and tested. The target sidebands are then swept through the subband in TAIL and NOSE aspects as in filter ripple test.

41.10.8.11 Sequence 5 Conclusion. There are no specific tests within sequence 5 where a failure will terminate the sequence. These failures and their respective DPs indicate a major problem and would cause several other pseudofailures and their DPs. If the sequence were allowed to continue, this would make RIO assessment and flight-line maintenance difficult. However, when one of these failures occur, it does not exclude the possibility of failures being present in untested areas of the sequence.

Upon conclusion of sequence 5, with either a pass or degrade, initiation of a digital entry 50 will repeat the sequence. Subsequent depression of the ENTER pushbutton will run the sequence again. Digital entries 51 and 52 will run portions of sequence 5 and, in doing so, will display a different presentation on the PTID. In both digital entry 51 and 52, detection sensitivity (DS) will be replaced by target level (T) and the transmitter and missile channels (XM, CH 1 through 8, MC 54 1 through 6, and MC 7 1 through 5) will be replaced by a vertical row of numbers (6 to 1) representing the subbands, and six three-digit numbers each representing the number of filters responding in each subband. Digital entry 51 repeats the paramp test on the selected channel and repeats the detection sensitivity test with FMR using slow sweep. Digital entry 52 repeats the paramp test on the selected channel and repeats the detection sensitivity test in range rate search mode with R-dot on high (FMR off) using fast sweep. DP 126 for T.O. phase-lock fail is only tested in digital entries 51 and 52, not in the normal sequence 5.

41.10.9 Sequence 6 Transmitter Test. The test sequence verifies the performance and detects and isolates faults to a WRA within the transmitter.

Sequence 6 BIT transmitter test comprises the following tests:

1. Synchronizer and PRF
2. Flood antenna switch
3. Transmitter turn-on and low-PRF peak power
4. CW illuminator power
5. High-PRF transmitter and receiver blanking test
6. Transmitter central-line power
7. Transmitter noise
8. Central-line power versus duty factor
9. Transmitter fault isolation.

41.10.9.1 Sequence 6 Displays. Analog readouts are displayed on the PTID during the test. These displays give the RIO a basic graphic indication of the condition of the transmitter. The test result displayed is transmitter peak power.

Throughout the sequence 6 test, the mode indication is pulse Doppler search (PD on mode drum and PD SRCH pushbutton illuminated). The scan pattern on the DDD is one-bar, ±0° and remains basically unchanged in appearance through the test (wavy lines vertically).

41.10.9.2 Sequence 6 Initiation. Sequence 6 is initiated by selecting BIT with the CATEGORY switch and depressing XMTR 6 pushbutton on the computer address panel. A flashing 6 in the upper left corner of the BIT box indicates that sequence 6 is running. The missile channel selected is displayed on the PTID along with the acronyms for peak power. If the transmitter is not turned on, a blinking XMT will appear above the BIT box and continue to blink for 30 seconds unless another BIT sequence is selected or the CAP CATEGORY switch is rotated out of BIT. The test remains in an idle loop while XMT is blinking. If the transmitter is turned on in time, the test will continue; if not, the test will terminate and display a degrade symbol.

41.10.9.3 Transmitter Noise Plot. After the transmitter is turned on, the test continues. The next display generated during the test is the transmitter noise plot. A –70 dB reference line is displayed. The transmitter is then slewed from 120 kHz closing to 20 kHz opening in approximately 1-kHz increments. The corresponding output voltages are measured at each point and displayed as a series of dots relative to the –70 dB reference line (Figure 41-34). The last display generated is the value of PP and its assessment.

41.10.9.4 Sequence 6 Conclusion. When the test ends, the 6 in the BIT box stops blinking and a D is displayed in the lower left corner of the BIT box if there were any DP; if not, a checkmark is displayed in the BIT box. The FAULT DISPL pushbutton may be depressed to display the failed DP along with the corresponding faulty WRA.

Once the test is completed, the RIO has the option of repeating the entire test by selecting digital entry 60. The repeat test can be performed on the same transmitter channel or any other missile channel (MC 54) selected. If desired, the RIO can repeat only the transmitter power test and the noise for one-third and one-half duty cycle by selecting digital entry 61 or 62 on the channel selected. This can be done for any transmitter channel. Digital entry 63 also allows the RIO to display the transmitter peak power on selected mode (PDS or PS) and a selected channel. It is not necessary to reinitiate the digital entry during channel or mode changes. Digital entry 64 can be used to present the decoded results of CM-indicated transmitter power faults.

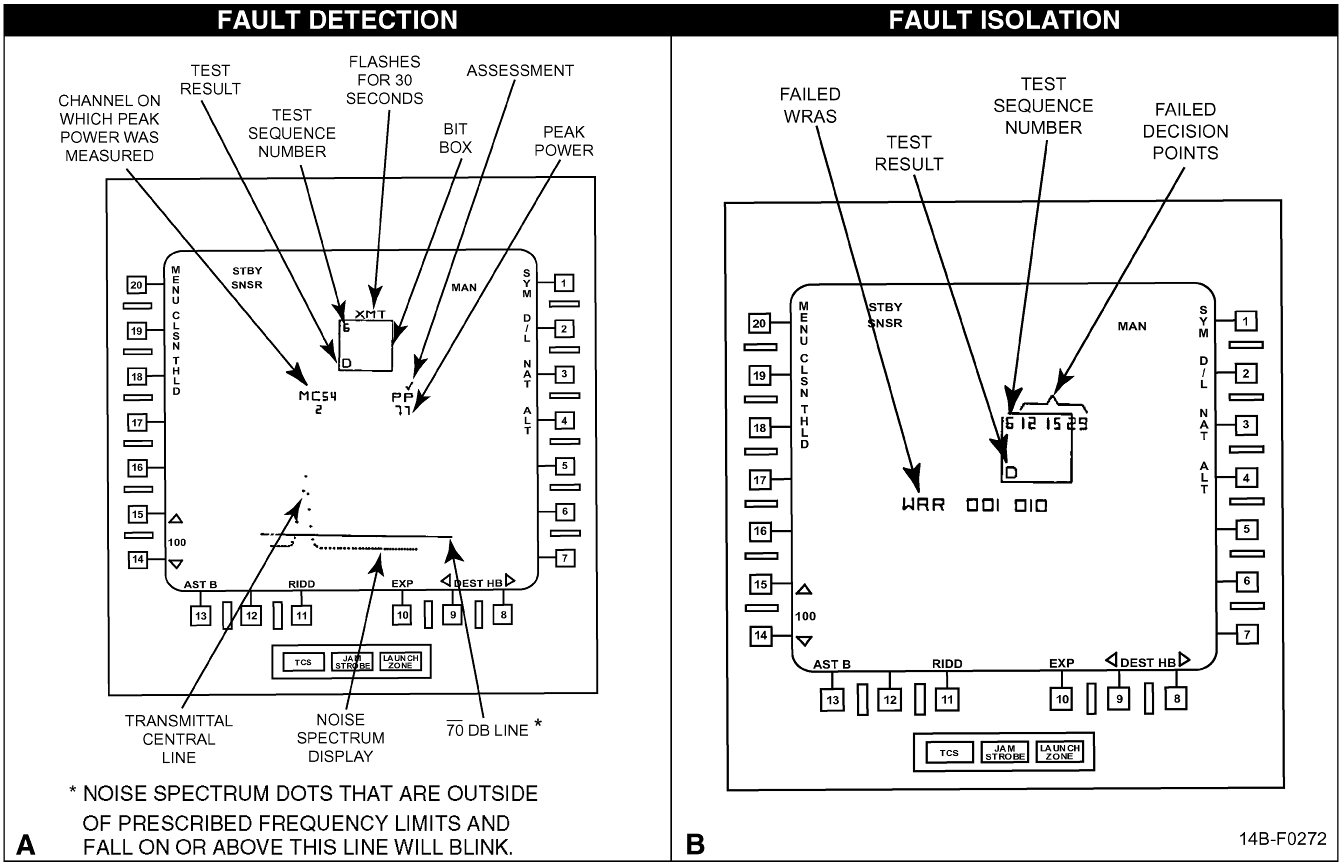


Figure 41-34. Sequence 6 Displays

41.10.10 Sequence 7 Antenna Servo Tests. Sequence 7 is programmed to test the antenna scan pattern program accuracy and response. Sequence 7 is entered by selecting BIT with CATEGORY switch and depressing the ANT IR 7 pushbutton on the CAP. After sequence 7 has been read into the computer from the MTM, a flashing 7 is displayed in the upper left corner of the BIT box. At the completion of the sequence, the 7 remains steady and the test results are displayed on the PTID (Figure 41-35).

Once the test is completed, the RIO may repeat the entire test by selecting digital entry 70. Digital entry 71 will cause the radar antenna scan pattern to be displayed on the PTID as shown in Figure 41-35. The commanded antenna elevation will appear in degrees as a digital readout on the left side of the PTID. The operator can select any combination of antenna azimuth scans and elevation bar steps and examine the resultant radar antenna scan pattern in azimuth versus elevation coordinates. The effects of elevation commands to the antenna can be observed by manually adjusting the antenna elevation control knob on the sensor control panel while the test is in progress. Also, the test can be run with stabilization in or out, as selected on the sensor control panel. Scan pattern under test should not change when selecting STAB in or STAB OUT. If it does, the CSDC platform loop is probably at fault.

Note

High aircraft roll rates sometimes cause oscillations on some signals between the CSDC(R) and the WCP. These oscillations cause the radar to drop as much as 20° on both ends of the scan. Running BIT sequence 7 will usually clear the problem.

41.10.11 Sequence 8 Single-Target Track Test. This test verifies the performance of both PSTT and PDSTT modes. Sequence 8 is initiated by selecting BIT with the CATEGORY switch and pressing the STT 8 pushbutton on the computer address panel.

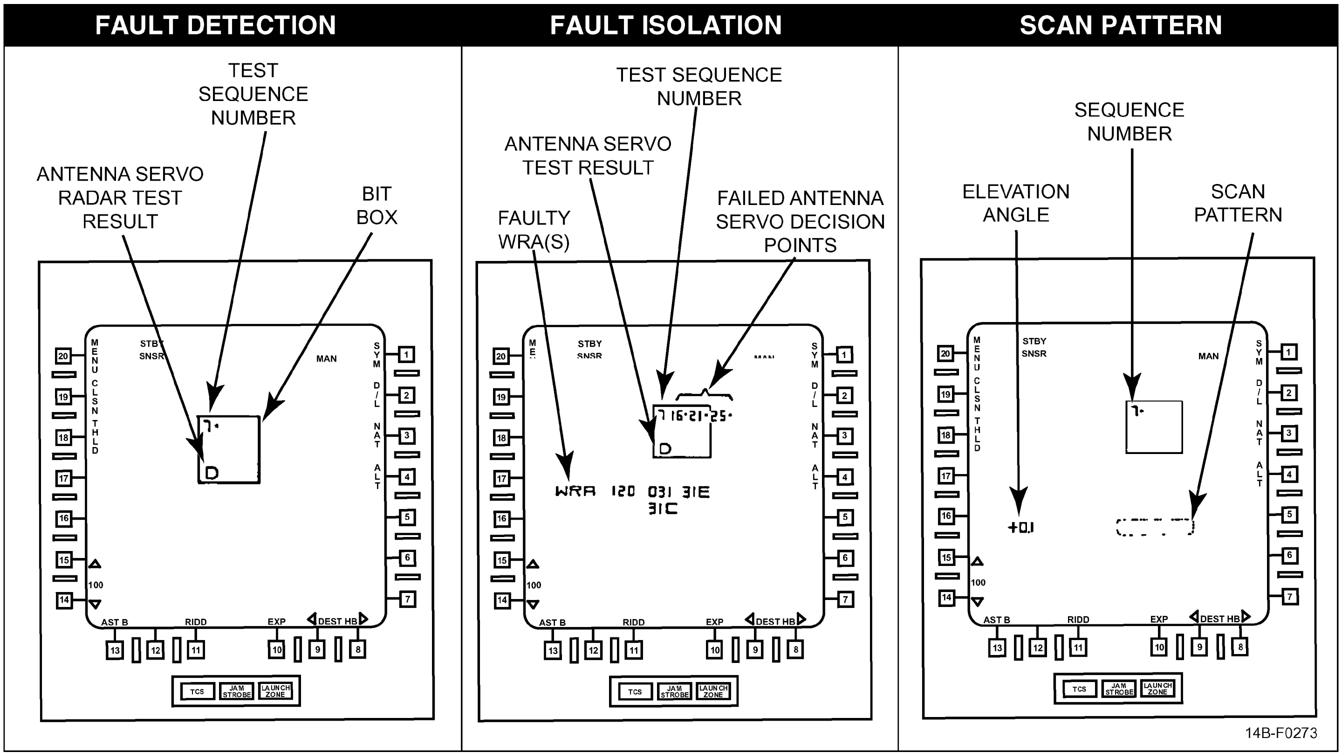


Figure 41-35. Sequence 7 Displays

41.10.11.1 Sequence 8 Test Sequence. This test sequence is executed in following order:

1. Program standard serial interface
2. Speed tracker submit
3. PDSTT
4. PSTT.

The SSI test is performed primarily to establish initial conditions for the test. The speed tracker test verifies proper operation of the radar to ensure it can acquire and track both constant and eclipsing target signals. Sensitivity is tested by decreasing the intensity of a simulated BIT target. PDSTT is also checked with the same BIT target. A Doppler jamming (JAM) track test is also conducted to verify that the system can operate in PSTT in JAT. An antenna angle rate memory test is performed during the PDSTT to verify antenna drift limits. The PSTT test simulates target acquisition when transferring from PDSTT. A radar-on-target and delayed velocity on-target condition will be indicated as a successful transition by the illumination on the radar on target (RDROT) and antenna track (ANT TRK) indicator lights on the DDD. Range and range rate are compared by ranging a simulated target from 5.0 to 2.5 nm. ACM threshold control and TWS to PSTT transition are tested to assure proper operation. PSTT and PSTT-jam angle track (JAT) sensitivity for tracking targets is verified.

41.10.11.2 Sequence 8 Test Displays. When the test is being read in from the magnetic tape memory, the BIT box on the PTID and a two-bar, ±40° scan on the DDD will be displayed by the BIT executive routine. As soon as the program has been read in, a flashing 8 is displayed in the upper left corner of the BIT box and the DDD shows an azimuth scan of ±0° and one-bar is shown in the EL meter. The scan center is 0° azimuth and –5.2° elevation. At this point, speed tracker tests are performed. An intermediate-frequency target is generated and then removed during the test of target eclipsing and antenna drift. The RDROT indicator will illuminate when fast frequency on target has been detected and the and ANT TRK indicator illuminates when delayed velocity on target has been detected. These two indicators illuminate and go out as the target eclipsing tests is performed. The target level and aspects are then changed to determine the PDSTT sensitivity. The BIT on-target filter tests are also performed at this time.

The RDROT and ANT TRK indicators illuminate, then go out, and the antenna is turned on and moves to 0° azimuth and –5.2° elevation (the horn target position). When lock-on is achieved, the RDROT and ANT TRK indicators illuminate again. The PDSTT angle track, horn target comparison, and high-PRF tracking loop gain tests are performed at this time. The RDROT indicator goes out and the JAT indicator illuminates indicating that the high-PRF jam track test is being performed. The ANT TRK and JAT indicators then go out and the antenna rate memory test is performed. The antenna sweeps to –30° in azimuth on the DDD and the antenna drifts down on the EL meter during the antenna servo fault isolation portion of the test.

41.10.11.3 Sequence 8 Mode Transfer. Mode transfer to PSTT is then performed. The PSTT mode pushbutton illuminates, PULSE is set on the mode drum, 10 nm is indicated on the DDD range drum, and RDROT ANT TRK indicators illuminate. The system tracks the target from 5.0 to 2.5 nm. The RDROT and ANT TRK indicators then go out and a target is reacquired at 5 nm.

The RDROT and ANT TRK indicators illuminate again and the system tracks the horn target (0° azimuth, –5.20 elevation). PSTT lock-on from TWS is performed at this time, although no external indication of TWS is given. Low-PRF tracking loop gain tests are also performed at this time. The JAT indicator is then illuminated and the RDROT and ANT TRK indicators go out. The low-PRF jam track tests are performed at this time and the antenna sweeps to the 30° left position in azimuth on the DDD and drifts down on the EL meter. The DDD then goes black and the transmitter oscillator leakage portion of the test is performed. Sequence 8 displays are shown in Figure 41-36.

41.10.12 Sequence 7 and 8 Shop Replaceable Assembly Fault Isolation. Fault isolation on the radar antenna is performed down to the SRA level. This results in some unique WRA displays. These displays may be displayed in combinations with each other or combinations with a WRA. Figure 41-37 shows the display, its meaning and applicable BIT sequence.

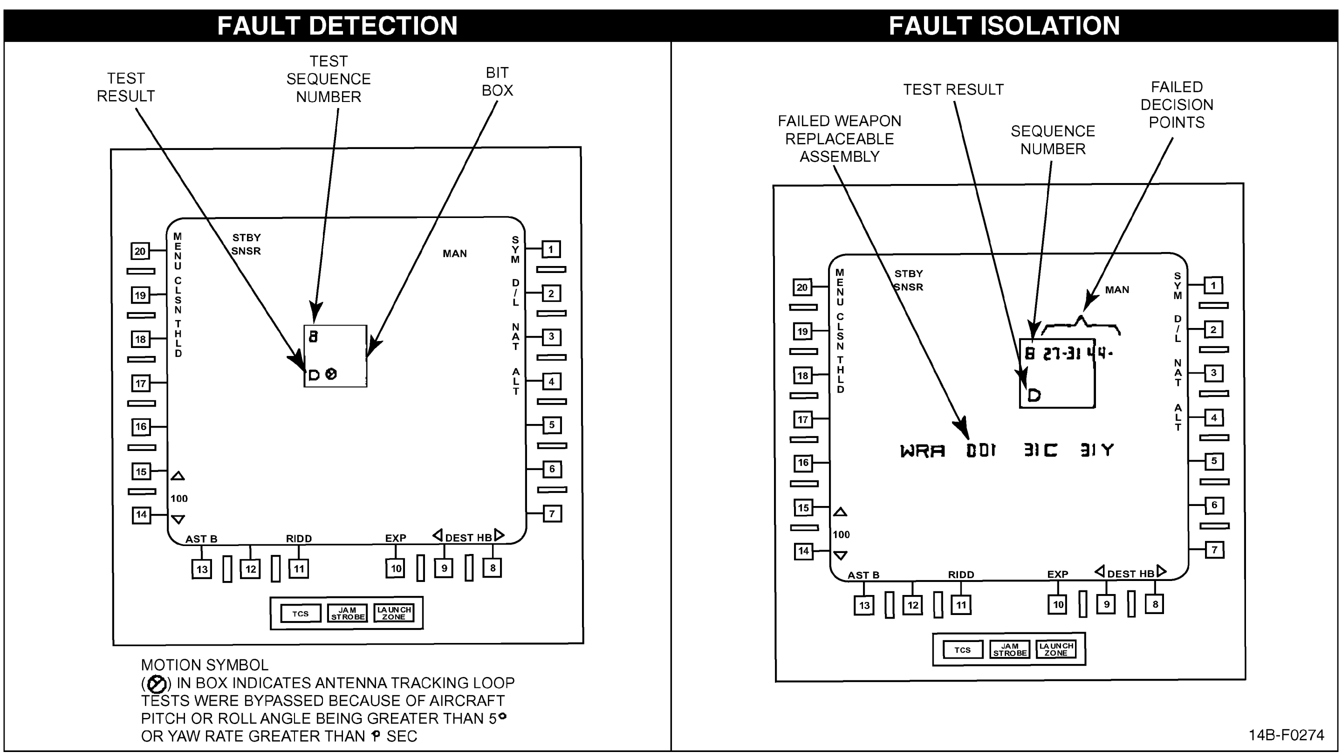


Figure 41-36. Sequence 8 Display

		BIT SEQUENCE	
DISPLAY	MEANING	7	8
31A	AZ hydraulic servovalve	X	
31B	EL hydraulic servovalve	X	
31C	AZ instrument gearbox	X	X
31D	EL instrument gearbox	X	X
31E	Electronics package	X	X
31H	Hydraulic power supply	X	
31X	AZ integrated gyro		X
31Y	EL integrating gyro		X

Figure 41-37. Sequence 7 and 8 SRA Fault Isolation

41.11 TEST TARGET

It is recommended that the RIO verify proper weapon system operation prior to each mission by running the confidence tests (sequences 1 through 4), which require about 5 minutes to perform. In cases where there is insufficient time to perform these checks, the test target can be used to quickly verify that the WCS is capable of detecting, processing, and displaying reasonable-size targets. It is available in and can be used to check the operation of PD or PULSE tactical modes. To use the test target, the RIO selects the TGT DATA category on the computer address panel and depresses the TEST TGT pushbutton. This activates the radar test horn in front of the radome. Normal mode operation continues. The radar test target will be processed and displayed on the DDD and PTID just as would any other newly detected target in the mode being tested.

In addition to testing the operation of the various modes, the test target can also be used for checking many of the WCS controls (such as display controls) and verifying computer functions such as hooking. For example, the RIO can hook the test target (which first appears as and unknown target) on the PTID; designate it hostile (noting symbol change); initiate single-target tracking on it (noting operation of ANT TRK and RDROT indicators); enter data pertaining to the target; and even test the track hold function after deselecting the test target.

41.11.1 Test Target Parameters. The PD test targets appear with the following parameters:

With the ASPECT switch set to:

1. NOSE — 1,800 knots closing at 50 nm; 600 knots closing at 20 nm.
2. BEAM — 600 knots closing at 20 nm; 1,800 knots closing at 50 nm.
3. TAIL — 600 knots closing at 20 nm; 600 knots opening at 20 nm (opening target may be deleted by altitude return filter).

The pulse test appears at 2 nm. All radar test targets appear at –5.2° elevation and 0° azimuth.

Note

When TEST TARGET is selected, a T is displayed on the PTID as an AWG-9 CM acronym.

41.11.2 Test Target Operation

41.11.2.1 On Deck

1. WCS switch — STBY (with SNIFF selected) or XMT.
2. TEST TGT pushbutton — Depress.

Note

Although TGT DATA category must be selected to achieve or deactivate TEST TGT, the targets retain their status when TGT DATA category is deselected.

3. RDR mode — As Desired.

41.11.2.2 In Flight

1. WCS switch — XMT.
2. TEST TGT pushbutton — Depress.

Note

This procedure supplements BIT; it does not replace BIT.

41.12 BIT MOVING TARGETS

The BIT moving-target generator program allows the RIO to simulate in-flight target intercept conditions.

It provides targets from the radome or MOAT horns to enable the RIO to effectively test all AWG-9 radar functions. The RIO, by making entries via the computer address panel, has the capability to generate targets at various ranges and closing rates in both high and low PRF except for low-PRF pulse compression targets.

41.12.1 BIT Moving Target Initiate

1. WCS switch — STBY or XMT.
2. CATEGORY switch — SPL.

Note

BIT moving target can be exercised while airborne if the pilot selects TNG.

3. MESSAGE pushbutton 7 — Depress and Release.

Note

Back lighting of function pushbutton indicates that program is reading in or has been read in. Verify that M (magnetic tape read) is removed from lower left quadrant of PTID display before proceeding. A normal tactical display appears at end of tape read.

4. The program is executed by making a digital entry in the format NBR BCD for the radome horn or NBR ABCD for the MOAT horn, then depressing ENTER on the computer address panel. Explanation of the format is as follows:

   a. A in the entry selects the MOAT horn. Any digit (such as 9) suffices for an A entry and results in M being displayed in the position A; otherwise, position A is blank.

   b. B in the entry selects starting range and closing rate of target. Various possible entries are listed in Figure 41-38.

   c. C in the entry selects target level. Various possible target level entries are listed in Figure 41-38.

   d. D in the entry selects number of targets to be displayed in pulse Doppler. If a 2 is entered, two targets are generated per entry B. Any other digit will result in a single target. If a pulse Doppler jamming target is desired for PDSTT, an entry of digit 7 is required. It is not required to depress ENTER. Depressing CLEAR will remove the jammer. If 7 is depressed, the position D display will blank and stay blank.

5. Once a valid entry code is entered, initial conditions for selected target(s) are set and MT ABCD is displayed below the flycatcher readout on PTID Figure 41-38.

6. Select SNIFF.

7. Adjust antenna elevation to approximately –5°.

8. Targets displayed on DDD are treated as valid by tactical program.

Note

- When the WCS is locked on to either the BMT or the test target in PDSTT, the ANT TRK light will blink as it does in the tactical program on an actual target.
- Target may be deselected by pressing and releasing CLEAR, ENTER

41.13 UPGRADE SYSTEM BIT

Upgrade System BIT, originated by the RIO, tests the PTID, PMDIG, AWG-15 Bus Controller (BC), and Mission Data Loader (MDL). Upgrade System BIT is obtained by selecting BIT on the PTID full menu page. The system and subsystem BITs are available by selecting the appropriate pushtile (Figure 41-39). Pushtile number 2 (ALL) causes BIT to execute on all avionics subsystem processors (BC, PTID, PMDIG and MDL). The two spaces directly beneath the processor legends display the software identification (ID) and checksum (CS) for that processor. Pushtile 3 (PTID) selects only the PTID BIT. Pushtile 4 (BBC) selects the BC portion of AWG-15H BIT (the CI portion is performed only during Class I OBC). Pushtile 5 (MDL) selects only the MDL BIT. Commanded BIT is terminated by re-selecting BIT, or by exiting the BIT page to the Tactical display or MENU. PMDIG Commanded BIT can only be activated via the ALL selection.

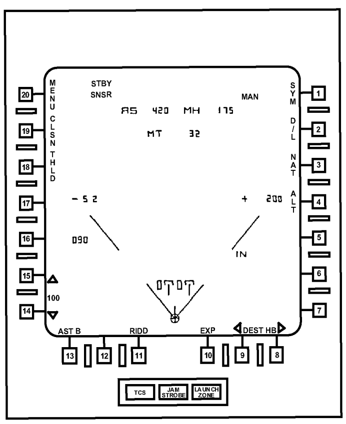
Note

- Running ALL BIT on deck will cause the PTID to blank for approximately 10 seconds. An airborne ALL BIT will not blank the PTID.
- When ALL is selected, “CBIT IN PROGRESS” is displayed on the ECMD while the PMDIG is in test.

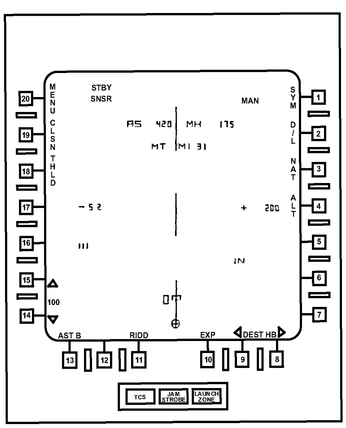
ENTRY "B"	STARTING RANGE* (nmi)	RANGE (KNOTS)
0	5	+100
1	10	+200
2	20	+200
3	32	+300
4	60	+300
5	80	+600
6	100	+1200
7	150	+1500
ENTRY "C"	**HPRF TARGET LEVEL**	**LPRF TARGET LEVEL**
1	LOWEST	LOW
2	↓	HIGH
3		HIGH
4		HIGH
5	HIGHEST	HIGH

*NO LPRF TARGET GENERATED IF RANGE IS GREATER THAN 33 MILES

TWS WITH RADOME HORN



PDSTT WITH MOAT HORN



14B-F0275

Figure 41-38. BIT Moving Target Generator Entries and Displays

- Running ALL, PTID, BBC, or MDL BITs on deck will clear loaded overlays. Airborne these BITs will not affect overlays.
- An MDL BIT will not run unless a valid MDL cartridge is installed.

The BIT decision point status table (for both Periodic and Commanded BIT) is displayed as a list of four digit, hexadecimal words in the column under the software checksum boxes on the BIT page. Selecting pushtile 11 (PAGE) will toggle between the two pages of BIT data. Words 25 to 28 on the second page contain the software IDs.

PMDIG BIT results are displayed on the ECMD along with data from ALR-67 and ALQ-126 BIT when "BIT" is selected on the ECMD Menu or with the ORIDE switch on the ECMD Control Panel. This switch only controls the display of results. It does not initiate BIT for any system. PMDIG commanded BIT is initiated from the PTID BIT Page. DECM BIT is initiated as described in the Upgrade NATOPS Supplement, Ch. E39.

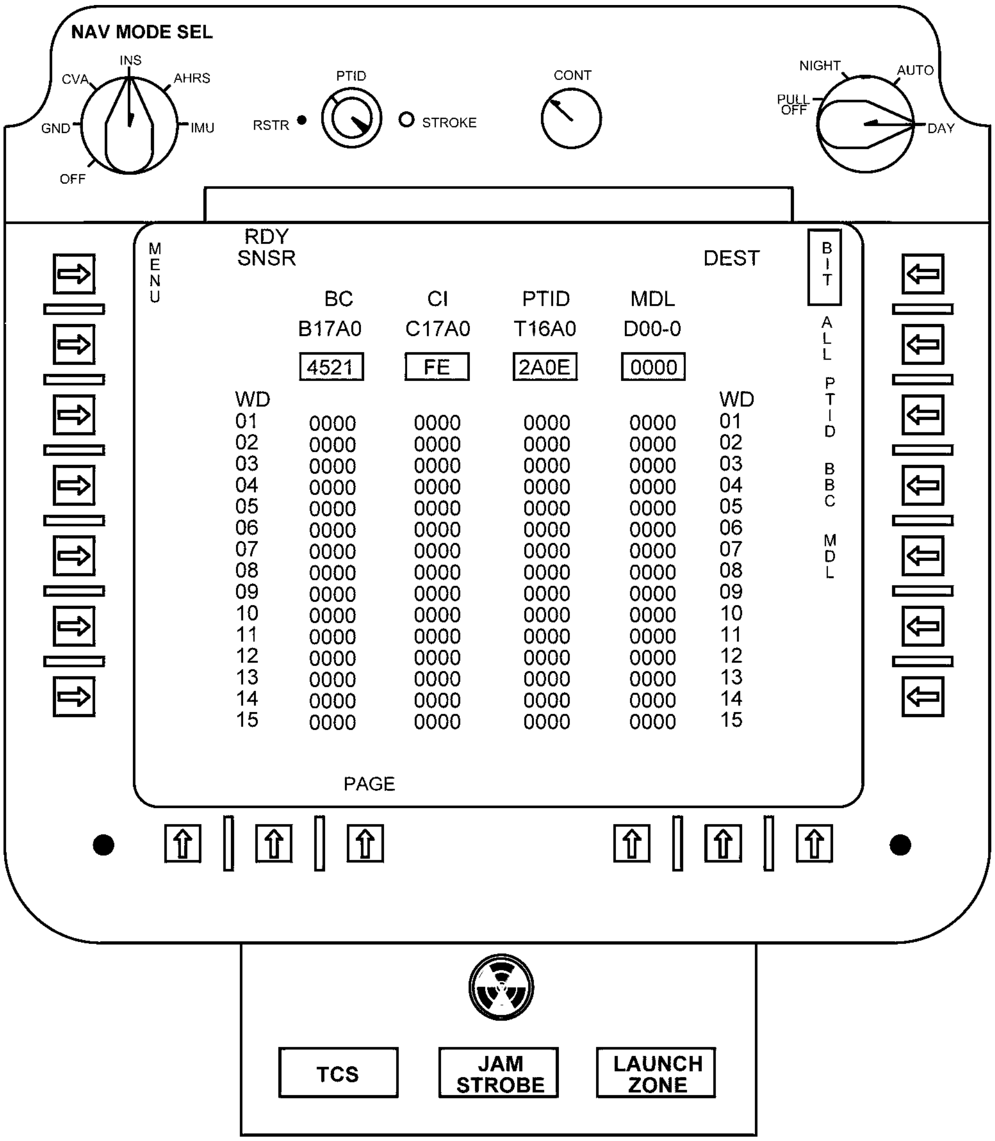
41.14 AWG-15H BUILT-IN TEST (BIT)

41.14.1 AWG-15H BBC BIT. The AWG-15H in the Upgrade aircraft is a dual processor computer. It incorporates the existing Control Indicator (CI) functions and adds a bus controller (BC) processor to communicate on the AVBUS and ARMBUS. Commanded BIT of the BC portion is selected using the BBC (or ALL) selection on the PTID BIT Page. Program ID (PID), checksum (CS), and the most recent coded BIT information for both processors is displayed in the CI and BC columns on the PTID BIT Page.

Note

The selection of BBC or ALL on the PTID BIT Page performs a commanded BIT of the BC portion only of the AWG-15H. The CI portion of the system completes commanded BIT only during Class I OBC. Results on the PTID BIT Page are from the latest Class I OBC

41.14.2 AWG-15H CI BIT. The AWG-15 CI BIT is conducted as part of in-flight OBC. On deck, a maintenance BIT can be performed only by maintenance technicians. On-deck performance is monitored by a BIT continuous monitoring test. CM is automatically performed at 10-second intervals on deck and in



14B-F0276

Figure 41-39. Upgrade System BIT Page

flight. CM detected failures are displayed on the PTID with no BIT fail time (Figure 41-40). In-flight BIT detected failures always display a fail time and are stored in the AWG-9 computer. Failure acronyms will identify the control indicator or power switching unit when maintenance readout is selected on the CAP. CM will detect and display these failures until the AWG-15 successfully passes BIT. On deck, stored failures can be differentiated from other CM detected failures by the presence of a BIT fail time on the PTID. All failures displayed on the deck are real. AWG-15 degraded mode assessment is available through flycatcher 7-00653. Detected failures will be reported in accordance with Figure 41-41.

Note

Reported fail times may vary ±20 ms because of computer polling and refresh cycles.

41.14.2.1 Preflight. The status of the AWG-15 CI is not checked on deck during OBC; however, upon completion of on-deck OBC, a CM is enabled. When CM is enabled and an AWG-15 failure is detected, the fail acronym(s) will be CIA or CIA followed by CPA or CPB. When an AWG-15 failure is detected in CM, the maintenance readout must be called up so the exact failures can be displayed for evaluation. See Figure 41-42 for acronym descriptions, and Figure 41-43 for aircrew responses.

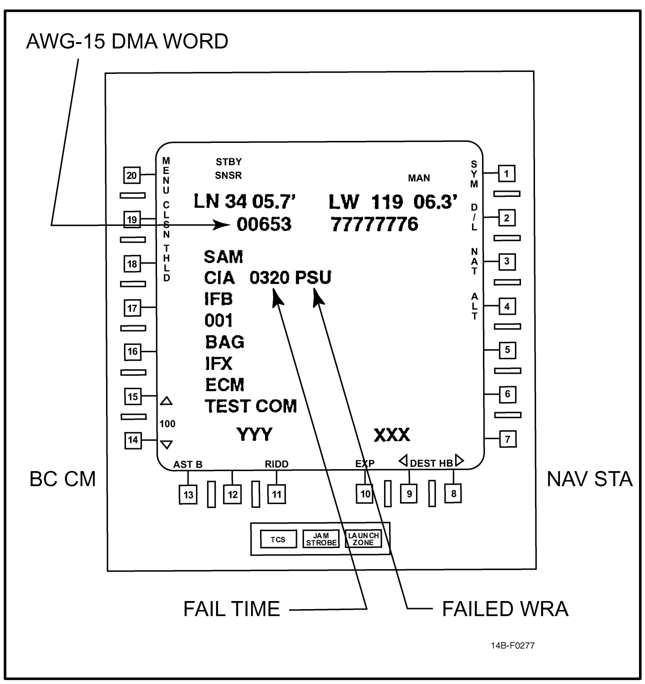


Figure 41-40. AWG-15 Built-In Test Display

TESTED FUNCTION	REPORTED FAIL TIME
SAFETY CHECKS	<0200
AIM-9 TEST	0320
AUX JETT TEST	0400
GUN TEST	1700
AIM-7 TEST	1720
AIM-54TEST	1760
DECODER TEST	3500

Figure 41-41. AWG-15 Fail Times

Note

Preflight OBC CIA, CI, or PSU acronyms with a displayed fail time indicate a Class I failure from a previous flight that has not been cleared by maintenance. This fail acronym cannot be erased by clearing MR. See Figure 41-44.

41.14.3 In Flight. Complete verification of AWG-15 status is only performed during in-flight OBC. The aircrew assesses the status of the AWG-15 CI from the acronyms and the time code reported at the completion of OBC (see Figure 41-44, and Figure 41-45). Failure data on each station and weapon type is available at the completion of OBC by monitoring flycatcher address 7-00653 (see Figure 41-46). CM detected failures will also be reported in flight. Procedures for running in-flight OBC are:

1. Verify ACM, A/G not selected.

Note

If ACM or A/G is selected, it will be interpreted as a failure and will terminate AWG-15 BIT.

2. MASTER TEST — OFF.
3. MASTER ARM — OFF.
4. Weapon select — OFF.
5. OBC — Initiate.
6. AWG-15 BIT display — Check.
7. Monitor flycatcher 7-00653.

LOCATION	ACRONYM	MEANING/ACTIONS
Continuous Monitoring (CM)	CIA	BIT failure in one of the AWG-15 components. **CAUTION** Aircrew must select MAINT DISP to determine failure when CIA acronym is displayed in CM. The possibility of inadvertent store release exists when this acronym is present. **Note** Aircrew should select MAINT DISP or OBC to read out failed components.
	CPA	Failure of the A power supply. No missile, A/G, or primary JETT capability. Gun and emergency jettison available on B power supply.
	CPB	Failure of the B power supply. Loss of the emergency jettison backup power supply. All weapon firing and jettison modes available.
OBC Maintenance Readout (MR)	CIA	Indicates possible failure of AWG-15 component(s). May be displayed alone or preceding the CPA, CPB, CI, and/or PSU acronyms. If displayed alone, could indicate unresolved failures from prior flight. An AWG-15 power failure is indicated if displayed with all of the following acronyms: CI, PSU, A1, A3, A4, A5, A6, A8, B2, B3, B4, and B7.
	CPA	Failure of the A power supply. No missile, AIG, or primary JETT capability. Gun and emergency jettison available on B power supply.
	CPB	Failure of the B power supply. Loss of the emergency jettison backup power supply. All weapon firing and jettison modes are available.
	CI	Control indicator failure. Caused by failure of the CI BIT circuitry. Acronym valid on deck. Refer to Figure 41-44 for degrades.
	PSU	Power switching unit failure. Caused by failure of the PSU BIT circuitry. Acronym valid on deck. Refer to Figure 41-44 for degrades. With valid PSU acronym on deck, flight with store capable of being launched or jettisoned is not authorized.
	CIA Ax or Bx	Acronym valid on deck. Refer to Figure 41-44 for degrades.

Figure 41-42. Preflight AWG-15 Acronyms

ON DECK (PREFLIGHT) OBC					
PTID ACRONYM		FAIL TIME	DMA* 00653	AIRCREW ACTIONS	MEANING
CM	CIA	None	N/A	Select MR and evaluate acronyms listed.	AWG-15 BIT failure. Further evaluation of failure is required.
CM	CPA	None	N/A	Abort mission.	Loss of all missile, A/G, and primary jett capability because of failure in primary side of power supply.
CM	CPB	None	N/A	Continue mission.	Loss of backup. Emergency jettison mode because of failure in backup power supply. Gun operation limited.
OBC	CI	<0200	N/A	Abort mission.	Critical failure from previous flight not cleared by maintenance.
OBC	CI	>0200	N/A	Evaluate Class I OBC when airborne.	Noncritical failure from previous flight may result in loss of some capability.
OBC	PSU	Any	N/A	Abort mission.	Failure from previous flight not cleared by maintenance. Possibility of inadvertent release of stores.
OBC	PSU	None	N/A	Abort mission.	CM detected failure.

*DMA word is updated at completion of CLASS I OBC. On deck only CM functions will update DMA (no station information is available). Failure of the trigger and/or bomb button will be detected by DMA.

Figure 41-43. Preflight Aircrew Responses

LOCATION	ACRONYM	MEANING/ACTIONS
Continuous Monitoring (CM)	CIA	BIT failure in one of the AWG-15 components. **CAUTION** Aircrew must select MAINT DISP to determine failure when CIA acronym is displayed in CM. The possibility of inadvertent store release exists when this acronym is present. **Note** Aircrew should select MAINT DISP or OBC to read out failed components.
	CPA	Failure of the A power supply. No missile, A/G, or primary JETT capability. Gun and emergency jettison available on B power supply. AGW-15 BIT in Class I OBC will not run.
	CPB	Failure of the B power supply. Loss of the emergency jettison backup power supply. All weapon firing and jettison modes available.
OBC Maintenance Readout (MR)	CIA	Indicates possible failure of AWG-15 component(s). May be displayed alone or preceding the CPA, CPB, CI, and/or PSU acronyms. If displayed alone, could indicate unresolved failures from prior flight. An AWG-15 power failure is indicated if displayed with all of the following acronyms: CI, PSU, A1, A3, A4, A5, A6, A8, B2, B3, B4, and B7.
	CPA	Failure of the A power supply. No missile, A/G, or primary JETT capability. Gun and emergency jettison available on B power supply. AWG-15 BIT in Class I OBC will not run.
	CPB	Failure of the B power supply. Loss of the emergency jettison backup power supply. All weapon firing and jettison modes are available.
	CI	Control indicator failure. Troubleshooting a CI or PSU acronym while airborne should be conducted only when operational necessity clearly dictates since gun firing and/or stores jettison, launch, or release may occur. Possible failure of LAU-7 detent solenoid. If LAU-7 mounted stores are loaded and carrier or field arrestment is anticipated, pull STA 1/8 AIM-9 REL PWR circuit breakers (6D4/6D3).
	PSU	Power switching unit failure. Safety-related failures will cause BIT to terminate. Safety failures are identified by DMA word 00653 display of 77777777 and a fail time less than 0200. Nonsafety related failures will not abort the rest and will update the DMA word. **CAUTION** • The possibility of inadvertent release of stores exists when this acronym is present. Mission should be aborted if stores are onboard. • LAU-7 detent solenoid may fail. If LAU-7 mounted stores are onboard and carrier or field arrestment is anticipated, pull STA 1/8 AIM-9 REL-PWR circuit breakers (6D4/6D3).
	CIA Ax or Bx	Station decoder failure. The probability is that only one of two independent channels in the decoder are bad. The remaining channel will provide full release and jettison capabilities. **Note** • A decoders provide the release signal to all missiles on STA 1 and 8 and to the AIM-54 and A/G on STA 3, 4, 5, and 6. • B decoders provide the release signal to the external tanks on STA 2 and 7 and to the AIM-7 on STA 3/6 and 4/5.

Figure 41-44. In-Flight AWG-15 Acronyms

CLASS I (IN-FLIGHT) OBC					
PTID ACRONYM		FAIL TIME	DMA* 00653	AIRCREW ACTIONS	MEANING
CM	CIA	None	N/A	Select MR and evaluate acronyms listed.	AWG-15 BIT Failure. Further evaluation of failure is required.
CM	CPA	None	N/A	Abort mission.	Loss of all missile, A/G, and primary jettison capability because of failure in primary side of power supply.
CM	CPB	None	N/A	Continue mission.	Loss of backup. Emergency jettison mode because of failure in backup power supply. Gun operation limited.
OBC	CI	<0200	77777777	Abort mission.	Critical failure. Test has aborted. Do not repeat test. Do not select MA.
OBC	CI	<0200	xxxxxxxx	Evaluate DMA.	Possible shorted trigger, launch button, or bomb button. Continue mission if DMA can isolate failure.
OBC	CI	>0200	7xxxxxxx	Evaluate DMA.	Noncritical failure may result in loss of some weapon capability on stations as listed in DMA.
OBC	CI	>3900	7xxxxxxx	Evaluate DMA.	Single-channel failure in CI. DMA will show release capabilities.
OBC	PSU	<3900	xxxxxxxx	Abort mission.	Failure of power switching unit. Possibility of inadvertent release of stores. Do not select MA. Do not repeat test.
OBC	PSU	>3900	xxxxxxxx	Continue mission.	Single-channel failure in PSU. DMA will show release capabilities.
OBC	Ax Bx	Any	xxxxxxxx	Evaluate DMA.	Decoder failure. DMA will show release capabilities.

*DMA word is updated at completion of CLASS I OBC.

Figure 41-45. In-Flight Aircrew Responses

WARNING

If the trigger and/or the bomb release button is shorted and the MASTER ARM switch is selected ON, gun firing and/or external stores jettison, launch, or release may occur at any time. Refer to DMA to determine if shorted trigger switch or bomb release button exists when BIT fail time is less than 0200.

Note

- A reported time greater than 3900 with no fail acronym indicates successful completion of the AWG-15 BIT.
- A fail acronym CI with fail time of 0400 ±20 may indicate the INTEG TRIM DC circuit breaker has been pulled. Reset circuit breaker and repeat test. With the INTEG TRIM DC circuit breaker pulled and AIM-7 on STA 3/6 or 4/5, SEL JETT may jettison the wrong station or both stations.

41.14.4 Fault Display Indicator. The FAULT IDENT indicator on the lower left corner of the CI is intended for maintenance (nonflight) use only.

The display allows an expanded BIT of the AWG-15 only on deck. The display is activated through the armament override switch and is used only on deck with weight on wheels and the MASTER ARM switch ON. The display is disabled in flight.

WARNING

Do not activate the FAULT IDENT display during preflight because overriding the armament safety override switch (gear up) could result in an inadvertent stores jettison.

41.14.5 Maintenance BIT. Maintenance BIT consists of all the tests performed during in-flight OBC as well as extensive testing that performs fault isolation on the weapons release system WRAs. Maintenance BIT performs a complete series of tests not covered by in-flight OBC and will test functions of the weapons system regardless of aircraft configuration.

WARNING

An inadvertent jettison will occur if maintenance BIT is run on an aircraft that has stores or weapons loaded.

41.14.6 Degraded Mode Assessment. Flycatcher 7-00653 monitors failure data on each station and weapon type at the completion of Class I (in flight) OBC. Flycatcher 7-00653 readout is opposite of CADC, CSDC, and WCS flycatchers. The normal octal readout after in-flight OBC is “77777777,” indicating all stations have passed the test. Any other numbers that appear in flycatcher 7-00653 indicate what has passed OBC and not what has failed.

41.15 NAVIGATION SYSTEM BUILT-IN-TEST (BIT)

Both continuous and initiated Built-In-Tests are available for the Upgrade Navigation System. Results of continuous tests are posted on the CDNU Status pages. Initiated tests are controlled and reported using the CDNU Test pages.

41.15.1 Status Monitoring. The CDNU continuously monitors the status of each of the navigation system weapon replaceable assemblies (WRAs). Each WRA executes Continuous Built In Test (CBIT) software which evaluates those items that can be assessed during normal operations. When a WRA detects a failure with its CBIT routines, a “✓ STATUS” annunciation appears on the annunciation line of the CDNU. Control inputs to a failed WRA are not prohibited. However, a “✓ xxxx STATUS” message (where “xxxx” indicates the WRA involved) is displayed in the scratchpad if an operation is attempted that cannot be performed. Outputs from a WRA indicating a failed status are not used for computations or display.

41.15.2 Reporting CBIT Results. Results from CBIT routines are displayed on the CDNU System Status page. Additionally, a detailed status page is available for each WRA. It should be noted that CBIT results and Initiated Built-In-Test (IBIT) results may be different because CBIT is not as extensive as IBIT, but it normally will catch failures first.

41.15.2.1 System Status Page. The CDNU System Status page displays the status of the CDNU, EGI, CSDC(R), SDC, and MDL. It also provides access to the individual WRA detail status pages for the CDNU, EGI, CSDC(R), and MDL.

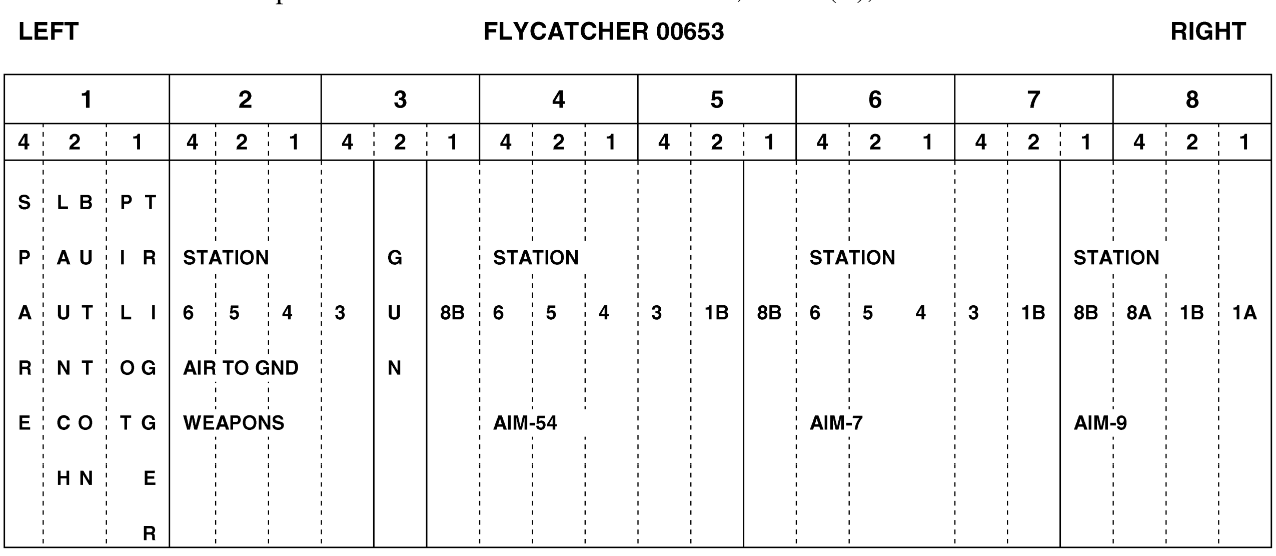


Figure 41-46. Degraded Mode Assessment

Check marks next to a WRA listed on the CDNU Status Page designate which WRA caused the "✓ STATUS" annunciation. The check mark is cleared when the detailed status page for the failed WRA is accessed or when LSK4 is pressed to clear all ✓ marks on the System Status page. Any event that causes the "✓ STATUS" annunciation on the CDNU will also cause the NAV COMP light to illuminate in the RIO's cockpit.

41.15.2.2 Detailed Status Pages. CBIT results for each Navigation System WRA are displayed on the respective detailed status pages. These are accessed by pressing the LSK adjacent the respective WRA on the System Status page. Unknown status (e.g., the bus controller is unable to communicate with a WRA) is indicated with dashes in the top level status field.

Note

The MDL is located on the Avionics Bus so the CDNU cannot directly interrogate the WRA to check its status. The CDNU instead queries the MDP (through the dual bus connection of the EGI) which then provides MDL status for display. There is no detailed MDL Status Page only provides a top level indication (GO or NOGO) of the MDL Status. Detailed MDL status is available via the PTID BIT Page.

A failure counter is provided on all detailed status pages to indicate the total number of hardware and MIL-STD-1553B data bus failures since the last time the fault counter was reset. This is done for each WRA by pressing LSK5 on the appropriate Status Page.

Status monitoring may be disabled for any WRA on its individual status page (for example, if an intermittent failure is causing nuisance alerts) by pressing LSK1 and setting "ENABLE" to "DISABLE". This inhibits the "✓ STATUS" annunciation for that WRA. All status monitoring results continue to be displayed on the detailed status page. The state of this toggle is always reset to "ENABLE" on CDNU power up.

An individual WRA failure will be indicated by a "NOGO" on the second line of the individual WRA status page. "GO" indicates normal operation, "DGO" (Degraded Go) indicates a partial failure, and "——" indicates no data are available (normally seen for a few seconds at startup). In the event of a data bus failure, "BUS NOGO-x" will be displayed on the third display line, where "x" can be either "A", "B", or "T" ("A" bus fail, "B" bus fail, or total bus failure, respectively).

Faults for the individual WRAs are displayed in hexadecimal format and can be interpreted using Figure 41-47.

HEX CODE DISPLAYED	INTERPRETATION
1	Indicates condition for 1 exists
2	Indicates condition for 2 exists
3	Indicates conditions for 1 and 2 exist
4	Indicates condition for 4 exists
5	Indicates conditions for 1 and 4 exist
6	Indicates conditions for 2 and 4 exist
7	Indicates conditions for 1, 2, and 4 exist
8	Indicates condition for 8 exists
9	Indicates conditions for 1 and 8 exist
A	Indicates conditions for 2 and 8 exist
B	Indicates conditions for 1, 2, and 8 exist
C	Indicates conditions for 4 and 8 exist
D	Indicates conditions for 1, 4, and 8 exist
E	Indicates conditions for 2, 4, and 8 exist
F	Indicates conditions for 1, 2, 4, and 8 exist

Note

The hexadecimal numbers describe the existence of four possible situations or some composite of the four.

Figure 41-47. Decoding Navigation System Status Page Fault Displays

41.15.2.2.1 CDNU Status. The CDNU Status Page provides CBIT results for the CDNU. The page (Figure 41-48) is accessed by depressing the "STAT" key on the CDNU to access the System Status page, then pressing LSK5 on the System Status page to access the CDNU Status page.

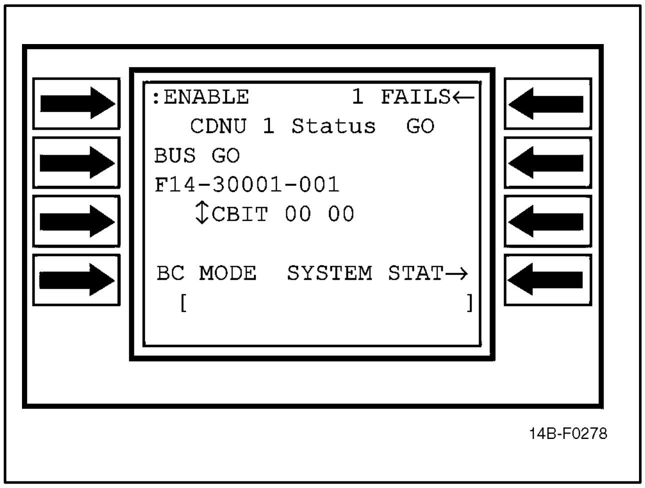


Figure 41-48. CDNU Detailed Status Page

Specific failures are displayed as a hexadecimal word on line five of the CDNU. Three failure words are accessible by scrolling up or down. The CBIT word contains failure codes for individual hardware assemblies, the IN word identifies which CNDU input discretes are set, and the OUT word indicates which CDNU output discretes are set. Figure 41-49 is a table of failure codes and their meaning.

The following list breaks down the more important failures shown in Figure 41-49, and indicates which failures will cause the total loss of the Navigation Bus.

Failure of the GRAPHICS CARD A2:

Converts display page data to digital signals.

Failure of the MEMORY CARD A5 and DISCRETE I/O CARD 5a:

Not used in the F-14A/B.

Failure of the IOC 1553 CARD A6:

MIL-STD-1553B encoders/decoders.*

MIL-STD-1553B parity generation/checking.*

MIL-STD-1553B terminal address comparison.

MIL-STD-1553B word count tracking.*

Failure of the IOC 1553 CARD A8:

MIL-STD-1553B coupling transformers.*

MIL-STD-1553B analog to Manchester converters.*

MIL-STD-1553B Manchester to analog converters.*

ARINC 429 transmitters.

Failure of the DISCRETE I/O CARD A7:

Discrete input signals.*

Discrete output signals.*

ARINC 429 receivers.

*Indicates a failure that will cause the CDNU to lose bus control with the subsequent total loss of the Navigation Bus.

41.15.2.3 CSDC(R) Status. The CSDC Status Page (shown in Figure 41-50) provides CBIT results for the CSDC(R). It is accessed by depressing LSK6 on the System Status Page. In the event of a CSDC(R) failure, the CBIT word will contain a hexadecimal code indicating the failure. (See Figure 41-51.)

EGI Status. The EGI Status Page (Figure 41-52) provides CBIT results for the EGI. It is accessed by pressing LSK2 on the System Status page. In the event of a partial EGI failure, the “EGI Status” will be “DGO” (Degraded GO) and the following will be displayed: “IMU NOGO” if the inertial electronics module failed, and “GPS NOGO” if the GPS module failed. In the event of a complete EGI failure, the “EGI Status” will be “NOGO”.

CBIT WORD		INPUT DISCRETE WORD		OUTPUT DISCRETE WORD	
HEX CODE	FAILURE	HEX CODE	FAILURE	HEX CODE	FAILURE
1 x x x	Discrete I/O Card A7	1 x x x	Spare	1 x x x	Spare
2 x x x	Discrete I/O Card A5a	2 x x x	Spare	2 x x x	Spare
4 x x x	1553 Terminal Flag	4 x x x	Spare	4 x x x	Spare
8 x x x	1553 Subsystem Flag	8 x x x	Spare	8 x x x	Spare
x 1 x x	Memory Card A3	x 1 x x	Spare	x 1 x x	Spare
x 2 x x	Memory Card A5	x 2 x x	Spare	x 2 x x	Spare
x 4 x x	IOC 1553 Cards A6, A7	x 4 x x	Spare	x 4 x x	Spare
x 8 x x	Graphics Card A2	x 8 x x	Spare	x 8 x x	Spare
x x 1 x	Spare	x x 1 x	CDNU Using Non-Upgrade Configuration Software	x x 1 x	Spare
x x 2 x	Spare	x x 2 x	Spare	x x 2 x	Spare
x x 4 x	Spare	x x 4 x	Spare	x x 4 x	Spare
x x 8 x	CPU Card	x x 8 x	Spare	x x 8 x	Spare
x x x 1	Spare	x x x 1	Master Zeroize Set	x x x 1	CAINS/WAYPT Selected*
x x x 2	Spare	x x x 2	Spare	x x x 2	Spare
x x x 4	Spare	x x x 4	Signal Data Converter Fail	x x x 4	Spare
x x x 8	Spare	x x x 8	Spare	x x x 8	Time of Day (PTTI)**
				*Normal indication when CAINS/ WAYPT selected on Data Link Reply and Antenna Control Panel. **Set when ARC-182 using EGI PTTI for HAVEQUICK function.	

Figure 41-49. CDNU CBIT Word Hex Codes

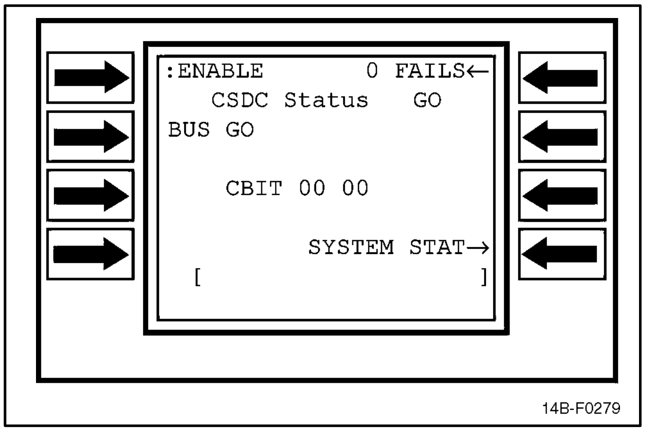


Figure 41-50. CSDC(R) Status Page

HEX CODE	FAILED CSDC(R) MODULE
1 x x x	Memory Discrete
2 x x x	Extended Input/Output Processor
4 x x x	Power Supply
8 x x x	Discrete Input/Output 1
x 1 x x	Discrete Input/Output 2
x 2 x x	Discrete Input/Output 3
x 4 x x	Miscellaneous Input/Output
x 8 x x	Serial Input/Output
x x 1 x	Converter Analog to Analog 1
x x 2 x	Converter Analog to Analog 2
x x 4 x	Analog Input Module
x x 8 x	Analog to Digital Converter
x x x 1	AC Power In 1
x x x 2	AC Power In 2
x x x 4	1553
x x x 8	Converter Analog to Analog Transformer

Figure 41-51. CSDC(R) CBIT Word Hex Codes

Each hexadecimal digit in the CBIT word represents a single possible failure. They are listed in descending order of priority. The left-hand (most significant) digit contains the most likely failure, the second digit from the left the second most likely failure, etc. Figure 41-53 contains a list of codes and their meanings. Scrolling vertically will display the complete contents of the EGI BIT Test Data —1553 Message. If a BIT failure is detected either in CBIT or IBIT (see below), any non-zero words in this message should be copied for use by maintenance personnel.

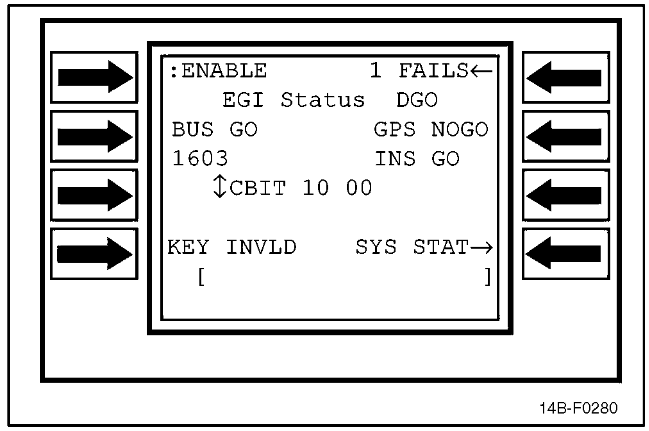


Figure 41-52. EGI Status Page

Display line 7 of the EGI Status page provides the status of the GPS keys. If the keys are not loaded, “NEED KEY” will be shown. If the keys are loaded, either “KEY VALID” or “KEY INVLD” will be shown. When the keys are initially loaded, “KEY INVLD” will be displayed, followed by “KEY VALID” once the keys have been verified using the GPS navigation message transmitted by the satellites.

41.15.3 Navigation System Initiated Tests. Initiated Built-in-Tests (IBIT) of the EGI, CDNU, and SDC can be selected from the CDNU System Test Page. The page is accessed by first pressing the “IDX” key on the CDNU to access the Index page, then Pressing LSK4 to access the System Test page.

Results from IBIT routines are compiled and reported to the WRA level on the System Test page. Additionally, a detailed test page is available for the EGI and CDNU. A test of the analog data path between the EGI and CSDC(R) can also be initiated from this page.

The results of an IBIT are latched so that the results of the last IBIT by each WRA are displayed until the next IBIT is performed. Because of this, the WRA test results reflected on the test pages may not correspond to the status page results, which are continuously monitored and updated.

While an IBIT is in progress, “TEST” is displayed next to the WRA name on the WRA detailed test page, on the System Test Page, and on the corresponding status pages. In addition, dashes appear in all test result fields of the WRA’s detailed status page while the test is in progress. If IBIT has not been requested since the last application of power, then all test result fields display dashes on the System Test and WRA detailed test pages.

HEX CODE	FAILED EGI MODULE
1	GPS Embedded Module (GEM)
2	System Processor
3	F-14 Input/Output Card
4	Spare
5	DC/DC Power Supply
6	Spare
7	Spare
8	Inertial Electronics
9	Spare
A	Inertial Sensor Assembly
B	Chassis
C–F	Spare

Figure 41-53. EGI Failure Codes

41.15.3.1 CDNU Test Page. The CDNU Test Page (Figure 41-54) is accessed by depressing LSK5 on the System Test Page. CDNU Initiated BIT can then be initiated using LSK1.

CAUTION

Selecting CDNU IBIT will cause loss of Navigation Bus control for approximately 10 seconds during the Initiate BIT. During that time all steering information to the VDIG and HSD will be lost.

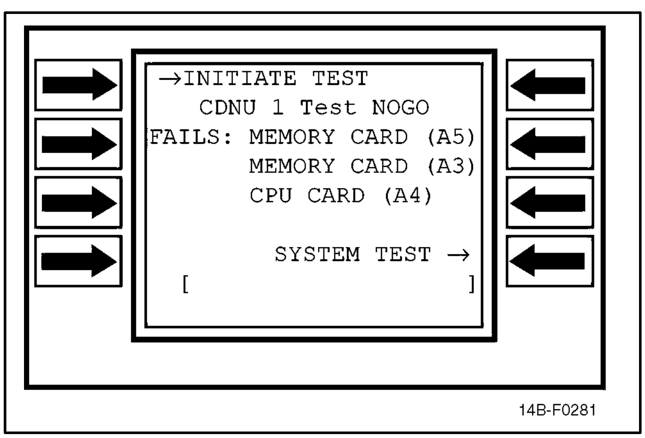


Figure 41-54. CDNU Test Page

CAUTION

If "EGI" is selected on the TACAN Command Panel (see Chapter 20), putting the CDNU into Initiated Test will cause loss of steering signals to the BDHI for a minimum of 45 seconds. If "TACAN" is selected on the TACAN Command Panel, CDNU IBIT will have no impact on the BDHI.

A high level GO/NOGO indication on the right side of CDNU line 2 indicates the overall status of the WRA. If a NOGO indication exists, the detected faults are displayed. If more then three faults exist, the additional failures may be viewed by scrolling vertically.

41.15.3.2 EGI Test Page. The EGI Test Page (Figure 41-55) is accessed by depressing LSK2 on the System Test Page. The test may then be initiated by depressing LSK1. EGI IBIT only tests the GPS module; all other components are tested either during CBIT, or Start-up BIT (See Upgrade NATOPS, Ch. A20).

CAUTION

Putting the EGI into Initiated Test while in the air will cause loss of GPS aiding to the EGI for up to 4 minutes (or more if satellite acquisition, after the IBIT completes, is delayed for any reason). The GPS Solution will not be valid. The Blended Solution will be available, but Aided and Unaided position accuracies will be similar.

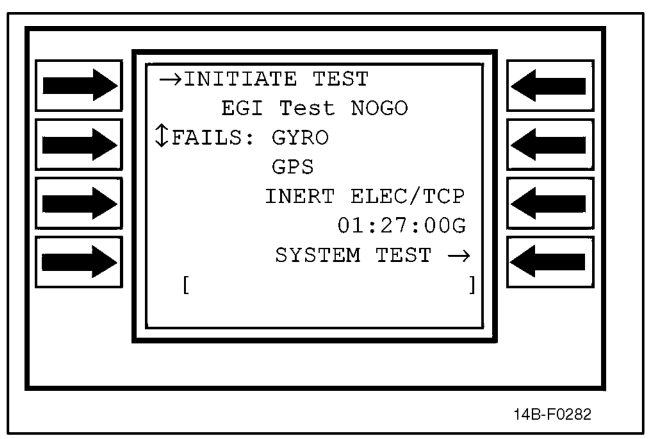


Figure 41-55. EGI Test Page

If the CDNU does not receive BIT results from the EGI within 240 seconds, a “NOGO” indication will be displayed on the EGI Test page.

After the test is complete, a high level GO/NOGO/DGO indication representing the overall status of the EGI is displayed on the right side of CDNU line 2. If a NOGO or DGO condition exists, the faulty EGI component causing the condition will be displayed. Figure 41-56 contains a list of possible faults, and the specific hardware associated with them. If more then three faults exist, the additional failures may be viewed by scrolling vertically.

CDNU DISPLAY	FAILED EGI MODULE
GYRO	Digital Gyros
ACCELEROMETER	Accelerometers
POWER SUPPLY/SYS	Power Supply
INERT ELEC/TCP	Inertial Sensor Assembly (IMU)
SYSTEM PROCESSOR	System Processor
1553 I/O	MIL-STD-1553 Bus I/O
MISSIONIZATION	Analog Attitude Output to CSDC(R)
WARNING ADVISORY	Kalman Filter Fault
GPS	GPS Embedded Module

Figure 41-56. EGI Test Page Failure Indications

41.15.3.3 Instrument Test. Instrument Test allows the aircrew to evaluate the analog attitude connection between the EGI and the CSDC(R). The test is selected by depressing LSK6 on the CDNU System Test Page.

During the test, the EGI generates a false attitude signal that drives the VDIG displays and PTID horizon bar through their entire attitude range. The test begins with the aircraft nose level and inverted and slowly pitches the nose toward the zenith while rolling either right or left (the direction reverses after one complete cycle). Pitch and roll occur at the same rate. The test is a visual test only: pass/fail determination is made by the aircrew based on the instrument displays. The Instrument Test is available only when the aircraft is on the ground. If it is attempted while in the air, “GROUND TEST ONLY” will be displayed in the CDNU scratchpad. If the test is active during takeoff, it will terminate once the aircraft is airborne (Weight-off-Wheels, and airspeed greater than 80 knots).

CAUTION

The RIO should ensure that the Instrument Test is stopped prior to taking the runway or approaching the catapult. While the test is active, attitude information to the primary flight instruments is lost.

41.15.3.4 Signal Data Converter (SDC) Initiated Test. The System Test page displays the latest recorded IBIT results for the SDC. Pressing LSK3 will initiate a partial Built-In-Test for the SDC. The test provides only a basic GO/NOGO indication without any detailed failure indications, and is available only when the aircraft is on the ground. “GROUND TEST ONLY” will be displayed in the CDNU scratchpad if the test is attempted while in the air. A more complete BIT, with detailed fault indications, is available to maintenance crews using the BIT button on the front panel of the SDC itself.

CAUTION

If the SDC circuit breaker is pulled (i.e., SDC power is off), CDNU commanded SDC BIT will always result in a “GO” condition, regardless of the state of the SDC.

PART X

NATOPS Evaluation

CHAPTER 42

NATOPS Evaluation

42.1 NATOPS EVALUATION PROGRAM

42.1.1 Concept. The standard operating procedures prescribed in this manual represent the optimum method of operating the aircraft. The NATOPS evaluation is intended to evaluate compliance with NATOPS procedures by observing and grading individuals and units. This evaluation is tailored for compatibility with various operational commitments and missions of both Navy and Marine Corps units. The prime objective of the NATOPS evaluation program is to assist the unit commanding officer in improving unit readiness and safety through constructive comment. Maximum benefit from the NATOPS program is achieved only through the vigorous support of the program by commanding officers as well as by flight crewmembers.

42.1.2 Implementation. The NATOPS evaluation program shall be carried out in every unit operating naval aircraft. The various categories of flight crewmembers desiring to attain and retain qualification in the F-14B shall be evaluated initially in accordance with OPNAVINST 3710 series, and at least once during the 18 months (not to exceed 24 months) following initial and subsequent evaluations. Individual NATOPS evaluations will be conducted annually; however instruction in and observation of adherence to NATOPS procedures must be on a daily basis within each unit to obtain maximum benefits from the program. The NATOPS coordinators, evaluators, and instructors shall administer the program as outlined in OPNAVINST 3710 series. Evaluees who receive a grade of Unqualified on a ground or flight evaluation shall be allowed 30 days in which to complete a reevaluation. A maximum of 60 days may elapse between the date of the initial ground and flight evaluation and the date that qualification is satisfactorily completed. F-14A/B NATOPS evaluations can be accomplished during the same evaluation flight, provided the currency requirements for each model established in Chapter 5 are met. The results will be recorded on the NATOPS Evaluation Form (OPNAV Form 3710.7), Figure 42-1.

42.1.3 Definition. The following terms used throughout this section are defined below as to their specific meaning within the NATOPS program.

42.1.3.1 NATOPS Evaluation. A periodic evaluation of individual flight crewmembers standardization consisting of an open-book examination, closed-book examination, oral examination, and flight evaluation.

42.1.3.2 NATOPS Reevaluation. A partial NATOPS evaluation administered to a flight crewmember who has been placed in an Unqualified status by receiving an Unqualified grade for any ground examination or for the flight evaluations. Only those areas in which an unsatisfactory level was identified need be observed during a reevaluation.

42.1.3.3 Qualified. The evaluation term applied to a flight crewmember who is well standardized and who demonstrated highly professional knowledge of and compliance with NATOPS standards and procedures. Momentary deviations from or minor omission in noncritical areas are permitted if prompt and timely remedial action was initiated by the evaluee.

42.1.3.4 Conditionally Qualified. The evaluation term applied to a flight crewmember who is satisfactorily standardized, who may have made one or more significant deviations from NATOPS standards and procedure but made no errors in critical areas and no errors jeopardizing mission accomplishment or flight safety.

42.1.3.5 Unqualified. The evaluation term applied to a flight crewmember who is not acceptably standardized, who failed to meet minimum standards regarding knowledge of and/or ability to apply NATOPS procedures, or who made one or more significant deviations from NATOPS standards and procedures that could jeopardize mission accomplishment or flight safety.

42.1.3.6 Area. An area is a routine of preflight, flight, or postflight.

NATOPS EVALUATION REPORT
OPNAV 3710/7 (4-90) S/N 0107-LF-009-8000 **REPORT SYMBOL OPNAV 3710-21**

NAME (Last, first, initial)	GRADE	SERVICE NUMBER
SQUADRON/UNIT	AIRCRAFT MODEL	CREW POSITION
TOTAL PILOT/FLIGHT HOURS	TOTAL HOURS IN MODEL	DATE OF LAST EVALUATION

NATOPS EVALUATION

REQUIREMENT	DATE COMPLETED	GRADE		
		Q	CQ	U
OPEN BOOK EXAMINATION				
CLOSED BOOK EXAMINATION				
ORAL EXAMINATION				
*EVALUATION FLIGHT				

FLIGHT DURATION	AIRCRAFT BUNO	OVERALL FINAL GRADE

REMARKS OF EVALUATOR/INSTRUCTOR

☐ CHECK IF CONTINUED ON REVERSE SIDE

GRADE, NAME OF EVALUATOR/INSTRUCTOR	SIGNATURE	DATE
GRADE, NAME OF EVALUEE	SIGNATURE	DATE

REMARKS OF UNIT COMMANDER

RANK, NAME OF UNIT COMMANDER	SIGNATURE	DATE

* WST, OFT, COT, or cockpit check in accordance with OPNAVINST 3710.7 (effective edition)

Figure 42-1. NATOPS Evaluation Report

42.1.3.7 Subarea. A subarea is a performance sub-division within an area that is covered and evaluated during an evaluation flight.

42.1.3.8 Critical Area and Subarea. A critical area or subarea is any area or subarea that coves items of significant importance to the overall mission requirements, the marginal performance of which would jeopardize safe conduct of the flight.

42.2 GROUND EVALUATION

Prior to commencing the flight evaluation, an evaluee must achieve a minimum grade of Qualified on the open-book and closed-book examinations. The oral examination is also part of the ground evaluation but may be conducted as part of the flight evaluation. To assure a degree of standardization between units, the NATOPS instructors may use the bank of questions contained in this chapter in preparing portions of the written examinations.

42.2.1 Open-Book Examination. The open-book examination shall consist of but not be limited to the question bank. The purpose of the open-book examination portion of the written examination is to evaluate the flight crewmember's knowledge of appropriate publications and the aircraft.

42.2.2 Closed-Book Examination. The closed-book examination may be taken from but shall not be limited to the question bank and shall include questions concerning normal and emergency procedures and aircraft limitations. Questions designated critical will be so marked.

42.2.3 Oral Examination. The questions may be taken from this manual and may be drawn from the experience of the instructor-evaluator. Such questions should be direct and positive and should in no way be based solely on opinion.

42.2.4 Emergency. An emergency is an aircraft component or system failure or condition that requires instantaneous recognition, analysis, and proper action.

42.2.5 Malfunction. A malfunction is an aircraft component or system failure or condition that requires recognition and analysis but permits more deliberate action than that required for an emergency.

42.2.6 OFT and WST Procedures Evaluation. An OFT and WST may be used to assist in measuring the flight crewmember's efficiency in the execution of normal operating procedures and reaction to emergencies and malfunctions. In areas not covered by the OFT and WST facilities, this may be done by placing the flight crewmember in an aircraft and administering appropriate questions.

42.2.7 Grading Instructions. Examination grades shall use a 4.0 scale and be converted to an adjective grade of Qualified or Unqualified.

42.2.7.1 Open-Book Examination. To obtain a grade of Qualified, an evaluee must obtain a minimum score of 3.5.

42.2.7.2 Closed-Book Examination. To obtain a grade of Qualified, an evaluee must obtain a minimum score of 3.3.

42.2.7.3 Oral Examination and OFT and WST Procedure Check (If Conducted). A grade of Qualified or Unqualified shall be assigned by the instructor-evaluator.

42.3 FLIGHT EVALUATION

The flight evaluation may be conducted on any routine syllabus flight with the exception of flights launched for field carrier landing practice and carrier qualifications or electronic counter-countermeasures training. Emergencies will not be simulated.

The number of flights required to complete the flight evaluation should be kept to a minimum, normally one flight. The areas and subareas to be observed and graded on a flight evaluation are outlined in the grading criteria with critical areas marked by an asterisk (*). Grades on subareas will be assigned in accordance with the grading criteria. Grades on subareas shall be combined to arrive at the overall grade for the flight. If desired, grades of areas shall also be determined in this manner. At the discretion of the squadron or unit commander, the evaluation may be conducted in WST, OFT, or COT.

42.3.1 Instrument Flight Evaluation. Annual NATOPS instrument flight evaluations and the IFR portions of NATOPS flight evaluations, whether conducted in flight or in an approved simulator, must be conducted by a NATOPS-qualified pilot or RIO who is designated in writing by the unit commanding officer.

Such instrument flight evaluations must be conducted in accordance with the procedures outlined in OPNAVINST 3710.7.

42.4 OPERATIONAL DEPLOYABLE SQUADRONS

Pilots and RIOs assigned to operational deployable squadrons will normally be checked as a team with the flight evaluation being conducted by the checkcrew flying wing. RIO commentary will be transmitted on the ground-controlled intercept or CIC control frequency in use.

42.5 TRAINING AND EVALUATION SQUADRONS

Units with training or evaluation missions that are concerned with individual instructor pilot or RIO standardization rather than with team standardization may conduct the flight evaluation with the checkcrew pilot flying wing or on an individual basis. A pilot may be individually checked with the instructor-evaluator conducting the flight evaluation from the rear seat. The RIO may be individually checked by flying with the instructor-evaluator as the pilot.

42.6 FLIGHT EVALUATIONS

The areas and subareas in which pilots and RIOs may be observed and graded for adherence to standardized operating procedures are outlined in the following paragraphs.

Note

If desired, units with training missions may expand the flight evaluation to include evaluation of standardized training methods and techniques.

(*) The IFR portions of the flight evaluation shall be in accordance with the procedure outlined in the NATOPS Instrument Flight Manual.

42.6.1 Mission, Planning, and Briefing

1. Flight planning (pilot and RIO)
2. Briefing (pilot and RIO)
3. Personal flying equipment (pilot and RIO).

42.6.2 Preflight and Line Operations. Inasmuch as preflight and line operations procedures are graded in detail during the ground evaluation, only those areas observed on the flight check will be graded.

1. Aircraft acceptance (pilot and RIO)
2. Start
3. Before-taxiing procedures (pilot).

42.6.3 Taxi and Runup

(*) Takeoff and Transition

1. ATC clearance (pilot)
2. Takeoff (pilot)
3. Transition to climb schedule.

42.6.4 Climb and Cruise

1. Departure (pilot)
2. Climb and level-off (pilot)
3. Procedures en route (pilot).

(*) Approach and Landing

1. Radar, tacan (pilot)
2. Recovery (pilot).

42.6.5 Communications

1. Receiving and transmitting procedures (pilot and RIO)
2. Visual signals (pilot and RIO)
3. IFF and SIF procedures (RIO).

42.6.6 Emergency and Malfunction Procedures. In this area, the pilot and RIO will be evaluated only in the case of actual emergencies unless evaluation is conducted in the COT, WST, or OFT.

42.6.7 Postflight Procedures

1. Taxi in (pilot)
2. Shutdown (pilot and RIO)
3. Inspection and records (pilot and RIO)
4. Flight debriefing (pilot and RIO).

42.6.8 Mission Evaluation. This area includes missions covered in the NATOPS Flight Manual, F-14A Tactical Manual, and naval warfare publications for which standardized procedures and techniques have been developed.

42.7 RECORDS AND REPORTS

A NATOPS evaluation report (OPNAV Form 3710.7) shall be completed for each evaluation and forwarded to the evaluee's commanding officer only. This report shall be filed and retained in the individual's NATOPS Jacket. In addition, an entry shall be made in the pilot and RIO flight log books under "Qualifications and Achievements," as follows:

QUALIFICATION	DATE	SIGNATURE
NATOPS EVALUATION (Aircraft Model) (Crew Position)	(Date)	(Authenticating signature) (Unit that administered evaluation)

42.7.1 Critique. The critique is the terminal point in the NATOPS evaluation and will be given by the evaluator-instructor administering the check. Preparation for the critique involves processing, reconstructing data collected, and oral presentation of the NATOPS evaluation report. Deviations from standard operating procedures will be covered in detail using all collected data and worksheets as a guide. Upon completion of the critique, the pilot and RIO will receive the completed copy of the NATOPS evaluation report for certification and signature. The completed NATOPS evaluation report will then be presented to the unit commanding officer.

42.8 FLIGHT EVALUATION GRADING CRITERIA

Only those subareas provided or required shall be graded. The grades assigned for a subarea shall be determined by comparing the degree of adherence to standard operating procedures with adjectival ratings listed below. Momentary deviations from standard operating procedures should not be considered as unqualifying provided such deviations do not jeopardize flight safety and the evaluee applied prompt corrective action.

42.8.1 Flight Evaluation Grade Determination. The following procedure shall be used in determining the flight evaluation grade: A grade of Unqualified in any critical area and subarea will result in an overall grade of Unqualified for the flight. Otherwise, flight evaluation (or area) grades shall be determined by assigning the following numerical equivalents to the adjective grade for each subarea. Only the numerals 0, 2, or 4 will be assigned in subareas. No interpolation is allowed.

1. Unqualified — 0.0.
2. Conditionally Qualified — 2.0.
3. Qualified — 4.0.

To determine the numerical grade for each area and the overall grade for the flight, add all the points assigned to the subareas and divide this sum by the number of subareas graded. The adjective grade shall then be determined on the basis of the following scale.

1. 0.0 to 2.19 — Unqualified.
2. 2.2 to 2.99 — Conditionally Qualified.
3. 3.0 to 4.0 — Qualified.

Example: (Add subarea numerical equivalents)

$$\frac{4 + 2 + 4 + 2 + 4}{5} = \frac{16}{5} = 3.20 \text{ or Qualified}$$

42.8.2 Final Grade Determination. The final NATOPS evaluation grade shall be the same as the grade assigned to the flight evaluation. An evaluee who receives an Unqualified on any ground examination or the flight evaluation shall be placed in an Unqualified status until a grade of Conditionally Qualified or Qualified is achieved on a reevaluation.

42.9 APPLICABLE PUBLICATIONS

The NATOPS Flight Manual contains the standard operations criteria for F-14B aircraft. Publications regarding environmental procedures peculiar to shore-based and shipboard operations and tactical missions are listed below:

1. F-14 Tactical Manual (NAVAIR 01-14AAA-1T)
2. NWP
3. NATOPS Air-to-Air Refueling Manual (NAVAIR 00-80T-110)
4. Air Traffic Control Center/Carrier Air Traffic Control Center (ATCC/CATCC) Manual
5. Local Air Operations Manual
6. Carrier Air Operations Manual.

42.10 NATOPS EVALUATION QUESTION BANK

The following bank of questions is intended to assist the unit NATOPS instructor-evaluator in the preparation of ground examinations and to provide an abbreviated study guide. The questions from the bank may be combined with locally originated questions in the preparation of ground examinations. The closed-book examination will consist of not less than 50 questions nor more than 75 questions. The time limit for the closed-book examination is 1 hour and 30 minutes. The requirements for the open-book examination are the same as those for the closed-book examination except there is no time limit.

For an additional bank of questions associated with the aircraft weapons systems, refer to NAVAIR 01-F14AAA-A.

NATOPS EVALUATION QUESTION BANK

NAME:______________________________

DATE:______________________________

1. The aircraft weighs approximately___________ including trapped fuel, oil, gun, pilot, and aircrew.

2. The aircraft is____________in length and has a wing span of_____________at 20° and in ___________oversweep.

3. The L INLET and R INLET caution lights indicate_________________________________.

4. During normal system operation, the status of AICS ramp control is as follows:

   Speed — Ramp Hydraulic Power

   M < 0.35 — ON/OFF
   Restrained by____________________________.

   M 0.35 to 0.5 — ON/OFF
   Commanded______________________________.

   M > 0.5 — ON/OFF
   Programmed as a function of________________.

5. An AICS failure that causes illumination of an INLET and or RAMP caution light results in the following:

   Speed — Ramp Resultant

   M < 0.35 ___________________________.

   M 0.5 to 0.9 ___________________________.

   M > 0.9 ___________________________.

6. During the AICS portion of OBC, simulated variant flight conditions cycle the____________ throughtheir full range of operation in about ______seconds. This exercises the _________ ______________________________________.

7. Operation of the L and R AICS is completely independent.

   a. True

   b. False

8. AICS anti-ice is available between_______IMN and_______IMN.

9. With the gear handle down and one or more ramps not in the stow position, the ramp light will be illuminated.

   a. True

   b. False

10. The installed thrust of the F110-GE-400 engine is__________pounds at MRT and___________ pounds at MAX A/B.

11. In SEC mode, both main engine fuel flow and compressor VSVs are scheduled________by the __________, and fan speed is limited______by the___________________.

12. A 3-percent increase in windmill rpm can be achieved by selecting____________________.

13. Nonemergency selection of the SEC mode should be performed in_________________________.

14. The augmenter fan temperature control system regulates five parameters of the engine to provide stall-free operation for any rate of throttle movement throughout the flight envelope. These parameters are:

    a. ______________________________

    b. ______________________________

    c. ______________________________

    d. ______________________________

    e. ______________________________

15. The engine electrical control subsystem is powered by an engine gearbox mounted (ac or dc) alternator that contains separate windings, which are:

    a. ______________________________

    b. ______________________________

    c. ______________________________

    d. ______________________________

16. What are the two power sources for fan speed limiting.

    a. ______________________________.

    b. ______________________________.

17. The backup ignition is powered by the aircraft ____________________BUS.

18. Autorelight logic is provided by the___________ _____________________________.

19. What are the throttle interlocks at the military power detent?

    a. ______________________________.

    b. ______________________________.

    c. ______________________________.

20. Autothrottle may be preflight ground tested on deck either in__________________or_________ ________. Indications that a malfunction exists in the autothrottle system are________________ or__________________.

21. List oil pressure readings:
    MRT________________________psi
    Minimum at IDLE_____________psi

22. An engine stall with no overtemperature will illuminate the appropriate STALL WARNING light in both PRI and SEC mode.

    a. True

    b. False

23. Normal ranges of nozzle position are:

    IDLE weight on wheels ________________.

    In-flight MR ________________.

    MIN A/B ________________.

    MAX A/B ________________.

24. What interlocks must be satisfied to activate the nozzle to the fully open position to reduce residual thrust?

    a. ______________________________.

    b. ______________________________.

25. Minimum rpm for ground start of the F110-GE-400 engine is___________percent rpm.

26. Maximum allowable EGT for ground starting the F110-GE-400 engine is____________°C.

27. The starting temperature limits are the same for both groundstarts and airstarts.

    a. True.

    b. False

28. At EGT readings of_______°C ± 10 °C, a warning tone is present in the pilot earphones.

29. At________°C the EGT chevrons begin to flash.

30. A hot engine should not be started until EGT is below________°C airborne.

31. Zero- or negative-g flight is limited to a maximum of____seconds in military power or less and____ seconds in afterburner in order not to ________ ____.

32. Above_______rpm the MEC should shut off fuel flow to the F110-GE-400 engine.

33. If the throttle boost system fails, the throttles automatically revert to manual mode, and the throttle mode switch returns to MAN.

    a. True

    b. False

34. What pilot action is required to reset the boost mode of throttle control subsequent to reversion to the manual mode?_________________________ _______________________.

35. ____ is the controlling parameter for the APCS.

36. Autothrottle engagement range is between ____________and____________percent rpm.

37. If the autothrottles are disengaged by any means, AUTO THROT light illuminates for a 10-second duration.

    a. True

    b. False

38. Engine rpm must be above________percent to supply sufficient power for the main engine ignition system.

39. When attempting a crossbreed or normal ground start, the ENG CRANK switch will not reengage if the engine is spooling down and engine rpm is between___________and___________percent.

40. During spooldown airstarts, hung starts in the low-rpm range (less than 45 percent) can be assisted with____________________________. Hung starts in the mid-rpm range (50 to 60 percent) can be corrected by________________.

41. If the IGV linkage breaks, the IGVs assume a__________position, which is near normal for____________power settings.

42. The number of delta Ps to check on each engine during preflight is________________________.

43. During an engine ground fire or abnormal start, be sure that the BACK UP IGNITION switch is in the ___________________position.

44. The L or R FIRE warning lights illuminate when the respective entire sensing loop is heated approximately_________°F or when any 6-inch section is heated to approximately__________°F.

45. What procedures should be followed to check oil level if it was not checked within 5 to 30 minutes after shutdown?__________________________ ____.

46. During preflight the oil sight gauge is always a reliable indicator of oil level.

    a. True

    b. False

47. The No. ___________bearing receives priority lubrication in the event of a loss of oil.

48. During cold starts, oil pressure greater than 65 psi should not be exceeded for more than_________ minute(s).

49. The electrical source for the oil pressure indicator is______________________________________.

50. The OIL PRESS warning light will illuminate when the pressure drops below_________psi and extinguishes when pressure rises above_____psi.

51. The L or R OIL HOT warning light indicates that the supply oil temperature has exceeded________ or the scavenge pump temperature has exceeded ____.

52. The INLET ICE caution light illuminates when ______________or_____________.

53. In AUTO, pitot probe heat is available only with weight off wheels.

    a. True

    b. False

54. RATS in available in SEC mode.

    a. True

    b. False

55. List the requirements for the RATS A/C circuitry to be enabled_____________________________.

56. Which of the following would result in illumination of the FUEL PRESS caution light?

    a. Failure of a motive flow pump

    b. Failure of a main fuel pump stage.

57. Failure of a motive flow fuel pump will have what effect on the engine and fuel system operation?

58. Failure of the main engine fuel pump will have what effect on engine operation?

59. The loss of an engine-driven boost pump will have what effect on operation of both engines?

60. Selecting either AFT or FWD with the fuel FEED switch performs what functions in the fuel system?

    a. ____________________

    b. ____________________

    c. ____________________

    d. ____________________

    e. ____________________.

61. The L/R FUEL LOW light illuminates with approximately_________pounds remaining in the respective feed group.

62. Automatic shutoff of wing and drop tank transfer occurs with WING/EXT TRANS switch in either AUTO or ORIDE.

    a. True

    b. False

63. The engine boost pump is powered by________ ____________________.

64. Is vent tank fuel quantity included in the fuel totalizer on the AFT and L indicator readings?

65. When should the FEED switch be activated to FWD or AFT?____________________.

66. What medium is used to actuate the feed tank interconnect valve, wing motive flow shutoff valves, and fuel dump valve?________________ ____________________.

67. Wing fuel is transferred by:

    a. Engine bleed air

    b. Motive flow fuel

68. The fuel thermistors in the outboard section of the wing tank perform what function?____________ ____________________.

69. The fuel thermistors in fuel cells No. 2 and No. 5 perform these functions when either is uncovered:

    a. ____________________

    b. ____________________

    c. ____________________

    d. ____________________

    e. ____________________.

70. All fuel entering the vent tank is vented overboard through the vent mast in the tailhook attachment fairing.

    a. True

    b. False

71. Fuel transfer from the external drop tanks is accomplished by__________________________.

72. External fuel transfer can be checked on the deck by_________________or___________________.

73. Fuel dump is prohibited with speedbrakes open and/or afterburner operation.

    a. True

    b. False

74. When the fuel dump circuit is activated, wing and external drop tank transfer is automatically initiated.

    a. True

    b. False

75. Is it possible to refuel in flight and accomplish total fuel transfer without electrical power or a combined hydraulic system? If not, why?______ ____________________.

76. On engine start with the generator switch in normal, the generator is automatically excited and the generator control unit brings it on the line when engine rpm is approximately_____percent.

77. ___________stage bleed air is used for IDG oil ground cooling.

78. If the thermal cutout decouples the drive clutch to either main generator in flight, the IDG may be recoupled (reset) a maximum of three times.

 a. True

 b. False

79. Failure of either ac generator automatically connects the left and right main ac buses to the operative generator. The cockpit indicator will be a___________________________caution light.

80. The emergency generator is powered by_______ ____.

81. If the emergency generator switch is in NORM, it will come on the line automatically when_______ ____.

82. When operating on the emergency generator, the cockpit lighting available consists of_______and _________.

83. A single engine-driven pump on the left powers the combined hydraulic system and a single engine-driven pump on the right powers the flight hydraulic system.

 a. True

 b. False

84. If the pilot extinguishes the MASTER CAUTION light after a failure of one main hydraulic system, failure of the other system (will or will not) illuminate the MASTER CAUTION light. Why? ____ ____.

85. List the requirements for operation of DLC.

86. With the left engine shut down in flight and 0 windmill rpm, the combined hydraulic system can be powered by___________________________ ____.

87. The hydraulic transfer pump will supply approximately________psi on the failed side with 3,000 psi on the other side.

88. With total loss of fluid from either main hydraulic system, the hydraulic transfer pump will:_______ ____.

89. The cockpit handpump will charge the brake accumulator in flight if_____________________ ____.

90. Loss of all hydraulic fluid from the flight hydraulic system will mean loss of power to the right inlet ramps.

 a. True

 b. False

91. With loss of the combined hydraulic system (combined system pressure zero), the main flaps are powered by________________________and the auxiliary flaps are______________________

92. With the landing gear emergency blown down, the nosewheel steering and normal brakes will operate after touchdown.

 a. True

 b. False

93. The outboard spoiler module uses combined system fluid.

 a. True

 b. False

94. Outboard spoilers are inoperative with wing-sweep angles aft of________________________.

95. The outboard spoiler module thermal cutout is inhibited when____________________________ ____.

96. The ON-OFF flag in the spoiler window of the hydraulic indicator indicates:

 a. The outboard spoiler module is energized.

 b. The outboard spoiler system is pressurized.

97. With loss of the combined hydraulic system (combined system pressure zero), the inboard spoilers will:____________________________ ____.

98. The backup flight control module powers the_________________and the____________ ____________________________.

99. With backup flight control module switch in AUTO, the module is automatically energized when___________________________________ ____ ____.

100. The backup flight control module switch has three positions, AUTO,______and______.

101. The backup flight control module operates in the high-speed mode when____________________ ____.

102. Operational status of the backup flight control module is indicated in the cockpit by__________ ____.

103. LC requires an operable outboard spoiler module.

  a. True

  b. False

104. Failure of either the combined or flight hydraulic system will have what effect on wing sweep?___ ____.

105. On the wing-sweep indicator, there are three position indicators. These show_______, _______ and______wing-sweep position.

106. The aircraft is being operated with the wing aft of the forward limit. The wing-sweep control mode indicator reads MAN. If speed is now increased beyond where the wing-sweep angle and forward limit coincide, the control mode indicator will read____________________and the wings will ____________________.

107. The most forward wing-sweep angle allowed in bomb mode is___________________________ _________________________.

108. The emergency wing-sweep mode is a manual method of positioning the wings. This method incorporates locks every____________from 20° to 68° to prevent random wing movement in this mode.

109. Illumination of the WING SWEEP advisory light means: __________________________________ ____.

110. Illumination of the WING SWEEP advisory light means: __________________________________ ____.

111. Transient failures in the CADC may be reset by: ____ ____.

112. The CADC is self-tested in_________________ ____.

113. When instrument test has been selected on the MASTER TEST panel, the EIG indications after 5 seconds are:

RPM __________________________

00EGT __________________________

FUEL FLOW __________________________

114. A degraded mode of EIG operation is indicated by ____.

115. Maneuver flaps can be lowered at any wing-sweep angle between 20° and_________.

116. The maneuvering flap thumbwheel will lower the main flaps______________, the auxiliary flaps and the slats______________. Use of the maneuvering devices (does or does not) put more restrictive g limitations on the aircraft.

117. What is the meaning of the following (besides CADC failure)?

  a. FLAP caution light:____________________

  b. REDUCE SPEED warning light:

    1)_________________________

    2)_________________________

    3)_________________________

118. Power for emergency extension of the landing gear is supplied by:________________________ ____.

119. The minimum bottle pressure for accomplishing emergency extension of the landing gear is ________psi, but a minimum preflight bottle pressure should be_________psi at 70 °F (21 °C).

120. Full lateral trim in the direction of stick displacement will provide approximately_________° of spoiler deflection.

121. Full slat asymmetry of 17° can result in an out-of-control situation at________________ units AOA or greater, even with 55° of spoilers available.

122. The rudder pedal shaker is armed with main flaps greater than___________° and the___________ computer operating.

123. With DLC engaged, full-up DLC positions the inboard spoilers at____________° and the horizontal stab trailing edges at_____________.

124. The initial position for spoilers when DLC is engaged is_______________________________.

125. The correct positioning for stabilizers when DLC is given full-down command (from trim) is_____ _____________________________trailing edge.

126. Full rudder throw of ±________° corresponds to ±________inches of rudder pedal travel.

127. Control surface authority of the stability augmentation system is:

    Pitch ±______________________________°

    Roll ±_______________________________°

    Yaw ±______________________________°

128. The gear handle is down and the three gear position indicators show the gear down, but the transition light is illuminated. What does this indicate and what action should be taken?

129. The ANTI SKID SPOILER BK switch is OFF and the BRAKE light is illuminated. This would indicate:

    a. ____________________________________

    b. ____________________________________

130. The BRAKE light (ANTI SKID SPOILER BK switch OFF) operates only when the brakes are depressed or the parking handle is pulled.

    a. ____________________________________

    b. ____________________________________

131. The two procedures for lowering the launch bar are:_______________or_________________.

132. Nosewheel steering cannot be engaged until the weight is on wheels.

    a. True

    b. False

133. With the nosewheel <70°, the nosewheel assumes the position commanded by the rudder pedals when nosewheel steering is engaged.

    a. True

    b. False

134. BLEED DUCT light indicates temperatures in excess of_______°F between engine and primary heat exchanger, or greater than______°F between primary heat exchanger and the ECS turbine.

135. The ram air door can be opened only if the ______or______button is depressed on the ECS control panel.

136. The ram air door automatically closes with selection of L ENG, R ENG or BOTH ENG on the ECS control panel.

    a. True

    b. False

137. The ram air door requires_______seconds to go full open and vice versa.

138. The RIO has a low-cockpit pressure caution light (CABIN PRESS) that illuminates if_________or _________________.

139. The OXY LOW light indicates__________. This low quantity should supply each flight crewmember with _____hours of oxygen at 20,000 feet (8,000-foot cabin altitude).

140. Pulling the emergency oxygen actuator releases gaseous oxygen charged to________psi and will provide approximately a________minute supply.

141. Windshield rain removal is accomplished by blowing 390 °F air over the outside of the windshield. If the temperature sensor detects an overtemperature condition, the WSHLD HOT advisory light will illuminate and________ ________________________________.

142. Maximum allowable headwind for the open canopy is_________knots.

143. When the canopy is jettisoned, the sill locks are released by_______________________________.

144. The canopy pneumatic reservoir must be serviced by ground servicing unit.

   a. True

   b. False

145. The pilot can tell the position of the command ejection lever by__________________________.

146. The RIO can eject both himself and the pilot with EJECT CMD handle set to PILOT.

   a. True

   b. False

147. The pilot can eject both himself and the RIO with the EJECT CMD handle set to MCO.

   a. True

   b. False

148. In the event the canopy does not separate from the aircraft when either flight crewmember has initiated ejection using the primary firing ring handle, actuating the alternate firing handle will allow "through the canopy" ejection.

   a. True

   b. False

149. There are_________safety pins per ejection seat.

150. Command ejection by either flight crewmember will eject the RIO in_______seconds and the pilot __________seconds later.

151. The time-release mechanism is set for______feet ±________.

152. All exterior lighting controls except for the light are located on the MASTER LIGHT panel on the pilot console, and the exterior light master switch on the outboard throttle.

   a. True

   b. False

153. When the wings are swept aft of____________, the__________position lights are disabled and the glove vane position lights are operable.

154. When the ANTI-COLLISION light switch is ON, the position lights flasher switch is disabled.

   a. True

   b. False

155. A proper indicator light test has the MASTER CAUTION light on steady.

   a. True

   b. False

156. The RIO can monitor SW tones by selection of _________position on the ICS panel.

157. The standby attitude indicator is capable of providing reliable attitude information within___ _________for up to___________minutes after a complete loss of power.

158. On deck, the allowable error between the primary, reset mode, and standby readings is______feet, and both modes should agree within______feet at field elevation.

159. The angle-of-attack indicator is checked during __________and the indexer during__________. Proper indications are:

   a. Indexer ____.

   b. Indicator ____.

160. In the landing configuration, 15 units AOA is equivalent in airspeed for:

   a. 48,000 pounds (DLC not engaged) =__________KIAS

   b. 48,000 pounds (DLC engaged) =__________KIAS

   c. 50,000 pounds (DLC engaged) =__________KIAS

161. With an airspeed indicator failure, list the angle of attack to fly for the following conditions (drag index 8):

   a. Catapult__________________

   b. Climb (MIL) SL TO___________COMBAT CEILING

   c. Cruise OPT. ALT.______________________

   d. Endurance at OPT. ALT.________________

162. The stores jettison system is the______________.

163. ACM jettison requires MASTER ARM ON.

   a. True

   b. False

164. Selective jettison can be completely controlled by either flight crewmember.

   a. True

   b. False

165. In the emergency jettison mode, the weight-on-wheels interlock is bypassed.

   a. True

   b. False

166. Emergency jettison mode will jettison Sidewinders.

   a. True

   b. False

167. Sidewinder is jettisoned by firing the motor and safing the warhead.

   a. True

   b. False

168. The pretaxi (weight on wheels) OBC master test is a complete check of the AWG-15 system.

   a. True

   b. False

169. Selection of any pulse dogfight mode automatically provides stab out aircraft reference.

   a. True

   b. False

170. The RIO must clear maintenance display prior to running OBC for current test results.

   a. True

   b. False

171. Class I OBC tests can be performed only.

   a. True

   b. False

172. For normal UHF operation with the ARC-182, the AM/FM switch should be in the_______position.

173. With track files established in TWS, the HUD and VDI provides the pilot complete steering information to the centroid of the targets.

   a. True

   b. False

174. The navigation system may be updated by five methods, they are:

   a. ____________________________________

   b. ____________________________________

   c. ____________________________________

   d. ____________________________________

   e. ____________________________________

175. In tacan BIT, the range and bearing on the HSD and BDHI should indicat_______nm and______.

176. The target designator (diamond) is valid to ±_____° off the nose.

177. With MASTER ARM OFF, the HUD and VDI armament legend will appear with________ ____.

178. The PLM button must be held depressed for at least 2 seconds to acquire a radar lock.

a. True

b. False

179. To obtain an attack presentation, the air-to-air button must be selected on the PDCP.

a. True

b. False

180. The AWG-9 aligns the EGI.

a. True

b. False

181. COOLING AIR light refers to air cooling out of tolerance while AWG-9 COND light indicates cooling out of tolerance.

a. True

b. False

182. The PTID is oriented to______north, with selection of GND STAB on the PTID mode switch.

183. RWS initiated targets can be hooked by the RIO for information readout.

a. True

b. False

184. Which of the following R/C presentations are available to the pilot:

a. IRS

b. PS

c. PDS

d. TWS

185. A________acronym indicates a failure of the AWG-15 (COATS incorporated) primary power supplies, thus preventing normal separation of stores in any launch mode.

186. If the radar antenna drive fails, the________may continue to display the antenna scan commanded on the sensor control panel.

187. The erase control continues to function in all STT modes.

a. True

b. False

188. The upper limit of VSL HI is_________; the lower limit of VSL LO is___________.

189. The LIQ COOLING switch in the RIO cockpit controls liquid coolant to the________system and _________missiles.

190. Hostile area altitude is entered in the_________ pseudo file to properly reject altitude line return.

191. Selecting PLM will break an existing radar lock.

a. True

b. False

192. MLC can be displayed on the DDD with the MLC switch in the________________position.

193. In sequence 5, the evaluation of search and missile channels with a circled check mark above the channel number indicates that channel has______ ____ ____.

194. In sequence 7, fault isolation, decision points in the BIT box would indicate:_________________ ____.

195. The RIO can read the NDRO tactical program number and its revision directly from the PTID in BIT sequence.

a. True

b. False

196. Maximum range displayed on the HUD is ______nm.

197. Maximum range displayed on the VDI is ______nm.

198. In aircraft without EGI, wind is automatically computed by the AWG-9 in the IMU/AM mode.

   a. True

   b. False

199. List the navigation files available for command steering on the HSD and ECMD:

   a. ____________ ____________________

   b. ____________ ____________________

   c. ____________ ____________________

   d. ____________ ____________________

   e. ____________ ____________________

   f. ____________ ____________________

   g. ____________ ____________________

200. A wind of 35 knots and 057° relative to the duty runway represents a headwind component of_______knots and crosswind of_______knots.

201. CM masking is initiated upon completion of OBC or with maintenance file displayed when the RIO selects______________________________
_____________________________________.

202. A CM mask may be cleared by:

   a. Clear_________, ___________, __________

   b. Run_______________________________

   c. __________________________________

203. A blinking LAR indicates

   a. TGT at MIN RANGE

   b. TGT at OPT RANGE

   c. TGT at MAX RANGE

   d. A and B

   e. All of the above

204. List the five modes of AIM-54 operation

   a. _________________________________.

   b. _________________________________.

   c. _________________________________.

   d. _________________________________.

   e. _________________________________.

205. What does a station six checkerboard on deck mean with a Phoenix on board the station: _____________________________________.

206. The Phoenix active displayed LARS are determined by the position of the___________switch.

207. A transition from PDSTT to PSTT with a CW AIM-7 in flight will cause CW Illumination to transmit through the CW flood antenna.

   a. True

   b. False

208. After completion of AIM-7 tune, the CW channel can be changed by selecting the desired MSL CHAN and recycling the______________switch.

209. A flashing BIT box during MAS sequence 4 means_________________________________.

210. The RTGS diamond indicates a____foot solution.

211. The RTGS pipper indicates a______foot solution.

212. Hydraulic power to drive the gun comes from the ________________system.

213. The gun can be fired with a CPA acronym in CM (COATS incorporated).

   a. True

   b. False

214. At 1,000 feet, the width of the diamond equals _________feet.

215. Pilot selection of the COMP mode commands the INS to use manually entered magnetic variation.

a. True

b. False

216. In non-EGI aircraft, with an AHRS advisory light, the INS automatically uses manually entered magnetic variation.

a. True

b. False

217. Failure of auto sequence 2 to run to completion will inhibit manual SAT.

a. True

b. False

218. With an STT, the director solution is represented by the ________________________________ and the LCOS solution is represented by the ________________________________.

PART XI

Performance Data

For aircraft performance data and charts, refer to NAVAIR 01-F14AAA-1.1

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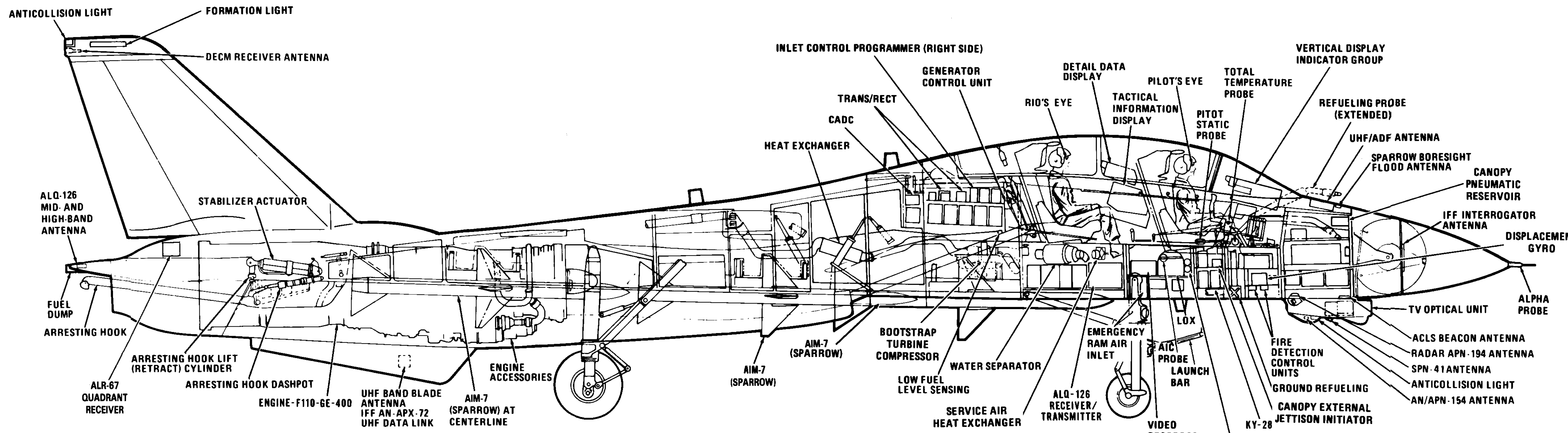
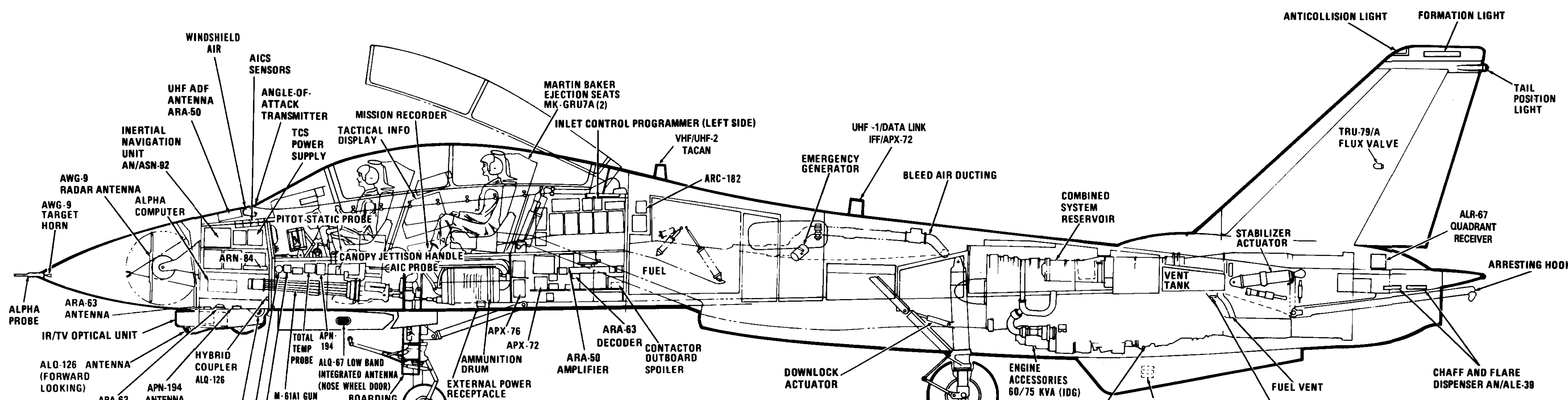


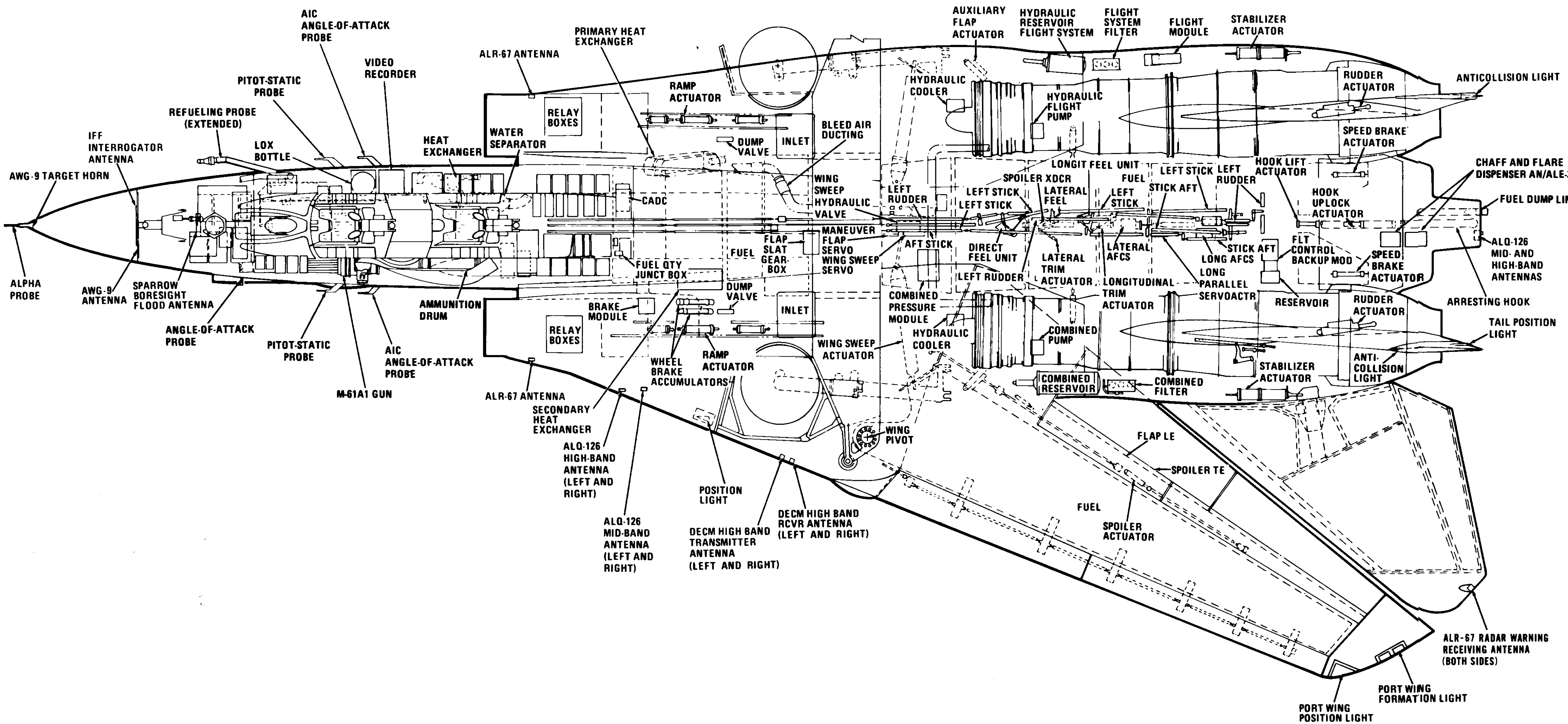
VIEW LOOKING INBOARD RIGHT SIDE



VIEW LOOKING INBOARD LEFT SIDE

14B-F0283

General Arrangement (Sheet 1 of 2)



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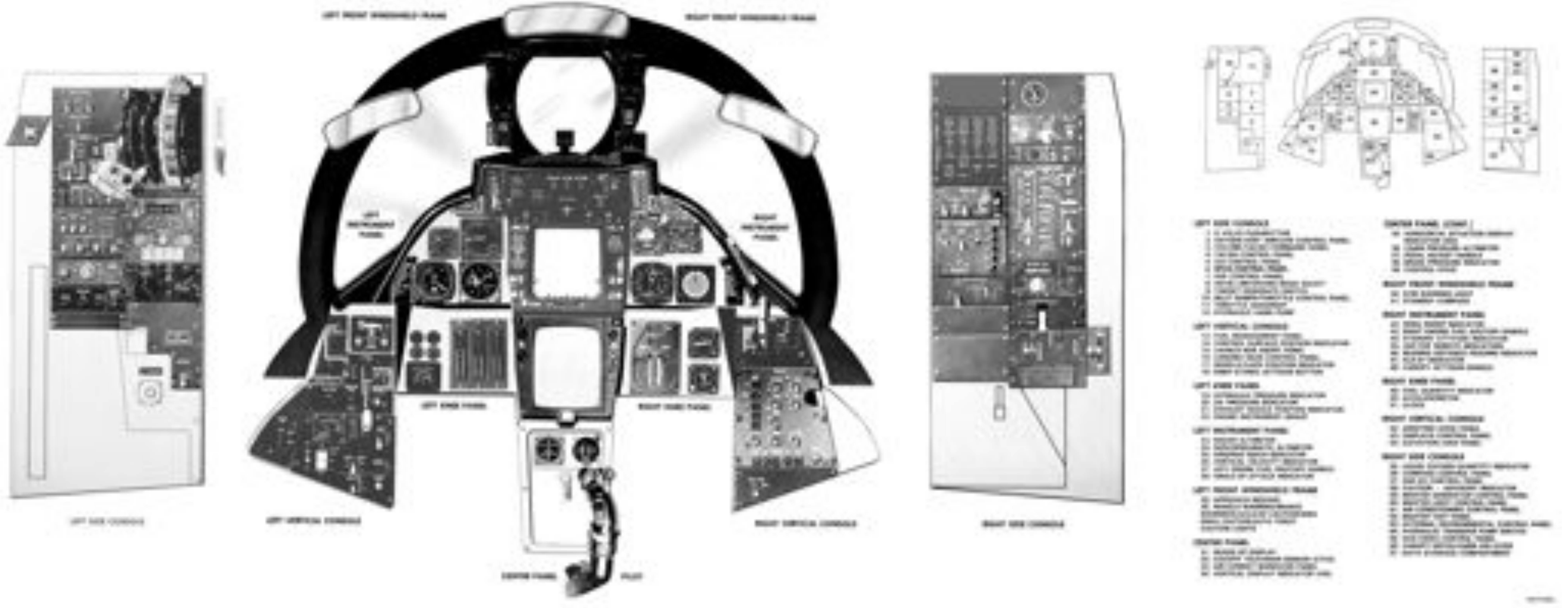
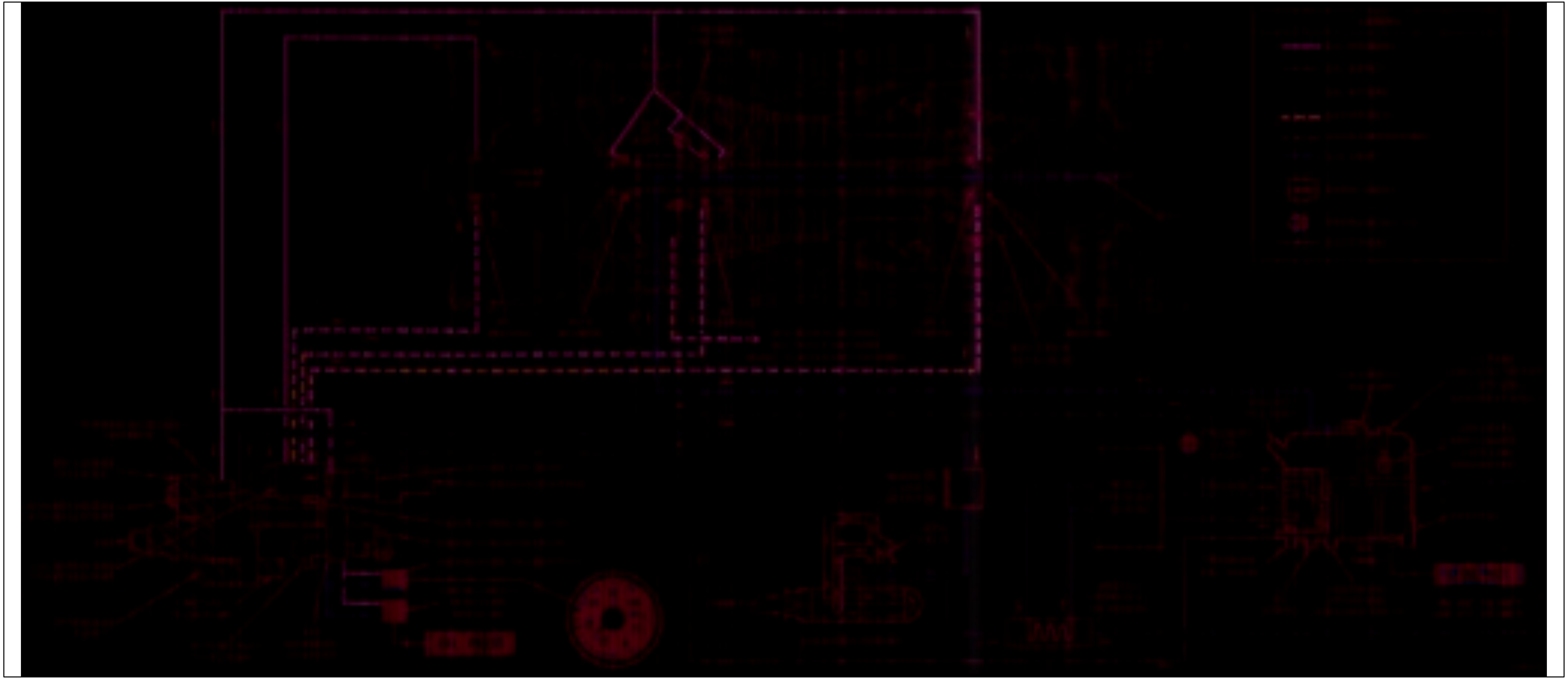
14B-F0284

General Arrangement (Sheet 2 of 2)



Pilot Instrument Panel and Console

RIO Instrument Panel and Consoles

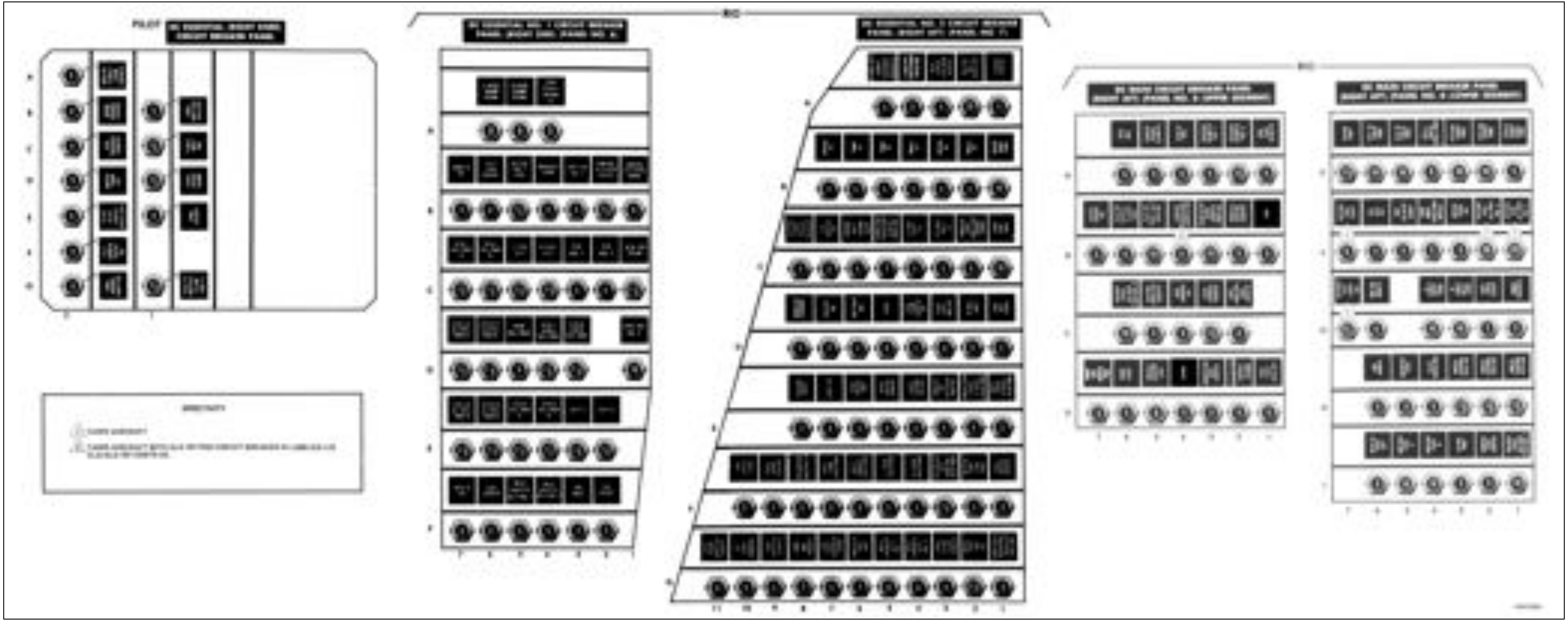


Engine Oil System

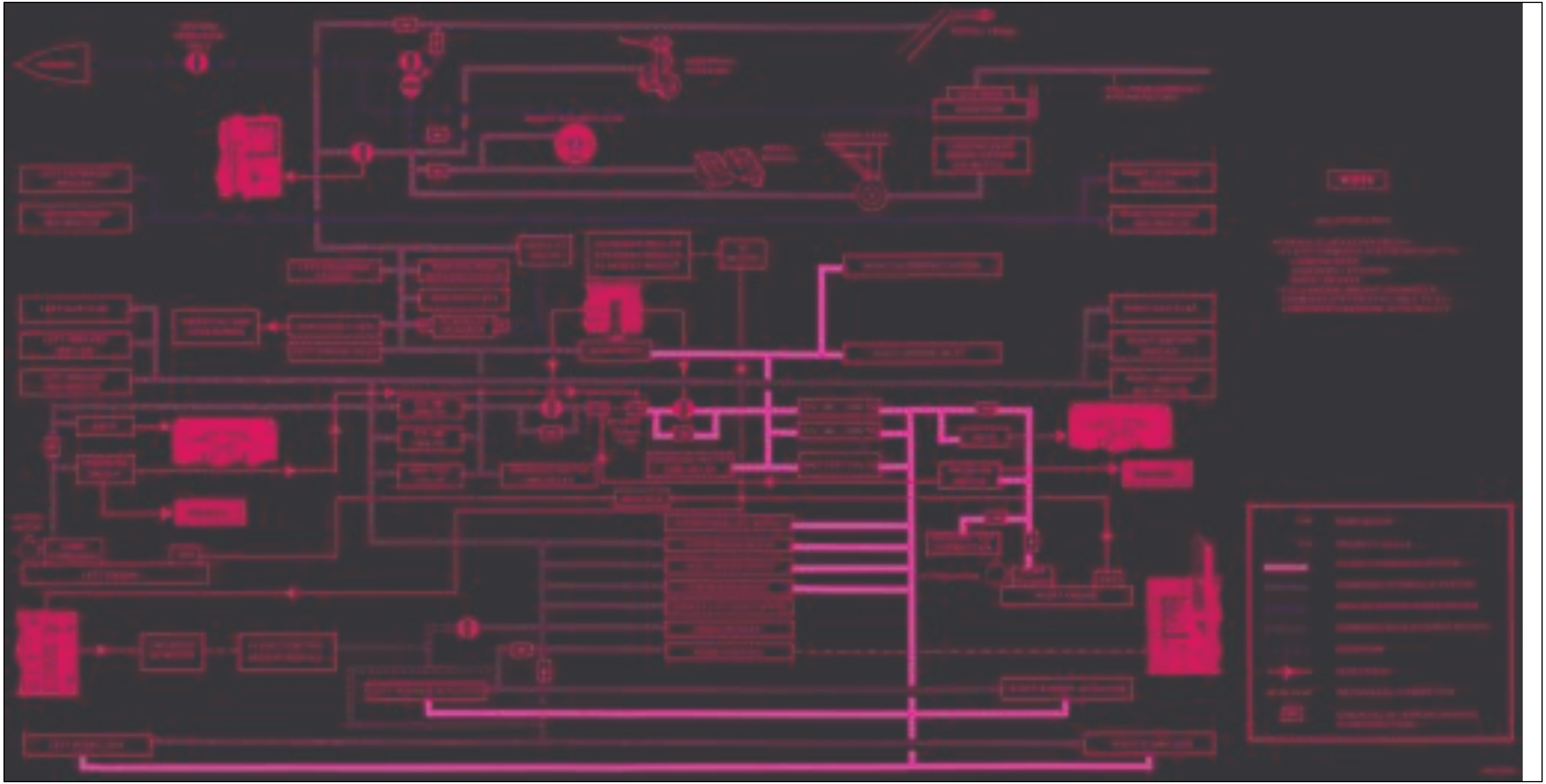
Aircraft Fuel System

Electrical Power System

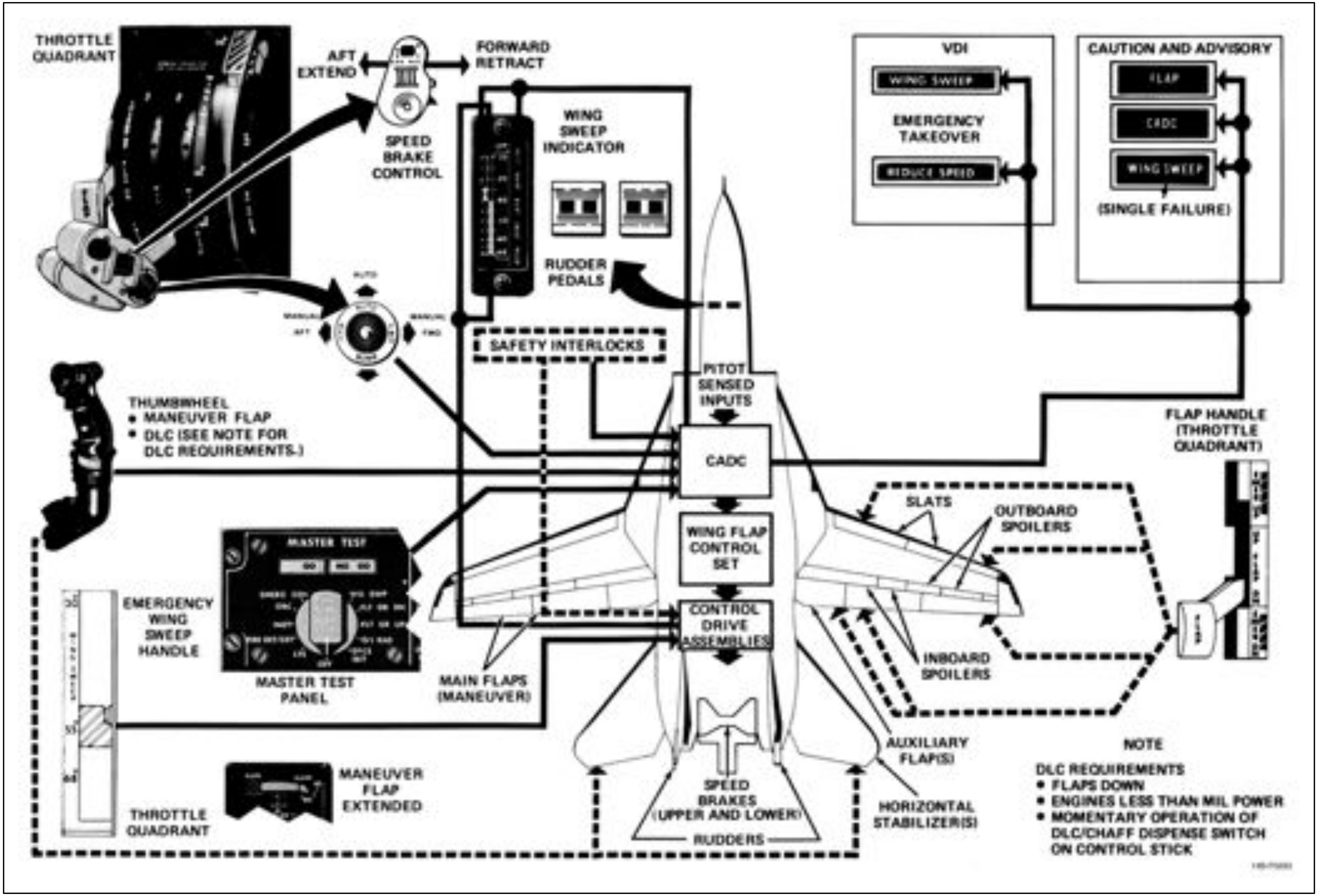
AC Cockpit Circuit Breaker Panels



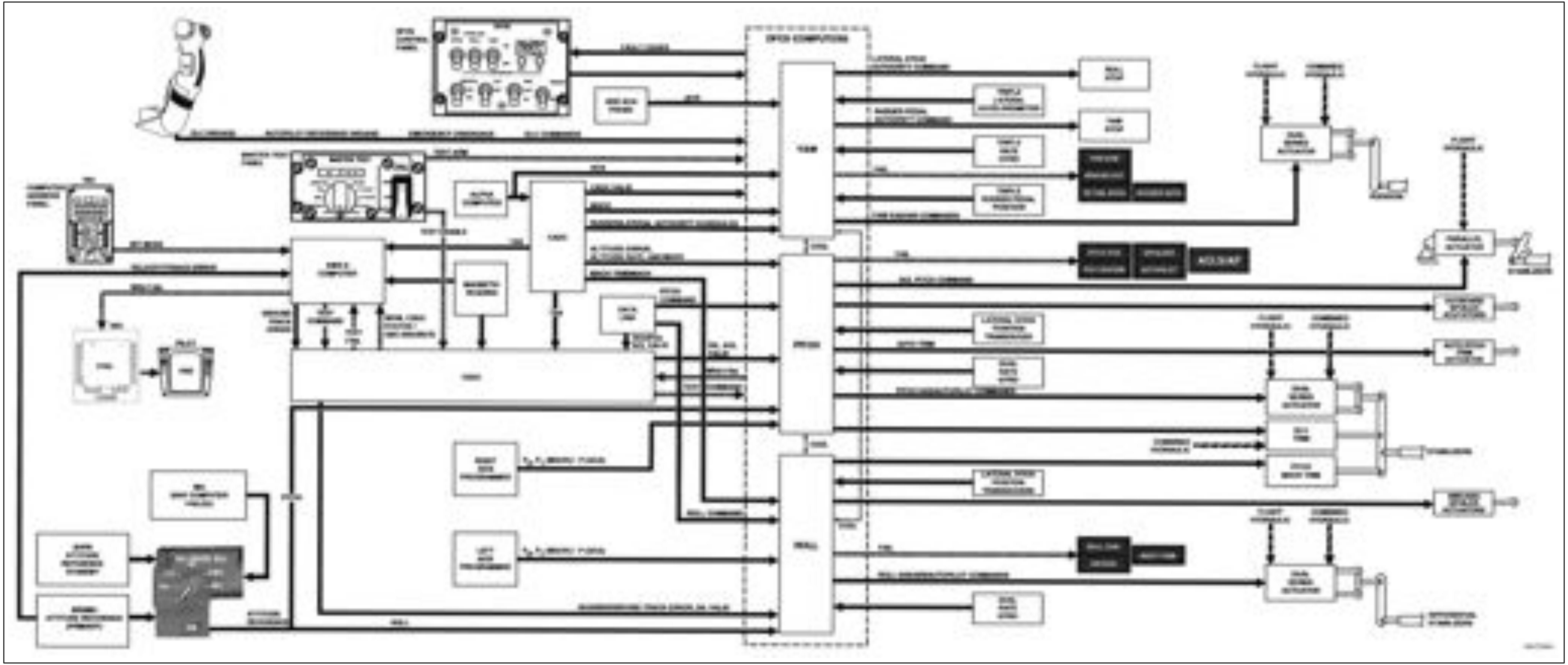
DC Cockpit Circuit Breaker Panels



Hydraulic System



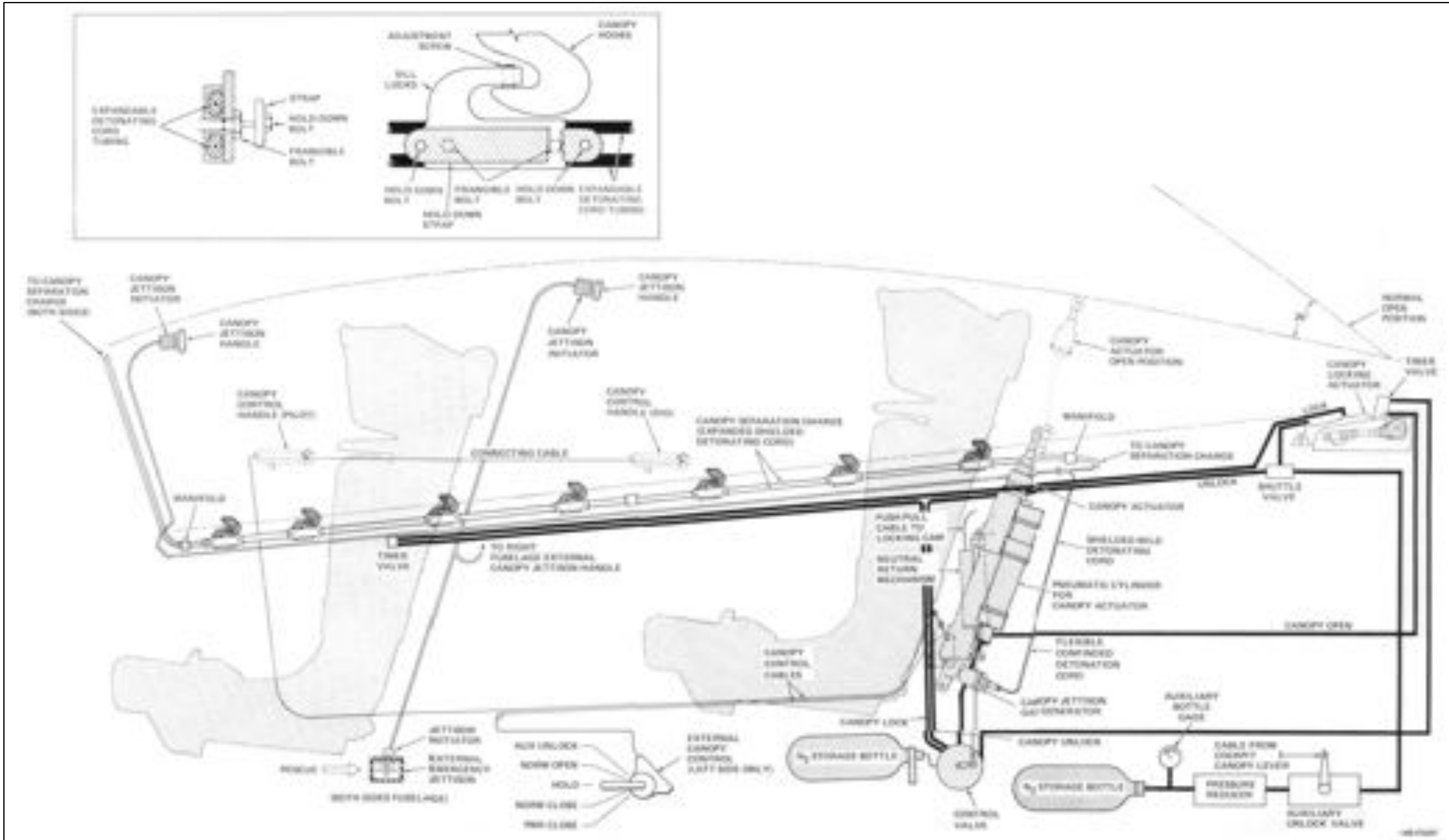
Wing Sweep and Control Surfaces



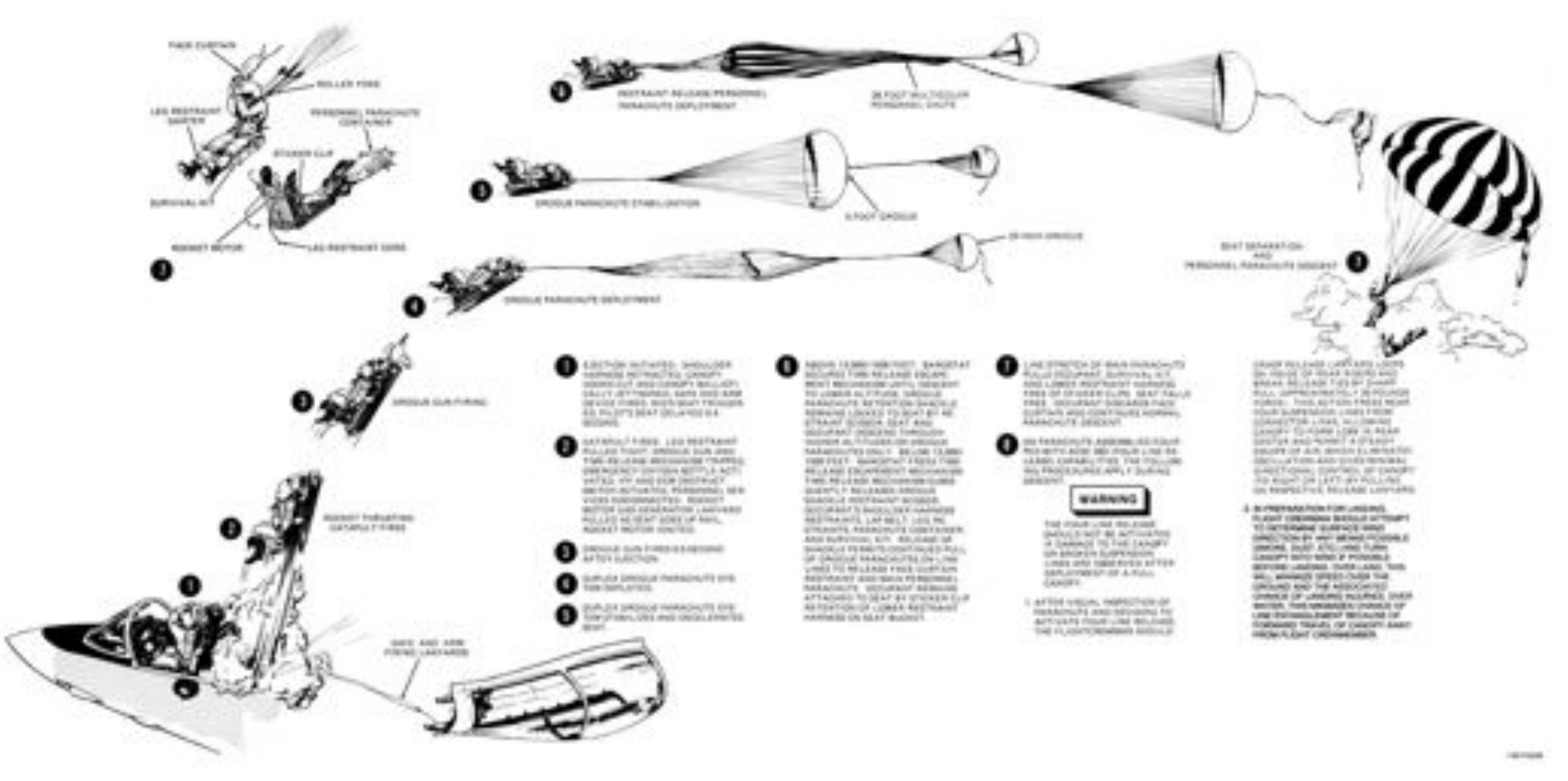
Digital Flight Control System

Environmental Control System

AIM-54 and Avionic Equipment Cooling

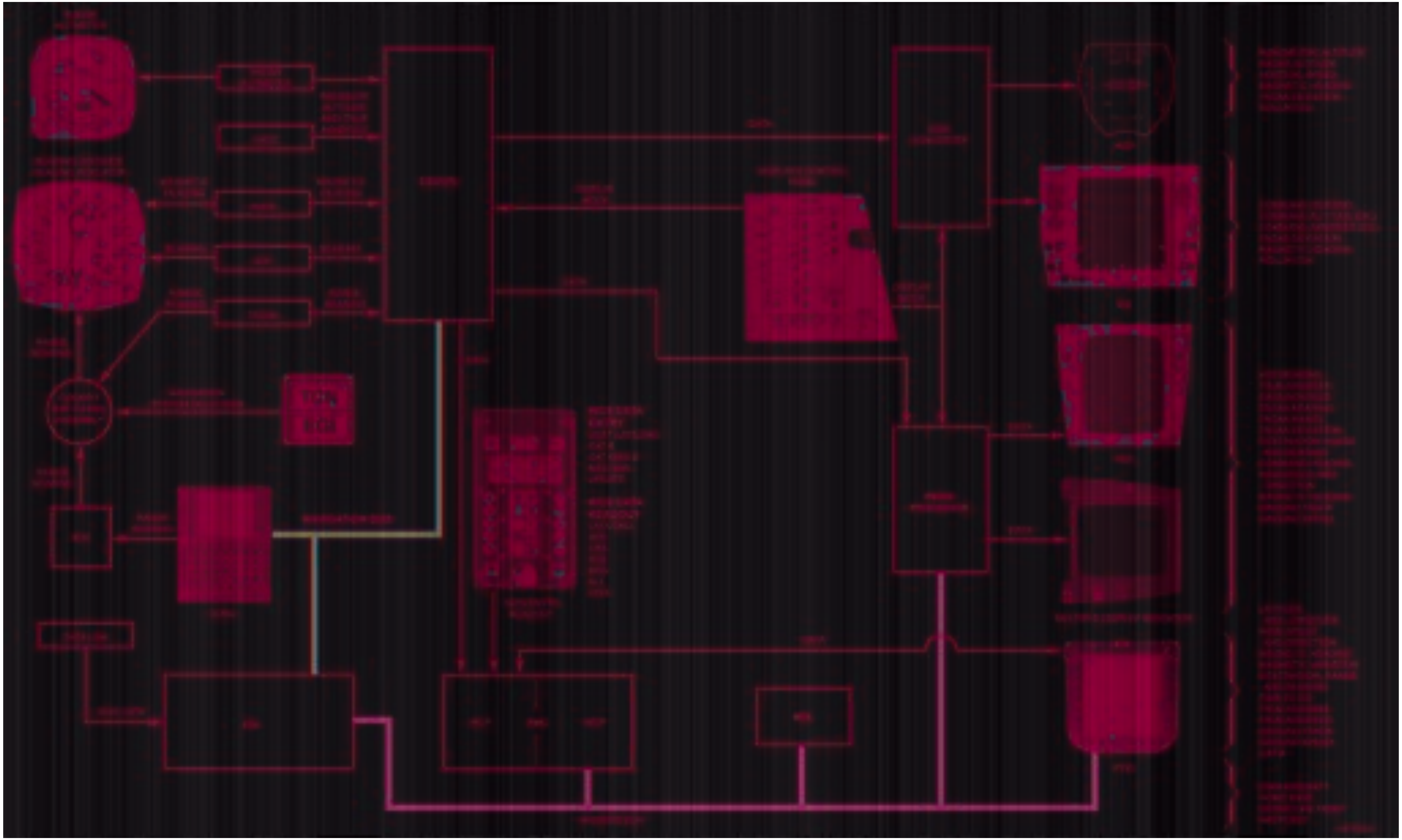


Canopy Pneumatic and Pyrotechnic Systems

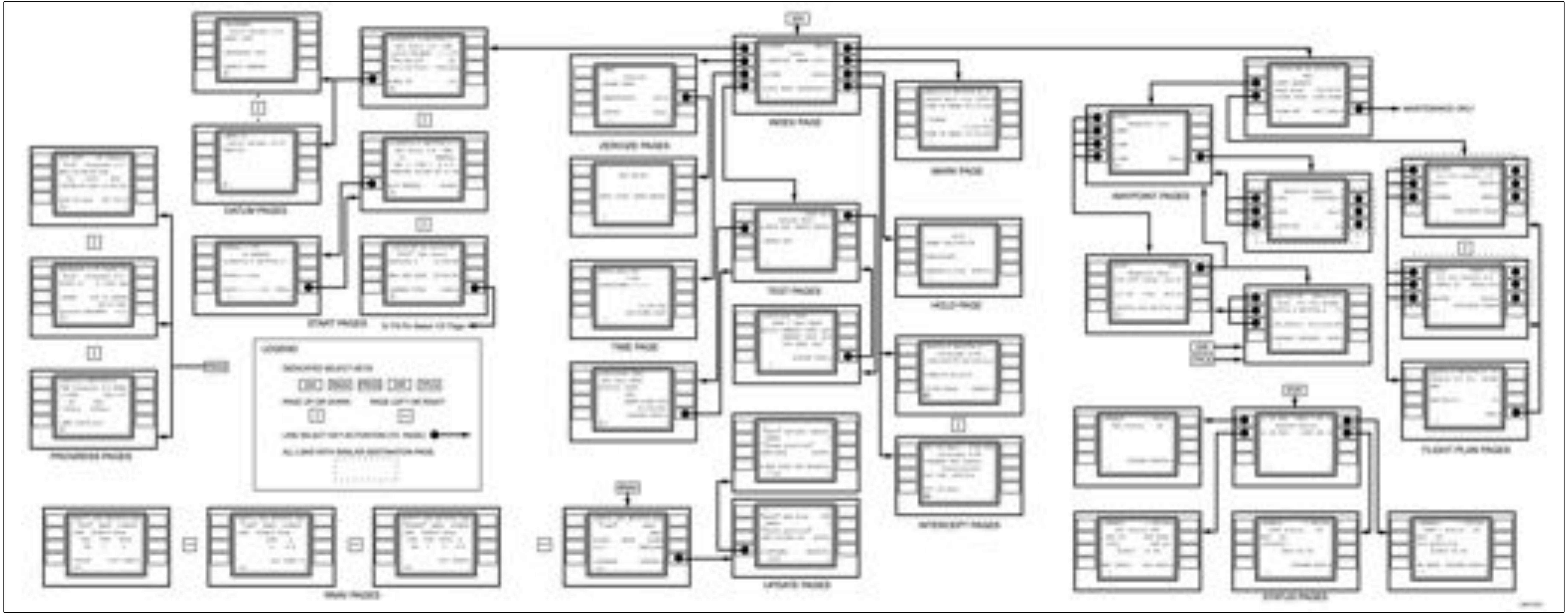


Ejection Sequence

Deck/Ground Handling Signals



Navigation Systems Overview



CDNU Page Trees

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