WARNING

DO NOT USE THIS MANUAL OR ANY OF THE RELATED MATERIALS IN ANY WAY IN THE OPERATION, USE OR MAINTENANCE OF ANY AIRCRAFT. THESE MATERIALS HAVE BEEN PREPARED AND ARE PROVIDED SOLELY TO GIVE GUIDANCE ON THE LAYOUT AND STRUCTURE OF A TYPICAL AIRCRAFT MANUAL. THESE MATERIALS HAVE NOT BEEN APPROVED BY ANY AVIATION ADMINISTRATION FOR USE ON ANY AIRCRAFT AND SHOULD NEVER BE SO USED UNDER ANY CIRCUMSTANCES. FAILURE TO FOLLOW THIS WARNING COULD LEAD TO SERIOUS INJURY OR DEATH.

787-8

Flight Crew Operations Manual

The Boeing Company

Document Number D615Z003-TBC
October 31, 2007

Revision Number: 0
Revision Date: October 31, 2007

October 31, 2007

Volume 1

Volume 2

Quick Reference Handbook (QRH)

General

The airplanes listed in the table below are covered in this manual. The numbers are used to distinguish data peculiar to one or more, but not all of the airplanes. Where data applies to all airplanes listed, no reference is made to individual airplane numbers.

The table permits flight crew correlation of configuration differences by Registry Number in alpha/numeric order within an operator's fleet for airplanes covered in this manual. Configuration data reflects the airplane as delivered configuration and is updated for service bulletin incorporations in conformance with the policy stated in the introduction section of this chapter.

Airplane number is supplied by the operator. Registry number is supplied by the national regulatory agency. Serial and tabulation numbers are supplied by Boeing.

Airplane Number	Registry Number	Serial Number	Tabulation Number
TBC-8	787-8	78708	ZX008

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General

This Flight Crew Operations Manual (FCOM) has been prepared by Boeing Commercial Airplanes, Commercial Aviation Services organization. The purpose of this FCOM is to:

- provide the operating limitations, procedures, performance, and systems information the flight crew needs to safely and efficiently operate the 787 airplane during all anticipated airline operations
- serve as a comprehensive reference for use during transition training for the 787 airplane
- serve as a review guide for use in recurrent training and proficiency checks
- provide necessary operational data from the FAA approved Airplane Flight Manual (AFM) to ensure that legal requirements are satisfied
- establish standardized procedures and practices to enhance Boeing operational philosophy and policy

This manual is prepared for the owner/operator named on the title page specifically for the airplanes listed in the “Model Identification” section. It contains operational procedures and information, which apply only to these airplanes. The manual covers the Boeing delivered configuration of these airplanes. Changes to the delivered configuration are incorporated when covered by contractual revision agreements between the owner/operator and The Boeing Company

This manual is not suitable for use for any airplanes not listed in the “Model Identification” section. Further, it may not be suitable for airplanes that have been transferred to other owners/operators.

Owners/operators are solely responsible for ensuring the operational documentation they are using is complete and matches the current configuration of the listed airplanes. This includes the accuracy and validity of all information furnished by the owner/operator or any other party. Owners/operators receiving active revision service are responsible to ensure that any modifications to the listed airplanes are properly reflected in the operational procedures and information contained in this manual.

This manual is structured in a two-volume format with a Quick Reference Handbook (QRH). Volume 1 includes operational limitations, normal and supplementary procedures, plus both dispatch and inflight performance data. Volume 2 contains systems information. The QRH contains all checklists necessary for normal and non-normal procedures as well as critical in-flight performance data.

The manual is periodically revised to incorporate pertinent procedural and systems information. Items of a more critical nature are incorporated in operational bulletins and distributed in a timely manner. In all cases, such revisions and changes must remain compatible with the approved AFM with which the operator must comply. In the event of conflict with the AFM, the AFM shall supersede.

This manual is written under the assumption that the user has had previous multi-engine jet aircraft experience and is familiar with basic jet airplane systems and basic pilot techniques common to airplanes of this type. Therefore, this manual does not contain basic flight information that is considered prerequisite training.

Any questions about the content or use of this manual should be directed to:

787 Training Director
P. O. Box 3707, M/C 20–86
Seattle, Washington 98124–2207 USA

Organization

The FCOM is organized in the following manner.

Volume 1 –

- Preface – contains general information regarding the manual's purpose, structure, and content. It also contains lists of abbreviations, a record of revisions, bulletins, and a list of effective pages
- Limitations and Normal Procedures chapters cover operational limitations and amplified normal procedures. All operating procedures are based on a thorough analysis of crew activity required to operate the airplane, and reflect the latest knowledge and experience available
- Supplementary Procedures chapter covers those procedures accomplished as required rather than routinely on each flight
- Performance Dispatch and Inflight chapters contain performance information necessary for self dispatch and to supplement performance data from the FMC

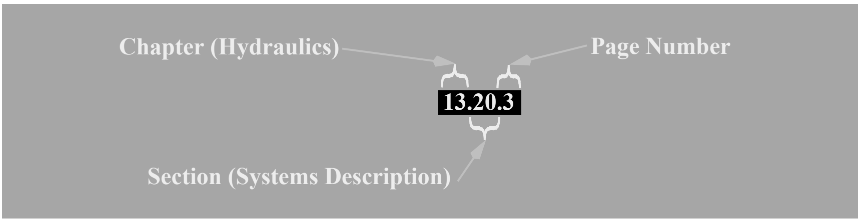
Volume 2 – Chapters 1 through 15 contain general airplane and systems information. These chapters are generally subdivided into sections covering controls and indicators and systems descriptions.

Quick Reference Handbook (QRH) – The QRH covers normal checklists, critical inflight performance, non–normal checklists, and maneuvers.

Page Numbering

The FCOM uses a decimal page numbering system. The page number is divided into three fields; chapter, section, and page. An example of a page number for the hydraulics chapter follows: chapter 13, section 20, page 3.

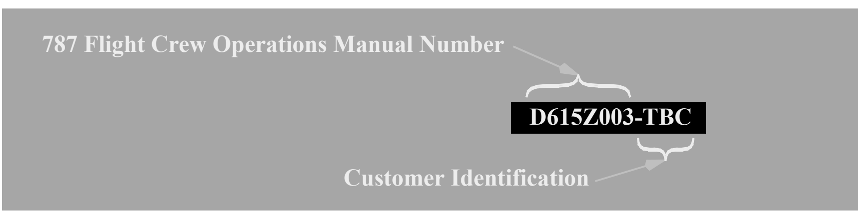
Example Page Number



Page Identification

Each page is identified by a customer document number and a page date. The customer document number is composed of the general 787 FCOM number, D615Z003–, and is followed by the customer identification.

Example Page Identification



Warnings, Cautions, and Notes

The following levels of written advisories are used throughout the FCOM and are not to be confused with EICAS messages, which are separately identified in the text.

WARNING: An operating procedure, technique, etc., that may result in personal injury or loss of life if not carefully followed.

CAUTION: An operating procedure, technique, etc., that may result in damage to equipment if not carefully followed.

Note: An operating procedure, technique, etc., considered essential to emphasize. Information contained in notes may also be safety related.

FCOM/QRH Configuration

Customer airplane configuration determines the data provided in this manual. The Boeing Company keeps a list of each airplane configuration as it is built and modified through the Common Change and Service Bulletin processes. The FCOM does not reflect customer originated modifications without special contract provisions.

Customer Configured Airplane Effectivity

Differences in airplane configuration for customer specific documents are shown by use of airplane effectivity throughout Volumes 1, 2, and QRH. The following rules are used to express airplane effectivity within customer documents:

- airplane effectivity can be displayed in one of four different formats; by tabulation number, serial number, registry number or (customer defined) airplane number. The default FCOM/QRH document effectivity display is by tabulation number
- airplane effectivities are listed in alpha-numeric order. A range of airplanes is defined by a dash, e.g. ZX008 - ZX014. A comma in the effectivity range indicates a break in the range, e.g. ZX008 - ZX014, ZX019, ZX021 - ZX025
- airplane effectivities apply only to the paragraph, illustration, operational note, procedural step, etc. and to subordinate items (if any) just below the specific effectivity range annotation;

Example (with subordinate items):

ZX008 - ZX014
Tail skid ....Check

Verify that the tail skid is not damaged.

Horizontal stailizer and elevator ....Check

In this example, the effectivity ZX008 - ZX014 applies to the first procedural step (Tail skid .....) and further indented/subordinate step (Verify ....). The effectivity does not apply to the next equivalently indented step (Horizontal stabilizer .....).

Example (without subordinate items):

ZX008 - ZX014
CARGO TEMPERATURE selector....................................... As needed
FORWARD CARGO AIR CONDITIONING........................ As needed

In this example, the effectivity ZX008 - ZX014 applies to the first procedural step (CARGO TEMP.....) only. The effectivity does not apply to the next procedural step (FORWARD CARGO .....).

When airplane effectivities are centered immediately below a checklist title, the entire checklist applies to the listed airplanes. In the following example, the PACK L, R checklist is applicable to ZX008 - ZX014 only:

[] PACK L, R

ZX008 - ZX014

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General

The following abbreviations may be found throughout the manual. Some abbreviations may also appear in lowercase letters. Abbreviations having very limited use are explained in the chapter where they are used.

A	
A	At or Above
ABS	Absolute
AC	Alternating Current
ACARS	Aircraft Communications Addressing and Reporting System
ACE	Actuator Control Electronics
ACP	Audio Control Panel
ACT	Active
ADF	Automatic Direction Finder
ADM	Air Data Module
ADRF	Air Data Reference Function
ADRS	Air Data Reference System
ADRU	Air Data Reference Unit
ADS	Automatic Dependant Surveillance
AFDC	Autopilot Flight Director Computer
AFDS	Autopilot Flight Director System
AFM	Airplane Flight Manual (FAA approved)
AGL	Above Ground Level
AHRU	Attitude Heading Reference Unit
AI	Anti–Ice
AIL	Aileron
ALT	Altitude
ALTN	Alternate
AM	Amplitude Modulation
AMI	Airline Modifiable Information
ANP	Actual Navigation Performance
ANT	Antenna
AOA	Angle of Attack
APP	Approach
APU	Auxiliary Power Unit
A/C	Air Conditioning
A/P	Autopilot

ARINC	Aeronautical Radio, Incorporated
APT	Airport
ASG	APU Starter Generator
ATA	Actual Time of Arrival
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
ATN	Aeronautical Telecommunications Network
ATP	Alerting and Transponder Control Panel
ATRU	Autotransformer Rectifier Unit
ATSP	Air Traffic Service Provider
ATT	Attitude
ATU	Autotransformer Unit
AUTO	Automatic
AUX	Auxiliary
AVAIL	Available
AVS	Alternate Ventilation System

B	
B	At or Below
BAC	Back Course
BARO	Barometric
BAT	Battery
BCRS	Back Course
BFO	Beat Frequency Oscillator
BITE	Built In Test Equipment
BPCU	Bus Power Control Unit
BPT	Break Power Transfer
BRG	Bearing
BRT	Bright
BSCU	Brake System Control Unit
BTB	Bus Tie Breaker
BTL DISCH	Bottle Discharge (fire extinguishers)

C	
C	Captain Celsius Center
CAB	Cabin
CAC	Cabin Air Compressor
CALC	Calculated
CANC/ RCL	Cancel/Recall
CAPT	Captain
CAS	Calibrated Airspeed
CB	Circuit Breaker
CBIC	Circuit Breaker Indication and Control
CCD	Cursor Control Device
CCR	Common Computing Resource

CCS	Common Core System or Cursor Control Selector
CDN	Common Data Network
CDU	Control Display Unit
CG	Center of Gravity
CHKL	Checklist
CIPS	CAC Ice Protection System
CLB	Climb
CLR	Clear
CO	Company
COMM	Communication
CON	Continuous
CONFIG	Configuration
CORR	Corrected
CRS	Course
CRZ	Cruise
CTL	Control
CTR	Center
CTRL	Control
CVR	Cockpit Voice Recorder

D	
DA(H)	Decision Altitude (Height)
DC	Direct Current
DDG	Dispatch Deviations Guide
D/D	Drift Down
DECR	Decrease
DEL	Delete or Deleted
DEP ARR	Departure Arrival
DES	Descent
DEST	Destination
DIR	Directory or Direct or Direction
DISC	Disconnect
DIST	Distance
DME	Distance Measuring Equipment
DN	Down
DSP	Display Select Panel
DSPL	Display
DTG	Distance To Go
DU	Display Unit

E	
EBA	Electric Brake Actuator
EBAC	Electric Brake Actuator Controller
E-BPSU	Electric Brake Power Supply Unit
ECB	Electronic Circuit Breaker
ECS	Environmental Control System

ECON	Economy
E/D	End of Descent
EEC	Electronic Engine Control
E/E	Electrical and Electronic
EFB	Electronic Flight Bag
EFC	Expected Further Clearance
EFIS	Electronic Flight Instrument System
EGT	Exhaust Gas Temperature
EICAS	Engine Indication and Crew Alerting System
ELEC	Electrical
ELEV	Elevator
EMER	Emergency
EMG	Emergency
EMP	Electric Motor Pump
ENG	Engine
EO	Engine Out
EP	External Power
EPGSS	Electrical Power Generation and Start System
EST	Estimated
ETA	Estimated Time of Arrival
EVAC	Evacuation
EXEC	Execute
EXT	Extend or External

F	
F	Fahrenheit
FA	Final Approach
FAC	Final Approach Course
FCAC	Forward Cargo Air Conditioning
FCE	Flight Control Electronics
FCOM	Flight Crew Operations Manual
FCTL	Flight Control
FD	Flight Deck
F/D	Flight Director
FF	Fuel Flow
FL	Flight Level
FLCH	Flight Level Change
FLPRN	Flaperon
FLT	Flight
FLT DIR	Flight Director
FMC	Flight Management Computer
FMS	Flight Management System
F/O	First Officer
FPA	Flight Path Angle
FPM	Feet Per Minute

FPV	Flight Path Vector
FR	From
FT	Feet
FWD	Forward

G	
GA	Go–Around
GCB	Generator Control Breaker
GCU	Generator Control Unit
GEN	Generator
GLS	GPS Landing System
GND	Ground
GP	Glidepath
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
GR WT	Gross Weight
GS	Groundspeed
G/S	Glideslope
GTK	Ground Track

H	
HBB	Hot Battery Bus
HDG	Heading
HDG REF	Heading Reference
HDG SEL	Heading Select
HF	High Frequency
HPA	Hectopascals
HT	Height
HUD	Head Up Display
H/WIND	Head Wind

I	
IAN	Integrated Approach Navigation
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organization
ICS	Integrated Cooling System
IDENT	Identification
IFE	In-Flight Entertainment System
IFR	Instrument Flight Rules
IGS	Instrument Guidance System
ILS	Instrument Landing System
IN	Inches
INBD	Inboard
INCR	Increase
IND LTS	Indicator Lights
INFO	Information
INIT	Initialize or Initialization
INOP	Inoperative
INT	Interphone
INTC CRS	Intercept Course

IRS	Inertial Reference System
IRU	Inertial Reference Unit
ISFD	Integrated Standby Flight Display
ISLN	Isolation
ISS	Integrated Surveillance System

K	
K	Knots
KG or KGS	Kilograms

L	
L	Left
LAT	Latitude
LB or LBS	Pounds
LCD	Liquid Crystal Display
LDA	Localizer-Type Directional Aid
LDG ALT	Landing Altitude
LED	Light Emitting Diode
LIM	Limit
LNAV	Lateral Navigation
LOC	Localizer
LONG	Longitude
LRC	Long Range Cruise
LRU	Line Replaceable Unit
LSK	Line Select Key
LTB	Left Tie Bus
LVL	Level
LVTO	Limited Visibility Takeoff
LWR CTR	Lower Center
LWR DSPL	Lower Display
L1	Left Engine Generator #1
L2	Left Engine Generator #2

M	
MAG	Magnetic
MAN	Manual
MAX	Maximum
MBR	Main Battery Relay
MCP	Mode Control Panel
MCS	Miscellaneous Cooling System
MDA(H)	Minimum Descent Altitude (Height)
MEL	Minimum Equipment List
MFD	Multifunction Display
MFK	Multifunction Keyboard
MHZ	Megahertz
MIC	Microphone
MIN	Minimum
MISC	Miscellaneous
MKR	Marker Beacon

MMO	Maximum Operating Mach
MOD	Modify
MSG	Message
MSL	Mean Sea Level
MTRS	Meters

N	
N	Normal
NAV	Navigation
NAV RAD	Navigation Radio
N/A	Not Applicable
NBPT	No-Break Power Transfer
ND	Navigation Display
NGS	Nitrogen Generation System
NM	Nautical Miles
NO	Number
NORM	Normal
NPS	Navigation Performance Scales
N1	Low Pressure Rotor Speed
N2	High Pressure Rotor Speed (General Electric engines) Intermediate Pressure Rotor Speed (Rolls–Royce engines)
N3	High Pressure Rotor Speed (Rolls-Royce engines)

O	
OAT	Outside Air Temperature
OBS	Observer
OFAR	Overhead Flight Attendant Rest
OFCR	Overhead Flight Crew Rest
OHU	Overhead Unit
OMS	On-board Maintenance System
OP	Operational
OPC	Operational Program Configuration
OPT	Optimum
OUTBD DSPL	Outboard Display
OVHD	Overhead
OVRD	Override

P	
PA	Passenger Address
PASS	Passenger
PCS	Power Conversion System
PECS	Power Electronics Cooling System
PERF	Performance
PERF INIT	Performance Initialization
PF	Pilot Flying

PFC	Primary Flight Computers
PFD	Primary Flight Display
PG	Page
PM	Pilot Monitoring
PMG	Permanent Magnet Generator
PNL	Panel
POS	Position
POS INIT	Position Initialization
PPDS	Primary Power Distribution System
PRED	Predicted
PREV	Previous
PROC	Procedure
PROG	Progress
PSU	Passenger Service Unit
PTH	Path
PTT	Push-To-Talk
PWS	Predictive Windshear System

Q	
QFE	(altitude above station)
QNH	(altitude above sea level)
QRH	Quick Reference Handbook
QTY	Quantity
QUAD	Quadrant

R	
R	Right
RA	Radio Altitude or Resolution Advisory
RAD	Radio
RAT	Ram Air Turbine
RCD	Record
RDC	Remote Data Concentrator
RECIRC	Recirculation
RECMD	Recommended
REF	Reference
REL	Relative
RESTR	Restriction
RET	Retract
RF	Refill
RNP	Required Navigation Performance
RNV	Area Navigation (RNAV)
RPDS	Remote Power Distribution System
RPTG	Reporting
RTA	Required Time of Arrival
RTB	Right Tie Breaker
RTE	Route
RVSM	Reduced Vertical Separation Minimum
RW	Runway

RWY	Runway
R1	Right Engine Generator #1
R2	Right Engine Generator #2

S	
SAT	Static Air Temperature or Satellite
SATCOM	Satellite Communication System
S/C	Step Climb
SDF	Simplified Directional Facility
SEL	Select
SELCAL	Selective Calling System
SID	Standard Instrument Departure
SPD	Speed
SPU	Start Power Unit
STA	Station
STAB	Stabilizer
STAR	Standard Terminal Arrival Route
STAT	Status
STBY	Standby
STD	Standard
SUPP	Supplemental
SYS	System

T	
T	True or Turbulence
TA	Traffic Advisory
TAC	Thrust Asymmetry Compensation
TAI	Thermal Anti Ice
TAMS	Thrust Asymmetry Minimum Speed
TAS	True Airspeed
TAT	Total Air Temperature
TBC	The Boeing Company
TBD	To Be Determined
TCAS	Traffic Alert and Collision Avoidance System
TCB	Thermal Circuit Breaker
TCP	Tuning and Control Panel
T/C	Top of Climb
T/D	Top of Descent
TEMP	Temperature
TERR	Terrain
TFC	Traffic
TGT	Target
THR	Thrust
TO	Takeoff
TOGW	Takeoff Gross Weight
TOT	Total
TO/GA	Takeoff/Go–Around

TPR	Turbofan Power Ratio
TRANS	Transition
TRK	Track
TRU	Transformer Rectifier Unit
TRU	True (reference to True North)
TTG	Time To Go
TWIP	Terminal Weather Information for Pilots

U	
UL	Up Link
UNAVAIL	Unavailable
UNLKD	Unlocked
UPR DSPL	Upper Display
USB	Upper Side Band
UTC	Universal Time Coordinated

V	
V_A	Design Maneuvering Speed
VAR	Variation
V/B	Vertical Bearing
VERT	Vertical
VFR	Visual Flight Rules
VFSG	Variable Frequency Starter Generator
VHF	Very High Frequency
VMC	Visual Meteorological Condition
VMO	Maximum Operating Speed
VNAV	Vertical Navigation
VOR	VHF Omnidirectional Range
VR	Rotation Speed
VREF	Reference Speed
VSD	Vertical Situation Display
V/S	Vertical Speed
VTK	Vertical Track
V1	Takeoff Decision Speed
V2	Takeoff Safety Speed

W	
WGS-84	World Geodetic Survey 1984
WIPS	Wing Ice Protection System
WPT	Waypoint
WX	Weather Radar
WXR	Weather Radar

X	
X	(generic reference to a variable instance)
XFR	Transfer
XPDR	Transponder
XTK	Cross Track
X/WIND	Crosswind

Z	
ZFW	Zero Fuel Weight

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Revision Transmittal Letter

To: All holders of The Boeing Company 787 Flight Crew Operations Manual, Boeing Document Number D615Z003-TBC.

Subject: Flight Crew Operations Manual Revision.

This revision reflects the most current information available to The Boeing Company 45 days before the subject revision date. The following revision highlights explain changes in this revision. General information below explains the use of revision bars to identify new or revised information.

Revision Record

No.	Revision Date	Date Filed	No.	Revision Date	Date Filed
0	October 31, 2007				

General

The Boeing Company issues flight crew operations manual revisions to provide new or revised procedures and information. Formal revisions also incorporate appropriate information from previously issued flight crew operations manual bulletins.

The revision date is the approximate date the manual is mailed to the customer.

Formal revisions include a Transmittal Letter, a new Revision Record, Revision Highlights, and a current List of Effective Pages. Use the information on the new Revision Record and List of Effective Pages to verify the manual content.

Pages containing revised technical material have revision bars associated with the changed text or illustration. Editorial revisions (for example, spelling corrections) may have revision bars with no associated highlight.

The record above should be completed by the person incorporating the revision into the manual.

Filing Instructions

Consult the List of Effective Pages (0.5). Pages identified with an asterisk (*) are either replacement pages or new (original) issue pages. Remove corresponding old pages and replace or add new pages. Remove pages that are marked DELETED; there are no replacement pages for deleted pages.

Revision Highlights

This section (0.4) replaces the existing section 0.4 in your manual.

Be careful when inserting changes not to throw away pages from the manual that are not replaced. Using the List of Effective Pages (0.5) can help determine the correct content of the manual.

Throughout the manual, airplane effectivity may be updated to reflect coverage as listed on the Preface - Model Identification page, or to show service bulletin airplane effectivity. Highlights are not supplied.

This manual is published from a database; the text and illustrations are marked with configuration information. Occasionally, because the editors rearrange the database markers, or mark items with configuration information due to the addition of new database content, some customers may receive revision bars on content that appears to be unchanged. Pages may also be republished without revision bars due to slight changes in the flow of the document.

Preface — Chapter 0
V1V2 List of Effective Pages — Section 5

Page	Date
Volume 1	
* Title Page	October 31, 2007
* Copyright	October 31, 2007
* 0.0.1-2	October 31, 2007
* 0.1.1-2	October 31, 2007
* 0.2.1-6	October 31, 2007
* 0.3.1-12	October 31, 2007
Revision Record (tab)	
* 0.4.1-2	October 31, 2007
* 0.5.1-4	October 31, 2007
Bulletins (tab)	
* 0.6.1-2	October 31, 2007
* 0.7.1-2	October 31, 2007
Limitations (tab)	
* L.TOC.0.1-2	October 31, 2007
* L.10.1-6	October 31, 2007
Normal Procedures (tab)	
* NP.TOC.0.1-2	October 31, 2007
* NP.11.1-8	October 31, 2007
* NP.21.1-42	October 31, 2007
Supplementary Procedures (tab)	
* SP.TOC.0.1-4	October 31, 2007
* SP.05.1-2	October 31, 2007
* SP.1.1-2	October 31, 2007
* SP.2.1-2	October 31, 2007
* SP.3.1-2	October 31, 2007
* SP.4.1-10	October 31, 2007

Page	Date
Supplementary Procedures (cont)	
* SP.5.1-2	October 31, 2007
* SP.6.1-2	October 31, 2007
* SP.7.1-2	October 31, 2007
* SP.10.1-2	October 31, 2007
* SP.11.1-4	October 31, 2007
* SP.12.1-2	October 31, 2007
* SP.16.1-20	October 31, 2007
Performance - Dispatch (tab)	
* PD.TOC.1-2	October 31, 2007
* PD.TOC.10.1-2	October 31, 2007
* PD.10.1-10	October 31, 2007
* PD.11.1-10	October 31, 2007
* PD.12.1-6	October 31, 2007
* PD.13.1-6	October 31, 2007
Performance - Inflight (tab)	
* PI.TOC.1-2	October 31, 2007
* PI.TOC.10.1-4	October 31, 2007
* PI.10.1-22	October 31, 2007
* PI.11.1-8	October 31, 2007
* PI.12.1-24	October 31, 2007
* PI.13.1-12	October 31, 2007
* PI.14.1-4	October 31, 2007
* PI.15.1-4	October 31, 2007
* PI.16.1-4	October 31, 2007
* PI.17.1-4	October 31, 2007
* PI.18.1-12	October 31, 2007
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* = Revised, Added, or Deleted

* = Revised, Added, or Deleted

* = Revised, Added, or Deleted

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* = Revised, Added, or Deleted

Preface — Chapter 0
Bulletin Record — Section 6

General

The Boeing Company issues Flight Crew Operations Manual Bulletins to provide important information to flight crews prior to the next formal revision of the Flight Crew Operations Manual. The transmitted information may be of interest to only specific Operators or may apply to all Operators of this model airplane. Each bulletin will vary.

Bulletins are dated and numbered sequentially. Each bulletin identifies airplanes affected by the bulletin. Absence of airplane effectivity indicates the bulletin applies to all airplanes in an Operator's fleet. When appropriate, the next formal Flight Crew Operations Manual revision will include an updated bulletin record page to reflect current bulletin status.

Bulletin status is defined as follows:

- In Effect (IE) – the bulletin contains pertinent information not otherwise covered in the Flight Crew Operations Manual. The bulletin remains active and should be retained in the manual
- Incorporated (INC) – the bulletin operating information has been incorporated into the Flight Crew Operations Manual. However, the bulletin remains active and should be retained in the manual
- Cancelled (CANC) – the bulletin is no longer active and should be removed from the Flight Crew Operations Manual. All bulletins previously cancelled are no longer listed in the Bulletin Record.

The person filing a new or revised bulletin should amend the Bulletin Record as instructed in the Administrative Information section of the bulletin. When a bulletin includes replacement pages for the Flight Crew Operations Manual or QRH, the included pages should be filed as instructed in the Flight Crew Operations Manual Information section of the bulletin.

Number	Subject	Date	Status

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Service Bulletin Coverage

Data supporting service bulletins requiring mandatory installation are automatically incorporated in the FCOM. Optional service bulletins are covered in the manual both with and without the service bulletin incorporation configurations.

The dual condition coverage continues until such time that the customer advises the Senior Manager of Flight Technical Integration & Data of the status of the airplane modification. Upon notification by the customer, the operations manual is modified to remove unnecessary information.

If the customer has not informed the Senior Manager of Flight Technical Integration & Data of the incorporation or rejection of an optional service bulletin within two years of the issue of the last revision to the service bulletin, the manual is automatically modified to reflect the most conservative approach of the service bulletin situation.

When content is affected by a service bulletin, a paragraph heading states the bulletin effectivity for the paragraph. When a condition exists where some airplanes have been modified with and without the service bulletin, additional paragraphs with headings designating the effectivity for each paragraph appear in sequence to provide correct data for the airplanes without the service bulletin incorporated.

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Limitations — Chapter L

Table of Contents — Section 0

Limitations — Chapter L

Operating Limitations — Section 10

General

This chapter contains Airplane Flight Manual (AFM) limitations and Boeing recommended non-AFM operating limitations. Limitations that are obvious, shown on displays or placards, or incorporated within an operating procedure are not contained in this chapter.

Note: The symbol (#) indicates recall limitations. Recall limitations are those operationally significant limitations that must be committed to memory. Memorization is necessary because there are no placards, display indications, or markings indicating a limitation exists.

[Option – TBC]

Note: Information referring to airplane options and configuration differences is shown in [brackets]. These items are applicable to the -TBC operations manual only, and do not appear in customer Operations Manuals.

Airplane General

Operational Limitations

# Runway slope	+/- 2%
# Maximum Operating Altitude	43,100 feet pressure altitude
# Maximum Takeoff and Landing Altitude [Basic]	8,400 feet pressure altitude
# Maximum Takeoff and Landing Altitude [Option]	9,800 feet pressure altitude
# Maximum Takeoff and Landing Tailwind Component	15 knots *
* The airplane has demonstrated takeoffs and landings with tailwinds up to 15 knots. This does not constitute operational approval to conduct takeoffs or landings with tailwind in excess of 10 knots.	

Non–AFM Operational Information

Turbulent air penetration speed (in severe turbulence) is defined as:

- 290 KIAS below 25,000 feet
- 310 KIAS/.85 Mach (whichever is lower) at and above 25,000 feet. Maintain a minimum speed of 15 knots above the minimum maneuvering speed (amber band) when below 0.82 Mach

The maximum demonstrated takeoff and landing crosswind is (TBD) knots.

[Option – HF radios]

Do not operate HF radios during refueling operations.

[Option – English / Metric units]

Do not operate weather radar in a hangar or within 50 feet / 15.25 meters of any personnel or a fuel spill.

Note: The hanger and personnel restrictions do not apply to the weather radar test mode.

RVSM Operations

Non-AFM Operational Information

Prior to takeoff the maximum allowable difference between Captain's or First Officer's altitude display and field elevation is 75 feet.

The standby altimeter (TBD) does not meet altimeter accuracy requirements of RVSM airspace.

Weight Limitations

[Option – Basic 787-8, English / Metric units]

Weights	Pounds	Kilograms
# Maximum Taxi Weight	486,000	220,445
# Maximum Takeoff Weight	484,000	219,538
# Maximum Landing Weight	370,000	167,829
# Maximum Zero Fuel Weight	345,000	156,489

Door Mounted Power Assists and Escape Slides

Main door emergency evacuation slide/raft and pneumatic door opening systems must be armed with the mode select handle in the automatic position prior to taxi whenever passengers are carried.

Flight Deck Security Door

Verify that an operational check of the Flight Deck Access System has been accomplished according to approved procedures once each flight day.

[Option – Flight crew rest]

Crew Rest Compartment

Occupancy of the Overhead Flight Crew Rest (OFCR) and Overhead Flight Attendant Rest (OFAR) are to be occupied by crew members only if they have been trained in use of the crew rest evacuation routes, fire fighting procedures and depressurization procedures.

Air Systems

Cabin Pressurization

Maximum differential pressure (relief valves)	9.1 psi
Maximum allowable cabin pressure differential for takeoff and landing	0.11 psi

Anti-Ice, Rain

Engine anti-ice must be ON during all ground operations, and either ON or AUTO during flight, when icing conditions exist or are anticipated, except when temperature is below –40 degrees C OAT.

Do not use anti-ice if OAT or TAT exceeds 10 degrees C.

Autoflight

Autopilot/Flight Director System

Do not use the autopilot below 100 feet RA at airport pressure altitudes above 8,400 feet.

The autopilot must not be engaged below a minimum engage altitude of 200 feet AGL after takeoff.

The autopilot must be disengaged before the airplane descends more than 50 feet below the MDA unless it is coupled to an ILS glideslope and localizer or in the go–around mode.

Without LAND 2 or LAND 3 annunciated, the autopilot must be disengaged below 200 feet AGL.

Automatic Landing

When landing weather minima are predicated on autoland operations the following limits apply:

Headwind	25 knots
Tailwind	15 knots
Crosswind	25 knots

The maximum glideslope angle is 3.25 degrees.

The minimum glideslope angle is 2.5 degrees.

Automatic landings can be made using flaps 20 or 30, with both engines operative or one engine inoperative. The autopilot flight director system (AFDS) autoland status annunciation must have LAND 2 or LAND 3 displayed and the SLATS DRIVE EICAS message must not be present.

Category III operations and autoland are not approved with flaps 25.

Category II automatic approach with manual landing (both engines operative or single engine inoperative) is approved for dual or triple channel (LAND 2 or LAND 3 annunciated) and for autopilot minimum use height of 100 feet AGL.

Communications

Flight Deck Communications Systems (Datalink)

The datalink from the COMPANY format is limited to the transmission and receipt of messages, which will not create an unsafe condition if the message is improperly received, such as the following conditions:

- the message or parts of the message are delayed or not received,
- the message is delivered to the wrong recipient, or
- the message content may be frequently corrupted

However, Pre-Departure Clearance, Digital Automatic Terminal Information Service, Oceanic Clearances, Weight & Balance, and Takeoff Data messages can be transmitted and received via the COMPANY format if they are verified per approved operational procedures.

Engines

Engine Configurations

787-8

[Option – RR engines]

Rolls Royce Model Trent-1000 Series

[Option – GE engines]

General Electric Model GEnx Series

Engine Limit Display Markings

Maximum and minimum limits are red.

Caution limits are amber.

Engine Oil System

[Option – RR engines]

Oil temperature must be greater than -10 degrees C for engine start and 80 degrees C before advancing thrust levers to takeoff power.

[Option – GE engines]
Oil temperature must be greater than -40 degrees C for engine start and have an indicated increase before advancing thrust levers to takeoff power.

Engine Fuel System

The use of JP–4 and Jet B fuels is prohibited.

The maximum tank fuel temperature is 49 degrees C (120degrees F) for Jet A, Jet A-1, JP-5 or JP-8.

Tank fuel temperature prior to takeoff must not be less than -40 degrees C or 3 degrees C above the fuel freezing point, whichever is higher. In-flight tank fuel temperature must be maintained at least 3 degrees C above the freezing point of the fuel being used. The use of Fuel System Icing Inhibitor additives does not change the minimum fuel tank temperature limit.

Reverse Thrust

Intentional selection of reverse thrust in flight is prohibited.

Backing the airplane with use of reverse thrust is prohibited.

Position reverse thrust levers full down (forward thrust) only after engines have decelerated to reverse idle.

Airplane Structure

Flight Controls

Takeoff is permitted only in the normal flight control mode.

Avoid rapid and large alternating control inputs, especially in combination with large changes in pitch, roll, or yaw (e.g. large side slip angles) as they may result in structural failure at any speed, including below V_A.

Do not extend flaps above 20,000 feet.

Non-AFM Operational Information

Ground wind limits for all doors:

- 40 knots while opening or closing
- 65 knots while open

Flight Instruments, Displays

Electronic Flight Bag (EFB)

Do not use Airport Map display as a primary navigation reference.

EFB portable keyboard and attaching cable must be stowed during takeoff and landing.

Flight Management, Navigation

IRS

IRS alignment must not be attempted at latitudes greater than 78 degrees, 14.75 minutes.

QFE Selection

A QFE altitude reference for the primary flight displays must be selected in the flight management system whenever QFE is used instead of QNH.

The use of VNAV and/or LNAV is prohibited with QFE selected.

Fuel System

Main tanks must be scheduled to be full if center tank fuel is loaded.
[Option – English / Metric units]

Note: The center tank may contain up to 3000 pounds / 1360 kilograms of fuel with less than full main tanks provided center tank fuel weight plus actual zero fuel weight does not exceed the maximum zero fuel weight, and center of gravity limits are observed.

Warning Systems

GPWS - Look-Ahead Terrain Alerting

Do not use the terrain display for navigation.

The use of look-ahead terrain alerting and terrain display functions is prohibited within 15 NM of takeoff, approach or landing at an airport or runway not contained in the GPWS terrain database. Refer to Honeywell Document 060-4267-000 for airports and runways contained in the installed GPWS database.

TCAS

Pilots are authorized to deviate from their current ATC clearance to the extent necessary to comply with a TCAS II resolution advisory.

Normal Procedures — Chapter NP
Table of Contents — Section 0

General

This chapter gives:

- an introduction to the normal procedures philosophy and assumptions
- step by step normal procedures

Normal Procedures Philosophy and Assumptions

Normal procedures verify for each phase of flight that:

- the airplane condition is satisfactory
- the flight deck configuration is correct

Normal procedures are done on each flight. Refer to the Supplementary Procedures (SP) chapter for procedures that are done as needed, for example the adverse weather procedures.

Normal procedures are used by a trained flight crew and assume:

- all systems operate normally
- the full use of all automated features (LNAV, VNAV, autoland, autopilot, and autothrottle)

Normal procedures also assume coordination with the ground crew before:

- hydraulic system pressurization, or
- flight control surface movement, or
- airplane movement

Normal procedures do not include steps for flight deck lighting and crew comfort items.

Normal procedures are done by recall and scan flow. The panel illustration in this section shows the scan flow. The scan flow sequence may be changed as needed.

Configuration Check

It is the crew member’s responsibility to verify correct system response. Before engine start, use lights or indications to verify each system's condition or configuration.

If there is an incorrect configuration or response:

- verify that the system controls are set correctly
- check the respective circuit breaker as needed. Maintenance must first determine that it is safe to reset a tripped circuit breaker on the ground
- test the respective system light as needed

Before engine start, review the EICAS alert messages and status display. If there are unexpected messages:

- check the Dispatch Deviations Guide (DDG) or the operator equivalent to decide if the condition has a dispatch effect
- decide if maintenance is needed

If, during or after engine start, there is an alert message:

- do the respective non-normal checklist (NNC)
- on the ground, check the DDG or the operator equivalent

After engine start, EICAS alert messages are the primary means of alerting the flight crew to non-normal conditions or incorrect configurations.

After engine start, there is no need to check status messages. Any message that has an adverse affect on safe continuation of the flight appears as an EICAS alert message.

Crew Duties

Preflight and postflight crew duties are divided between the captain and first officer. Phase of flight duties are divided between the Pilot Flying (PF) and the Pilot Monitoring (PM).

Each crewmember is responsible for moving the controls and switches in their area of responsibility. The Area of Responsibility illustrations in this section show the area of responsibility for both normal and non-normal procedures. Typical panel locations are shown.

The captain may direct actions outside of the crewmember’s area of responsibility.

The general PF phase of flight responsibilities are:

- taxiing
- flight path and airspeed control
- airplane configuration
- navigation

The general PM phase of flight responsibilities are:

- checklist reading
- communications
- tasks asked for by the PF
- monitoring taxiing, flight path, airspeed, airplane configuration, and navigation

PF and PM duties may change during a flight. For example, the captain could be the PF during taxi but be the PM during takeoff through landing.

Normal procedures show who does a step by crew position (C, F/O, PF, or PM):

- in the procedure title, or
- in the far right column, or
- in the column heading of a table

The mode control panel is the PF's responsibility. When flying manually, the PF directs the PM to make the changes on the mode control panel.

The captain is the final authority for all tasks directed and done.

Control Display Unit (CDU) Procedures

Before taxi, the captain or first officer may make CDU entries. The other pilot must verify the entries.

Make CDU entries before taxi or when stopped, when possible. If CDU entries must be made during taxi, the PM makes the entries. The PF must verify the entries before they are executed.

In flight, the PM usually makes the CDU entries. The PF may also make simple, CDU entries when the workload allows. The pilot making the entries executes the change only after the other pilot verifies the entries.

During high workload times, for example departure or arrival, try to reduce the need for CDU entries. Do this by using the MCP heading, altitude, and speed control modes. The MCP can be easier to use than entering complex route modifications into the CDU.

Autopilot Flight Director System (AFDS) Procedures

The crew must always monitor:

- airplane course
- vertical path
- speed

When selecting a value on the MCP, verify that the respective value changes on the flight instruments, as applicable.

The crew must verify manually selected or automatic AFDS changes. Use the FMA to verify mode changes for the:

- autopilot
- flight director
- autothrottle

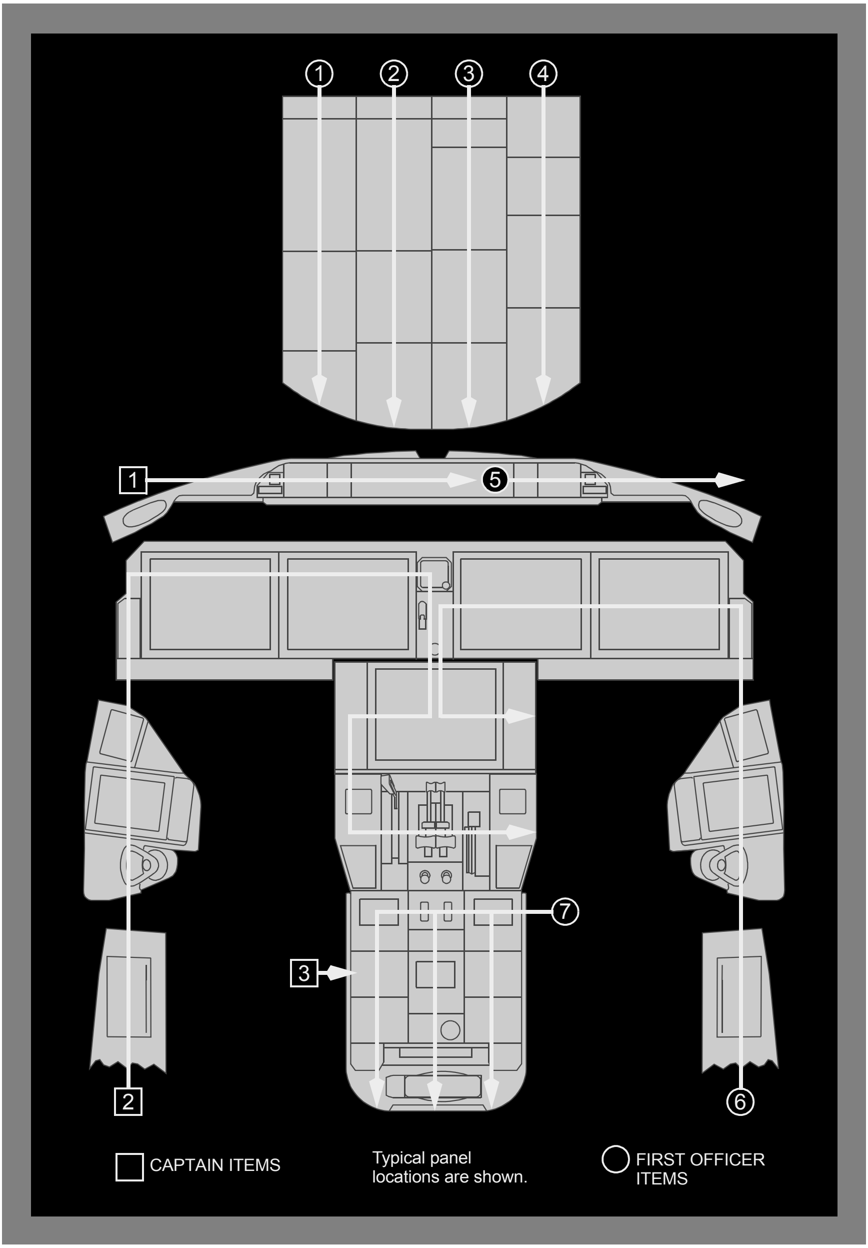
During LNAV and VNAV operations, verify all changes to the airplane's:

- course
- vertical path

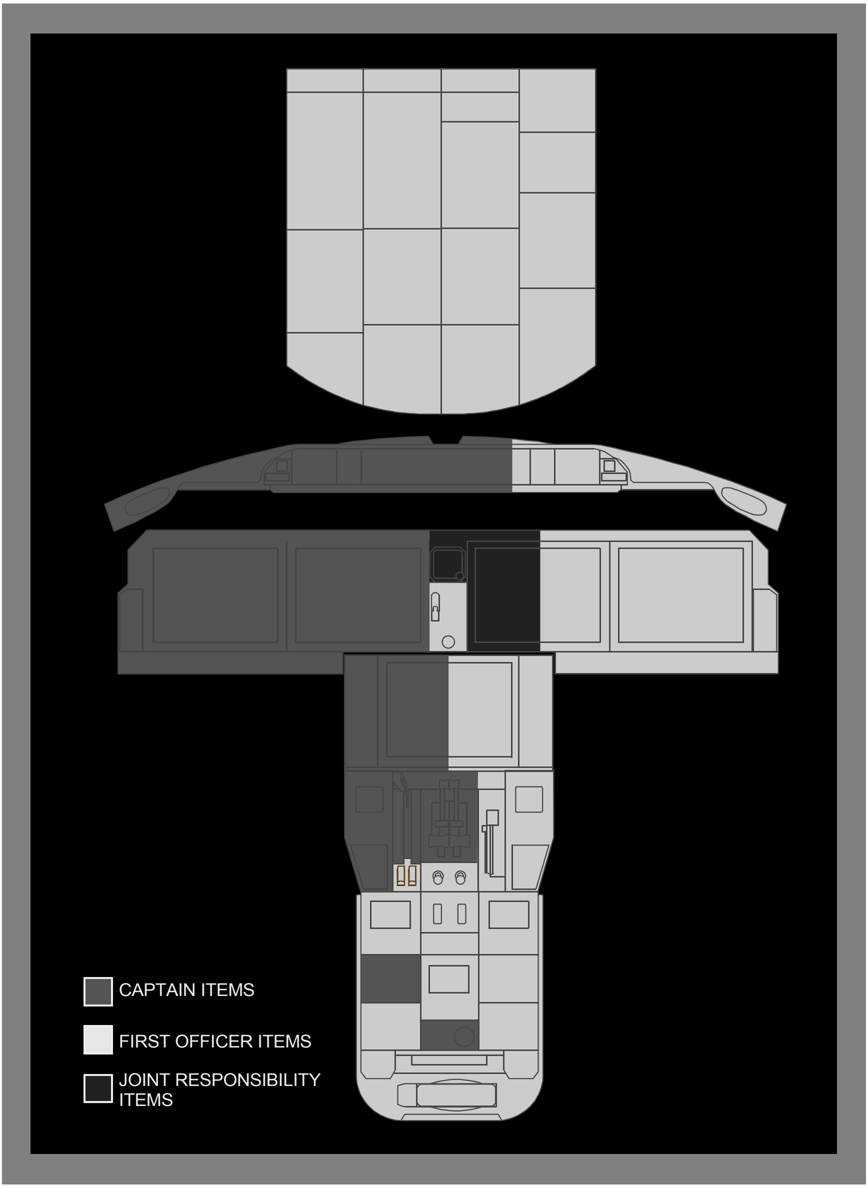
- thrust
- speed

Announcing changes on the FMA and thrust mode display when they occur is a good CRM practice.

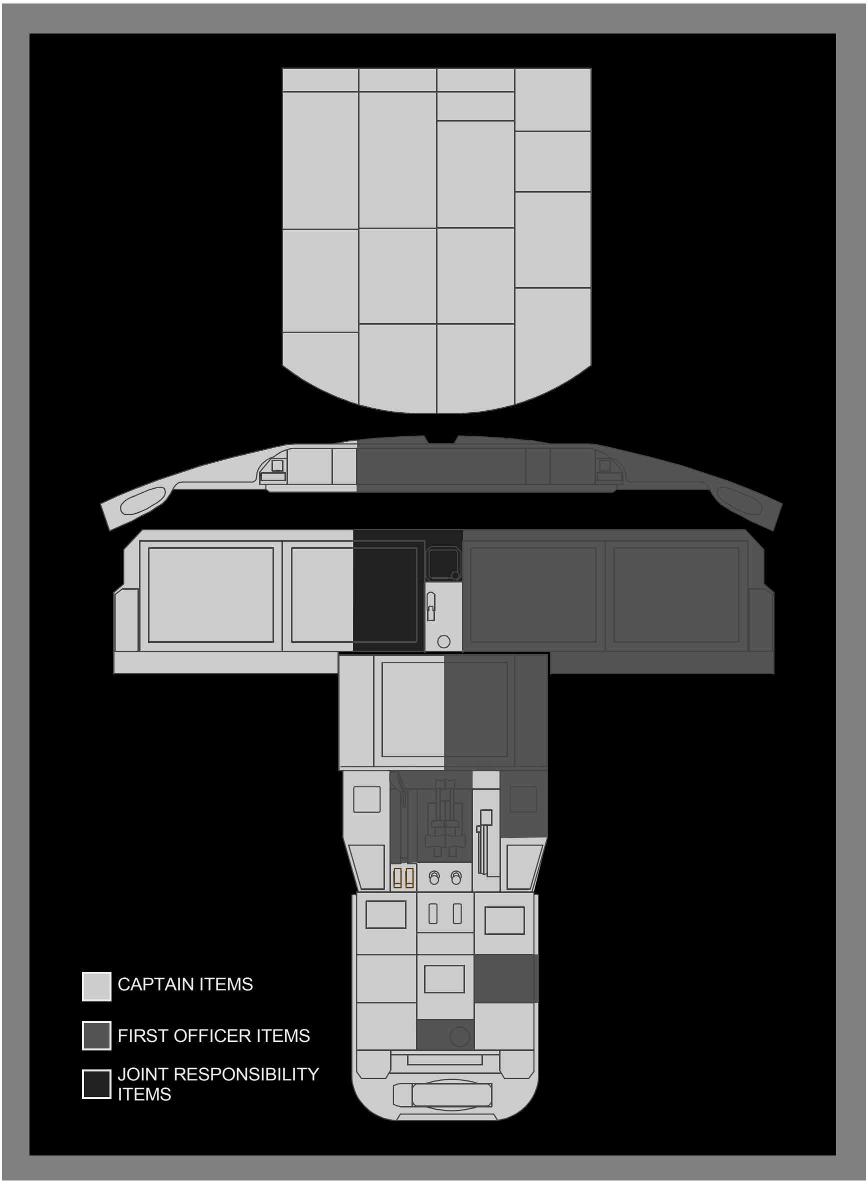
Preflight and Postflight Scan Flow



Areas of Responsibility - Captain as Pilot Flying or Taxiing



Areas of Responsibility - First Officer as Pilot Flying or Taxiing



Intentionally
Blank

Normal Procedures — Chapter NP
Amplified Procedures — Section 21

Preliminary Preflight Procedure – Captain or First Officer

The Preliminary Preflight Procedure assumes that the Electrical Power Up supplementary procedure is complete.

IRS selector .... OFF 30 seconds, then ON

Verify that the ON BAT light is extinguished.

STATUS display .... Check

Verify that only expected messages are shown.

Verify that the following are sufficient for flight:
- oxygen pressure
- hydraulic quantity
- engine oil quantity

Do the remaining actions after a crew change or maintenance action.

Maintenance documents .... Check

Emergency equipment .... Check

Fire extinguisher – Checked and stowed

Crash axe – Stowed

Flight deck overhead door - Closed and latched

Emergency escape inertial reels - Stowed

Other needed equipment – Checked and stowed

Parking brake .... As needed

Set the parking brake if brake wear indicators will be checked during the exterior inspection.

CDU Preflight Procedure - Captain and First Officer

Start the CDU Preflight Procedure anytime after the Preliminary Preflight Procedure. The Initial Data and Navigation Data entries must be complete before the flight instrument check during the Preflight Procedure. The Performance Data entries must be complete before the Before Start Checklist.

The captain or first officer may make CDU entries. The other pilot must verify the entries.

Enter data in all the boxed items on the following CDU pages.

Enter data in the dashed items or modify small font items that are listed in this procedure. Enter or modify other items at pilot's discretion.

Failure to enter enroute winds can result in flight plan time and fuel burn errors.

Initial Data .... Set

IDENT page:

Verify that the MODEL is correct.

Verify that the ENG RATING is correct.

Verify that the navigation database ACTIVE date range is current.

POS INIT page:

Verify that the time is correct.

Enter the present position on the SET INERTIAL POS line. Use the most accurate latitude and longitude.

Navigation Data .... Set

RTE page:

Enter the route.

Enter the FLT NO.

Activate and execute the route.

DEPARTURES page:

Select the runway and departure routing.

Execute the runway and departure routing.

Verify that the RTE and LEGS pages are correct.

Verify that the route is correct on the RTE page. Check the LEGS pages as needed to ensure compliance with the flight plan.

NAV RADIO page:

Tune the navigation radios as needed.

Performance Data ....Set

PERF INIT page:

Enter the ZFW.

Verify that the FUEL on the CDU, the dispatch papers, and EICAS agree.

Verify that the fuel is sufficient for flight.

Verify that the GR WT on the CDU and the dispatch papers agree.

THRUST LIM page:

Select an assumed temperature, or a fixed derate takeoff, or both as needed.

Select a full or a derated climb thrust as needed.

TAKEOFF REF page:

Make data entries on page 2/2 before page 1/2.

Exterior Inspection

Before each flight the captain, first officer, or maintenance crew must verify that the airplane is satisfactory for flight.

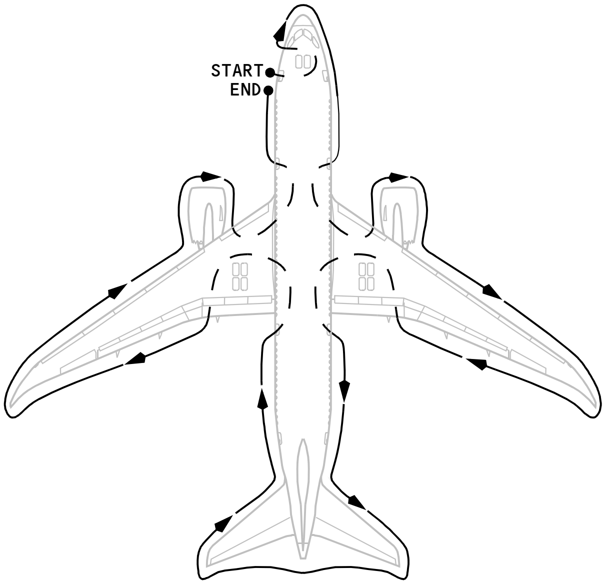
Items at each location may be checked in any sequence.

Use the detailed inspection route below to check that:

- the surfaces and structures are clear, not damaged, not missing parts and there are no fluid leaks
- the tires are not too worn, not damaged, and there is no tread separation
- the gear struts are not fully compressed
- the engine inlets and tailpipes are clear, the access panels are secured, the exterior is not damaged, and the reversers are stowed
- the doors and access panels that are not in use are latched
- the probes, vents, and static ports are clear and not damaged
- the antennae are not damaged
- the light lenses are clean and not damaged

For cold weather operations see the Supplementary Procedures.

Inspection Route



Left Forward Fuselage

Probes, sensors, ports, vents, and drains (as applicable) .... Check

Doors and access panels (not in use) ....Latched

Wing illumination light .... Check

Nose

Radome .... Check

Diverter strips - Secure

Forward access door ....Secure

Nose Wheel Well

Tires and wheels .... Check

Gear strut and doors .... Check

Hydraulic lines ....Secure

Nose wheel steering assembly .... Check

Gear pin ....As needed

Nose gear towing lever .... NORMAL

Nose gear towing lever pin ....Verify removed

Exterior lights .... Check

Parking brake light indication .... Check

Wheel well light switches ....As needed

APU remote control panel ....Secure

Forward E and E door ....Secure

Right Forward Fuselage

Probes, sensors, ports, vents, and drains (as applicable) .... Check

Doors and access panels (not in use) ....Latched

Wing illumination light .... Check

Right Wing Root, Pack, and Lower Fuselage

Negative pressure relief vents .... Closed

Probes, sensors, ports, vents, and drains (as applicable) .... Check

Oxygen pressure relief green disc .... In place

Exterior lights .... Check

Pack inlets and pneumatic access doors .... Secure

Leading edge flaps .... Check

Right Engine

Probes, sensors, ports, vents, and drains (as applicable) .... Check

Fan blades, probes, and spinner .... Check

Thrust reverser .... Stowed

Exhaust area and tailcone .... Check

Right Wing and Leading Edge

Access panels .... Latched

Leading edge slats .... Check

Wing Surfaces .... Check

Fuel tank vent .... Check

Right Wing Tip and Trailing Edge

Navigation and strobe lights .... Check

Static discharge wicks .... Check

Fuel jettison nozzle .... Check

Aileron, flaperon, and trailing edge flaps .... Check

Right Main Gear

Tires, brakes and wheels .... Check

Verify that the wheel chocks are in place as needed.

If the parking brake is set, the brake wear indicator pins must extend out of the guides.

Gear strut, actuators, and doors .... Check

Hydraulic lines .... Secure

Gear pins .... As needed

Right Main Wheel Well

Wheel well .... Check

Right Aft Fuselage

Ram air turbine door .... Check

Doors and access panels (not in use) .... Latched

Probes, sensors, ports, vents, and drains (as applicable) .... Check

Oxygen pressure relief green disc .... In place

Tail

Vertical stabilizer and rudder .... Check

Tail skid .... Check

Verify that the tail skid is not damaged.

Horizontal stabilizer and elevator .... Check

Static discharge wicks .... Check

Navigation and strobe light .... Check

APU exhaust outlet .... Check

Left Aft Fuselage

Aft outflow valve .... Check

Doors and access panels (not in use) .... Latched

Left Main Wheel Well

Wheel well .... Check

Left Main Gear

Tires, brakes and wheels .... Check

Verify that the wheel chocks are in place as needed.

If the parking brake is set, the brake wear indicator pins must extend out of the guides.

Gear strut, actuators and doors .... Check

Hydraulic lines .... Secure

Gear pins .... As needed

Left Wing Tip and Trailing Edge

Navigation and strobe lights .... Check

Static discharge wicks .... Check

Aileron, flaperon, and trailing edge flaps .... Check

Fuel jettison nozzle .... Check

Fuel tank vent .... Check

Left Wing and Leading Edge

Wing Surfaces .... Check

Fuel tank vent .... Check

Leading edge slats .... Check

Access panels .... Latched

Left Engine

Exhaust area and tailcone .... Check

Thrust reverser ....Stowed

Probes, sensors, ports, vents, and drains (as applicable) .... Check

Access panels ....Latched

Fan blades, probes, and spinner .... Check

Left Wing Root, Pack, and Lower Fuselage

Probes, sensors, ports, vents, and drains (as applicable) .... Check

Exterior lights .... Check

Pack inlet and pneumatic access doors ....Secure

Negative pressure relief vents ....Closed

Positive pressure relief valves ....Closed

Leading edge flaps .... Check

Forward outflow valve .... Check

Preflight Procedure – First Officer

The first officer normally does this procedure. The captain may do this procedure as needed.

FLIGHT CONTROL SURFACES panel .... Set

Verify that guards are closed and the lights are extinguished.

HEADING REFERENCE switch .... NORM

PRIMARY FLIGHT COMPUTERS
DISCONNECT switch .... Guard closed

Verify that the DISC light is extinguished.

ELECTRICAL panel .... Set

BATTERY switch – ON

Verify that the OFF light is extinguished.

IFE/PASS SEATS power switch – ON

Verify that the OFF light is extinguished.

CABIN/UTILITY power switch – ON

Verify that the OFF light is extinguished.

APU GENERATOR switches – ON

Verify that the OFF lights are extinguished.

ENGINE GENERATOR switches – ON

Verify that the OFF lights are illuminated.

Verify that the DRIVE lights are illuminated.

APU selector (as needed) .... START, then ON

Do not allow the APU selector to spring back to the ON position.

Verify that the FAULT light is extinguished.

L HUD BRIGHTNESS control .... IN

L WIPER selector .... OFF

TOWING POWER panel lights .... Off

FLIGHT DECK DOOR POWER switch ....ON

CCR RESET switches ....Guards closed

EMERGENCY LIGHTS switch ....Guard closed

SERVICE INTERPHONE switch .... OFF

Note: Do not push the PASSENGER OXYGEN switch. The switch causes deployment of the passenger oxygen masks.

PASSENGER OXYGEN ON light .... Verify extinguished

WINDOW HEAT panel ....Set

BACKUP WINDOW HEAT switches – ON

PRIMARY WINDOW HEAT switches – ON

Verify that the INOP lights are extinguished.

WARNING: Do not push the RAM AIR TURBINE switch. The switch causes deployment of the ram air turbine.

RAM AIR TURBINE UNLOCKED light .... Verify extinguished

HYDRAULIC panel ....Set

LEFT and RIGHT ENGINE PRIMARY pump switches – ON

Verify that the FAULT lights are illuminated.

CENTER 1 and CENTER 2 ELECTRIC pump selectors – OFF

Verify that the FAULT lights are illuminated.

LEFT and RIGHT ELECTRIC DEMAND pump selectors – OFF

Verify that the FAULT lights are illuminated.

SEAT BELT SIGNS selector ....Set

Lighting panel .... Set

OVERHEAD panel light control – Mid position

MASTER BRIGHTNESS switch – ON

MASTER BRIGHTNESS control – As needed

GLARESHIELD PANEL light control – Mid position

LANDING light switches – OFF

GROUND TEST selector .... NORM

APU fire panel... Set

Verify that the APU BTL DISCH light is extinguished.

APU fire switch – In

Verify that the APU fire warning light is extinguished.

CARGO FIRE panel .... Set

CARGO FIRE ARM switches – Off

Verify that the FWD and AFT fire warning lights are extinguished.

Verify that the cargo fire DISCH light is extinguished.

ENGINE panel .... Set

EEC MODE switches – NORM

START selectors – NORM

FUEL JETTISON panel .... Set

FUEL JETTISON NOZZLE switches – Off

Verify that the VALVE lights are extinguished.

FUEL TO REMAIN selector – IN

FUEL JETTISON ARM switch – Off

Verify that the FAULT light is extinguished.

FUEL panel ....Set

CROSSFEED switch – OFF

Verify that the VALVE light is extinguished.

FUEL PUMP switches – OFF

Verify that the left aft pump PRESS light is extinguished if the APU is on or is illuminated if the APU is off.

Verify that the other left and right pump PRESS lights are illuminated.

Verify that the center pump PRESS lights are extinguished.

Fuel BALANCE switch – Off

Verify that the ON light is extinguished.

Verify that the FAULT light is extinguished.

ANTI–ICE panel...Set

WING anti–ice selector – AUTO

ENGINE anti–ice selectors – AUTO

Lighting panel ....Set

BEACON light switch – OFF

NAVIGATION light switch – As needed

LOGO light switch – As needed

WING light switch – As needed

INDICATOR LIGHTS switch – As needed

RUNWAY TURNOFF light switches – OFF

TAXI light switch – OFF

STROBE light switch – OFF

[Option – F/D Humidify]
HUMIDIFICATION switch ....ON

[Option – Forward cargo A/C]
CARGO TEMPERATURE selector ....As needed

[Option – Forward cargo A/C]
FORWARD CARGO AIR CONDITIONING .... As needed

BULK CARGO HEAT switch .... As needed

AIR CONDITIONING panel .... Set

EQUIPMENT COOLING switches – AUTO

Verify that the OVRD lights are extinguished.

RECIRCULATION FANS switches – ON

FLIGHT DECK TEMPERATURE control – mid position

CABIN TEMPERATURE control – Mid position

If APU is running:

PACK switches – AUTO

Verify that the OFF lights are extinguished.

TRIM AIR switches – ON

Verify that the FAULT lights are extinguished.

VENTILATION switch – NORM

Verify that the ALTN light is extinguished.

PRESSURIZATION panel .... Set

OUTFLOW VALVE switches – AUTO

Verify that the MAN lights are extinguished.

LANDING ALTITUDE selector – IN

R WIPER selector ....OFF

R HUD BRIGHTNESS selector ....IN

FLIGHT DIRECTOR switch .... ON

Display select panel.. Set

EFIS control panel .... Set

MINIMUMS reference selector – RADIO or BARO

MINIMUMS selector – Set decision height or altitude reference

FLIGHT PATH VECTOR switch – As needed

METERS switch – As needed

BAROMETRIC reference selector – IN or HPA

BAROMETRIC selector – Set local altimeter setting

MAP, PLAN, MENU selector – MAP

MENU – Select

Map data – As needed

VSD – Select on

ND CENTER switch – As needed

ND range selector – 0.5, 1, 2 or 5

Displays airport map

CAUTION: The Airport Map application is designed to aid flight crew positional awareness only. It does not provide guidance for initiation of turns or stops, nor does it assist in maintaining separation from other ground traffic. Due to system design and accuracy limitations, do not use the Airport Map application as a primary navigation reference. Avoid fixation on the display at the expense of airplane control and visual lookout.

ND WXR switch – Off

Verify that the weather radar indications are not shown on the ND or PFD mini-map.

ND TFC and TERR switches – As needed

Oxygen .... Test and set

Oxygen mask – Stowed and doors closed

RESET/TEST switch – Push and hold

Verify that the yellow cross shows momentarily in the flow indicator.

RESET/TEST switch – Release

Verify that the yellow cross does not show in the flow indicator.

Normal/100% selector – 100%

Crew oxygen pressure – Check EICAS

Verify that the pressure is sufficient for dispatch.

ELECTRONIC FLIGHT BAG .... Set

FORWARD PANEL brightness control ....Mid position

INBOARD and OUTBOARD DISPLAY brightness and CONTRAST controls ....Mid position

AIR DATA/ATTITUDE source selector .... AUTO

PFD/MFD selector .... NORM

Do the Initial Data and Navigation Data steps from the CDU Preflight Procedure and verify that the IRS alignment is complete before checking the flight instruments.

Flight instruments .... Check

Verify that the flight instrument indications are correct.

Verify that only these flags are shown:
- TCAS OFF
- NO VSPD until takeoff V–speeds are selected

Verify that the flight mode annunciations are correct:
- autothrottle mode is blank
- roll mode is TO/GA or HUD TO/GA
- pitch mode is TO/GA
- AFDS status is FLT DIR

Select the map mode and VSD.

Landing gear panel ....Set

Landing gear lever – DN

ALTERNATE GEAR switch – Guard closed

AUTOBRAKE selector – RTO

EICAS display .... Check

Secondary engine indications – Display

Verify that the engine indications show existing conditions.

Verify that no exceedance is shown.

MFD .... Check

Select the status display.

Status messages – Check

CHECKLIST display switch – Push

RESETS – Select

Verify that the AIRLINE DB is current.

RESET ALL – Select

Left tuning and control panel..Set

Verify that the OFF light is extinguished.

Observer's audio control panel ....As needed

FLIGHT DECK DOOR ACCESS selector ....AUTO

Engine fire panel..Set

Verify that the ENG BTL 1 DISCH and ENG BTL 2 DISCH lights are extinguished.

Engine fire switches – In

Verify that the LEFT and RIGHT fire warning lights are extinguished.

GLIDESLOPE INHIBIT
switch ....BELOW G/S light extinguished

TRANSPONDER MODE selector ....STBY

AURAL CANCEL light ....Extinguished

Flight deck printer ....Set

Verify that the FAIL and PAPER lights are extinguished.

Right tuning and control panel ....Set

Verify that the OFF light is extinguished.

VHF - Select

R VHF – Set

HF - Select

R HF – Set

WEATHER RADAR – Select

GAIN and MODE – As needed

TRANSPONDER – Select

F/O TCAS DISPLAY – As needed

F/O TCAS alt – As needed

First officer's audio control panel .... As needed

FLOOR LIGHTS switch .... As needed

EVACUATION COMMAND switch ....Guard closed

Observer AUDIO selector .... NORM

AISLE STAND PANEL light control ....Mid position

AISLE STAND FLOOD light control ....Mid position

WARNING: Do not put objects between the seat and the aisle stand. Injury can occur when the seat is adjusted.

Seat .... Adjust

Adjust the seat for optimum eye reference.

Rudder pedals .... Adjust

Adjust the rudder pedals to allow full rudder pedal and brake pedal movement. Stow the rudder pedal adjust crank.

HUD combiner .... Down

HUD brightness – Adjust

Seat belt and shoulder harness .... Adjust

Do the PREFLIGHT checklist on the captain’s command.

Preflight Procedure – Captain

The captain normally does this procedure. The first officer may do this procedure if needed.

EFIS control panel .... Set

MINIMUMS reference selector – RADIO or BARO

MINIMUMS selector – Set decision height or altitude reference

FLIGHT PATH VECTOR switch – As needed

METERS switch – As needed

BAROMETRIC reference selector – IN or HPA

BAROMETRIC selector – Set local altimeter setting

MAP, PLAN, MENU selector – MAP

MENU – Select

Map data – As needed

VSD – Select on

ND CENTER switch – As needed

ND range selector – 0.5, 1, 2 or 5

Displays airport map.

CAUTION: Do not use the Airport Map application as a primary navigation reference. The Airport Map application is designed to aid flight crew positional awareness only.

ND WXR switch – Off

Verify that the weather radar indications are not shown on the ND.

ND TFC and TERR switches – As needed

Display select panel .... Set

EICAS TRANSFER switch – As needed

Select EICAS to the desired side.

Mode control panel ....Set

FLIGHT DIRECTOR switch – ON

AUTOTHROTTLE ARM switches – ARM

Autopilot DISENGAGE bar – UP

HEADING/TRACK reference switch – As needed

BANK LIMIT selector – AUTO

VERTICAL SPEED/FLIGHT PATH ANGLE reference switch – As needed

ALTITUDE increment selector – As needed

Oxygen ....Test and set

Oxygen mask – Stowed and doors closed

RESET/TEST switch – Push and hold

Verify that the yellow cross shows momentarily in the flow indicator.

RESET/TEST switch – Release

Verify that the yellow cross does not show in the flow indicator.

Normal/100% selector – 100%

Crew oxygen pressure – Check EICAS

Verify that the pressure is sufficient for dispatch.

ELECTRONIC FLIGHT BAG ....Set

FORWARD PANEL brightness control .... Mid position

INBOARD and OUTBOARD DISPLAY brightness and CONTRAST controls .... Mid position

AIR DATA/ATTITUDE source selector ....AUTO

PFD/MFD selector ....NORM

Do the Initial Data and Navigation Data steps from the CDU Preflight Procedure and verify that the IRS alignment is complete before checking the flight instruments.

Flight instruments .... Check

Verify that the flight instrument indications are correct.

Verify that only these flags are shown:
- TCAS OFF
- NO VSPD until takeoff V–speeds are selected

Verify that the flight mode annunciations are correct:
- autothrottle mode is blank
- roll mode is TO/GA or HUD TO/GA
- pitch mode is TO/GA
- AFDS status is FLT DIR

Select the map mode and VSD.

Integrated standby flight display .... Set

Verify that the approach mode display is blank.

Set local altimeter setting.

Verify that the flight instrument indications are correct.

Verify that no flags or messages are shown.

SPEEDBRAKE lever ....DOWN

Reverse thrust levers .... Down

Forward thrust levers.. Closed

Flap lever .... Set

The flap position indicator does not show when the flaps are up.

Set the flap lever to agree with the flap position.

Parking brake .... Set

Verify that the PARKING BRAKE SET message is shown.

STABILIZER cutout switches .... Guards closed

FUEL CONTROL switches .... CUTOFF

FUEL CONTROL switch fire warning lights .... Verify extinguished

ALTERNATE FLAPS panel .... Set

ALTERNATE FLAPS ARM switch – OFF

ALTERNATE FLAPS selector – OFF

Left tuning and control panel .... Set

WEATHER RADAR – Select

GAIN and MODE – As Needed

TRANSPONDER – Select

CAP TCAS DISPLAY – As needed

CAP TCAS ALT – As needed

Captain’s audio control panel .... As needed

WARNING: Do not put objects between the seat and the aisle stand. Injury can occur when the seat is adjusted.

HUD combiner .... Down

HUD brightness – Adjust

Seat .... Adjust

Adjust the seat for optimum eye reference.

Rudder pedals .... Adjust

Adjust the rudder pedals to allow full rudder pedal and brake pedal movement.

Seat belt and shoulder harness .... Adjust

Call “PREFLIGHT CHECKLIST.”

Before Start Procedure

Start the Before Start Procedure after papers are on board.

Flight deck door .... Closed and locked F/O

Do the CDU Preflight Procedure – Performance Data steps before completing this procedure.

Tuning control panels .... Set C, F/O

Normally the L tuning control panel is set to VHF L.

Normally the C tuning control panel is set to CABIN interphone or SATCOM as needed.

Normally the R tuning control panel is set to VHF R.

CDU display .... Set C, F/O

Normally the PF selects the TAKEOFF REF page.

Normally the PM selects the LEGS page.

MCP .... Set C

IAS/MACH selector – Set V2

Arm LNAV as needed.

Arm VNAV.

Initial heading or track – Set

Initial altitude – Set

Taxi and Takeoff briefings .... Complete C, F/O

The pilot who will do the takeoff does the taxi and takeoff briefings.

Exterior doors ....Verify closed F/O

Start clearance .... Obtain C, F/O

Obtain a clearance to pressurize the hydraulic systems.

Obtain a clearance to start the engines.

If pushback is needed:

Nose gear steering ....Verify locked out C

HYDRAULIC panel .... Set F/O

WARNING: If the tow bar is connected, do not pressurize the hydraulic systems until the nose gear steering is locked out. Unwanted tow bar movement can occur.

Right ELECTRIC DEMAND pump selector – AUTO

Verify that FAULT light is extinguished.

CENTER 1 and CENTER 2 ELEC pump selectors – AUTO

Verify that the FAULT lights are extinguished.

Left ELECTRIC DEMAND pump selector – AUTO

Verify that the FAULT light is extinguished.

Fuel panel .... Set F/O

LEFT and RIGHT FUEL PUMP switches – ON

If the FUEL IN CENTER message shows:

CENTER FUEL PUMP switches – ON

Both PRESS lights will stay illuminated until after the engine start because of load shedding.

BEACON light switch ....ON F/O

CANCEL/RECALL switch ....Push F/O

Verify that only the expected alert messages are shown.

CANCEL/RECALL switch ....Push F/O

Verify that the messages cancel.

Trim ....Set C

Stabilizer trim – ___ UNITS

Set the trim for takeoff.

Verify that the trim is in the greenband.

Aileron trim – 0 units

Rudder trim – 0 units

Call “BEFORE START CHECKLIST.” C

Do the BEFORE START checklist. F/O

Pushback or Towing Procedure

The Engine Start procedure may be done during pushback or towing.

Ground handling personnel ....Establish communications C

CAUTION: Do not turn the nose wheel tiller during pushback or towing. This can damage the nose gear or the tow bar.

CAUTION: Do not use airplane brakes to stop the airplane during pushback or towing. This can damage the nose gear or the tow bar.

Parking brake .... Set or release C

Set or release as directed by ground handling personnel.

When pushback or towing is complete:

Tow bar .... Verify not connected C

Nose gear steering .... Verify not locked out C

Engine Start Procedure

Select the secondary engine indications. F/O

Start sequence .... Announce C

The engines may be started at the same time.

Call “START ____ ENGINE” C

Engine START selector .... START F/O

FUEL CONTROL switch .... RUN C

If the engines were not started at the same time:

After the engine is stable at idle, start the other engine.

Autostart corrects for:

- no EGT rise

[Option – GE engines]

- no oil pressure rise
- a hot start
- a hung start
- no N1 rotation
- a compressor stall
- failure of both starters
- a start time that exceeds the maximum starter duty cycle time

[Option – RR engines]
No crew monitoring or action is required for oil pressure during start. If the EICAS message ENG OIL PRESS is displayed, accomplish the ENG OIL PRESS checklist.

Before Taxi Procedure

APU selector .... OFF F/O

ENGINE ANTI–ICE selectors .... As needed F/O

Verify that the ground equipment is clear. C, F/O

Call "FLAPS___" as needed for takeoff. C

Flap lever ....Set takeoff flaps F/O

Flight controls ....Check C

Move the control wheel and the control column to full travel in both directions and verify:

- freedom of movement
- that the controls return to center

Hold the nose wheel tiller disconnect switch down during the rudder check to prevent nose wheel movement.

Move the rudder pedals to full travel in both directions and verify:

- freedom of movement
- that the rudder pedals return to center

Transponder .... As needed F/O

At airports where ground tracking is not available, select STANDBY. At airports equipped to track airplanes on the ground, select TRANSPONDER.

Recall ....Check C, F/O

Verify that only expected alert messages are shown.

Update changes to the taxi briefing, as needed. C or PF

Call "BEFORE TAXI CHECKLIST." C

Do the BEFORE TAXI checklist. F/O

Before Takeoff Procedure

Pilot Flying	Pilot Monitoring
	Notify the cabin crew to prepare for takeoff. Verify that the cabin is secure.
The pilot who will do the takeoff updates changes to the takeoff briefing as needed.	
Set the weather radar display as needed. **[Option – GPWS Lookahead peaks]** Set the terrain display as needed.	
Call "BEFORE TAKEOFF CHECKLIST."	Do the BEFORE TAKEOFF checklist.

Takeoff Procedure

Pilot Flying	Pilot Monitoring
	When entering the departure runway, set the STROBE light switch to ON. Use other lights as needed. Set the transponder mode selector to TA/RA.
Verify that the brakes are released. Align the airplane with the runway.	When cleared for takeoff, set the LEFT and RIGHT LANDING light switches to ON.
[Option – GE engines] Advance the thrust levers to approximately 40% N1. **[Option – RR engines]** Advance the thrust levers to approximately 35 TPR. Allow the engines to stabilize.	
Push the TO/GA switch.	
Verify that the correct takeoff thrust is set.	
	Monitor the engine instruments during the takeoff. Call out any abnormal indications. Adjust takeoff thrust before 80 knots as needed. During strong headwinds, if the thrust levers do not advance to the planned takeoff thrust by 80 knots, manually advance the thrust levers.
After takeoff thrust is set, the captain’s hand must be on the thrust levers until V1.	
Monitor airspeed. Maintain light forward pressure on the control column.	Monitor airspeed and call out any abnormal indications.
Verify 80 knots and call “CHECK.”	Call “80 KNOTS.”
Verify V1 speed.	Verify the automatic V1 callout or call “V1.”
At VR, rotate toward 15° pitch attitude. After liftoff, follow F/D commands. Establish a positive rate of climb.	At VR call “ROTATE.” Monitor airspeed and vertical speed.
	Verify a positive rate of climb on the altimeter and call “POSITIVE RATE.”

Pilot Flying	Pilot Monitoring
Verify a positive rate of climb on the altimeter and call “GEAR UP.”	
	Set the landing gear lever to UP.
Above 400 feet radio altitude, call for a roll mode as needed.	Select or verify the roll mode. Verify VNAV engaged.
Verify that climb thrust is set.	
Verify acceleration at the acceleration height. Call “FLAPS___” according to the flap retraction schedule.	
	Set the flap lever as directed.
Engage the autopilot when above the minimum altitude for autopilot engagement.	
	After flap retraction is complete, set the Engine Anti-Ice Selectors to AUTO.
Call “AFTER TAKEOFF CHECKLIST.”	Do the AFTER TAKEOFF checklist.

Takeoff Flap Retraction Speed Schedule

Takeoff Flaps	At “Display”	Select Flaps
20 or 15	VREF 30 + 20 “5” “1”	5 1 UP
5	VREF 30 + 40 “1”	1 UP

Climb and Cruise Procedure

Complete the After Takeoff Checklist before starting the Climb and Cruise Procedure.

Pilot Flying	Pilot Monitoring
	At or above 10,000 feet MSL, set the LANDING light switches to OFF.
	Set the seatbelt signs as needed.
At transition altitude, set and crosscheck the altimeters to standard.	
	If the FUEL IN CENTER message shows, set both CENTER FUEL PUMP switches to ON. When the FUEL LOW CENTER message shows, set both CENTER FUEL PUMP switches to OFF.
	Before the top of descent, modify the active route as needed for the arrival and approach. Verify or enter the correct RNP for the arrival.

Descent Procedure

Start the Descent Procedure before the airplane descends below the cruise altitude for arrival at destination.

Complete the Descent Procedure by 10,000 feet MSL.

Pilot Flying	Pilot Monitoring
Review all alert messages. Review all operational notes.	Recall and review all alert messages. Recall and review all operational notes.
Verify VREF on the APPROACH REF page.	Enter VREF on the APPROACH REF page.
Set the RADIO/BARO minimums as needed for the approach.	
	Set the NAV RADIO page for the approach.
	Set the AUTOBRAKE selector to the needed brake setting.
Do the approach briefing.	
Call “DESCENT CHECKLIST.”	Do the DESCENT checklist.

Approach Procedure

The Approach Procedure is normally started at transition level.

Complete the Approach Procedure before:

- the initial approach fix, or
- the start of radar vectors to the final approach course, or
- the start of a visual approach

Select the approach procedure on the ARRIVALS page. Do not manually build the approach or add waypoints to the selected FMC procedure. Add cold temperature corrections to waypoint altitude constraints as appropriate.

Pilot Flying	Pilot Monitoring
	Set the seatbelt signs as needed.
	At or above 10,000 feet MSL, set the LEFT and RIGHT LANDING light switches to ON.
At transition level, set and crosscheck the altimeters.	
Update changes to the arrival and approach, as needed. Update changes to the RNP as needed.	
Update the approach briefing as needed.	
Call “APPROACH CHECKLIST.”	Do the APPROACH checklist.

Flap Extension Schedule

Current Flap Position	At Speed Tape “Display”	Select Flaps	Command Speed for Selected Flaps
UP	“UP”	1	“1”
1	“1”	5	“5”
5	“5”	20	“20”
20	20	25 or 30	(VREF25 or VREF30) + wind additives

Landing Procedure - ILS

Pilot Flying	Pilot Monitoring
	Notify the cabin crew to prepare for landing. Verify that the cabin is secure.
Call “FLAPS___” according to the flap extension schedule.	Set the flap lever as directed.
When on localizer intercept heading: • verify that the ILS is tuned and identified • verify that the LOC and G/S pointers are shown	
Arm the APP mode.	
Use HDG SEL/TRK SEL or HDG HOLD /TRK HOLD to intercept the final approach course as needed.	
Verify that the localizer is captured.	
	Call “GLIDESLOPE ALIVE.”
At glideslope alive, call: • “GEAR DOWN” • “FLAPS 20”	
	Set the landing gear lever to DN. Set the flap lever to 20.
Set the speedbrake lever to ARM.	
At glideslope capture, call “FLAPS___” as needed for landing.	Set the flap lever as directed.
Set the missed approach altitude on the MCP.	
Call “LANDING CHECKLIST.”	Do the LANDING checklist.
At the final approach fix or OM, verify the crossing altitude.	
Monitor the approach. Verify the autoland status at 500 feet radio altitude.	

Landing Procedure - IAN

Pilot Flying	Pilot Monitoring
	Notify the cabin crew to prepare for landing. Verify that the cabin is secure.
Call “FLAPS___” according to the flap extension schedule.	Set the flap lever as directed.
When on Final Approach Course intercept heading: • verify that the intended approach is indicated on the PFD • verify that FAC and GP anticipation pointers are shown in the correct position.	
Arm the APP mode.	
Use appropriate roll mode to capture FAC.	
Verify that the FAC is captured.	
	Call “GLIDEPATH ALIVE.”
At glidepath alive, call: • “GEAR DOWN” • “FLAPS 20”	
	Set the landing gear lever to DN. Set the flap lever to 20.
Set the speedbrake lever to ARM.	
At glidepath capture, call “FLAPS___” as needed for landing.	Set the flap lever as directed.
Set the missed approach altitude on the MCP.	
Call “LANDING CHECKLIST.”	Do the LANDING checklist.
At the final approach fix or OM, verify the crossing altitude.	
Monitor the approach. Disconnect the autopilot no later than 100 AGL. **Note:** per the AFM limit. (this will have to be rewritten)	

Go–Around and Missed Approach Procedure

Pilot Flying	Pilot Monitoring
At the same time: • push the TO/GA switch • call “FLAPS 20”	
	Position the flap lever to 20.
Verify: • the rotation to go–around attitude • that the thrust increases	
	Verify that the thrust is sufficient for the go-around or adjust as needed.
	Verify a positive rate of climb on the altimeter and call “POSITIVE RATE.”
Verify a positive rate of climb on the altimeter and call “GEAR UP.”	
	Set the landing gear lever to UP.
Above 400 feet radio altitude, verify or select a roll mode.	Verify that the missed approach altitude is set.
Verify that the missed approach route is tracked.	
At acceleration height, set speed to the maneuver speed for the planned flap setting.	
Call “FLAPS___” according to the flap retraction schedule.	Set the flap lever as directed.
After flap retraction to the planned flap setting, select FLCH or VNAV as needed.	
Verify that climb thrust is set.	
Verify that the missed approach altitude is captured.	
Call “AFTER TAKEOFF CHECKLIST.”	Do the AFTER TAKEOFF checklist.

Landing Roll Procedure

Pilot Flying	Pilot Monitoring
Verify that the thrust levers are closed. Verify that the SPEEDBRAKE lever is UP.	Verify that the SPEEDBRAKE lever is UP. Call “SPEEDBRAKES UP.” If the SPEEDBRAKE lever is not UP, call “SPEEDBRAKES NOT UP.”
Monitor the rollout progress.	
Verify correct autobrake operation.	
WARNING: After the reverse thrust levers are raised, a full stop landing must be made. If an engine remains in reverse, safe flight is not possible.	
Without delay, raise the reverse thrust levers to the interlocks and hold light pressure until the interlocks release. Then apply reverse thrust as needed.	
By 60 knots, start movement of the reverse thrust levers to reach the reverse idle detent before taxi speed.	Call “60 KNOTS.”
After the engines are at reverse idle, move the reverse thrust levers full down.	
Before taxi speed, disarm the autobrakes. Use manual braking as needed.	
Before turning off the runway, disconnect the autopilot.	

After Landing Procedure

Start the After Landing Procedure when clear of the active runway.

Pilot Flying	Pilot Monitoring
The captain positions or verifies that the SPEEDBRAKE lever is DOWN.	
	Set the APU selector to START, then ON.
	Set the STROBE light switch to OFF. Set the LANDING and TAXI light switches as needed.
Set the weather radar to off.	
	Set the AUTOBRAKE selector OFF.
	Set the flap lever to UP.
	Set the transponder mode selector as needed. At airports where ground tracking is not available, select STANDBY. At airports equipped to track airplanes on the ground, select TRANSPONDER.

Shutdown Procedure

Start the Shutdown Procedure after taxi is complete.

Parking brake .... Set C

Verify that the PARKING BRAKE SET message is shown.

Electrical power .... Set F/O

If APU power is needed:

Check that the APU RUNNING message is shown.

If external power is needed:

Verify that the FORWARD EXTERNAL POWER L AVAIL light is illuminated.

FORWARD EXTERNAL POWER L switch – Push

Verify that the ON light is illuminated.

If the FORWARD EXTERNAL POWER R AVAIL light is illuminated:

FORWARD EXTERNAL POWER R switch – Push

Verify that the ON light is illuminated.

FUEL CONTROL switches .... CUTOFF C

If towing is needed:

Ground handling personnel .....Establish communications C

WARNING: If the nose gear steering is not locked out, any change to hydraulic power with the tow bar connected may cause unwanted tow bar movement.

Nose gear steering .... Verify locked out C

CAUTION: Do not turn the nose wheel tiller during pushback or towing. This can damage the nose gear or the tow bar.

CAUTION: Do not use airplane brakes to stop the airplane during pushback or towing. This can damage the nose gear or the tow bar.

Parking brake .... Set or release C

Set or release as directed by ground handling personnel.

SEATBELTS selector .... OFF F/O

HYDRAULIC panel..Set F/O

LEFT ELECTRIC pump selector – OFF

CENTER 1 and CENTER 2 ELECTRIC pump SELECTORS – OFF

RIGHT ELECTRIC pump selector – OFF

FUEL PUMP switches .... OFF F/O

BEACON light switch .... OFF F/O

FLIGHT DIRECTOR switches .... OFF C, F/O

EFB CLOSE FLIGHT ....Select C, F/O

Status messages ....Check F/O

Note: Disregard EICAS alert and status messages displayed during the PFC self test after hydraulic shutdown. Wait approximately 3 minutes after HYD PRESS SYS L+C+R message is shown before recording status and alert messages in the maintenance log.

After wheel chocks are in place:

Parking brake .... Release		C
APU selector .... As needed		F/O
Call "SHUTDOWN CHECKLIST."		C
Do the SHUTDOWN checklist.		F/O

Secure Procedure

IRS switch .... OFF		F/O
FLIGHT DECK DOOR POWER switch .... OFF		C, F/O
EMERGENCY LIGHTS switch .... OFF		F/O
PACK switches .... OFF		F/O
EFB POWER switch .... Push		C, F/O
HUD combiner .... Stow		C, F/O
Call "SECURE CHECKLIST."		C
Do the SECURE checklist.		F/O

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Supplementary Procedures — Chapter SP
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General

This chapter contains procedures (adverse weather operation, and so on) that are accomplished as required rather than routinely performed on each flight. Systems tests are described in the System Description chapter of the applicable system.

Note: System tests are not normally a flight crew action.

Procedures accomplished in flight, or those that are an alternate means of accomplishing normal procedures, are usually accomplished by recall. Infrequently used procedures, not normally accomplished are usually accomplished by reference.

Supplementary procedures are provided by section. Section titles correspond to the respective chapter title for the system being addressed except for the Adverse Weather section.

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Doors

Entry/Service Door Closing

Gust lock latch .... Release

Door .... Close

Manually position the door aft and inboard to cover the entry.

Door handle .... Rotate

Rotate forward 180° to the closed position. The door lowers into position, latches, and locks.

Mode select lever .... ARM

Observe yellow forward and aft girt bar flags are in view.

Entry/Service Door Opening

Mode select lever (interior only) .... DISARM

Note: Escape slide/raft and powered door opening is disarmed automatically when the door is opened from outside.

Door handle .... Rotate

Rotate aft 180° to the open position. The door is lifted clear of the pressure stops.

Door .... Open

Manually position the door outboard and forward to open. The gust lock latch automatically engages and locks door in the open position.

Emergency Equipment

Emergency Oxygen Use

Emergency oxygen should be used when necessary to provide positive pressure in the masks and goggles to prevent or evacuate contaminants. When positive pressure is not required, but contamination of flight deck air exists, 100% oxygen must be used. If prolonged use is required and the situation permits, oxygen availability should be extended by selecting normal flow. When oxygen use is no longer required, close the left hand oxygen compartment door to restore normal boom microphone operation.

Flight Deck Door Access System Test

Flight deck door power switch .... ON

Flight deck door access selector .... AUTO

Flight deck door .... Open

Verify FD DOOR OPEN advisory EICAS message is displayed.

Emergency access code .... Enter

ENT key .... Push

Verify alert sounds.

Verify FD DOOR AUTO UNLOCK warning EICAS message is displayed and MWL is on.

Flight deck door access selector .... DENY

Verify FD DOOR AUTO UNLOCK warning EICAS message extinguishes.

Flight deck door power switch .... OFF

Verify FD DOOR LOCK FAIL advisory EICAS message is displayed.

Flight deck door power switch .... ON

Verify FD DOOR LOCK FAIL advisory EICAS message extinguishes.

Air Conditioning Packs

Ground Air Conditioning Cart Use

Before connecting ground air conditioning cart:

PACK switches (both) – OFF

RECIRCULATION FANS switches (both) – OFF
[Allows cart to operate at maximum efficiency.]

After disconnecting ground air conditioning cart:

PACK switches (both) – AUTO

RECIRCULATION FANS switches (both) – ON

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Anti–Ice Operation

Requirements for use of anti-ice and operational procedures for engine and wing anti-ice are contained in Supplementary Procedures, Adverse Weather Section SP.16.

Windshield Wiper Use

CAUTION: Windshield scratching will occur if the windshield wipers are operated on a dry windshield.

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AFDS

AFDS Operation

FLIGHT DIRECTOR switches ....ON

Verify FLT DIR is displayed in the AFDS system status annunciator.

If the autopilot is desired:

AUTOPILOT engage switch ....Push

Verify A/P is displayed in the AFDS system status annunciator.

Heading Hold

If the airplane is operating in polar regions:

HEADING REFERENCE switch ....TRUE

HEADING/TRACK reference switch ....Push

Verify HDG is displayed in the HDG/TRK window.

Heading/track HOLD switch ....Push

Verify HDG HOLD is displayed in the roll mode annunciator.

Heading Select

Maintains the airplane heading the same as the selected heading.

If the airplane is operating in polar regions:

HEADING REFERENCE switch ....TRUE

HEADING/TRACK reference switch ....Push

Verify HDG is displayed in the HDG/TRK window.

Heading/track SELECT switch ....Push

Verify HDG SEL is displayed in the roll mode annunciator.

Heading/track selector ....Rotate

Set desired heading in the HDG/TRK window.

Track Hold

If the airplane is operating in polar regions:

HEADING REFERENCE switch ....TRUE

HEADING/TRACK switch .... Push

Verify TRK is displayed in the HDG/TRK window.

Heading/track HOLD switch.. Push

Verify TRK HOLD is displayed in the roll mode annunciator.

Track Select

Maintains the airplane track the same as the selected track.

If the airplane is operating in polar regions:

HEADING REFERENCE switch ....TRUE

HEADING/TRACK reference switch.. Push

Verify TRK is displayed in the HDG/TRK window.

Heading/track SELECT switch .... Push

Verify TRK SEL is displayed in the roll mode annunciator.

Heading/track selector..Rotate

Set desired track in the HDG/TRK window.

Altitude Hold

Altitude HOLD switch .... Push

Verify ALT is displayed in the pitch mode annunciator.

Flight Level Change, Climb or Descent

ALTITUDE selector ....Rotate

Set the desired altitude in the MCP ALTITUDE window.

FLCH switch .... Push

Verify FLCH SPD is displayed in the pitch mode annunciator.

IAS/MACH selector ....Rotate

Set the desired speed in the IAS/MACH window.

Vertical Speed, Climb or Descent

ALTITUDE selector .... Rotate

Set the desired altitude in the MCP ALTITUDE window.

VERTICAL SPEED/FLIGHT PATH ANGLE reference switch...... Push

Verify V/S is displayed in the vertical speed/flight path angle window.

VERTICAL SPEED/FLIGHT PATH ANGLE switch .... Push

Verify V/S is displayed in the pitch mode annunciator.

VERTICAL SPEED/FLIGHT PATH ANGLE selector .... Rotate

Set the desired vertical speed in the VERTICAL SPEED/FLIGHT PATH ANGLE window.

If a climb is desired:

Select climb thrust limit on the CDU THRUST LIM page.

Flight Path Angle, Climb or Descent

ALTITUDE selector .... Rotate

Set the desired altitude in the MCP ALTITUDE window.

VERTICAL SPEED/FLIGHT PATH ANGLE Reference switch .... Push

Verify FPA is displayed in the vertical speed/flight path angle window.

VERTICAL SPEED/FLIGHT PATH ANGLE switch .... Push

Verify FPA is displayed in the pitch mode annunciator.

VERTICAL SPEED/FLIGHT PATH ANGLE selector .... Rotate

Set the desired flight path angle in the VERTICAL SPEED/FLIGHT PATH ANGLE window.

If a climb is desired:

Select climb thrust limit on the CDU THRUST LIM page.

Autothrottle Operation

AUTOTHROTTLE ARM switches .... ARM

If the pitch mode is TO/GA:

TO/GA switch .... Push

Verify that THR REF is displayed in the autothrottle mode annunciator. THR REF changes to HOLD at 80 knots.

If the pitch mode is ALT, V/S, FPA, G/S, or no pitch mode:

AUTOTHROTTLE switch .... Push

Verify that SPD is displayed in the autothrottle mode annunciator.

If a constant speed is desired:

IAS/MACH selector ....Rotate

Set the desired speed in the IAS/MACH window.

If climb or continuous thrust is desired:

CLB CON switch.. Push

Verify that THR REF is displayed in the autothrottle mode annunciator.

If FLCH or VNAV is desired:

FLCH or VNAV switch .... Push

Verify that THR REF, THR, SPD, IDLE, or HOLD as appropriate is displayed in the autothrottle mode annunciator.

If TO/GA is desired:

TO/GA switch .... Push

The pitch mode changes to TO/GA. Verify that THR or THR REF is displayed in the autothrottle mode annunciator.

If the pitch mode is VNAV PTH, VNAV ALT, VNAV SPD, or FLCH SPD:

AUTOTHROTTLE engage switch .... Push

Verify THR REF, THR, SPD, IDLE, or HOLD as appropriate is displayed in the autothrottle mode annunciator.

Instrument Approach Using VNAV

Note: This procedure is not authorized using QFE.

Note: Operational approval required for the use of an MDA(H) as a DA(H). If required to remain at or above MDA(H) during the missed approach, missed approach must be initiated at least 50 feet above MDA(H).

Recommended roll modes for final approach:

- RNAV or GPS approach: LNAV
- LOC-BC, VOR or NDB approach: LNAV, TRK SEL, or HDG SEL
- LOC, SDF, or LDA approach: LOC or LNAV

For LOC, LOC-BC, SDF or LDA approaches, ensure appropriate navaids are tuned and identified prior to commencing approach and monitor raw data throughout the approach. For VOR or NDB approaches, raw data should be monitored if available.

FMC approach procedure .... Select

Select the approach procedure on the ARRIVALS page. Do not manually build the approach or add waypoints to the selected FMC procedure. Add cold temperature corrections to waypoint altitude constraints as appropriate.

Verify VNAV glidepath angle displayed on final approach segment of LEGS page.

RNP appropriate for approach (if required) .... Verify/Enter

Allows appropriate alerting to occur if ANP exceeds RNP.

Approximately 2 NM prior to the FAF and after ALT or VNAV PTH/VNAV ALT is annunciated:

MCP altitude ....Set MDA(H)/DA(H)

Allows VNAV to command descent in VNAV PTH.

Note: There may be a level segment beyond the FAF before intercepting the descent path.

Prior to reaching FAF:

AFDS Roll Mode .... Verify/Select

Verify appropriate roll mode annunciates.

VNAV switch (if required) .... Push

Select VNAV if in ALT. Verify VNAV PTH annunciates.

Speed Intervention .... Select

Autopilot .... Verify engaged

Autopilot should remain engaged until suitable visual reference is established.

Prior to reaching MDA(H)/DA(H) and when airplane is at least 300 feet below missed approach altitude:

MCP altitude .... Set Missed Approach Altitude

At MDA(H)/DA(H)/Missed Approach Point:

If suitable visual reference is not established, execute missed approach.

After suitable visual reference is established:

A/P Disengage switch .... Push

Disengage autopilot before descending below MDA(H)/DA(H).

Instrument Approach Using Vertical Speed (V/S) or Flight Path Angle (FPA)

Note: Autopilot use is recommended until suitable visual reference is established.

Note: If required to remain at or above MDA(H) during the missed approach, missed approach must be initiated at least 50 feet above MDA(H).

Recommended roll modes:

- RNAV, GPS, LOC-BC, VOR or NDB approach: LNAV, TRK SEL, or HDG SEL
- LOC, SDF, or LDA approach: LOC or LNAV

Ensure appropriate navaids (VOR, LOC, or NDB) are tuned and identified prior to commencing the approach.

RNP appropriate for approach (if required) .... Verify/Enter

Allows appropriate alerting to occur if ANP exceeds RNP.

Before descent to MDA(H):

MCP altitude .... Set

Set the first intermediate altitude constraint or MDA(H). When the current constraint is assured, the next constraint may be set prior to ALT engaged to achieve continuous descent path.

If constraints or MDA(H) do not end in zero zero (00) (for example, 1820), set MCP ALTITUDE window to the closest 100 foot increment below the constraint or the closest 10 foot increment above the MDA(H).

At descent point:

V/S or FPA switch .... Push

Verify V/S or FPA mode annunciates.

Desired V/S or FPA .... Set

Set desired V/S or FPA to descend to MDA(H). Use a V/S or FPA that results in no level flight segment at MDA(H).

Approximately 300 feet above MDA(H):

MCP altitude .... Set Missed Approach Altitude

At MDA(H)/missed approach point:

If suitable visual reference is not established, execute missed approach.

After suitable visual reference is established:

A/P Disengage switch .... Push

Disengage autopilot before descending below MDA(H).

Circling Approach

Note: Autopilot use is recommended until intercepting the landing profile.

MCP Altitude selector .... Set

Accomplish an instrument approach, establish suitable visual reference, and level off at MDA(H).

Verify ALT or VNAV ALT mode annunciates.

MCP Altitude selector .... Set Missed Approach Altitude

HDG SEL/TRK SEL switch .... Push

Verify HDG SEL or TRK SEL mode annunciates.

Intercepting the landing profile:

Autopilot disengage switch .... Push

Intentionally
Blank

Flight Deck Communications System (Datalink)

The following procedures are one means which may be used to verify Pre-Departure Clearance, Digital-Automatic Terminal Information Service (D-ATIS), Oceanic Clearances, Weight and Balance and Takeoff Data messages transmitted via the COMPANY format.

Pre-Departure Clearance

The flight crew shall manually verify (compare) the filed flight plan versus the digital pre-departure clearance and shall initiate voice contact with Air Traffic Control if any question/confusion exists between the filed flight plan and the digital pre-departure clearance.

Digital-Automatic Terminal Information Service

The flight crew shall verify that the D-ATIS altimeter setting numeric value and alpha value are identical. If the D-ATIS altimeter setting numeric value and alpha value are different, the flight crew must not accept the D-ATIS altimeter setting.

Oceanic Clearances

The flight crew shall manually verify (compare) the filed flight plan versus the digital oceanic clearance and initiate voice contact with Air Traffic Control if any questions/confusion exists between the filed flight plan and the digital oceanic clearance.

Weight and Balance

The flight crew shall verify that the Weight and Balance numeric and alphabetic values are identical. If the Weight and Balance numeric and alphabetic values are different, the flight crew must not accept the Weight and Balance data.

Takeoff Data

The flight crew shall verify that the Takeoff Data numeric and alphabetic values are identical. If the Takeoff Data numeric and alphabetic values are different, the flight crew must not accept the Takeoff Data message.

Intentionally
Blank

Electrical Power Down

The following procedure is accomplished to remove all electrical power from the airplane.

Before accomplishing the following steps, verify, IRS, EMER LIGHTS, and PACK switches are off and HYD PRESS SYS L+C+R message is displayed.

APU selector and/or EXTERNAL POWER switch(es) .... OFF

BATTERY switch .... OFF

Electrical Power Up

The following procedure is accomplished to permit safe application of electrical power.

Note: See Chapter 1, Airplane General, Common Core System (CCS) for electrical power initialization and related start-up modes.

BATTERY switch ....ON

C1 and C2 ELEC pump selectors .... OFF

DEMAND pump selectors .... OFF

WIPER selectors .... OFF

Landing gear lever ....DN

ALTN FLAPS selector .... OFF

Electrical power ....Establish

If external power is desired:

EXT PWR AVAIL light(s) – Illuminated

EXT PWR switch(es) – Push

If APU power is desired:

APU GENERATOR switches – ON

APU selector – START, then ON

Intentionally
Blank

Engine Cross Start

Verify the area behind the airplane is clear of equipment and personnel prior to increasing thrust on operating engine.

Thrust lever (operating engine) .... Advance

Increase thrust until 5% N2 above idle.

Accomplish normal engine start.

Intentionally
Blank

QFE Operation

This procedure is accomplished when ATC altitude assignments are referenced to QFE altimeter settings.

Note: Do not use LNAV and/or VNAV below transition altitude/level. Altitudes in the navigation database are not referenced to QFE. Use only raw data for navigation.

CDU APPROACH REF page .... Select

LANDING REF key .... Push

Verify QFE selected.

[This sets the landing altitude to zero.]

Altimeters .... Set

Set altimeters to QFE when below transition altitude/level.

If the QFE altimeter setting is beyond the range of the altimeters, QNH procedures must be used with QNH set in the altimeters.

Intentionally
Blank

Alignment/Position Update

If a position update is desired during an automatic realignment (on ground only):

CDU – SET

When dash prompts appear on the SET INERTIAL POS line of the POS INIT page, enter the most accurate position.

If a manual alignment is desired (on ground only):

IRS selectors – OFF 30 seconds, then ON

Wait an additional 30 seconds.

CDU – SET

Enter the most accurate position on the SET INERTIAL POS line of the POS INIT page if the following is displayed on the SET INERTIAL POS line:

- a latitude/longitude position

Alignment requires from six to fifteen minutes depending on latitude (six minutes at the equator, ten minutes average).

FMS Position Update

When the FMC message VERIFY POSITION is displayed, the FMC position may require updating.

POS REF page .... Select

POS REF is the second page of POS INIT.

Compare the FMS positions with the displayed GPS, RADIO, and INERTIAL positions.

Select the most appropriate source for FMC position updating.

UPDATE ARM key .... Select

The ARM prompt changes to ARMED and NOW prompts appear to the right of the remaining position sources.

Appropriate source UPDATE NOW key .... Push

Navaid Inhibit

Note: GPS position updates are allowed for all United States National Airspace approach operations. Outside of this region, GPS position updates are allowed during approaches only if the FMC database and approach charts are referenced to the WGS-84 reference datum. GPS updates should be inhibited for all other approach operations, unless other appropriate procedures are used.

To inhibit GPS:

POS REF page .... Select

POS REF is the second page of POS INIT.

GPS NAV key .... Push

Verify GPS NAV OFF selected.

To inhibit VORs, VOR/DMEs, VORTACs, or DMEs:

INIT REF key .... Push

INDEX key .... Push

NAV DATA key .... Push

To inhibit all VOR/DME data:

VOR/DME NAV key .... Push

Verify VOR/DME NAV OFF selected.

Enter identifiers of specific navaids or VORs to be inhibited on the NAVAID INHIBIT or VOR ONLY INHIBIT lines.

RNP Manual Entry

The FMC automatically supplies default RNP values based on phase of flight. When the airplane is on a procedure or airway that has an RNP requirement, and does not have an RNP value stored in the navigation database, a manual RNP entry may be made.

POS REF page .... Select

POS REF is the second page of POS INIT.

If the displayed RNP is different from the RNP for the current airway or procedure:

RNP .... Enter

When the manually entered RNP is no longer required:

POS REF page 2/4 .... Select

RNP .... Delete

Intentionally
Blank

Supplementary Procedures — Chapter SP

Fuel — Section 12

Fuel Balancing

If fuel leak is suspected:

Accomplish the FUEL LEAK checklist.

If fuel balancing is desired prior to display of the FUEL IMBALANCE alert message:

Accomplish the FUEL IMBALANCE non-normal checklist.

Intentionally
Blank

Introduction

Airplane operation in adverse weather conditions may require additional considerations due to the effects of extreme temperatures, precipitation, turbulence, and windshear. Procedures in this section supplement normal procedures and should be observed when applicable.

Takeoff - Wet or Contaminated Runway Conditions

The following information applies to takeoffs on wet or contaminated runways:

- Do not use reduced thrust (assumed temperature method) for takeoff if the runway is contaminated by slush, snow, standing water, or ice
- Reduced thrust (assumed temperature method) is allowed for takeoff on a wet runway if suitable performance accountability is made for the increased stopping distance on a wet surface
- V1 may be reduced to minimum V1 to provide increased stopping margin provided the field length required for a continued takeoff from the minimum V1 and obstacle clearance meet the regulatory requirements. The determination of such minimum V1 may require a real-time performance calculation tool or other performance information supplied by dispatch
- Takeoffs are not recommended when slush, wet snow, or standing water depth is more than 1/2 inch (13 mm) or dry snow depth is more than 4 inches (102 mm)

Cold Weather Operations

Considerations associated with cold weather operation are primarily concerned with low temperatures and with ice and snow on the airplane, ramps, taxiways, and runways.

Icing conditions exist when OAT (on the ground) or TAT (in-flight) is 10°C or below and:

- visible moisture (clouds, fog with visibility less than one statute mile (1600m), rain, snow, sleet, ice crystals, and so on) is present, or
- standing water, ice, or snow is present on the ramps, taxiways, or runways

CAUTION: Do not use engine anti-ice when OAT (on the ground) is above 10°C. Do not use engine or wing anti-ice when OAT (in-flight) is above 10°C.

Exterior Inspection

Although removal of surface snow, ice and frost is normally a maintenance function, during preflight procedures, the captain or first officer should carefully inspect areas where surface snow or frost could change or affect normal system operations.

Do the normal Exterior Inspection with the following additional steps:

Surfaces .... Check

Takeoff with light coatings of frost, up to 1/8 inch (3mm) in thickness on lower wing surfaces due to cold fuel is permissible; however, all leading edge devices, all control surfaces, and upper wing surfaces must be free of snow or ice.

Thin hoarfrost is acceptable on the upper surface of the fuselage provided all vents and ports are clear. Thin hoarfrost is a uniform white deposit of fine crystalline texture, which usually occurs on exposed surfaces on a cold and cloudless night, and which is thin enough to distinguish surface features underneath, such as paint lines, markings or lettering.

Pitot probes and static ports .... Check

Verify that all pitot probes and static ports are free of snow and ice. Water rundown after snow removal may freeze immediately forward of static ports and cause an ice buildup which disturbs airflow over the static ports resulting in erroneous static readings even when static ports are clear.

Air conditioning inlets and exits .... Check

Verify that the air inlets and exits, including the outflow valves, are free of snow and ice.

Engine inlets .... Check

Verify that the inlet cowling is free of snow and ice.

Fuel tank vents .... Check

Verify that all traces of ice and frost are removed.

Landing gear doors .... Check

Landing gear doors should be free of snow and ice.

APU air inlets .... Check

The APU inlet door must be free of snow and ice before APU start.

Engine Start Procedure

Do the normal Engine Start Procedure with the following considerations:

- Oil pressure may be slow to rise
- Initial oil pressure rise may be higher than normal
- Additional warm-up time may be needed to allow oil temperature to reach the normal range
- Displays may require additional warm-up time before displayed engine indications accurately show changing values. Displays may appear less bright than normal

Engine Anti-ice Operation - On the Ground

Engine anti-ice must be selected ON immediately after both engines are started and remain on during all ground operations when icing conditions exist or are anticipated, except when the temperature is below –40°C OAT.

WARNING: Do not rely on airframe visual icing cues before activating engine anti–ice. Use the temperature and visible moisture criteria because late activation of engine anti-ice may allow excessive ingestion of ice and result in engine damage or failure.

CAUTION: Do not use engine anti-ice when OAT is above 10°C.

When engine anti-ice is needed:

ENGINE ANTI-ICE selectors .... ON F/O

When engine anti-ice is no longer needed:

ENGINE ANTI-ICE selectors ....AUTO F/O

Before Taxi Procedure

Do the normal Before Taxi Procedure with the following modifications:

If taxi route is through slush or standing water in low temperatures or if precipitation is falling with temperatures below freezing, taxi out with the flaps up. Taxiing with the flaps extended subjects the flaps and flap drives to snow and slush accumulations from the main gear wheels. Leading edge devices are also susceptible to slush accumulations.

Call “FLAPS ___” as needed. C

Flap lever .... Set flaps, as needed F/O

Taxi–Out

CAUTION: Taxi at a reduced speed. Use smaller tiller and rudder inputs, and apply minimum thrust evenly and smoothly. Taxiing on slippery taxiways or runways at excessive speed or with high crosswinds may start a skid.

When engine anti-ice is required and the OAT is 3°C or below, do an engine run up, as needed, to minimize ice build-up. Use the following procedure: C

Check that the area behind the airplane is clear.

[Option – GE engines]
Run-up to a minimum of (TBD)% N1 for approximately (TBD) second duration at intervals no greater than 60 minutes.

[Option – RR engines]
Run-up to a minimum of 35% N1 for approximately 60 second duration at intervals no greater than 60 minutes.

De-icing / Anti-icing

Testing of undiluted de-icing/anti-icing fluids has shown that some of the fluid remains on the wing during takeoff rotation and initial climb. The residual fluid causes a temporary decrease in lift and increase in drag, however, the effects are temporary. Takeoff operations with reduced thrust (assumed temperature method or fixed derate) are permitted provided takeoff performance accounts for the runway surface condition. Use the normal takeoff rotation rate.

CAUTION: Operate the APU during de-icing only if necessary. If the APU is running, ingestion of de-icing fluid causes objectionable fumes and odors to enter the airplane. Ingestion of snow, slush, ice, or de-icing/anti-icing fluid can also cause damage to the APU.

If de-icing / anti-icing is needed:

APU .... As needed F/O

The APU should be shut down unless APU operation is necessary.

Call “FLAPS UP” C

Flaps .... UP F/O

Prevents ice and slush from accumulating in flap cavities during de-icing.

Thrust levers .... Idle C

Reduces the possibility of injury to personnel at inlet or exhaust areas.

PACK switches .... OFF

After de-icing / anti-icing is completed:

APU .... As needed F/O

Before Takeoff Procedure

Do the normal Before Takeoff Procedure with the following modification:

Do the following steps after clear of snow and slush but before completing the normal Before Takeoff Procedure:

Call “FLAPS ___” as needed for takeoff. PF

Flap lever ....Set takeoff flaps, as needed PM

Extend the flaps to the takeoff setting at this time if they have been held because of slush, standing water, or icing conditions, or because of exterior de-icing / anti-icing.

[Option – RR engines]
Engine oil temperature.................................Minimum 50° C PF

Oil temperature must be at least 50° C before takeoff.

When engine anti-ice is required and the OAT is 3°C or below, the takeoff must be preceded by a static engine run-up. Use the following procedure:

[Option – RR engines]

Run-up to a minimum of 50% N1 and confirm stable engine operation before the start of the takeoff roll.

[Option – GE engines]

Run-up to as high a thrust setting as practical and confirm stable engine operation before the start of the takeoff roll.

Engine Anti-ice Operation - In-flight

Engine anti–ice must be AUTO or ON during all flight operations when icing conditions exist or are anticipated, except when the temperature is below –40°C TAT.

CAUTION: Do not use engine anti-ice when TAT is above 10°C.

Manual Use of Engine Anti-ice

When using the engine anti-ice system manually in areas of possible icing, activate engine anti–ice before entering icing conditions.

WARNING: If using the engine anti–ice system manually, do not rely on airframe visual icing cues before activating engine anti–ice. Use the temperature and visible moisture criteria because late activation of engine anti-ice may allow excessive ingestion of ice and result in engine damage or failure.

When manual use of engine anti-ice is needed:

ENGINE ANTI–ICE selectors .... ON PM

When manual use of engine anti-ice is no longer needed:

ENGINE ANTI–ICE selectors .... AUTO or OFF PM

Fan Ice Removal

CAUTION: Avoid prolonged operation in moderate to severe icing conditions.

If moderate to severe icing conditions are encountered:

[Option – GE engines]

During flight in moderate to severe icing conditions for prolonged periods with N1 settings at or below 70%, or when fan icing is suspected due to high engine vibration, the fan blades must be cleared of any ice. Do the following procedure every 15 minutes on both engines, one engine at a time: reduce thrust toward idle then increase to a minimum of 70% N1 for 10 to 30 seconds.

[Option – GE engines]

Note: Operation in icing conditions may result in displayed vibration levels up to and exceeding the normal operating range. Extended operation at high vibration levels in icing conditions will not result in engine damage.

[Option – RR engines]

During flight in moderate to severe icing conditions for prolonged periods, if fan icing is suspected due to high engine vibration, the fan blades must be cleared of any ice. Do the following procedure on both engines, one engine at a time: quickly reduce thrust to idle for 5 seconds then restore the required thrust. If vibration persists, advance thrust lever to 90% N1 momentarily.

Wing Anti-ice Operation - In-flight

Ice accumulation on the flight deck window frames, windshield center post, or windshield wiper arm, or side windows may be used as an indication of structural icing conditions and the need to turn on wing anti–ice.

The wing anti–ice system may be used as a de–icer or anti–icer in flight only. The primary method is to use the automatic ice detection system which acts as a de–icer by allowing ice to accumulate before turning wing anti–ice on. This procedure provides the cleanest airfoil surface, the least possible runback ice formation, and the least thrust and fuel penalty.

The secondary method is to select the WING ANTI–ICE selector ON when wing icing is possible and use the system as an anti–icer.

The airplane is capable of continued safe flight and landing in icing conditions in the event of an in-flight failure of the wing anti-ice system.

CAUTION: Do not use wing anti-ice when TAT is above 10°C.

Manual Use of Wing Anti-ice

When manual use of wing anti–ice is needed:

WING ANTI–ICE switch .... ON PM

When manual use of wing anti–ice is no longer needed:

WING ANTI–ICE switch .... AUTO or OFF PM

Cold Temperature Altitude Corrections

Extremely low temperatures create significant altimeter errors and greater potential for reduced terrain clearance. When the temperature is colder than ISA, true altitude will be lower than indicated altitude.

The following altitude correction procedures should be considered when operating at or near airports where high terrain and/or obstacles exist in combination with very cold temperatures (-30°C or colder), or when en route minimum altitudes are affected by terrain clearance:

- no corrections are required for reported temperatures above 0°C
- corrections apply to QNH and QFE operations
- pilots should not correct altimeter barometric reference settings

- ATC assigned altitudes or flight levels should not be adjusted for temperature
- apply corrections to all published minimum departure, en route and approach altitudes, including missed approach altitudes, according to the table below. Advise ATC of the corrections
- MDA/DA settings should be set at the corrected minimum altitudes for the approach
- subtract the elevation of the altimeter barometric reference setting source (normally the departure or destination airport elevation) from the published minimum altitude to be flown to determine "height above altimeter source"
- enter the table with Airport Temperature and with "height above altimeter source." Read the correction where these two entries intersect. Add the correction to the published minimum altitude to be flown to determine the corrected indicated altitude to be flown. To correct an altitude above the altitude in the last column, use linear extrapolation (e.g., to correct 6000 feet or 1800 meters, use twice the correction for 3000 feet or 900 meters, respectively)
- if the corrected indicated altitude to be flown is between 100 foot increments, set the MCP altitude to the closest 100 foot increment above the corrected indicated altitude to be flown

Altitude Correction Table (Heights and Altitudes in Feet)

[Option – English units]

Airport Temp °C	Height Above Altimeter Source (feet)											
	200	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1500**	**2000**	**3000**
0°	20	20	30	30	40	40	50	50	60	90	120	170
-10°	20	30	40	50	60	70	80	90	100	150	200	290
-20°	30	50	60	70	90	100	120	130	140	210	280	420
-30°	40	60	80	100	120	140	150	170	190	280	380	570
-40°	50	80	100	120	150	170	190	220	240	360	480	720
-50°	60	90	120	150	180	210	240	270	300	450	590	890

Altitude Correction Table (Heights and Altitudes in Meters)

[Option – Metric units]

Airport Temp °C	Height Above Altimeter Source (meters)											
	60	90	120	150	180	210	240	270	300	450	600	900
0°	5	5	10	10	10	15	15	15	20	25	35	50
-10°	10	10	15	15	20	20	25	30	30	45	60	90
-20°	10	15	20	25	25	30	35	40	45	65	85	130
-30°	15	20	25	30	35	40	45	55	60	85	115	170
-40°	15	25	30	40	45	50	60	65	75	110	145	220
-50°	20	30	40	45	55	65	75	80	90	135	180	270

After Landing Procedure

CAUTION: Taxi at a reduced speed. Use smaller tiller and rudder inputs, and apply minimum thrust evenly and smoothly. Taxiing on slippery taxiways or runways at excessive speed or with high crosswinds may start a skid.

Do the normal After Landing Procedure with the following modifications:

After prolonged operation in icing conditions with the flaps extended, or when an accumulation of airframe ice is observed, or when landing on a runway contaminated with ice, snow, or slush:

Do not retract the flaps until the flap areas have been checked to be free of contaminats.

Engine anti-ice must be selected ON and remain on during all ground operations when icing conditions exist or are anticipated, except when the temperature is below –40°C OAT.

WARNING: Do not rely on airframe visual icing cues before activating engine anti–ice. Use the temperature and visible moisture criteria because late activation of engine anti-ice may allow excessive ingestion of ice and result in engine damage or failure.

CAUTION: Do not use engine anti-ice when OAT is above 10°C.

When engine anti-ice is needed:

ENGINE ANTI-ICE selectors .... ON F/O

When engine anti-ice is no longer needed:

ENGINE ANTI-ICE selectors .... AUTO F/O

When engine anti-ice is required and the OAT is 3°C or below, do an engine run up, as needed, to minimize ice build-up. Use the following procedure: C

Check that the area behind the airplane is clear.

[Option – GE engines]
Run-up to a minimum of (TBD)% N1 for approximately (TBD) second duration at intervals no greater than 15 minutes.

[Option – RR engines]
Run-up to a minimum of 35% N1 for approximately 60 second duration at intervals no greater than 60 minutes.

Secure Procedure

Do the following steps after completing the normal Secure Procedure:

If the airplane will be attended:

PACK switches .... AUTO F/O

Use normal air conditioning procedures, with all packs, trim air, and recirculation fans on, to provide cabin heating.

If the airplane will not be attended, or if staying overnight at off-line stations or at airports where normal support is not available, the flight crew must arrange for or verify that the following steps are done:

OUTFLOW VALVE switches .... MAN F/O

OUTFLOW VALVE MANUAL switches ....CLOSE F/O

Position the outflow valves fully closed to inhibit the intake of snow or ice.

Wheel chocks ....Verify in place C or F/O

Parking brake ....Released C

Reduces the possibility of frozen brakes.

Cold weather maintenance procedures for securing the airplane may be required. These procedures are found in the approved Aircraft Maintenance Manual.

Hot Weather Operation

During extended ground operations prior to flight deck preparation, consideration should be given to reducing the heat being generated on the flight deck. Window heat, radar, and other electronic components which contribute to a high temperature level on the flight deck may be turned off. All the flight deck air outlets should be open.

Both packs should be used (when possible) for maximum cooling. Recirculation fans should be on for maximum cooling capacity. To maximize the cooling capacity of the air conditioning system, the flight deck side windows and all doors, including cargo doors, should be kept closed as much as possible. All gasper outlets should be open and window shades on the hot (sun–exposed) side of the passenger cabin should be closed. Flight deck cooling can be improved by closing the flight deck door and lowering the side trays adjacent to the pilot seats.

Note: If only cooling air from ground air conditioning cart is supplied (no pressurized air from the APU or ground external air), then the TAT probe is not aspirated. Because of high TAT probe temperatures, the FMCs may not accept an assumed temperature derate. Delay selecting an assumed temperature derate until after bleed air is available.

Severe Turbulence

The turbulent air penetration speed provides ample protection from stall and high speed buffet, while also providing protection from exceeding the structural limit.

The recommended procedures for flight in severe turbulence are summarized below:

Passenger signs .... ON

Advise passengers to fasten seatbelts prior to entering areas of reported or anticipated turbulence. Instruct flight attendants to check all passengers' seat belts are fastened.

Structural Considerations

Flap extension in an area of known turbulence should be delayed as long as possible because the airplane can withstand higher gust loads in the clean configuration. Diversion to another airfield is recommended if severe turbulence persists in the area.

Climb, Cruise, and Descent Considerations

After takeoff, and when established in a clean climb configuration, use of the autoflight system is recommended for flight through turbulence.

During climb and descent, use of VNAV or flight level change may result in excessive pitch changes as the AFDS attempts to fly speed with the elevators. Therefore, vertical speed mode (speed on autothrottles) is recommended for climb and descent in severe turbulence.

During cruise, VNAV and altitude hold modes both fly speed on autothrottles and can be used in turbulence.

[Option – RR engines]

In severe turbulence during cruise, it may be necessary to disconnect the autothrottles to prevent excessive thrust changes. Thrust setting guidance is available on EICAS when VNAV is engaged. Set TPR at or slightly above the magenta VNAV target TPR indication. Change thrust setting only if required to modify an unacceptable speed trend.

[Option – GE engines]

In severe turbulence during cruise, it may be necessary to disconnect the autothrottles to prevent excessive thrust changes. Thrust setting guidance is available on EICAS when VNAV is engaged. Set N1 at or slightly above the magenta VNAV target N1 indication. Change thrust setting only if required to modify an unacceptable speed trend.

Manual Flight in Severe Turbulence

If manual flight in severe turbulence becomes necessary, trim the airplane for the turbulent air penetration speed. Control the airplane pitch attitude with the elevators using the attitude indicator as the primary instrument. In extreme drafts, large altitude changes may occur. Do not make sudden large control inputs. Corrective actions to regain the desired attitude should be smooth and deliberate. Altitude variations are likely in severe turbulence and should be allowed to occur if terrain clearance is adequate. Control airplane attitude first, then make corrections for airspeed, altitude, and heading.

Windshear

Windshear is a change of wind speed and/or direction over a short distance along the flight path. Indications of windshear are listed in the Non-Normal Maneuvers section in this manual.

Avoidance

The flight crew should search for any clues to the presence of windshear along the intended flight path. Presence of windshear may be indicated by:

- thunderstorm activity
- virga (rain that evaporates before reaching the ground)
- pilot reports
- low level windshear alerting (LLWAS) warnings

Stay clear of thunderstorm cells and heavy precipitation and areas of known windshear. If the presence of windshear is confirmed, delay takeoff or do not continue an approach.

Precautions

If windshear is suspected, be alert to any of the danger signals and be prepared for the possibility of an inadvertent encounter. The following precautionary actions are recommended if windshear is suspected:

Takeoff

- use maximum takeoff thrust instead of reduced thrust
- for optimum takeoff performance, use flaps 20 for takeoff unless limited by obstacle clearance and/or climb gradient. Flaps 15 may be used as a precautionary setting and will provide nearly equivalent performance to Flaps 20
- use the longest suitable runway provided it is clear of areas of known windshear
- use the flight director after takeoff
- consider increasing VR speed to the performance limited gross weight rotation speed, not to exceed actual gross weight VR+20 knots. Set V speeds for the actual gross weight. Rotate at the adjusted (higher) rotation speed. This increased rotation speed results in an increased stall margin, and meets takeoff performance requirements. If windshear is encountered at or beyond the actual gross weight VR, do not attempt to accelerate to the increased VR, but rotate without hesitation
- be alert for any airspeed fluctuations during takeoff and initial climb. Such fluctuations may be the first indication of windshear
- know the all-engine initial climb pitch attitude. Rotate at the normal rate to this attitude for all non-engine failure takeoffs. Minimize reductions from the initial climb pitch attitude until terrain and obstruction clearance is assured, unless stick shaker activates
- crew coordination and awareness are very important. Develop an awareness of normal values of airspeed, attitude, vertical speed and airspeed build-up. Closely monitor vertical flight path instruments such as vertical speed and altimeters. The pilot monitoring should be especially aware of vertical path instruments and call out any deviations from normal
- should airspeed fall below the trim airspeed, unusual control column forces may be required to maintain the desired pitch attitude. Stick shaker must be respected at all times

Approach and Landing

- use either Flaps 25 or 30 for landing
- establish a stabilized approach no lower than 1000 feet above the airport to improve windshear recognition capability
- use the most suitable runway that avoids the areas of suspected windshear and is compatible with the crosswind or tailwind limitations. Use ILS G/S, VNAV path or VASI/PAPI indications to detect flight path deviations and help with timely detection of windshear
- if the autothrottle is disengaged, or is planned to be disengaged prior to landing, add an appropriate airspeed correction (correction applied in the same manner as gust), up to a maximum of 20 knots
- avoid large thrust reductions or trim changes in response to sudden airspeed increases as these may be followed by airspeed decreases
- crosscheck flight director commands using vertical flight path instruments
- crew coordination and awareness are very important, particularly at night or in marginal weather conditions. Closely monitor the vertical flight path instruments such as vertical speed, altimeters and glideslope displacement. The pilot monitoring should call out any deviations from normal. Use of autopilot and autothrottle for the approach may provide more monitoring and recognition time

Recovery

Accomplish the WINDSHEAR ESCAPE MANEUVER found in the Non-Normal Maneuvers section of this manual.

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Performance Dispatch Chapter PD

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Performance Dispatch — Chapter PD
Takeoff — Section 10

Takeoff Field Corrections - Dry Runway
Slope Corrections

FIELD LENGTH AVAILABLE (FT)	SLOPE CORRECTED FIELD LENGTH (FT)								
	RUNWAY SLOPE (%)								
	-2.0	-1.5	-1.0	-0.5	0.0	0.5	1.0	1.5	2.0
4200	4370	4330	4290	4240	4200	4130	4050	3980	3910
4600	4820	4760	4710	4650	4600	4500	4400	4310	4210
5000	5260	5200	5130	5070	5000	4880	4760	4630	4510
5400	5710	5630	5550	5480	5400	5250	5110	4960	4810
5800	6150	6070	5980	5890	5800	5630	5460	5290	5120
6200	6600	6500	6400	6300	6200	6000	5810	5610	5420
6600	7040	6930	6820	6710	6600	6380	6160	5940	5720
7000	7490	7370	7240	7120	7000	6760	6510	6270	6020
7400	7930	7800	7670	7530	7400	7130	6860	6590	6320
7800	8380	8230	8090	7940	7800	7510	7210	6920	6630
8200	8820	8670	8510	8360	8200	7880	7560	7250	6930
8600	9270	9100	8930	8770	8600	8260	7920	7570	7230
9000	9710	9530	9360	9180	9000	8630	8270	7900	7530
9400	10160	9970	9780	9590	9400	9010	8620	8230	7840
9800	10600	10400	10200	10000	9800	9380	8970	8550	8140
10200	11050	10830	10620	10410	10200	9760	9320	8880	8440
10600	11490	11270	11050	10820	10600	10140	9670	9210	8740
11000	11940	11700	11470	11230	11000	10510	10020	9530	9040
11400	12380	12140	11890	11650	11400	10890	10370	9860	9350
11800	12830	12570	12310	12060	11800	11260	10720	10190	9650

Wind Corrections

SLOPE CORR'D FIELD LENGTH (FT)	SLOPE & WIND CORRECTED FIELD LENGTH (FT)							
	WIND COMPONENT (KTS)							
	-15	-10	-5	0	10	20	30	40
4200	3050	3440	3820	4200	4450	4710	4960	5220
4600	3390	3790	4200	4600	4860	5120	5380	5650
5000	3720	4150	4570	5000	5270	5540	5810	6080
5400	4060	4510	4950	5400	5680	5950	6230	6510
5800	4400	4860	5330	5800	6080	6370	6650	6940
6200	4730	5220	5710	6200	6490	6780	7070	7370
6600	5070	5580	6090	6600	6900	7200	7500	7800
7000	5400	5940	6470	7000	7310	7610	7920	8230
7400	5740	6290	6850	7400	7710	8030	8340	8660
7800	6070	6650	7220	7800	8120	8440	8760	9090
8200	6410	7010	7600	8200	8530	8860	9190	9520
8600	6750	7360	7980	8600	8940	9270	9610	9950
9000	7080	7720	8360	9000	9340	9690	10030	10380
9400	7420	8080	8740	9400	9750	10100	10450	10810
9800	7750	8440	9120	9800	10160	10520	10880	11240
10200	8090	8790	9500	10200	10570	10930	11300	11670
10600	8420	9150	9870	10600	10970	11350	11720	12100
11000	8760	9510	10250	11000	11380	11760	12140	12530
11400	9100	9860	10630	11400	11790	12180	12570	12960
11800	9430	10220	11010	11800	12200	12590	12990	13390

Takeoff Field & Climb Limit Weights - Dry Runway

Flaps 15

Sea Level Pressure Altitude

CORR'D FIELD LENGTH (FT)	FIELD LIMIT WEIGHT (1000 LB)										
	OAT										
°C	-40	10	14	18	22	26	30	38	42	46	50
°F	-40	50	57	64	72	79	86	100	108	115	122
5400	429.4	395.8	393.3	390.9	388.6	386.2	383.9	364.0	353.9	345.0	334.8
5800	446.2	411.3	408.7	406.3	403.8	401.4	399.0	378.4	367.9	358.7	348.1
6200	462.1	426.1	423.4	420.9	418.4	415.9	413.4	392.1	381.2	371.7	360.8
6600	477.4	440.2	437.5	434.8	432.2	429.7	427.1	405.1	393.9	384.1	372.9
7000	491.9	453.7	450.9	448.2	445.5	442.9	440.3	417.7	406.2	396.1	384.6
7400	504.6	465.8	462.9	460.1	457.4	454.7	452.1	429.1	417.4	407.1	395.4
7800	518.0	478.3	475.4	472.6	469.8	467.0	464.3	440.8	428.8	418.3	406.3
8200	533.4	492.4	489.3	486.4	483.5	480.7	477.9	453.5	441.1	430.3	417.9
8600	545.0	506.4	503.3	500.2	497.3	494.3	491.4	466.2	453.3	442.1	429.2
9000	545.0	518.9	515.7	512.6	509.5	506.5	503.5	477.5	464.3	452.7	439.5
9400	545.0	529.0	525.7	522.5	519.4	516.3	513.2	486.8	473.3	461.5	447.9
9800	545.0	538.9	535.6	532.3	529.1	525.9	522.8	495.8	482.0	470.0	456.2
10200	545.0	545.0	545.0	541.7	538.5	535.2	532.1	504.5	490.5	478.2	464.1
10600	545.0	545.0	545.0	545.0	545.0	544.3	541.1	513.0	498.7	486.2	471.8
11000	545.0	545.0	545.0	545.0	545.0	545.0	545.0	521.4	506.9	494.1	479.5
CLIMB LIMIT WT (1000 LB)	527.1	522.8	522.4	522.1	521.8	521.5	521.2	486.6	464.6	446.4	425.9

2000 FT Pressure Altitude

CORR'D FIELD LENGTH (FT)	FIELD LIMIT WEIGHT (1000 LB)										
	OAT										
°C	-40	10	14	18	22	26	30	38	42	46	50
°F	-40	50	57	64	72	79	86	100	108	115	122
5400	408.9	375.1	372.8	370.4	366.1	361.9	354.0	338.1	329.6	319.4	308.2
5800	424.9	389.8	387.4	385.0	380.6	376.2	368.0	351.6	342.7	332.2	320.6
6200	440.1	403.9	401.4	398.9	394.3	389.8	381.3	364.3	355.2	344.3	332.3
6600	454.6	417.3	414.8	412.2	407.4	402.8	394.0	376.6	367.1	355.9	343.5
7000	468.5	430.2	427.6	424.9	420.0	415.2	406.3	388.3	378.6	367.1	354.4
7400	480.9	441.9	439.2	436.4	431.5	426.6	417.5	399.2	389.3	377.6	364.7
7800	493.8	453.8	451.1	448.3	443.2	438.2	428.9	410.2	400.1	388.1	374.9
8200	508.3	467.0	464.2	461.3	456.1	450.9	441.2	421.9	411.5	399.0	385.4
8600	522.9	480.2	477.2	474.2	468.8	463.5	453.4	433.4	422.6	409.7	395.6
9000	536.0	491.9	488.9	485.8	480.3	474.7	464.4	443.8	432.6	419.4	404.8
9400	545.0	501.5	498.4	495.2	489.5	483.9	473.4	452.3	441.0	427.4	412.5
9800	545.0	510.8	507.6	504.4	498.6	492.9	482.2	460.7	449.1	435.3	420.1
10200	545.0	519.8	516.6	513.3	507.4	501.5	490.6	468.7	456.9	442.8	427.3
10600	545.0	528.6	525.3	522.0	515.9	510.0	498.8	476.5	464.5	450.1	434.4
11000	545.0	537.3	533.9	530.5	524.4	518.3	507.0	484.3	472.0	457.4	441.3
CLIMB LIMIT WT (1000 LB)	503.3	499.5	499.2	499.0	498.7	498.4	482.4	446.4	429.0	409.4	389.4

With engine anti-ice on, decrease field limit weight by 400 lb and climb limit weight by 500 lb.
With engine and wing anti-ice on, decrease field limit weight by 400 lb and climb limit weight by 500 lb.

Takeoff Field & Climb Limit Weights - Dry Runway

Flaps 15

4000 FT Pressure Altitude

CORR'D FIELD LENGTH (FT)	FIELD LIMIT WEIGHT (1000 LB)										
	OAT										
°C	-40	10	14	18	22	26	30	38	42	46	50
°F	-40	50	57	64	72	79	86	100	108	115	122
5400	387.2	350.7	348.5	346.4	344.2	337.5	330.4	314.8	304.5	293.9	283.4
5800	402.4	364.6	362.3	360.1	357.9	351.0	343.6	327.3	316.7	305.7	294.9
6200	416.8	377.8	375.5	373.2	370.9	363.7	356.1	339.3	328.3	317.0	305.7
6600	430.7	390.4	388.0	385.6	383.3	375.9	368.1	350.7	339.5	327.7	316.1
7000	443.9	402.6	400.1	397.6	395.2	387.6	379.6	361.8	350.2	338.1	326.2
7400	455.8	413.7	411.2	408.7	406.2	398.5	390.3	372.2	360.4	348.1	336.0
7800	468.1	425.0	422.5	419.9	417.4	409.5	401.1	382.6	370.5	357.9	345.5
8200	481.8	437.3	434.6	432.0	429.3	421.2	412.5	393.4	380.9	367.9	355.0
8600	495.5	449.3	446.6	443.8	441.1	432.7	423.7	403.8	390.9	377.4	364.1
9000	507.7	460.2	457.3	454.5	451.7	443.0	433.8	413.3	400.0	386.1	372.5
9400	517.5	469.0	466.1	463.3	460.4	451.5	442.1	421.2	407.6	393.5	379.5
9800	527.2	477.7	474.8	471.8	468.9	459.9	450.2	429.0	415.1	400.7	386.4
10200	536.5	486.1	483.1	480.1	477.1	467.9	458.1	436.4	422.2	407.5	393.0
10600	545.0	494.2	491.1	488.1	485.1	475.7	465.7	443.6	429.2	414.2	399.4
11000	545.0	502.3	499.2	496.1	493.0	483.4	473.2	450.7	436.0	420.8	405.7
CLIMB LIMIT WT (1000 LB)	476.7	472.5	472.3	472.0	471.7	458.2	444.0	412.6	394.0	374.9	356.1

6000 FT Pressure Altitude

CORR'D FIELD LENGTH (FT)	FIELD LIMIT WEIGHT (1000 LB)										
	OAT										
°C	-40	10	14	18	22	26	30	38	42	46	50
°F	-40	50	57	64	72	79	86	100	108	115	122
5400	361.2	331.2	329.2	327.1	321.0	313.9	306.5	288.5	278.6	268.6	258.7
5800	375.5	344.4	342.3	340.1	333.8	326.5	318.8	300.1	289.8	279.6	269.3
6200	389.1	356.9	354.7	352.5	346.0	338.4	330.5	311.2	300.5	289.9	279.3
6600	402.1	368.9	366.6	364.4	357.6	349.8	341.7	321.8	310.8	299.8	288.9
7000	414.5	380.5	378.1	375.8	368.9	360.9	352.5	332.0	320.7	309.5	298.2
7400	425.9	391.2	388.8	386.5	379.4	371.3	362.7	341.9	330.4	319.0	307.5
7800	437.5	402.0	399.6	397.2	389.9	381.6	372.9	351.6	339.8	328.1	316.4
8200	450.1	413.5	410.9	408.4	400.9	392.4	383.3	361.3	349.1	337.0	324.9
8600	462.7	424.7	422.0	419.5	411.7	402.8	393.4	370.6	358.0	345.5	332.9
9000	473.9	434.8	432.1	429.4	421.4	412.3	402.6	379.1	366.2	353.2	340.3
9400	483.1	443.1	440.4	437.7	429.5	420.1	410.3	386.3	373.1	359.9	346.7
9800	492.0	451.3	448.5	445.7	437.4	427.8	417.8	393.3	379.8	366.4	352.9
10200	500.7	459.2	456.3	453.5	445.0	435.2	425.0	400.0	386.3	372.6	358.9
10600	509.1	466.8	463.9	461.0	452.3	442.4	432.0	406.6	392.6	378.6	364.6
11000	517.4	474.4	471.4	468.4	459.6	449.5	438.9	413.0	398.8	384.5	370.3
CLIMB LIMIT WT (1000 LB)	452.1	449.3	449.1	448.9	436.5	422.2	407.8	375.5	357.6	339.8	322.2

With engine anti-ice on, decrease field limit weight by 400 lb and climb limit weight by 500 lb.
With engine and wing anti-ice on, decrease field limit weight by 400 lb and climb limit weight by 500 lb.

Takeoff Field & Climb Limit Weights - Dry Runway

Flaps 15

8000 FT Pressure Altitude

CORR'D FIELD LENGTH (FT)	FIELD LIMIT WEIGHT (1000 LB)										
	OAT										
	°C	-40	10	14	18	22	26	30	38	42	46	50
	°F	-40	50	57	64	72	79	86	100	108	115	122

CORR'D FIELD LENGTH (FT)	-40 °C / -40 °F	10 °C / 50 °F	14 °C / 57 °F	18 °C / 64 °F	22 °C / 72 °F	26 °C / 79 °F	30 °C / 86 °F	38 °C / 100 °F	42 °C / 108 °F	46 °C / 115 °F	50 °C / 122 °F
5800	353.4	324.9	322.9	317.3	310.6	303.4	295.5	276.5	266.8	257.0	247.1
6200	366.2	336.7	334.7	328.9	322.0	314.5	306.4	286.8	276.7	266.6	256.3
6600	378.5	348.1	346.0	340.0	332.9	325.2	316.8	296.6	286.3	275.8	265.2
7000	390.3	359.1	356.9	350.8	343.5	335.6	326.9	306.2	295.5	284.8	274.0
7400	401.2	369.4	367.2	361.0	353.6	345.5	336.7	315.6	304.8	293.9	282.8
7800	412.3	379.7	377.5	371.1	363.5	355.3	346.2	324.7	313.6	302.4	291.1
8200	424.0	390.4	388.1	381.5	373.6	365.1	355.8	333.4	322.0	310.5	298.7
8600	435.6	400.8	398.4	391.5	383.4	374.6	364.9	341.8	329.9	318.0	305.8
9000	446.1	410.2	407.7	400.7	392.3	383.2	373.2	349.4	337.2	324.9	312.4
9400	454.6	418.0	415.5	408.3	399.7	390.5	380.3	356.0	343.5	331.0	318.2
9800	463.0	425.7	423.1	415.8	407.0	397.6	387.2	362.4	349.7	336.9	323.9
10200	471.1	433.1	430.4	422.9	414.0	404.4	393.8	368.5	355.6	342.5	329.2
10600	479.0	440.2	437.5	429.9	420.8	411.0	400.2	374.5	361.2	347.9	334.4
11000	486.8	447.3	444.5	436.8	427.5	417.5	406.6	380.3	366.9	353.3	339.6
CLIMB LIMIT WT (1000 LB)	428.1	426.0	425.9	416.6	405.0	391.9	377.7	344.4	327.6	310.7	293.6

10000 FT Pressure Altitude

CORR'D FIELD LENGTH (FT)	FIELD LIMIT WEIGHT (1000 LB)										
	OAT										
	°C	-40	10	14	18	22	26	30	38	42	46	50
	°F	-40	50	57	64	72	79	86	100	108	115	122

CORR'D FIELD LENGTH (FT)	-40 °C / -40 °F	10 °C / 50 °F	14 °C / 57 °F	18 °C / 64 °F	22 °C / 72 °F	26 °C / 79 °F	30 °C / 86 °F	38 °C / 100 °F	42 °C / 108 °F	46 °C / 115 °F	50 °C / 122 °F
5800	329.3	303.0	297.7	291.8	285.4	278.1	269.4	251.1	241.9	232.6	222.9
6200	341.3	314.1	308.7	302.6	296.0	288.4	279.4	260.5	251.0	241.3	231.4
6600	352.8	324.8	319.2	312.9	306.1	298.2	289.0	269.5	259.7	249.8	239.5
7000	364.0	335.1	329.4	322.9	315.9	307.9	298.4	278.4	268.3	258.1	247.5
7400	374.4	345.1	339.2	332.7	325.5	317.3	307.7	287.3	277.0	266.6	255.9
7800	384.8	354.8	348.8	342.1	334.8	326.4	316.5	295.7	285.2	274.5	263.5
8200	395.7	364.6	358.4	351.5	343.9	335.2	325.1	303.5	292.6	281.6	270.2
8600	406.2	374.1	367.6	360.5	352.6	343.6	333.1	310.7	299.5	288.1	276.3
9000	415.8	382.7	376.1	368.7	360.6	351.3	340.5	317.5	305.9	294.1	282.0
9400	423.8	389.9	383.2	375.6	367.4	358.0	346.9	323.4	311.6	299.6	287.2
9800	431.5	397.0	390.1	382.5	374.1	364.4	353.1	329.1	317.1	304.8	292.2
10200	439.0	403.8	396.8	389.0	380.4	370.6	359.0	334.6	322.3	309.8	297.0
10600	446.2	410.4	403.3	395.3	386.5	376.5	364.8	339.9	327.4	314.7	301.6
11000	453.4	416.9	409.7	401.5	392.6	382.4	370.5	345.1	332.4	319.4	306.1
CLIMB LIMIT WT (1000 LB)	400.9	398.8	390.9	380.9	369.5	356.2	340.7	309.1	293.2	277.1	260.9

With engine anti-ice on, decrease field limit weight by 400 lb and climb limit weight by 500 lb.
With engine and wing anti-ice on, decrease field limit weight by 400 lb and climb limit weight by 500 lb.

Takeoff Field Corrections - Wet Runway

Slope Corrections

FIELD LENGTH AVAILABLE (FT)	SLOPE CORRECTED FIELD LENGTH (FT)								
	RUNWAY SLOPE (%)								
	-2.0	-1.5	-1.0	-0.5	0.0	0.5	1.0	1.5	2.0
4200	4360	4320	4280	4240	4200	4140	4080	4030	3970
4600	4810	4760	4700	4650	4600	4530	4450	4380	4310
5000	5260	5190	5130	5060	5000	4910	4820	4730	4640
5400	5700	5630	5550	5480	5400	5300	5190	5090	4980
5800	6150	6060	5970	5890	5800	5680	5560	5440	5320
6200	6600	6500	6400	6300	6200	6060	5930	5790	5660
6600	7040	6930	6820	6710	6600	6450	6300	6140	5990
7000	7490	7370	7250	7120	7000	6830	6670	6500	6330
7400	7940	7800	7670	7530	7400	7220	7030	6850	6670
7800	8390	8240	8090	7950	7800	7600	7400	7200	7000
8200	8830	8680	8520	8360	8200	7990	7770	7560	7340
8600	9280	9110	8940	8770	8600	8370	8140	7910	7680
9000	9730	9550	9360	9180	9000	8750	8510	8260	8020
9400	10180	9980	9790	9590	9400	9140	8880	8620	8350
9800	10620	10420	10210	10010	9800	9520	9250	8970	8690
10200	11070	10850	10630	10420	10200	9910	9610	9320	9030
10600	11520	11290	11060	10830	10600	10290	9980	9670	9370
11000	11960	11720	11480	11240	11000	10680	10350	10030	9700
11400	12410	12160	11910	11650	11400	11060	10720	10380	10040
11800	12860	12590	12330	12060	11800	11440	11090	10730	10380

Wind Corrections

SLOPE CORR'D FIELD LENGTH (FT)	SLOPE & WIND CORRECTED FIELD LENGTH (FT)							
	WIND COMPONENT (KTS)							
	-15	-10	-5	0	10	20	30	40
4200	2960	3370	3790	4200	4510	4810	5120	5420
4600	3290	3730	4160	4600	4920	5230	5550	5860
5000	3630	4080	4540	5000	5330	5650	5980	6300
5400	3960	4440	4920	5400	5740	6070	6410	6740
5800	4300	4800	5300	5800	6150	6490	6840	7180
6200	4630	5150	5680	6200	6560	6910	7270	7620
6600	4960	5510	6050	6600	6970	7330	7700	8060
7000	5300	5870	6430	7000	7380	7750	8130	8500
7400	5630	6220	6810	7400	7790	8170	8560	8940
7800	5970	6580	7190	7800	8200	8590	8990	9380
8200	6300	6930	7570	8200	8610	9010	9420	9820
8600	6630	7290	7940	8600	9020	9430	9850	10260
9000	6970	7650	8320	9000	9430	9850	10280	10700
9400	7300	8000	8700	9400	9840	10270	10710	11140
9800	7640	8360	9080	9800	10250	10690	11140	11580
10200	7970	8710	9460	10200	10660	11110	11570	12020
10600	8310	9070	9840	10600	11070	11530	12000	12460
11000	8640	9430	10210	11000	11480	11950	12430	12900
11400	8970	9780	10590	11400	11890	12370	12860	13340
11800	9310	10140	10970	11800	12300	12790	13290	13780

Takeoff Field & Climb Limit Weights - Wet Runway

Flaps 15

Sea Level Pressure Altitude

CORR'D FIELD LENGTH (FT)	FIELD LIMIT WEIGHT (1000 LB)										
	OAT										
	°C -40	10	14	18	22	26	30	38	42	46	50
	°F -40	50	57	64	72	79	86	100	108	115	122
6000	454.9	416.8	414.0	411.3	408.6	406.0	403.4	379.8	370.2	360.5	349.9
6200	462.1	423.4	420.6	417.8	415.1	412.4	409.8	385.8	376.0	366.1	355.3
6600	476.6	436.6	433.7	430.8	428.0	425.3	422.6	397.8	387.7	377.6	366.4
7000	490.8	449.7	446.7	443.7	440.9	438.0	435.2	409.8	399.4	388.9	377.4
7400	504.1	462.1	459.0	456.0	453.1	450.2	447.3	421.3	410.7	400.0	388.3
7800	518.3	475.2	472.0	468.9	465.9	462.9	460.0	433.3	422.3	411.3	399.3
8200	534.9	490.0	486.7	483.5	480.3	477.2	474.2	446.4	435.0	423.6	411.1
8600	545.0	505.0	501.5	498.2	494.9	491.7	488.5	459.5	447.7	435.8	422.8
9000	545.0	518.5	514.9	511.5	508.1	504.8	501.5	471.5	459.2	447.0	433.5
9400	545.0	529.7	526.1	522.6	519.1	515.7	512.3	481.6	469.1	456.5	442.7
9800	545.0	540.7	537.0	533.4	529.8	526.3	522.9	491.5	478.7	465.8	451.7
10200	545.0	545.0	545.0	543.8	540.1	536.6	533.1	501.1	488.0	474.8	460.4
10600	545.0	545.0	545.0	545.0	545.0	545.0	543.0	510.4	497.0	483.7	469.0
11000	545.0	545.0	545.0	545.0	545.0	545.0	545.0	519.5	505.9	492.3	477.3
11400	545.0	545.0	545.0	545.0	545.0	545.0	545.0	528.4	514.6	500.7	485.5
11800	545.0	545.0	545.0	545.0	545.0	545.0	545.0	537.2	523.1	509.0	493.5
12200	545.0	545.0	545.0	545.0	545.0	545.0	545.0	545.0	531.3	516.9	501.2
12600	545.0	545.0	545.0	545.0	545.0	545.0	545.0	545.0	539.2	524.6	508.6
CLIMB LIMIT WT (1000 LB)	527.1	522.8	522.4	522.1	521.8	521.5	521.2	486.6	464.6	446.4	425.9

2000 FT Pressure Altitude

CORR'D FIELD LENGTH (FT)	FIELD LIMIT WEIGHT (1000 LB)										
	OAT										
	°C -40	10	14	18	22	26	30	38	42	46	50
	°F -40	50	57	64	72	79	86	100	108	115	122
6000	431.5	393.4	390.3	385.0	380.8	378.2	369.9	352.6	343.5	333.4	323.1
6200	438.4	399.6	396.4	391.1	386.8	384.1	375.7	358.1	348.9	338.6	328.1
6600	452.0	412.1	408.8	403.2	398.9	396.1	387.4	369.3	359.7	349.1	338.3
7000	465.6	424.5	421.1	415.3	410.9	408.0	399.0	380.4	370.6	359.7	348.5
7400	478.3	436.3	432.8	427.0	422.4	419.5	410.3	391.3	381.2	370.1	358.8
7800	491.8	448.7	445.1	439.1	434.4	431.4	422.0	402.4	392.1	380.6	369.0
8200	507.3	462.4	458.7	452.5	447.6	444.5	434.6	414.3	403.5	391.7	379.5
8600	523.0	476.2	472.4	465.9	460.8	457.5	447.3	426.1	414.9	402.5	389.9
9000	537.2	488.8	484.8	478.1	472.8	469.4	458.9	436.9	425.4	412.6	399.5
9400	545.0	499.3	495.2	488.3	482.9	479.5	468.7	446.2	434.4	421.3	407.9
9800	545.0	509.6	505.4	498.4	492.8	489.3	478.3	455.3	443.2	429.8	416.1
10200	545.0	519.5	515.3	508.1	502.4	498.8	487.6	464.1	451.8	438.1	424.1
10600	545.0	529.2	524.8	517.5	511.7	508.1	496.6	472.8	460.2	446.2	432.0
11000	545.0	538.6	534.2	526.7	520.9	517.2	505.5	481.2	468.4	454.2	439.7
11400	545.0	545.0	543.4	535.8	529.9	526.1	514.2	489.4	476.4	461.9	447.2
11800	545.0	545.0	545.0	544.7	538.7	534.8	522.7	497.5	484.2	469.5	454.5
12200	545.0	545.0	545.0	545.0	545.0	543.2	530.8	505.2	491.7	476.8	461.5
12600	545.0	545.0	545.0	545.0	545.0	545.0	538.8	512.7	499.0	483.8	468.2
CLIMB LIMIT WT (1000 LB)	503.3	499.5	499.2	499.0	498.7	498.4	482.4	446.4	429.0	409.4	389.4

With engine anti-ice on, decrease field limit weight by 400 lb and climb limit weight by 500 lb.
With engine and wing anti-ice on, decrease field limit weight by 400 lb and climb limit weight by 500 lb.

Takeoff Field & Climb Limit Weights - Wet Runway

Flaps 15

4000 FT Pressure Altitude

CORR'D FIELD LENGTH (FT)	FIELD LIMIT WEIGHT (1000 LB)										
	OAT										
	°C -40	10	14	18	22	26	30	38	42	46	50
	°F -40	50	57	64	72	79	86	100	108	115	122
6000	407.1	366.1	363.6	361.3	358.9	351.5	343.8	327.3	317.7	307.9	298.2
6200	413.5	371.9	369.4	366.9	364.5	357.1	349.2	332.4	322.7	312.7	302.9
6600	426.4	383.4	380.9	378.4	375.9	368.2	360.0	342.8	332.7	322.5	312.3
7000	439.2	395.0	392.3	389.7	387.2	379.3	370.9	353.1	342.8	332.2	321.8
7400	451.3	406.2	403.5	400.8	398.2	390.1	381.6	363.4	352.9	342.1	331.4
7800	464.1	417.7	414.9	412.2	409.5	401.2	392.4	373.7	362.9	351.8	340.8
8200	478.5	430.2	427.3	424.5	421.7	413.1	403.9	384.5	373.2	361.7	350.3
8600	493.0	442.7	439.7	436.7	433.8	424.8	415.3	395.0	383.3	371.3	359.4
9000	506.1	454.1	451.0	447.9	444.9	435.6	425.7	404.8	392.7	380.3	368.0
9400	517.1	463.8	460.6	457.5	454.4	444.9	434.8	413.3	400.9	388.2	375.6
9800	527.7	473.3	470.0	466.8	463.7	453.9	443.6	421.7	409.0	396.0	383.1
10200	538.0	482.5	479.1	475.9	472.7	462.7	452.2	429.8	416.9	403.6	390.5
10600	545.0	491.4	488.0	484.7	481.4	471.3	460.6	437.8	424.6	411.1	397.7
11000	545.0	500.2	496.7	493.4	490.0	479.7	468.8	445.6	432.2	418.4	404.8
11400	545.0	508.8	505.3	501.8	498.4	487.9	476.8	453.2	439.5	425.5	411.6
11800	545.0	517.2	513.6	510.1	506.7	496.0	484.6	460.6	446.7	432.4	418.3
12200	545.0	525.3	521.6	518.1	514.6	503.7	492.2	467.7	453.6	439.0	424.7
12600	545.0	533.1	529.4	525.8	522.2	511.1	499.4	474.6	460.2	445.4	430.8
CLIMB LIMIT WT (1000 LB)	476.7	472.5	472.3	472.0	471.7	458.2	444.0	412.6	394.0	374.9	356.1

6000 FT Pressure Altitude

CORR'D FIELD LENGTH (FT)	FIELD LIMIT WEIGHT (1000 LB)										
	OAT										
	°C -40	10	14	18	22	26	30	38	42	46	50
	°F -40	50	57	64	72	79	86	100	108	115	122
6000	377.9	344.4	342.1	339.9	333.2	325.7	318.0	301.2	292.1	282.9	273.7
6200	383.8	349.8	347.5	345.2	338.4	330.8	323.0	305.9	296.6	287.3	278.0
6600	395.8	360.7	358.3	356.0	349.0	341.1	333.1	315.4	305.9	296.2	286.6
7000	407.7	371.6	369.1	366.7	359.5	351.4	343.1	325.0	315.1	305.2	295.3
7400	419.1	382.3	379.8	377.3	369.9	361.7	353.2	334.7	324.6	314.5	304.4
7800	431.0	393.2	390.6	388.0	380.4	372.0	363.3	344.2	333.9	323.5	313.1
8200	444.1	404.7	402.0	399.3	391.5	382.6	373.6	353.8	343.0	332.2	321.4
8600	457.1	416.1	413.3	410.5	402.3	393.1	383.7	363.1	351.8	340.6	329.3
9000	469.0	426.6	423.7	420.8	412.3	402.8	393.1	371.8	360.1	348.5	336.8
9400	479.1	435.6	432.6	429.7	421.0	411.3	401.3	379.5	367.6	355.7	343.7
9800	488.9	444.5	441.4	438.4	429.5	419.6	409.4	387.0	374.9	362.7	350.5
10200	498.4	453.1	450.0	446.9	437.9	427.7	417.3	394.5	382.1	369.7	357.2
10600	507.6	461.5	458.3	455.2	446.0	435.6	425.0	401.8	389.2	376.5	363.9
11000	516.7	469.7	466.5	463.3	453.9	443.4	432.6	409.0	396.1	383.2	370.3
11400	525.6	477.8	474.5	471.2	461.7	451.0	440.0	415.9	402.8	389.7	376.5
11800	534.3	485.6	482.3	479.0	469.3	458.3	447.2	422.7	409.3	395.9	382.6
12200	542.7	493.1	489.7	486.4	476.5	465.4	454.0	429.1	415.5	401.9	388.3
12600	545.0	500.4	497.0	493.6	483.5	472.2	460.6	435.3	421.5	407.7	393.8
CLIMB LIMIT WT (1000 LB)	452.1	449.3	449.1	448.9	436.5	422.2	407.8	375.5	357.6	339.8	322.2

With engine anti-ice on, decrease field limit weight by 400 lb and climb limit weight by 500 lb.
With engine and wing anti-ice on, decrease field limit weight by 400 lb and climb limit weight by 500 lb.

Takeoff Field & Climb Limit Weights - Wet Runway

Flaps 15

8000 FT Pressure Altitude

CORR'D FIELD LENGTH (FT)	FIELD LIMIT WEIGHT (1000 LB)										
	OAT										
	°C -40	10	14	18	22	26	30	38	42	46	50
	°F -40	50	57	64	72	79	86	100	108	115	122
6000	354.8	323.7	321.6	316.0	309.7	302.8	295.4	278.5	269.8	261.1	252.2
6200	360.4	328.8	326.6	320.9	314.5	307.6	300.0	282.8	274.0	265.2	256.1
6600	371.6	339.0	336.8	330.9	324.3	317.1	309.4	291.6	282.5	273.4	264.1
7000	382.8	349.2	346.9	340.9	334.1	326.7	318.7	300.4	291.1	281.7	272.1
7400	393.8	359.4	357.1	351.0	344.0	336.5	328.3	309.6	300.1	290.5	280.7
7800	405.0	369.7	367.2	361.0	353.8	346.1	337.6	318.5	308.7	298.8	288.7
8200	417.0	380.3	377.7	371.2	363.8	355.7	347.0	327.0	316.8	306.5	296.1
8600	428.9	390.6	388.0	381.2	373.5	365.1	356.0	335.2	324.5	313.8	302.9
9000	439.8	400.3	397.6	390.5	382.5	373.8	364.4	342.9	331.9	320.8	309.6
9400	449.2	408.7	405.9	398.7	390.5	381.6	371.9	349.9	338.7	327.3	315.8
9800	458.3	416.9	414.1	406.7	398.3	389.2	379.3	356.8	345.3	333.7	321.9
10200	467.2	425.0	422.1	414.5	406.0	396.7	386.6	363.7	351.9	340.1	328.1
10600	475.9	432.9	429.9	422.2	413.5	404.1	393.8	370.4	358.5	346.4	334.2
11000	484.4	440.6	437.5	429.7	420.9	411.2	400.8	377.0	364.8	352.6	340.1
11400	492.7	448.1	445.0	437.1	428.0	418.2	407.6	383.3	371.0	358.5	345.8
11800	500.8	455.4	452.3	444.2	435.0	425.0	414.2	389.5	376.9	364.2	351.2
12200	508.6	462.4	459.2	451.0	441.6	431.5	420.5	395.4	382.5	369.6	356.5
12600	516.1	469.2	465.9	457.6	448.0	437.7	426.5	401.0	388.0	374.8	361.4
CLIMB LIMIT WT (1000 LB)	428.1	426.0	425.9	416.6	405.0	391.9	377.7	344.4	327.6	310.7	293.6

10000 FT Pressure Altitude

CORR'D FIELD LENGTH (FT)	FIELD LIMIT WEIGHT (1000 LB)										
	OAT										
	°C -40	10	14	18	22	26	30	38	42	46	50
	°F -40	50	57	64	72	79	86	100	108	115	122
6000	330.6	302.1	297.1	291.5	285.4	278.5	270.6	254.4	246.1	237.8	229.3
6200	335.8	306.8	301.7	296.0	289.9	282.8	274.8	258.3	249.9	241.5	232.8
6600	346.3	316.3	311.1	305.2	298.9	291.6	283.3	266.3	257.7	249.0	240.0
7000	356.7	325.9	320.5	314.5	307.9	300.5	291.9	274.4	265.6	256.6	247.4
7400	367.1	335.6	330.1	324.0	317.3	309.6	300.9	283.0	274.0	264.8	255.4
7800	377.6	345.2	339.5	333.2	326.3	318.5	309.5	291.1	281.8	272.4	262.7
8200	388.5	354.8	348.9	342.3	335.2	327.0	317.7	298.6	288.9	279.1	269.1
8600	399.2	364.1	358.0	351.1	343.7	335.2	325.5	305.6	295.5	285.2	274.8
9000	409.1	372.8	366.5	359.4	351.7	342.9	332.9	312.3	301.8	291.3	280.5
9400	417.7	380.6	374.1	366.8	358.9	349.9	339.7	318.6	307.9	297.0	286.0
9800	426.2	388.2	381.5	374.1	366.0	356.8	346.3	324.8	313.8	302.8	291.4
10200	434.4	395.7	388.9	381.3	373.1	363.7	353.0	331.0	319.8	308.5	297.0
10600	442.5	403.0	396.1	388.4	380.0	370.5	359.5	337.1	325.8	314.3	302.5
11000	450.3	410.2	403.1	395.3	386.7	377.0	365.9	343.1	331.5	319.8	307.8
11400	458.0	417.1	410.0	402.0	393.3	383.4	372.1	348.8	337.1	325.1	312.9
11800	465.5	423.9	416.6	408.5	399.6	389.5	378.0	354.3	342.4	330.2	317.8
12200	472.7	430.4	422.9	414.7	405.7	395.4	383.7	359.6	347.4	335.1	322.5
12600	479.7	436.6	429.0	420.6	411.5	401.0	389.1	364.6	352.3	339.7	326.8
CLIMB LIMIT TWT (1000 LB)	400.9	398.8	390.9	380.9	369.5	356.2	340.7	309.1	293.2	277.1	260.9

With engine anti-ice on, decrease field limit weight by 400 lb and climb limit weight by 500 lb.
With engine and wing anti-ice on, decrease field limit weight by 400 lb and climb limit weight by 500 lb.

Takeoff Obstacle Limit Weight
Flaps 15
Sea Level, 30°C & Below, Zero Wind

OBSTACLE HEIGHT (FT)	REFERENCE OBSTACLE LIMIT WEIGHT (1000 LB)											
	DISTANCE FROM BRAKE RELEASE (1000 FT)											
	8	10	12	14	16	18	20	22	24	26	28	30
10	456.2	512.7	543.3									
50	424.1	467.3	507.6	531.2								
100	395.0	435.3	467.6	500.1	520.2	533.3	543.5					
150	372.1	410.8	444.1	470.6	496.5	512.7	524.9	534.0	541.5			
200	352.7	392.3	425.0	451.1	472.3	494.1	507.8	518.8	527.3	534.2	540.1	
250	336.1	376.5	408.7	434.7	455.8	473.4	492.4	504.2	514.0	522.2	528.6	534.2
300	322.8	362.6	394.4	420.2	441.5	459.1	474.1	491.0	501.4	510.3	517.8	524.1
350	310.8	350.0	381.5	407.3	428.7	446.5	461.4	474.7	489.8	499.2	507.2	514.2
400		338.6	369.8	395.5	417.0	435.0	450.2	463.2	475.1	488.9	497.3	504.7
450		328.2	359.1	384.7	406.2	424.3	439.8	453.1	464.6	475.3	488.0	495.7
500		318.5	349.2	374.7	396.2	414.5	430.1	443.6	455.4	465.6	475.4	487.2
550		309.5	339.9	365.3	386.9	405.3	421.1	434.8	446.7	457.2	466.4	475.3
600		301.1	331.3	356.6	378.1	396.6	412.5	426.4	438.5	449.2	458.6	467.1
650		293.2	323.2	348.4	369.9	388.4	404.4	418.4	430.7	441.6	451.2	459.8
700		285.8	315.6	340.7	362.1	380.6	396.7	410.9	423.3	434.3	444.1	452.9
750			308.4	333.3	354.7	373.2	389.4	403.7	416.2	427.4	437.3	446.3
800			301.6	326.4	347.7	366.2	382.4	396.8	409.4	420.7	430.8	439.9
850			295.1	319.8	341.0	359.5	375.7	390.2	402.9	414.3	424.5	433.7
900			288.9	313.5	334.6	353.1	369.4	383.8	396.7	408.2	418.5	427.8
950			282.9	307.4	328.5	347.0	363.2	377.7	390.7	402.2	412.7	422.1
1000				301.7	322.7	341.1	357.4	371.9	384.9	396.5	407.1	416.5

Obstacle height must be calculated from lowest point of the runway to conservatively account for runway slope.

OAT Adjustments

OAT (°C)	REFERENCE OBSTACLE LIMIT WEIGHT (1000 LB)						
	300	340	380	420	460	500	540
30 & Below	0	0	0	0	0	0	0
32	-5.1	-5.9	-6.7	-7.4	-8.2	-8.9	-9.7
34	-10.3	-11.8	-13.3	-14.8	-16.3	-17.8	-19.4
36	-15.4	-17.7	-20.0	-22.2	-24.5	-26.8	-29.0
38	-20.6	-23.6	-26.6	-29.7	-32.7	-35.7	-38.7
40	-25.7	-29.5	-33.3	-37.1	-40.8	-44.6	-48.4
42	-30.4	-35.0	-39.6	-44.2	-48.8	-53.4	-58.0
44	-35.1	-40.5	-45.9	-51.3	-56.7	-62.2	-67.6
46	-39.7	-46.0	-52.2	-58.5	-64.7	-70.9	-77.2
48	-44.4	-51.4	-58.5	-65.6	-72.6	-79.7	-86.8
50	-49.0	-56.9	-64.8	-72.7	-80.6	-88.5	-96.4

Takeoff Obstacle Limit Weight
Flaps 15
Pressure Altitude Adjustments

ALT (FT)	OAT ADJUSTED OBSTACLE LIMIT WEIGHT (1000 LB)						
	300	340	380	420	460	500	540
S.L. & Below	0	0	0	0	0	0	0
1000	-12.9	-14.5	-16.2	-17.8	-19.4	-21.1	-22.7
2000	-25.8	-29.1	-32.3	-35.6	-38.9	-42.2	-45.4
3000	-34.5	-39.4	-44.2	-49.1	-54.0	-58.8	-63.7
4000	-43.3	-49.7	-56.1	-62.6	-69.0	-75.5	-81.9
5000	-52.7	-60.6	-68.5	-76.4	-84.3	-92.2	-100.1
6000	-62.2	-71.6	-80.9	-90.3	-99.6	-109.0	-118.3
7000	-71.1	-81.6	-92.1	-102.6	-113.1	-123.6	-134.1
8000	-80.0	-91.6	-103.3	-114.9	-126.5	-138.2	-149.8
9000	-89.9	-103.0	-116.2	-129.3	-142.5	-155.7	-168.8
10000	-99.8	-114.5	-129.1	-143.8	-158.5	-173.1	-187.8

Wind Adjustments

WIND (KTS)	OAT & ALT ADJUSTED OBSTACLE LIMIT WEIGHT (1000 LB)						
	300	340	380	420	460	500	540
15 TW	-63.5	-62.5	-61.5	-60.5	-59.5	-58.4	-57.4
10 TW	-42.3	-41.6	-41.0	-40.3	-39.6	-39.0	-38.3
5 TW	-21.2	-20.8	-20.5	-20.2	-19.8	-19.5	-19.1
0	0	0	0	0	0	0	0
10 HW	6.2	5.8	5.4	5.0	4.5	4.1	3.7
20 HW	12.4	11.6	10.7	9.9	9.1	8.3	7.4
30 HW	18.2	17.0	15.8	14.6	13.3	12.1	10.9
40 HW	24.0	22.4	20.8	19.2	17.6	16.0	14.4

With engine anti-ice on, decrease weight by 600 lb.
With engine and wing anti-ice on, decrease weight by 600 lb.

Performance Dispatch — Chapter PD
Enroute — Section 11

Long Range Cruise Maximum Operating Altitude
Max Climb Thrust
ISA + 10°C and Below

WEIGHT (1000 LB)	OPTIMUM ALT (FT)	TAT (°C)	MARGIN TO INITIAL BUFFET 'G' (BANK ANGLE)		
			1.30 (39°)	1.40 (44°)	1.50 (48°)
500	35000	-11	37100	35700	34300
480	35900	-13	38000	36500	35100
460	36700	-14	38900	37400	36000
440	37700	-14	39600	38100	36700
420	38600	-14	40200	38700	37200
400	39600	-14	40700	39200	37800
380	40700	-14	41400	39900	38400
360	41800	-14	42300	40700	39200
340	43000	-14	43100	41600	40100
320	43100	-14	43100	42500	41100
300	43100	-14	43100	43100	42100
280	43100	-14	43100	43100	43100

ISA + 15°C

WEIGHT (1000 LB)	OPTIMUM ALT (FT)	TAT (°C)	MARGIN TO INITIAL BUFFET 'G' (BANK ANGLE)		
			1.30 (39°)	1.40 (44°)	1.50 (48°)
500	35000	-6	37000*	35700	34300
480	35900	-8	37800*	36500	35100
460	36700	-8	38600*	37400	36000
440	37700	-8	39400*	38100	36700
420	38600	-8	40100*	38700	37200
400	39600	-8	40700	39200	37800
380	40700	-8	41400	39900	38400
360	41800	-8	42300	40700	39200
340	43000	-8	43100	41600	40100
320	43100	-8	43100	42500	41100
300	43100	-8	43100	43100	42100
280	43100	-8	43100	43100	43100

ISA + 20°C

WEIGHT (1000 LB)	OPTIMUM ALT (FT)	TAT (°C)	MARGIN TO INITIAL BUFFET 'G' (BANK ANGLE)		
			1.30 (39°)	1.40 (44°)	1.50 (48°)
500	35000	0	36300*	35700	34300
480	35900	-2	37000*	36500	35100
460	36700	-2	37800*	37400	36000
440	37700	-2	38600*	38100	36700
420	38600	-2	39300*	38700	37200
400	39600	-2	40000*	39200	37800
380	40700	-2	40800*	39900	38400
360	41800	-2	41700*	40700	39200
340	43000	-2	42500*	41600	40100
320	43100	-2	43100	42500	41100
300	43100	-2	43100	43100	42100
280	43100	-2	43100	43100	43100

***Denotes altitude thrust limited in level flight, 300 fpm residual rate of climb.**

Long Range Cruise Trip Fuel and Time

Ground to Air Miles Conversion

AIR DISTANCE (NM) HEADWIND COMPONENT (KTS)					GROUND DISTANCE (NM)	AIR DISTANCE (NM) TAILWIND COMPONENT (KTS)				
100	80	60	40	20		20	40	60	80	100
1059	996	938	887	842	800	766	735	706	679	655
1586	1492	1406	1330	1262	1200	1150	1104	1060	1021	985
2112	1987	1874	1773	1683	1600	1534	1472	1415	1362	1314
2637	2482	2340	2215	2103	2000	1918	1841	1770	1705	1645
3160	2975	2806	2657	2523	2400	2302	2211	2126	2048	1977
3683	3467	3271	3098	2943	2800	2686	2581	2482	2392	2309
4203	3959	3736	3539	3362	3200	3071	2951	2839	2736	2641
4722	4449	4201	3980	3782	3600	3456	3321	3195	3079	2973
5240	4939	4664	4420	4201	4000	3840	3691	3552	3423	3305
5757	5427	5127	4860	4620	4400	4224	4060	3908	3767	3638
6272	5915	5589	5300	5039	4800	4609	4430	4264	4111	3970
6786	6401	6051	5739	5458	5200	4993	4800	4620	4454	4302
7299	6887	6512	6177	5876	5600	5378	5170	4976	4798	4633
7810	7372	6972	6616	6295	6000	5762	5539	5332	5141	4965
8321	7856	7431	7054	6713	6400	6146	5909	5689	5485	5297
8829	8339	7890	7491	7131	6800	6531	6279	6045	5828	5629
9336	8820	8349	7928	7549	7200	6915	6649	6401	6171	5961
9842	9301	8806	8365	7967	7600	7299	7018	6756	6514	6292
10345	9780	9263	8802	8384	8000	7683	7387	7112	6857	6623

Reference Fuel and Time Required

AIR DIST (NM)	PRESSURE ALTITUDE (1000 FT) 31		33		35		37		39	
	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)
800	18.5	2:03	18.1	2:00	17.8	1:58	17.5	1:55	17.3	1:52
1200	26.7	3:01	26.1	2:57	25.6	2:53	25.0	2:49	24.6	2:43
1600	35.1	3:58	34.3	3:53	33.4	3:48	32.7	3:42	32.0	3:34
2000	43.5	4:55	42.4	4:49	41.3	4:43	40.3	4:35	39.4	4:25
2400	52.2	5:52	50.8	5:44	49.4	5:36	48.2	5:27	47.1	5:14
2800	60.9	6:48	59.2	6:39	57.6	6:30	56.1	6:19	54.8	6:03
3200	69.7	7:44	67.7	7:34	65.9	7:23	64.1	7:10	62.6	6:52
3600	78.7	8:39	76.4	8:27	74.3	8:16	72.3	8:00	70.6	7:41
4000	87.7	9:34	85.2	9:21	82.7	9:08	80.5	8:50	78.5	8:30
4400	97.1	10:27	94.2	10:14	91.5	9:59	88.9	9:39	86.8	9:19
4800	106.4	11:21	103.2	11:07	100.2	10:50	97.4	10:28	95.1	10:09
5200	115.9	12:15	112.4	11:59	109.1	11:40	106.0	11:18	103.6	10:58
5600	125.5	13:07	121.8	12:50	118.2	12:30	114.8	12:07	112.2	11:47
6000	135.2	14:00	131.1	13:41	127.3	13:19	123.5	12:56	120.8	12:36
6400	145.2	14:52	140.8	14:31	136.6	14:08	132.7	13:45	129.9	13:26
6800	155.2	15:43	150.5	15:21	145.9	14:57	141.8	14:34	138.9	14:15
7200	165.4	16:34	160.4	16:10	155.4	15:45	151.1	15:23	148.1	15:05
7600	175.8	17:24	170.3	16:58	165.1	16:34	160.6	16:12	157.6	15:54
8000	186.1	18:14	180.3	17:47	174.7	17:23	170.1	17:02	167.1	16:44

Long Range Cruise Trip Fuel and Time

Fuel Required Adjustment (1000 LB)

REFERENCE FUEL REQUIRED (1000 LB)	LANDING WEIGHT (1000 LB)				
	220	260	300	340	380
20	-2.8	-1.4	0.0	1.6	3.3
40	-5.5	-2.8	0.0	3.2	6.8
60	-8.3	-4.2	0.0	5.0	10.6
80	-11.1	-5.6	0.0	6.9	14.8
100	-14.0	-7.0	0.0	8.9	19.3
120	-16.8	-8.5	0.0	11.1	24.2
140	-19.6	-9.9	0.0	13.4	29.4
160	-22.5	-11.3	0.0	15.9	34.9
180	-25.4	-12.8	0.0	18.5	40.8
200	-28.3	-14.2	0.0	21.2	47.0

Based on 310/.85 climb, Long Range Cruise speed and .85/310/250 descent.

Long Range Cruise Step Climb

Ground to Air Miles Conversion

AIR DISTANCE (NM) HEAD WIND COMPONENT (KTS) 100	80	60	40	20	GROUND DISTANCE (NM)	AIR DISTANCE (NM) TAIL WIND COMPONENT (KTS) 20	40	60	80	100
1036	978	926	880	838	800	765	733	704	677	652
1542	1459	1384	1317	1256	1200	1149	1102	1059	1019	982
2047	1939	1841	1753	1673	1600	1533	1471	1415	1362	1313
2552	2419	2298	2190	2090	2000	1917	1841	1770	1705	1644
3057	2898	2755	2626	2508	2400	2301	2210	2126	2048	1975
3562	3378	3212	3062	2925	2800	2685	2579	2482	2391	2307
4066	3857	3669	3498	3342	3200	3069	2949	2838	2734	2638
4569	4336	4125	3934	3760	3600	3453	3318	3193	3078	2970
5073	4815	4581	4370	4177	4000	3838	3688	3550	3421	3302
5576	5293	5038	4805	4594	4400	4222	4058	3906	3765	3634
6079	5772	5494	5241	5011	4800	4606	4427	4262	4108	3965
6582	6250	5950	5677	5428	5200	4990	4797	4618	4452	4297
7085	6728	6406	6113	5845	5600	5375	5167	4974	4796	4629
7588	7207	6862	6548	6262	6000	5759	5536	5331	5139	4962
8091	7685	7318	6984	6679	6400	6143	5906	5687	5483	5294
8594	8163	7774	7420	7096	6800	6527	6276	6043	5827	5626
9097	8642	8230	7855	7513	7200	6912	6646	6399	6171	5958
9600	9120	8686	8291	7930	7600	7296	7015	6755	6514	6290
10104	9599	9142	8727	8348	8000	7680	7385	7112	6858	6621

Trip Fuel and Time Required

AIR DIST (NM)	TRIP FUEL (1000 LB) LANDING WEIGHT (1000 LB) 220	260	300	340	380	TIME (HR:MIN)
800	14.1	15.5	17.1	18.6	20.1	1:49
1200	19.9	21.9	24.3	26.5	28.6	2:40
1600	25.7	28.4	31.5	34.5	37.3	3:30
2000	31.7	35.0	38.9	42.6	46.1	4:20
2400	37.7	41.8	46.5	50.8	55.1	5:10
2800	43.8	48.6	54.2	59.2	64.3	5:59
3200	50.0	55.6	62.0	67.8	73.6	6:49
3600	56.2	62.7	69.9	76.4	83.2	7:38
4000	62.6	69.9	78.0	85.3	92.9	8:28
4400	69.1	77.3	86.2	94.2	102.8	9:17
4800	75.8	84.8	94.5	103.4	112.9	10:06
5200	82.5	92.5	102.9	112.7	123.1	10:55
5600	89.4	100.3	111.5	122.2	133.5	11:44
6000	96.4	108.2	120.3	131.9	144.1	12:33
6400	103.5	116.2	129.1	141.8	154.9	13:23
6800	110.7	124.4	138.2	151.9	165.9	14:12
7200	118.1	132.6	147.4	162.1	177.1	15:01
7600	125.7	141.1	156.8	172.5	188.6	15:50
8000	133.4	149.6	166.4	183.1	200.4	16:39

Based on 310/.85 climb, Long Range Cruise speed and .85/310/250 descent.
Valid for all pressure altitudes with 4000 ft step climb to 2000 ft above optimum altitude.

Short Trip Fuel and Time

Ground to Air Miles Conversion

AIR DISTANCE (NM) HEAD WIND COMPONENT (KTS)					GROUND DISTANCE (NM)	AIR DISTANCE (NM) TAIL WIND COMPONENT (KTS)				
100	80	60	40	20		20	40	60	80	100
89	77	68	61	55	50	46	43	40	37	35
156	140	128	117	108	100	93	87	82	78	74
221	202	186	172	160	150	141	133	126	119	113
284	262	243	227	213	200	189	179	170	162	154
346	321	300	281	265	250	237	225	214	205	196
407	380	356	335	317	300	285	272	259	248	238
468	438	412	389	369	350	333	318	304	291	280
529	497	468	443	420	400	381	364	349	335	322
591	556	525	497	473	450	430	411	394	378	363
655	617	583	552	525	500	477	457	438	420	404

Trip Fuel and Time Required

AIR DISTANCE (NM)		LANDING WEIGHT (1000 LB)					TIME (HR:MIN)
		220	260	300	340	380	
50	FUEL (1000 LB)	2.2	2.4	2.5	2.7	2.9	0:13
	ALT (FT)	11000	11000	11000	9000	9000	
100	FUEL (1000 LB)	3.4	3.7	3.9	4.2	4.4	0:22
	ALT (FT)	19000	17000	17000	17000	17000	
150	FUEL (1000 LB)	4.5	4.8	5.2	5.5	5.8	0:29
	ALT (FT)	25000	25000	23000	23000	21000	
200	FUEL (1000 LB)	5.4	5.9	6.3	6.7	7.1	0:36
	ALT (FT)	29000	27000	27000	27000	25000	
250	FUEL (1000 LB)	6.2	6.8	7.3	7.8	8.3	0:42
	ALT (FT)	37000	35000	31000	29000	29000	
300	FUEL (1000 LB)	7.0	7.6	8.3	8.9	9.5	0:47
	ALT (FT)	39000	37000	37000	35000	31000	
350	FUEL (1000 LB)	7.7	8.5	9.2	9.9	10.6	0:53
	ALT (FT)	43000	41000	39000	37000	37000	
400	FUEL (1000 LB)	8.4	9.3	10.1	10.9	11.6	0:58
	ALT (FT)	43000	43000	41000	39000	37000	
450	FUEL (1000 LB)	9.1	10.0	10.9	11.8	12.7	1:04
	ALT (FT)	43000	43000	41000	39000	37000	
500	FUEL (1000 LB)	9.8	10.8	11.8	12.8	13.7	1:11
	ALT (FT)	43000	43000	41000	39000	39000	

Holding Planning

Flaps Up

WEIGHT (1000 LB)	TOTAL FUEL FLOW (LB/HR)									
	PRESSURE ALTITUDE (FT)									
	1500	5000	10000	15000	20000	25000	30000	35000	40000	43000
500	12380	12170	12060	12030	12050	12080	12280	12850		
460	11530	11280	11080	11080	11130	11030	11200	11600		
420	10710	10450	10160	10090	10220	10000	10140	10360	10990	
380	9910	9650	9320	9180	9320	9020	9090	9260	9820	
340	9110	8880	8510	8400	8340	8060	8070	8190	8570	9080
300	8330	8110	7740	7630	7490	7140	7100	7150	7460	7750
260	7600	7340	7010	6860	6660	6330	6230	6200	6390	6590
220	6820	6540	6260	6090	5880	5620	5440	5370	5490	5630

Flaps 1

WEIGHT (1000 LB)	TOTAL FUEL FLOW (LB/HR)				
	PRESSURE ALTITUDE (FT)				
	1500	5000	10000	15000	20000
500	12910	12720	12550	12470	12510
460	11970	11750	11550	11440	11640
420	11040	10790	10560	10450	10700
380	10130	9860	9590	9510	9620
340	9260	9000	8670	8620	8590
300	8420	8190	7820	7770	7620
260	7610	7360	7000	6880	6680
220	6830	6550	6200	6010	5790

These tables include 5% additional fuel for holding in a racetrack pattern.

Crew Oxygen Requirements

Required Pressure (PSI) for One 115 Cubic Ft. Cylinder

BOTTLE TEMPERATURE		NUMBER OF CREW USING OXYGEN		
°C	°F	2	3	4
50	122	530	735	945
45	113	520	725	930
40	104	510	715	915
35	95	505	700	900
30	86	495	690	885
25	77	485	680	870
20	68	480	670	860
15	59	470	655	840
10	50	460	645	830
5	41	455	635	815
0	32	445	620	800
-5	23	440	610	785
-10	14	430	600	770

For more extensive than normal crew usage, add 1.2 psi/person/minute.

ENGINE INOP

MAX CONTINUOUS THRUST

Net Level Off Weight

PRESSURE ALTITUDE (1000 FT)	LEVEL OFF WEIGHT (1000 LB)		
	ISA + 10°C & BELOW	ISA + 15°C	ISA + 20°C
32	251.4	243.1	234.7
30	270.9	262.3	253.1
28	299.0	284.6	274.4
26	329.5	308.3	296.6
24	349.3	330.6	316.8
22	368.7	353.0	337.2
20	402.4	384.9	368.3
18	428.7	414.3	396.3
16	461.2	440.2	420.2
14	496.1	465.9	444.5
12	529.3	494.8	469.5
10	545.0	521.9	498.4
8		545.0	520.7
6			539.9
4			545.0

Anti-Ice Adjustment

ANTI-ICE CONFIGURATION	LEVEL OFF WEIGHT ADJUSTMENT (1000 LB)									
	PRESSURE ALTITUDE (1000 FT)									
	12	14	16	18	20	22	24	26	28	30
ENGINE ONLY	-0.2	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
ENGINE AND WING	-0.2	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4

ALL ENGINES

Long Range Cruise Critical Fuel Reserves

Ground to Air Miles Conversion

AIR DISTANCE (NM)					GROUND DISTANCE (NM)	AIR DISTANCE (NM)				
HEAD WIND COMPONENT (KTS)						TAIL WIND COMPONENT (KTS)				
100	80	60	40	20		20	40	60	80	100
297	270	249	230	214	200	188	177	167	159	151
594	541	497	460	428	400	375	354	334	317	302
891	812	746	690	642	600	563	531	502	476	452
1189	1083	995	920	856	800	751	707	669	634	603
1486	1354	1244	1151	1070	1000	939	884	836	793	754
1783	1625	1493	1381	1284	1200	1126	1061	1003	951	904
2081	1896	1742	1611	1498	1400	1314	1238	1170	1110	1055
2378	2167	1991	1841	1712	1600	1502	1415	1337	1268	1206
2675	2438	2240	2071	1926	1800	1689	1592	1505	1427	1356

Critical Fuel (1000 LB)

AIR DISTANCE (NM)	WEIGHT AT CRITICAL POINT (1000 LB)							
	220	260	300	340	380	420	460	500
200	6.2	6.6	6.9	7.3	7.7	8.1	8.5	8.9
300	8.9	9.4	9.9	10.4	10.9	11.5	12.0	12.5
400	11.6	12.2	12.8	13.5	14.2	14.9	15.5	16.2
500	14.2	15.0	15.8	16.6	17.4	18.2	19.1	19.9
600	16.9	17.8	18.7	19.7	20.7	21.6	22.6	23.5
700	19.6	20.6	21.7	22.8	23.9	25.0	26.1	27.1
800	22.2	23.4	24.6	25.8	27.0	28.3	29.5	30.7
900	24.9	26.1	27.5	28.8	30.2	31.6	33.0	34.3
1000	27.6	28.9	30.3	31.8	33.4	34.9	36.4	37.9
1100	30.2	31.6	33.2	34.9	36.5	38.2	39.9	41.5
1200	32.9	34.3	36.1	37.9	39.7	41.5	43.3	45.1
1300	35.6	37.1	39.0	40.9	42.9	44.8	46.7	48.6
1400	38.2	39.8	41.9	43.9	46.0	48.0	50.1	52.2
1500	40.9	42.5	44.7	46.8	49.1	51.2	53.5	55.7
1600	43.6	45.2	47.5	49.8	52.2	54.5	56.9	59.2
1700	46.2	47.9	50.3	52.7	55.3	57.7	60.3	62.7
1800	48.9	50.6	53.1	55.7	58.3	61.0	63.6	66.2

Based on: Emergency descent to 10000 ft, level cruise at 10000 ft, 250 KIAS descent to 1500 ft, 15 minutes hold at 1500 ft, approach and land.
Increase forecast headwind or decrease forecast tailwind by 5%.
Increase fuel required 0.8% per 10°C above ISA.
When icing conditions are forecast use the greater of the engine and wing anti-ice on (4%) for the total forecast time or engine and wing anti-ice on and ice drag (10%) for 10% of the forecast time.

Compare the fuel required for all engine and engine inoperative critical fuel reserves and use the higher of the two.

ENGINE INOP

Long Range Cruise Critical Fuel Reserves

Ground to Air Miles Conversion

AIR DISTANCE (NM)					GROUND DISTANCE (NM)	AIR DISTANCE (NM)				
HEAD WIND COMPONENT (KTS)						TAIL WIND COMPONENT (KTS)				
100	80	60	40	20		20	40	60	80	100
302	274	251	231	214	200	187	176	166	157	150
607	550	503	463	429	400	374	352	332	314	298
911	826	755	695	644	600	562	528	498	471	447
1216	1102	1007	927	859	800	749	704	664	628	596
1521	1377	1259	1159	1074	1000	936	879	830	785	745
1826	1653	1511	1391	1288	1200	1123	1055	995	942	894
2130	1929	1763	1623	1503	1400	1310	1231	1161	1099	1043
2435	2205	2015	1854	1718	1600	1497	1407	1327	1256	1191
2740	2481	2267	2086	1933	1800	1684	1583	1493	1412	1340

Critical Fuel (1000 LB)

AIR DISTANCE (NM)	WEIGHT AT CRITICAL POINT (1000 LB)							
	220	260	300	340	380	420	460	500
200	5.7	6.1	6.5	7.0	7.4	7.8	8.3	8.7
300	8.1	8.7	9.3	9.9	10.6	11.2	11.8	12.4
400	10.6	11.4	12.2	12.9	13.7	14.5	15.3	16.1
500	13.0	14.0	15.0	15.9	16.9	17.9	18.8	19.8
600	15.5	16.7	17.8	18.9	20.1	21.2	22.3	23.4
700	18.0	19.3	20.6	21.9	23.2	24.5	25.7	27.0
800	20.4	21.9	23.4	24.8	26.3	27.7	29.2	30.6
900	22.9	24.5	26.1	27.7	29.4	31.0	32.6	34.2
1000	25.3	27.0	28.9	30.6	32.5	34.2	36.0	37.8
1100	27.8	29.6	31.6	33.6	35.5	37.5	39.4	41.4
1200	30.3	32.1	34.3	36.5	38.6	40.7	42.9	44.9
1300	32.7	34.7	37.0	39.4	41.7	43.9	46.2	48.4
1400	35.2	37.2	39.8	42.3	44.7	47.1	49.5	51.9
1500	37.6	39.8	42.5	45.1	47.7	50.3	52.9	55.4
1600	40.1	42.3	45.1	47.9	50.7	53.4	56.2	59.0
1700	42.5	44.8	47.8	50.7	53.7	56.6	59.5	62.5
1800	45.0	47.3	50.4	53.6	56.7	59.8	62.9	65.9

Based on: Emergency descent to 10000 ft, level cruise at 10000 ft, 250 KIAS descent to 1500 ft, 15 minutes hold at 1500 ft, approach and land.
Increase forecast headwind or decrease forecast tailwind by 5%.
Increase fuel required 0.8% per 10°C above ISA.
When icing conditions are forecast use the greater of the engine and wing anti-ice on (2%) for the total forecast time or engine and wing anti-ice on and ice drag (12%) for 10% of the forecast time.

Compare the fuel required for all engine and engine inoperative critical fuel reserves and use the higher of the two.

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Landing Field Limit Weight - Dry Runway

Flaps 30

Wind Adjusted Field Length (FT)

FIELD LENGTH AVAILABLE (FT)	WIND COMPONENT (KTS)							
	-15	-10	-5	0	10	20	30	40
3000		2600	2800	3000	3150	3300	3450	3600
3400	2680	2920	3160	3400	3570	3740	3910	4080
3800	2960	3240	3520	3800	3990	4180	4370	4560
4200	3240	3560	3880	4200	4410	4620	4830	5040
4600	3520	3880	4240	4600	4830	5060	5290	5520
5000	3800	4200	4600	5000	5250	5500	5750	6000
5400	4080	4520	4960	5400	5670	5940	6210	6480
5800	4360	4840	5320	5800	6090	6380	6670	6960
6200	4640	5160	5680	6200	6510	6820	7130	7440
6600	4920	5480	6040	6600	6930	7260	7590	7920
7000	5200	5800	6400	7000	7350	7700	8050	8400
7400	5480	6120	6760	7400	7770	8140	8510	8880
7800	5760	6440	7120	7800	8190	8580	8970	9360
8200	6040	6760	7480	8200	8610	9020	9430	9840
8600	6320	7080	7840	8600	9030	9460	9890	10320
9000	6600	7400	8200	9000	9450	9900	10350	10800
9400	6880	7720	8560	9400	9870	10340	10810	11280
9800	7160	8040	8920	9800	10290	10780	11270	11760
10200	7440	8360	9280	10200	10710	11220	11730	12240
10600	7720	8680	9640	10600	11130	11660	12190	12720

Field Limit Weight (1000 LB)

WIND CORRECTED FIELD LENGTH (FT)	AIRPORT PRESSURE ALTITUDE (FT)					
	0	2000	4000	6000	8000	10000
4200	279.4					
4600	316.1	297.1	278.5			
5000	353.3	332.2	311.6	292.2	273.9	
5400	391.0	367.8	345.2	323.8	303.7	284.3
5800	424.4	403.6	379.0	355.6	333.6	312.4
6200	446.2	430.5	412.9	387.5	363.5	340.6
6600	467.5	450.9	434.7	418.8	393.7	368.9
7000	494.9	471.1	453.8	437.3	421.3	397.3
7400	514.0	496.3	472.7	455.4	438.7	422.4
7800	529.2	511.1	493.2	469.5	452.5	436.1
8200	543.8	525.3	506.9	489.0	465.2	448.4
8600	558.4	538.8	519.9	501.6	481.7	460.0
9000		552.3	532.5	513.8	495.5	471.6
9400			544.5	525.3	506.7	488.5
9800			556.5	536.5	517.5	498.9
10200				547.6	527.8	508.9
10600				558.8	537.8	518.5
11000					547.8	527.8
11400					557.7	536.7
11800						545.6

With manual speedbrakes, decrease weight by 52300 lb.
With 1 brake deactivated, decrease weight by TBS lb.
With 2 brakes deactivated, decrease weight by TBS lb.

Landing Field Limit Weight - Wet Runway

Flaps 30

Wind Adjusted Field Length (FT)

FIELD LENGTH AVAILABLE (FT)	WIND COMPONENT (KTS)							
	-15	-10	-5	0	10	20	30	40
3000				3000	3150	3300	3450	3600
3400			3180	3400	3570	3740	3910	4080
3800	3000	3270	3540	3800	3990	4180	4370	4560
4200	3280	3590	3890	4200	4410	4620	4830	5040
4600	3560	3910	4260	4600	4830	5060	5290	5520
5000	3850	4230	4620	5000	5250	5500	5750	6000
5400	4130	4550	4980	5400	5670	5940	6210	6480
5800	4410	4870	5330	5800	6090	6380	6670	6960
6200	4690	5190	5700	6200	6510	6820	7130	7440
6600	4960	5510	6050	6600	6930	7260	7590	7920
7000	5250	5830	6410	7000	7350	7700	8050	8400
7400	5520	6150	6780	7400	7770	8140	8510	8880
7800	5810	6470	7130	7800	8190	8580	8970	9360
8200	6080	6790	7490	8200	8610	9020	9430	9840
8600	6360	7110	7850	8600	9030	9460	9890	10320
9000	6640	7430	8210	9000	9450	9900	10350	10800
9400	6920	7750	8570	9400	9870	10340	10810	11280
9800	7200	8070	8940	9800	10290	10780	11270	11760
10200	7490	8390	9300	10200	10710	11220	11730	12240
10600	7760	8710	9660	10600	11130	11660	12190	12720

Field Limit Weight (1000 LB)

WIND CORRECTED FIELD LENGTH (FT)	AIRPORT PRESSURE ALTITUDE (FT)					
	0	2000	4000	6000	8000	10000
5000	292.9	275.2				
5400	325.0	305.4	286.3	241.9		
5800	357.4	336.1	315.3	295.6	277.1	
6200	390.2	367.0	344.4	323.1	303.0	283.7
6600	420.0	398.2	373.9	350.7	329.0	308.1
7000	440.1	424.6	403.4	378.5	355.1	332.6
7400	458.7	442.5	426.6	406.2	381.2	357.2
7800	481.7	460.0	443.5	427.3	407.4	381.8
8200	501.6	481.7	459.9	443.2	427.0	406.6
8600	517.0	499.2	478.0	458.1	441.5	425.3
9000	530.2	512.0	494.1	470.8	453.3	436.9
9400	542.9	524.3	506.0	487.7	464.3	447.6
9800	555.6	536.1	517.4	499.2	478.4	457.7
10200		547.9	528.4	509.8	491.0	467.8
10600		559.6	539.0	520.1	501.6	480.8
11000			549.5	529.9	511.2	492.8
11400			559.9	539.6	520.4	501.7
11800				549.3	529.4	510.4
12200				559.0	538.0	518.7
12600					546.7	526.8
13000					555.4	534.6
13400					564.0	542.3
13800						550.1
14200						557.9

With manual speedbrakes, decrease weight by 52300 lb.
With 1 brake deactivated, decrease weight by TBS lb.
With 2 brakes deactivated, decrease weight by TBS lb.

Landing Climb Limit Weight

Valid for approach with flaps 20 and landing with flaps 30

Based on anti-ice off

AIRPORT OAT		LANDING CLIMB LIMIT WEIGHT (1000 LB)						
		AIRPORT PRESSURE ALTITUDE (FT)						
°C	°F	-2000	0	2000	4000	6000	8000	10000
54	129	411.5	399.0					
52	126	421.7	409.3					
50	122	431.8	419.5	383.6				
48	118	441.3	429.6	393.5				
46	115	450.1	439.6	403.3	369.5			
44	111	458.7	449.0	413.1	378.9			
42	108	467.5	457.6	422.6	388.4	352.1		
40	104	481.4	466.1	431.5	397.5	361.1		
38	100	492.9	478.3	439.8	406.6	369.8	339.8	
36	97	501.7	491.8	448.1	415.0	378.5	348.2	
34	93	510.5	500.4	456.0	422.6	387.0	356.4	320.6
32	90	510.8	508.8	463.9	430.1	394.7	364.5	328.6
30	86	511.0	517.2	472.2	437.4	401.7	372.6	336.3
28	82	511.2	517.4	487.5	444.6	408.7	379.9	344.0
26	79	511.4	517.5	494.8	451.5	416.0	386.7	351.6
24	75	511.5	517.7	495.0	458.4	423.2	393.3	358.4
22	72	511.7	517.8	495.1	464.7	430.2	399.7	364.8
20	68	511.9	518.0	495.3	464.9	436.6	405.9	370.9
18	64	512.1	518.1	495.5	465.0	442.6	411.4	376.1
16	61	512.3	518.3	495.6	465.2	442.8	416.3	381.3
14	57	512.5	518.5	495.8	465.3	442.9	420.7	386.2
12	54	512.7	518.7	495.9	465.4	443.0	420.7	390.4
10	50	512.9	518.8	496.1	465.6	443.2	420.8	394.1
-40	-40	517.9	523.3	500.1	469.3	446.3	423.1	396.4

With engine anti-ice on, decrease weight by 1100 lb.
With engine and wing anti-ice on, decrease weight by 1100 lb.
When operating in icing conditions during any part of the flight with forecast landing temperature below 10°C, decrease weight by 37500 lb.

ENGINE INOP

ADVISORY INFORMATION

Go-Around Climb Gradient

Flaps 20, Gear Up

Based on anti-ice on or off

OAT (°C)	REFERENCE GO-AROUND GRADIENT (%)						
	PRESSURE ALTITUDE (FT)						
	-2000	0	2000	4000	6000	8000	10000
54	3.43	3.02	1.92	0.92			
50	4.06	3.68	2.53	1.50	0.44		
46	4.67	4.31	3.16	2.08	0.98	0.11	
42	5.23	4.92	3.76	2.68	1.53	0.63	
38	5.79	5.48	4.33	3.24	2.09	1.14	0.06
34	6.36	6.04	4.86	3.77	2.61	1.66	0.55
30	6.38	6.60	5.37	4.25	3.11	2.16	1.04
26	6.39	6.61	5.85	4.71	3.56	2.62	1.50
22	6.41	6.62	5.86	5.14	4.01	3.03	1.93
18	6.42	6.64	5.87	5.15	4.40	3.39	2.29
14	6.43	6.65	5.88	5.16	4.41	3.69	2.60
10	6.45	6.66	5.90	5.16	4.42	3.69	2.85

Weight Adjustment

WEIGHT (1000 LB)	REFERENCE GO-AROUND GRADIENT (%)							
	0	1	2	3	4	5	6	7
500	-2.17	-2.45	-2.74	-3.04	-3.34	-3.63	-3.93	-4.22
480	-2.00	-2.25	-2.50	-2.76	-3.03	-3.29	-3.55	-3.80
460	-1.77	-1.98	-2.20	-2.42	-2.65	-2.87	-3.09	-3.31
440	-1.48	-1.65	-1.83	-2.01	-2.20	-2.38	-2.57	-2.75
420	-1.12	-1.25	-1.39	-1.52	-1.66	-1.80	-1.94	-2.08
400	-0.70	-0.78	-0.86	-0.95	-1.04	-1.12	-1.21	-1.30
380	-0.24	-0.27	-0.30	-0.32	-0.35	-0.38	-0.41	-0.45
370	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
360	0.25	0.28	0.31	0.34	0.37	0.41	0.44	0.47
340	0.82	0.92	1.02	1.12	1.22	1.32	1.43	1.53
320	1.47	1.64	1.82	2.00	2.19	2.37	2.56	2.74
300	2.20	2.46	2.72	3.00	3.27	3.55	3.83	4.10
280	3.05	3.41	3.78	4.15	4.53	4.91	5.30	5.69

Speed Adjustment

SPEED (KIAS)	WEIGHT ADJUSTED GO-AROUND GRADIENT (%)										
	0	1	2	3	4	5	6	7	8	9	10
VREF30	-0.18	-0.18	-0.17	-0.17	-0.16	-0.15	-0.15	-0.14	-0.14	-0.14	-0.14
VREF30+5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VREF30+10	0.08	0.08	0.07	0.07	0.06	0.06	0.05	0.04	0.03	0.03	0.02
VREF30+15	0.11	0.10	0.09	0.08	0.07	0.06	0.04	0.02	0.00	-0.02	-0.03
VREF30+20	0.09	0.07	0.05	0.03	0.02	0.01	-0.02	-0.04	-0.08	-0.11	-0.14
VREF30+25	0.02	-0.02	-0.05	-0.07	-0.09	-0.11	-0.13	-0.17	-0.22	-0.26	-0.31
VREF30+30	-0.09	-0.15	-0.19	-0.22	-0.25	-0.27	-0.30	-0.35	-0.40	-0.46	-0.51

When operating in icing conditions during any part of the flight with forecast landing temperature below 10°C, decrease gradient by 0.8%.

Quick Turnaround Limit Weight

Flaps 30 Limit Weight (1000 LB)

AIRPORT OAT		AIRPORT PRESSURE ALTITUDE (FT)						
°C	°F	-2000	0	2000	4000	6000	8000	10000
54	129	405.7	391.3					
50	122	408.2	393.8	379.3				
45	113	411.5	396.9	382.3	367.9			
40	104	414.8	400.0	385.4	370.8	356.8		
35	95	418.3	403.3	388.6	373.9	359.7	345.6	
30	86	421.9	406.7	391.9	377.0	362.6	348.6	334.6
25	77	425.7	410.1	395.2	380.2	365.6	351.5	337.5
20	68	429.5	413.7	398.6	383.5	368.7	354.6	340.4
15	59	433.5	417.3	402.0	386.9	372.0	357.7	343.5
10	50	437.6	421.2	405.6	390.4	375.4	360.9	346.6
5	41	441.8	425.2	409.3	394.0	378.8	364.3	350.0
0	32	446.1	429.2	413.0	397.5	382.4	367.7	353.4
-5	23	450.5	433.5	416.9	401.2	385.9	371.2	357.0
-10	14	455.0	437.9	421.0	405.0	389.6	374.7	360.2
-15	5	459.7	442.4	425.3	408.9	393.4	378.3	363.6
-20	-4	464.5	447.0	429.7	413.0	397.3	382.0	367.1
-30	-22	475.7	456.7	439.0	421.6	405.3	389.8	374.5
-40	-40	491.5	467.1	449.0	431.0	413.9	398.1	382.3
-50	-58	503.2	482.3	459.5	441.2	423.4	406.7	390.0
-54	-65	508.0	488.8	463.9	445.4	427.4	410.1	393.1

Increase weight by 3700 lb per 1% uphill slope. Decrease weight by 9200 lb per 1% downhill slope. Increase weight by 10400 lb per 10 knots headwind. Decrease weight by 61200 lb per 10 knots tailwind.

Decrease weight by TBS lb when one brake is deactivated. Decrease weight by TBS lb when two brakes are deactivated.

After landing at weights exceeding those shown above, adjusted for slope and wind, wait at least 65 minutes and check that wheel thermal plugs have not melted before executing a takeoff.

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Performance Dispatch — Chapter PD
Text — Section 13

Introduction

This chapter contains self dispatch performance data intended primarily for use by flight crews in the event that information cannot be obtained from the airline dispatch office. The data provided is for a single takeoff flap at max takeoff thrust. The range of conditions covered is limited to those normally encountered in airline operation. In the event of conflict between data presented in this chapter and that contained in the Approved Flight Manual, the Flight Manual shall always take precedence.

Takeoff

The maximum allowable takeoff weight will be the least of the Field, Climb, and Obstacle Limit Weights as determined from the following tables. Tire and Brake Energy Limits are not shown as they are not limiting for the range of conditions shown in this chapter.

Field Limit Weight - Slope and Wind Corrections

These tables for dry and wet runways provide corrections to the field length available for the effects of runway slope and wind component along the runway. Enter the Slope Correction table with the available field length and runway slope to determine the slope corrected field length. Now enter the Wind Correction table with slope corrected field length and wind component to determine the slope and wind corrected field length.

Field and Climb Limit Weight

Tables are presented for selected airport pressure altitudes and runway condition and show both Field and Climb Limit Weights. Enter the appropriate table for pressure altitude and runway condition with “Slope and Wind Corrected Field Length” determined above and airport OAT to obtain Field Limit Weight. Also read Climb Limit Weight for the same OAT. Intermediate altitudes may be interpolated or use next higher altitude.

When finding a maximum weight for a wet runway, the dry runway limit weight must also be determined and the lower of the two weights used.

Obstacle Limit Weight

This table provides obstacle limit weights for reference airport conditions based on obstacle height above the runway surface and distance from brake release. Enter the correction tables to correct the reference Obstacle Limit Weight for the effects of OAT, pressure altitude and wind as indicated. In the case of multiple obstacles, enter the tables successively with each obstacle and determine the most limiting weight.

Brakes Deactivated

When operating with brakes deactivated, the field limit weight and the V1 must be reduced to allow for reduced braking capability. A simplified method which conservatively accounts for the reduced braking capability of one brake deactivated is to reduce the normal runway limited weight by TBS lb for a dry runway or TBS lb for a wet runway and the V1 associated with the reduced weight by TBS knots. With two brakes deactivated, reduce the normal runway limited weight by TBS lb for a dry runway or TBS lb for a wet runway and the V1 associated with the reduced weight by TBS knots for a dry runway or TBS knots for a wet runway. If the resulting V1 is less than minimum V1, takeoff is permitted with V1 set equal to V1(MCG) provided the dry accelerate stop distance corrected for wind and slope exceeds approximately TBS ft for one brake deactivated or TBS ft for two brakes deactivated. For wet runways, the corrected accelerate stop distance should exceed approximately TBS ft for one brake deactivated or TBS ft for two brakes deactivated

Detailed analysis for the specific case from the Airplane Flight Manual may yield a less restrictive penalty.

One Thrust Reverser Inoperative

Wet runway takeoff performance presented for all brakes operating is based on the use of one thrust reverser during deceleration. When operating with a thrust reverser inoperative, the runway/obstacle limited takeoff weight and V1 speed must be reduced to account for the reduced deceleration capability. A simplified method which conservatively accounts for this is to reduce the normal wet runway/obstacle limited weight by 12900 lb and the V1 associated with the reduced weight by the amount shown in the table below.

THRUST REVERSER INOPERATIVE V1 ADJUSTMENTS	
FIELD LENGTH (FT)	V1 ADJUSTMENTS (KIAS)
6000	- 3
8000	- 3
10000	- 3
12000	- 2
14000	- 2
16000	- 2

If the resulting V1 is less than minimum V1, takeoff is permitted with V1 set equal to V1(MCG) provided the accelerate stop distance available corrected for wind and slope exceeds approximately 6600 ft.

Enroute

Long Range Cruise Maximum Operating Altitude

These tables provide the maximum operating altitude in the same manner as the FMC. Maximum altitudes are shown for a given cruise weight and maneuver capability. Note that these tables consider both thrust and buffet limits, providing the more limiting of the two. Any data that is thrust limited is denoted by an asterisk and represents only a thrust limited condition in level flight with 300 ft/min residual rate of climb. Flying above these altitudes with sustained banks in excess of approximately 20° may cause the airplane to lose speed and/or altitude. The altitudes shown in the table are limited to the maximum certified altitude of 43100 ft.

Long Range Cruise Trip Fuel and Time

These tables are provided to determine trip fuel and time required to destination. Data is based on economy climb and descent speeds, and Long Range Cruise. Tables are presented for low altitudes for shorter trip distances and high altitudes for longer trip distances.

To determine trip fuel and time for a constant altitude cruise, first enter the Ground to Air Miles Conversion table to convert ground distance and enroute wind to an equivalent still air distance for use with the Reference Fuel and Time tables. Next, enter the Reference Fuel and Time Table with air distance from the Ground to Air Miles Conversion Table and the desired altitude and read Reference Fuel and Time Required. Lastly, enter the Fuel Required Adjustment Table with the Reference Fuel and the planned landing weight to obtain fuel required at the planned landing weight.

Long Range Cruise Step Climb Trip Fuel and Time

These tables are provided to determine trip fuel and time required to destination when flying a step climb profile. Step climb profiles are based on 4000 ft step climbs to keep the flight within 2000 ft of the optimum altitude for the current cruise weight. To determine trip fuel and time, enter the Ground to Air Miles Conversion table and determine air distance as discussed above. Then enter the Trip Fuel and Time required with air distance and planned landing weight to read trip fuel. Continue across the table to read trip time.

Short Trip Fuel and Time

These tables are provided to determine trip fuel and time for short distances or alternates. The data considers the use of the FMC short trip optimum altitude. Obtain air distance from upper table using the ground distance and wind component to the alternate. Enter Trip Fuel and Time table with air distance and read trip fuel required for the expected landing weight, together with time to alternate at right. For distances greater than shown or other altitudes, use the Long Range Cruise Trip Fuel and Time tables.

Holding Planning

These tables provide total fuel flow information necessary for planning Flaps Up and Flaps 1 holding and reserve fuel requirements. Data is based on the FMC holding speed schedule which is the higher of the maximum endurance and flap maneuver speeds. As noted, the fuel flow is based on flight in a racetrack holding pattern. For holding in straight and level flight, reduce table values by 5%.

Oxygen Requirements

Flight Crew System

Regulations require that sufficient oxygen be provided to the flight crew to account for the greater of supplemental breathing oxygen in the event of a cabin depressurization or protective breathing in the event of smoke or harmful fumes in the flight deck. The oxygen quantity associated with these requirements is achieved with the minimum dispatch oxygen cylinder pressure. Enter the Crew Oxygen Requirements table with the number of crew plus observers using oxygen and read the minimum cylinder pressure required for the appropriate bottle temperature.

An additional quantity of oxygen is required when flight altitudes above 41000 ft are planned. Regulations require that one active duty pilot must don the oxygen mask and breathe diluted oxygen for the duration of the flight above 41000 ft. The additional quantity of oxygen required is 2.05 liters/person/minute (1.2 psi/person/minute for the single cylinder system), or 13 liters/person/minute (8 psi/person/minute) if 100% oxygen is selected during normal usage.

Net Level Off Weight

The Net Level Off Weight table is provided to determine terrain clearance capability in straight and level flight following an engine failure. Regulations require terrain clearance planning based on net performance which is the gross (or actual) gradient performance degraded by 1.1%. In addition, the net level off pressure altitude must clear the terrain by 1000 ft.

To determine the maximum weight for terrain clearance, enter the table with required net level off pressure altitude and expected ISA deviation to obtain weight. Adjust weight for anti-ice operation as noted below the table.

Extended Range Operations

Regulations require that flights conducted over a route that contains a point further than one hour’s time at “normal one engine inoperative speed” from an adequate diversion airport comply with rules set up specifically for “Extended Range Operation with Two Engine airplanes”. This section provides reserve fuel planning information for the "Critical Fuel Scenario" based on two engine operation at Long Range Cruise as well as single engine operation at Long Range Cruise.

Long Range Cruise Critical Fuel Reserves

Enter Ground to Air Mile Conversion table with forecast wind and ground distance to diversion airport from critical point to obtain air distance. Now enter Critical Fuel table with air distance and expected weight at the critical point and read required fuel. Apply the noted fuel adjustments as necessary.

As noted below each table, the fuel required is the greater of the two engine fuel and the single engine fuel. This fuel is compared to the amount of fuel normally onboard the airplane at that point in the route. If the fuel required by the critical fuel reserves exceeds the amount of fuel normally expected, the fuel load must be adjusted accordingly.

Landing

Tables are provided for determining the maximum landing weight as limited by field length or climb requirements for Flaps 30.

Maximum landing weight is the lowest of the field length limit weight, climb limit weight or maximum certified landing weight.

Landing Field Limit Weight

Obtain wind corrected field length by entering upper table with field length available and wind component along the runway. Now enter table with wind corrected field length and pressure altitude to read field limit weight for the expected runway condition.

Landing Climb Limit Weight

Enter table with airport OAT and pressure altitude to read landing climb limit weight. Apply the noted adjustments as required.

Go-Around Climb Gradient

Enter the Reference Go-around Gradient table with airport OAT and pressure altitude to determine the reference Go-Around Gradient. Then adjust the reference gradient for airplane weight and speed using the tables provided to determine the weight and speed adjusted Go-Around Gradient. Note that data is for one engine inoperative.

Quick Turnaround Limit Weight

Enter table with airport pressure altitude and OAT to read maximum quick turnaround weight. Apply the noted adjustments as required.

If the landing weight exceeds the maximum quick turnaround weight, wait the specified time and then check that the wheel thermal plugs have not melted before executing a subsequent takeoff.

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Intentionally
Blank

Performance Inflight — Chapter PI

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787-8 LB FAA

Intentionally
Blank

DO NOT USE FOR FLIGHT

Performance Inflight — Chapter PI

General — Section 10

Takeoff Speeds - Dry Runway

V1, VR, V2 for Max Takeoff Thrust

WEIGHT (1000 LB)	FLAPS 5			FLAPS 15			FLAPS 20		
	V1	VR	V2	V1	VR	V2	V1	VR	V2
540	165	170	174	160	163	168	153	156	161
500	159	162	168	153	156	162	147	149	155
460	154	157	164	148	151	158	142	144	151
420	146	149	157	141	143	151	135	136	145
380	138	140	149	132	135	144	126	128	138
340	127	131	142	122	126	136	117	120	131
300	117	121	134	113	116	129	108	111	124
260	106	111	126	102	107	121	99	101	116

Check V1(MCG) and/or Minimum VR.

V1, VR, V2 Adjustments*

TEMP		V1							VR							V2						
		PRESS ALT (1000 FT)							PRESS ALT (1000 FT)							PRESS ALT (1000 FT)						
°C	°F	-2	0	2	4	6	8	10	-2	0	2	4	6	8	10	-2	0	2	4	6	8	10
70	158	8	8						5	6						-1	-1					
60	140	6	6	7	9				4	4	5	6				-1	-1	-2	-2			
50	122	4	4	5	7	8	9	10	2	3	4	5	6	7	8	-1	-1	-1	-2	-2	-3	-3
40	104	1	2	3	5	6	8	9	1	1	2	3	5	6	7	-1	-1	-1	-1	-2	-2	-3
30	86	0	0	2	3	5	6	8	0	0	1	2	3	5	6	0	0	-1	-1	-1	-2	-2
20	68	0	0	1	2	3	5	6	0	0	1	1	2	3	5	0	0	0	0	-1	-1	-2
-60	-76	0	0	1	2	3	4	5	0	0	1	1	2	3	4	0	0	0	0	-1	-1	-1

Slope and Wind V1 Adjustments*

WEIGHT (1000 LB)	SLOPE (%)					WIND (KTS)							
	-2	-1	0	1	2	-15	-10	-5	0	10	20	30	40
540	-4	-2	0	2	3	-3	-2	-1	0	1	1	2	2
500	-4	-2	0	1	2	-3	-2	-1	0	0	1	1	1
460	-3	-2	0	1	1	-2	-1	-1	0	0	1	1	1
420	-3	-1	0	1	1	-2	-1	-1	0	0	0	1	1
380	-2	-1	0	1	1	-2	-1	-1	0	0	0	1	1
340	-2	-1	0	1	1	-1	-1	0	0	0	1	1	1
300	-1	0	0	1	1	-1	0	0	0	0	1	1	1
260	-1	0	0	1	1	0	0	0	0	1	1	1	1

***V1 not to exceed VR.**

V1(MCG), Minimum VR

Max Takeoff Thrust

TEMP		PRESSURE ALTITUDE (FT)													
		-2000		0		2000		4000		6000		8000		10000	
°C	°F	V1 MCG	Min VR	V1 MCG	Min VR	V1 MCG	Min VR	V1 MCG	Min VR	V1 MCG	Min VR	V1 MCG	Min VR	V1 MCG	Min VR
70	158	113	121	111	119										
60	140	113	121	111	119	108	117	106	115						
50	122	116	124	114	122	109	117	106	115	104	112	101	110	98	107
40	104	122	130	121	129	116	124	111	119	105	114	101	110	98	107
30	86	128	136	126	135	121	130	116	125	111	120	107	115	101	110
20	68	133	142	132	141	126	135	120	129	116	125	112	120	106	115
-60	-76	135	143	134	142	128	137	122	130	118	126	115	123	111	119

Takeoff Speeds - Wet Runway

V1, VR, V2 for Max Takeoff Thrust

WEIGHT (1000 LB)	FLAPS 5			FLAPS 15			FLAPS 20		
	V1	VR	V2	V1	VR	V2	V1	VR	V2
540	160	170	174	154	163	168	147	156	161
500	152	162	168	146	156	162	139	149	155
460	145	157	164	140	151	158	133	144	151
420	137	149	157	131	143	151	124	136	145
380	127	140	149	121	135	144	115	128	138
340	117	131	142	111	126	136	106	120	131
300	106	121	134	101	116	129	96	111	124
260	95	111	126	91	107	121	87	101	116

Check V1(MCG) and/or Minimum VR.

V1, VR, V2 Adjustments*

TEMP		V1							VR							V2						
		PRESS ALT (1000 FT)							PRESS ALT (1000 FT)							PRESS ALT (1000 FT)						
°C	°F	-2	0	2	4	6	8	10	-2	0	2	4	6	8	10	-2	0	2	4	6	8	10
70	158	12	13						5	6						-1	-1					
60	140	9	9	11	13				4	4	5	6				-1	-1	-2	-2			
50	122	5	5	7	9	12	13	15	2	3	4	5	6	7	8	-1	-1	-1	-2	-2	-3	-3
40	104	2	2	4	6	9	11	13	1	1	2	3	5	6	7	-1	-1	-1	-1	-2	-2	-3
30	86	0	0	2	4	6	8	11	0	0	1	2	3	5	6	0	0	0	-1	-1	-2	-2
20	68	0	0	1	2	4	6	8	0	0	1	1	2	3	5	0	0	0	0	-1	-1	-2
-60	-76	0	0	1	2	3	4	6	0	0	1	1	2	3	4	0	0	0	0	-1	-1	-1

Slope and Wind V1 Adjustments*

WEIGHT (1000 LB)	SLOPE (%)					WIND (KTS)							
	-2	-1	0	1	2	-15	-10	-5	0	10	20	30	40
540	-6	-3	0	2	5	-4	-3	-1	0	0	1	2	2
500	-5	-2	0	2	5	-4	-2	-1	0	1	1	2	3
460	-5	-2	0	2	4	-4	-2	-1	0	1	2	2	3
420	-4	-2	0	2	4	-4	-2	-1	0	1	2	3	3
380	-3	-1	0	3	4	-3	-2	-1	0	1	2	3	4
340	-3	-1	0	3	4	-3	-2	0	0	1	2	3	4
300	-3	-1	0	3	4	-3	-2	0	0	1	2	3	4
260	-2	-1	0	3	4	-2	-1	0	0	1	2	3	4

***V1 not to exceed VR.**

V1(MCG), Minimum VR
Max Takeoff Thrust

TEMP		PRESSURE ALTITUDE (FT)													
		-2000		0		2000		4000		6000		8000		10000	
°C	°F	V1 MCG	Min VR	V1 MCG	Min VR	V1 MCG	Min VR	V1 MCG	Min VR	V1 MCG	Min VR	V1 MCG	Min VR	V1 MCG	Min VR
70	158	113	121	111	119										
60	140	113	121	111	119	108	117	106	115						
50	122	116	124	114	122	109	117	106	115	104	112	101	110	98	107
40	104	122	130	121	129	116	124	111	119	105	114	101	110	98	107
30	86	128	136	126	135	121	130	116	125	111	120	107	115	101	110
20	68	133	142	132	141	126	135	120	129	116	125	112	120	106	115
-60	-76	135	143	134	142	128	137	122	130	118	126	115	123	111	119

Maximum Allowable Clearway

FIELD LENGTH (FT)	MAX ALLOWABLE CLEARWAY FOR V1 REDUCTION (FT)
4000	500
6000	700
8000	900
10000	1100
12000	1300
14000	1500

Clearway and Stopway V1 Adjustments

CLEARWAY MINUS STOPWAY (FT)	NORMAL V1 (KIAS)						
	DRY RUNWAY			WET RUNWAY			
	120	140	160	100	120	140	160
1000	-3	-4	-3				
800	-3	-4	-2				
600	-2	-3	-1				
400	-1	-2	-1				
200	0	-1	0				
0	0	0	0	0	0	0	0
-200	6	2	0	2	2	1	1
-400	7	3	1	4	3	2	1
-600	7	3	0	5	4	3	2
-800	7	4	0	6	5	3	2
-1000	7	4	0	7	6	4	2

Use of clearway not allowed on wet runways.
V1 not to exceed VR.

Stabilizer Trim Setting
Max Takeoff Thrust
Flaps 5

WEIGHT (1000 LB)	C.G. (% MAC)								
	6	10	14	18	22	26	30	34	38
500	10	9	7 3/4	6 3/4	5 1/2	4 1/2	3 1/2	2 1/4	1 1/4
484	10	9	7 3/4	6 3/4	5 1/2	4 1/2	3 1/2	2 1/4	1 1/4
480	10	8 3/4	7 3/4	6 3/4	5 1/2	4 1/2	3 1/4	2 1/4	1 1/4
460	9 1/2	8 1/2	7 1/2	6 1/4	5 1/4	4 1/4	3	2	1
440	9 1/4	8	7	6	5	4	2 3/4	1 3/4	3/4
420	9	8	6 3/4	5 3/4	4 3/4	3 3/4	2 3/4	1 1/2	1/2
400	8 3/4	7 3/4	6 3/4	5 3/4	4 1/2	3 1/2	2 1/2	1 1/2	1/4
380	8 3/4	7 1/2	6 1/2	5 1/2	4 1/2	3 1/4	2 1/4	1 1/4	1/4
360	8 1/2	7 1/2	6 1/4	5 1/4	4 1/4	3 1/4	2	1	1/4
340	8	7	6	4 3/4	3 3/4	2 3/4	1 3/4	3/4	1/4
320	7 1/2	6 1/2	5 1/2	4 1/2	3 1/2	2 1/2	1 1/2	1/2	1/4
300	7	6	5	4	3	2 1/4	1 1/4	1/4	1/4
280	6	5 1/4	4 1/4	3 1/2	2 3/4	1 3/4	1	1/4	1/4
260	5 1/4	4 1/2	3 3/4	3	2 1/4	1 1/2	1/2	1/4	1/4

Flaps 15

WEIGHT (1000 LB)	C.G. (% MAC)								
	6	10	14	18	22	26	30	34	38
500	11 3/4	10 1/4	9	7 1/2	6 1/4	4 3/4	3 1/2	2 1/4	3/4
484	11 3/4	10 1/4	9	7 1/2	6 1/4	4 3/4	3 1/2	2 1/4	3/4
480	11 1/2	10 1/4	8 3/4	7 1/2	6 1/4	4 3/4	3 1/2	2	3/4
460	11 1/4	10	8 1/2	7 1/4	6	4 1/2	3 1/4	2	1/2
440	11	9 3/4	8 1/4	7	5 3/4	4 1/4	3	1 3/4	1/4
420	10 3/4	9 1/4	8	6 3/4	5 1/2	4 1/4	2 3/4	1 1/2	1/4
400	10 1/4	9	7 3/4	6 1/2	5 1/4	4	2 3/4	1 1/2	1/4
380	9 3/4	8 1/2	7 1/2	6 1/4	5	3 3/4	2 1/2	1 1/4	1/4
360	9 1/2	8 1/4	7	6	4 3/4	3 1/2	2 1/4	1	1/4
340	8 3/4	7 3/4	6 1/2	5 1/2	4 1/4	3	2	3/4	1/4
320	8 1/4	7	6	5	3 3/4	2 3/4	1 1/2	1/2	1/4
300	7 1/2	6 1/2	5 1/2	4 1/2	3 1/4	2 1/4	1 1/4	1/4	1/4
280	7	6	5	4	3	2	1	1/4	1/4
260	6 1/4	5 1/4	4 1/2	3 1/2	2 1/2	1 1/2	3/4	1/4	1/4

Flaps 20

WEIGHT (1000 LB)	C.G. (% MAC)								
	6	10	14	18	22	26	30	34	38
500	12 1/2	11 1/4	9 3/4	8 1/2	7	5 3/4	4 1/4	3	1 1/2
484	12 1/2	11 1/4	9 3/4	8 1/2	7	5 3/4	4 1/4	3	1 1/2
480	12 1/2	11 1/4	9 3/4	8 1/4	7	5 1/2	4 1/4	2 3/4	1 1/2
460	12 1/4	10 3/4	9 1/2	8	6 3/4	5 1/4	4	2 3/4	1 1/4
440	11 3/4	10 1/2	9	7 3/4	6 1/4	5	3 1/2	2 1/4	1
420	11 1/2	10	8 3/4	7 1/4	6	4 3/4	3 1/4	2	3/4
400	11	9 3/4	8 1/4	7	5 3/4	4 1/2	3	1 3/4	1/2
380	10 3/4	9 1/4	8	6 3/4	5 1/2	4 1/4	2 3/4	1 1/2	1/4
360	10 1/4	9	7 3/4	6 1/2	5 1/4	3 3/4	2 1/2	1 1/4	1/4
340	9 3/4	8 1/2	7 1/4	6	4 3/4	3 3/4	2 1/2	1 1/4	1/4
320	9 1/4	8	7	5 3/4	4 1/2	3 1/2	2 1/4	1	1/4
300	8 3/4	7 3/4	6 1/2	5 1/2	4 1/4	3 1/4	2	1	1/4
280	8 1/4	7 1/4	6	5	4	2 3/4	1 3/4	1/2	1/4
260	7 3/4	6 3/4	5 3/4	4 1/2	3 1/2	2 1/2	1 1/2	1/4	1/4

VREF

WEIGHT (1000 LB)	FLAPS		
	30	25	20
500	161	164	166
480	158	162	164
460	156	160	161
440	153	156	157
420	149	152	154
400	145	149	150
380	142	145	146
360	138	141	142
340	134	137	138
320	130	133	134
300	126	129	130
280	122	124	125
260	120	120	121
240	120	120	121

For approach speed add wind factor of 1/2 headwind component + full gust (max 10 knots).

Flap Maneuver Speed

Sea Level Pressure Altitude

WEIGHT (1000 LB)	MANEUVER SPEED (KIAS)						
	FLAPS POSITION						
	UP	1	5	15	20	25	30
500	241	226	201	181	181	164	161
480	239	223	199	179	179	162	158
460	236	220	196	176	176	160	156
440	233	215	193	173	173	156	153
420	229	211	189	169	169	152	149
400	226	206	186	166	166	149	145
380	222	201	182	162	162	145	142
360	218	196	178	158	158	141	138
340	214	191	174	154	154	137	134
320	210	187	170	150	150	133	130
300	206	183	166	146	146	129	126
280	202	179	162	142	142	124	122
260	197	174	157	139	139	120	120
240	193	170	153	135	135	120	120

10000 FT Pressure Altitude

WEIGHT (1000 LB)	MANEUVER SPEED (KIAS)						
	FLAPS POSITION						
	UP	1	5	15	20	25	30
500	243	227	202	182	182	164	161
480	240	224	200	180	180	162	158
460	237	220	197	177	177	160	156
440	234	216	194	174	174	156	153
420	230	211	190	170	170	152	149
400	226	206	186	166	166	149	145
380	223	201	183	163	163	145	142
360	219	196	179	159	159	141	138
340	215	192	175	155	155	137	134
320	211	188	171	151	151	133	130
300	206	183	166	146	146	129	126
280	202	179	162	142	142	124	122
260	198	175	158	139	139	120	120
240	193	170	153	136	136	120	120

Flaps 25 maneuver speed based on VREF25.
Flaps 30 maneuver speed based on VREF30.

Flap Maneuver Speed
20000 FT Pressure Altitude and Above

WEIGHT (1000 LB)	MANEUVER SPEED (KIAS)						
	FLAPS POSITION						
	UP	1	5	15	20	25	30
500	250	233	204	184	184	164	161
480	246	229	201	181	181	162	158
460	242	226	199	179	179	160	156
440	236	220	195	175	175	156	153
420	232	214	192	172	172	152	149
400	228	208	188	168	168	149	145
380	224	203	184	164	164	145	142
360	220	197	180	160	160	141	138
340	216	193	176	156	156	137	134
320	212	189	172	152	152	133	130
300	207	184	167	147	147	129	126
280	203	180	163	143	143	124	122
260	198	175	158	139	139	120	120
240	193	170	153	136	136	120	120

Flaps 25 maneuver speed based on VREF25.
Flaps 30 maneuver speed based on VREF30.

ADVISORY INFORMATION

Slush/Standing Water Takeoff

Maximum Reverse Thrust

Weight Adjustment (1000 LB)

DRY FIELD/OBSTACLE LIMIT WEIGHT (1000 LB)	SLUSH/STANDING WATER DEPTH								
	0.12 INCHES (3 mm)			0.25 INCHES (6 mm)			0.50 INCHES (13 mm)		
	PRESS ALT (FT)			PRESS ALT (FT)			PRESS ALT (FT)		
	S.L.	5000	10000	S.L.	5000	10000	S.L.	5000	10000
540	-57.1	-66.6	-76.1	-70.5	-80.0	-89.5	-93.8	-103.3	-112.8
520	-53.3	-62.8	-72.3	-65.5	-75.0	-84.5	-86.5	-96.0	-105.5
500	-49.7	-59.2	-68.7	-60.7	-70.2	-79.7	-79.6	-89.1	-98.6
480	-46.3	-55.8	-65.3	-56.1	-65.6	-75.1	-73.0	-82.5	-92.0
460	-42.9	-52.4	-61.9	-51.7	-61.2	-70.7	-66.8	-76.3	-85.8
440	-39.7	-49.2	-58.7	-47.5	-57.0	-66.5	-60.9	-70.4	-79.9
420	-36.6	-46.1	-55.6	-43.6	-53.1	-62.6	-55.4	-64.9	-74.4
400	-33.6	-43.1	-52.6	-39.8	-49.3	-58.8	-50.2	-59.7	-69.2
380	-30.8	-40.3	-49.8	-36.3	-45.8	-55.3	-45.4	-54.9	-64.4
360	-28.0	-37.5	-47.0	-33.0	-42.5	-52.0	-41.0	-50.5	-60.0
340	-25.4	-34.9	-44.4	-29.9	-39.4	-48.9	-36.9	-46.4	-55.9
320	-23.0	-32.5	-42.0	-27.0	-36.5	-46.0	-33.1	-42.6	-52.1
300	-20.6	-30.1	-39.6	-24.3	-33.8	-43.3	-29.8	-39.3	-48.8
280	-18.4	-27.9	-37.4	-21.8	-31.3	-40.8	-26.7	-36.2	-45.7
260	-16.3	-25.8	-35.3	-19.6	-29.1	-38.6	-24.0	-33.5	-43.0
240	-14.3	-23.8	-33.3	-17.5	-27.0	-36.5	-21.7	-31.2	-40.7

V1(MCG) Limit Weight (1000 LB)

ADJUSTED FIELD LENGTH (FT)	SLUSH/STANDING WATER DEPTH								
	0.12 INCHES (3 mm)			0.25 INCHES (6 mm)			0.50 INCHES (13 mm)		
	PRESS ALT (FT)			PRESS ALT (FT)			PRESS ALT (FT)		
	S.L.	5000	10000	S.L.	5000	10000	S.L.	5000	10000
5400				207.6			226.2		
5800	229.8			241.2			260.2		
6200	263.5			275.3			294.9		
6600	297.9			310.2			330.1	217.8	
7000	333.0	221.6		345.8	232.7		366.0	251.7	
7400	369.0	255.0		382.2	266.7		402.6	286.1	
7800	406.0	289.2		419.6	301.4		440.0	321.2	209.4
8200	443.9	324.2	213.3	457.8	336.8	224.3	478.2	357.0	243.2
8600	482.9	360.0	246.6	497.1	373.1	258.1	517.2	393.4	277.5
9000	523.1	396.7	280.6	537.4	410.1	292.7		430.6	312.4
9400		434.3	315.3		448.2	327.9		468.5	348.0
9800		473.1	350.9		487.2	363.9		507.4	384.2
10200		512.9	387.4		527.2	400.8			421.2
10600			424.8			438.6			459.0
11000			463.3			477.3			497.6
11400			502.8			517.1			537.1

1. **Enter Weight Adjustment table with slush/standing water depth and dry field/obstacle limit weight to obtain slush/standing water weight adjustment.**
2. **Adjust field length available by -150 ft/+150 ft for every 5°C above/below 4°C.**
3. **Find V1(MCG) limit weight for adjusted field length and pressure altitude.**
4. **Max allowable slush/standing water limited weight is lesser of weights from 1 and 3.**

ADVISORY INFORMATION

Slush/Standing Water Takeoff
Maximum Reverse Thrust
V1 Adjustment (KIAS)

WEIGHT (1000 LB)	SLUSH/STANDING WATER DEPTH								
	0.12 INCHES (3 mm)			0.25 INCHES (6 mm)			0.50 INCHES (13 mm)		
	PRESS ALT (FT)			PRESS ALT (FT)			PRESS ALT (FT)		
	S.L.	5000	10000	S.L.	5000	10000	S.L.	5000	10000
500	-20	-18	-15	-16	-13	-11	-6	-3	-1
480	-21	-19	-16	-17	-14	-12	-7	-4	-2
460	-22	-20	-17	-18	-15	-13	-8	-6	-3
440	-23	-20	-18	-19	-16	-14	-10	-7	-5
420	-24	-21	-19	-20	-17	-15	-11	-9	-6
400	-24	-21	-19	-20	-18	-15	-13	-10	-8
380	-24	-22	-19	-21	-19	-16	-14	-12	-9
360	-24	-22	-19	-22	-19	-17	-16	-13	-11
340	-24	-22	-19	-22	-19	-17	-17	-14	-12
320	-24	-22	-19	-22	-20	-17	-18	-15	-13
300	-24	-22	-19	-22	-20	-17	-18	-16	-13
280	-24	-21	-19	-22	-20	-17	-18	-16	-13
260	-24	-21	-19	-22	-19	-17	-18	-16	-13
240	-23	-21	-18	-22	-19	-17	-18	-15	-13

1. **Obtain V1, VR and V2 for the actual weight using the Dry Runway Takeoff Speeds table.**
2. **If V1(MCG) limited, set V1 = V1(MCG). If not V1(MCG) limited, enter V1 Adjustment table with the actual weight to obtain V1 speed adjustment. If adjusted V1 is less than V1(MCG), set V1 = V1(MCG). V1 not to exceed VR.**

ADVISORY INFORMATION

Slush/Standing Water Takeoff

No Reverse Thrust

Weight Adjustment (1000 LB)

DRY FIELD/OBSTACLE LIMIT WEIGHT (1000 LB)	SLUSH/STANDING WATER DEPTH								
	0.12 INCHES (3 mm)			0.25 INCHES (6 mm)			0.50 INCHES (13 mm)		
	PRESS ALT (FT)			PRESS ALT (FT)			PRESS ALT (FT)		
	S.L.	5000	10000	S.L.	5000	10000	S.L.	5000	10000
540	-76.6	-87.1	-97.6	-90.7	-101.2	-111.7	-115.6	-126.1	-136.6
520	-71.9	-82.4	-92.9	-84.7	-95.2	-105.7	-106.8	-117.3	-127.8
500	-67.4	-77.9	-88.4	-79.1	-89.6	-100.1	-98.5	-109.0	-119.5
480	-63.1	-73.6	-84.1	-73.6	-84.1	-94.6	-90.8	-101.3	-111.8
460	-58.9	-69.4	-79.9	-68.5	-79.0	-89.5	-83.6	-94.1	-104.6
440	-55.0	-65.5	-76.0	-63.6	-74.1	-84.6	-77.0	-87.5	-98.0
420	-51.2	-61.7	-72.2	-58.9	-69.4	-79.9	-70.9	-81.4	-91.9
400	-47.7	-58.2	-68.7	-54.5	-65.0	-75.5	-65.3	-75.8	-86.3
380	-44.3	-54.8	-65.3	-50.4	-60.9	-71.4	-60.3	-70.8	-81.3
360	-41.1	-51.6	-62.1	-46.5	-57.0	-67.5	-55.9	-66.4	-76.9
340	-38.1	-48.6	-59.1	-42.8	-53.3	-63.8	-52.0	-62.5	-73.0
320	-35.3	-45.8	-56.3	-39.5	-50.0	-60.5	-48.7	-59.2	-69.7
300	-32.6	-43.1	-53.6	-36.3	-46.8	-57.3	-45.9	-56.4	-66.9
280	-30.2	-40.7	-51.2	-33.5	-44.0	-54.5	-43.6	-54.1	-64.6
260	-27.9	-38.4	-48.9	-30.8	-41.3	-51.8	-41.9	-52.4	-62.9
240	-25.9	-36.4	-46.9	-28.5	-39.0	-49.5	-40.8	-51.3	-61.8

V1(MCG) Limit Weight (1000 LB)

ADJUSTED FIELD LENGTH (FT)	SLUSH/STANDING WATER DEPTH								
	0.12 INCHES (3 mm)			0.25 INCHES (6 mm)			0.50 INCHES (13 mm)		
	PRESS ALT (FT)			PRESS ALT (FT)			PRESS ALT (FT)		
	S.L.	5000	10000	S.L.	5000	10000	S.L.	5000	10000
7400							224.0		
7800							260.0		
8200				227.9			296.5		
8600	219.9			264.8			333.6	201.7	
9000	257.0			302.4			371.3	237.4	
9400	294.7			340.5	205.0		409.6	273.6	
9800	333.2			379.4	241.7		448.6	310.3	
10200	372.3	233.7		419.1	278.8		488.3	347.6	215.1
10600	412.2	271.1		459.4	316.6		528.7	385.6	250.9
11000	452.9	309.1		500.7	355.1	218.8	569.7	424.1	287.3
11400	494.5	347.8	210.7	542.7	394.2	255.5		463.4	324.2
11800	537.0	387.2	247.7		434.1	292.9		503.4	361.8
12200	579.9	427.4	285.2		474.8	330.9		544.1	399.9
12600		468.4	323.5		516.3	369.6			438.8
13000		510.3	362.5		558.6	409.1			478.3
13400		553.1	402.2			449.3			518.5
13800			442.7			490.3			559.4
14200			484.0			532.1			
14600			526.3			574.5			
15000			569.2						

1. **Enter Weight Adjustment table with slush/standing water depth and dry field/obstacle limit weight to obtain slush/standing water weight adjustment.**
2. **Adjust field length available by -210 ft/+210 ft for every 5°C above/below 4°C.**
3. **Find V1(MCG) limit weight for adjusted field length and pressure altitude.**
4. **Max allowable slush/standing water limited weight is lesser of weights from 1 and 3.**

ADVISORY INFORMATION

Slush/Standing Water Takeoff
No Reverse Thrust
V1 Adjustment (KIAS)

WEIGHT (1000 LB)	SLUSH/STANDING WATER DEPTH								
	0.12 INCHES (3 mm)			0.25 INCHES (6 mm)			0.50 INCHES (13 mm)		
	PRESS ALT (FT)			PRESS ALT (FT)			PRESS ALT (FT)		
	S.L.	5000	10000	S.L.	5000	10000	S.L.	5000	10000
480	-33	-28	-23	-27	-22	-17	-12	-7	-2
460	-34	-29	-24	-28	-23	-18	-14	-9	-4
440	-35	-30	-25	-30	-25	-20	-16	-11	-6
420	-36	-31	-26	-31	-26	-21	-19	-14	-9
400	-37	-32	-27	-32	-27	-22	-21	-16	-11
380	-37	-32	-27	-33	-28	-23	-24	-19	-14
360	-37	-32	-27	-34	-29	-24	-26	-21	-16
340	-38	-33	-28	-35	-30	-25	-28	-23	-18
320	-38	-33	-28	-36	-31	-26	-30	-25	-20
300	-39	-34	-29	-36	-31	-26	-31	-26	-21
280	-39	-34	-29	-37	-32	-27	-32	-27	-22
260	-40	-35	-30	-38	-33	-28	-33	-28	-23
240	-40	-35	-30	-38	-33	-28	-33	-28	-23

1. **Obtain V1, VR and V2 for the actual weight using the Dry Runway Takeoff Speeds table.**
2. **If V1(MCG) limited, set V1 = V1(MCG). If not V1(MCG) limited, enter V1 Adjustment table with the actual weight to obtain V1 speed adjustment. If adjusted V1 is less than V1(MCG), set V1 = V1(MCG). V1 not to exceed VR.**

ADVISORY INFORMATION

Slippery Runway Takeoff
Maximum Reverse Thrust
Weight Adjustment (1000 LB)

DRY FIELD/OBSTACLE LIMIT WEIGHT (1000 LB)	REPORTED BRAKING ACTION								
	GOOD			MEDIUM			POOR		
	PRESS ALT (FT)			PRESS ALT (FT)			PRESS ALT (FT)		
	S.L.	5000	10000	S.L.	5000	10000	S.L.	5000	10000
540	0.0	-2.5	-5.0	-31.3	-33.8	-36.3	-58.2	-60.7	-63.2
520	0.0	-2.5	-5.0	-31.1	-33.6	-36.1	-56.0	-58.5	-61.0
500	-1.6	-4.1	-6.6	-30.7	-33.2	-35.7	-53.7	-56.2	-58.7
480	-3.2	-5.7	-8.2	-30.2	-32.7	-35.2	-51.4	-53.9	-56.4
460	-4.4	-6.9	-9.4	-29.5	-32.0	-34.5	-49.1	-51.6	-54.1
440	-5.3	-7.8	-10.3	-28.6	-31.1	-33.6	-46.8	-49.3	-51.8
420	-5.9	-8.4	-10.9	-27.6	-30.1	-32.6	-44.4	-46.9	-49.4
400	-6.1	-8.6	-11.1	-26.4	-28.9	-31.4	-42.1	-44.6	-47.1
380	-6.0	-8.5	-11.0	-25.1	-27.6	-30.1	-39.7	-42.2	-44.7
360	-5.6	-8.1	-10.6	-23.6	-26.1	-28.6	-37.3	-39.8	-42.3
340	-4.8	-7.3	-9.8	-21.9	-24.4	-26.9	-34.8	-37.3	-39.8
320	-3.8	-6.3	-8.8	-20.1	-22.6	-25.1	-32.4	-34.9	-37.4
300	-2.4	-4.9	-7.4	-18.1	-20.6	-23.1	-29.9	-32.4	-34.9
280	-0.6	-3.1	-5.6	-15.9	-18.4	-20.9	-27.4	-29.9	-32.4
260	0.0	-2.5	-5.0	-13.6	-16.1	-18.6	-24.8	-27.3	-29.8
240	0.0	-2.5	-5.0	-11.2	-13.7	-16.2	-22.3	-24.8	-27.3

ADVISORY INFORMATION

Slippery Runway Takeoff
Maximum Reverse Thrust
V1(MCG) Limit Weight (1000 LB)

ADJUSTED FIELD LENGTH (FT)	REPORTED BRAKING ACTION								
	GOOD			MEDIUM			POOR		
	PRESS ALT (FT)			PRESS ALT (FT)			PRESS ALT (FT)		
	S.L.	5000	10000	S.L.	5000	10000	S.L.	5000	10000
4200	223.0								
4600	278.5								
5000	336.0	229.8							
5400	395.8	285.5		226.4					
5800	458.1	343.3	236.7	267.0					
6200	523.5	403.4	292.6	309.2	201.5				
6600		466.1	350.7	353.1	241.5		220.8		
7000		531.9	411.1	399.1	282.6		249.3		
7400			474.2	447.4	325.5	216.5	278.6		
7800			540.3	498.5	370.1	256.7	308.8		
8200				552.6	416.9	298.5	339.8	220.8	
8600					466.2	342.0	371.8	249.3	
9000					518.4	387.4	405.0	278.6	
9400					573.1	435.1	439.3	308.8	
9800						485.4	475.0	339.8	220.8
10200						538.8	512.1	371.8	249.3
10600							550.9	405.0	278.6
11000								439.3	308.8
11400								475.0	339.8
11800								512.1	371.8
12200								550.9	405.0
12600									439.3
13000									475.0
13400									512.1
13800									550.9

1. **Enter Weight Adjustment table with reported braking action and dry field/obstacle limit weight to obtain slippery runway weight adjustment.**
2. **Adjust "Good" field length available by -90 ft/+90 ft for every 5°C above/below 4°C.**
   Adjust "Medium" field length available by -130 ft/+130 ft for every 5°C above/below 4°C.
   Adjust "Poor" field length available by -170 ft/+170 ft for every 5°C above/below 4°C.
3. **Find V1(MCG) limit weight for adjusted field length and pressure altitude.**
4. **Max allowable slippery runway limited weight is lesser of weights from 1 and 3.**

ADVISORY INFORMATION

Slippery Runway Takeoff
Maximum Reverse Thrust
V1 Adjustment (KIAS)

WEIGHT (1000 LB)	REPORTED BRAKING ACTION								
	GOOD			MEDIUM			POOR		
	PRESS ALT (FT)			PRESS ALT (FT)			PRESS ALT (FT)		
	S.L.	5000	10000	S.L.	5000	10000	S.L.	5000	10000
500	-8	-5	-3	-18	-16	-13	-30	-28	-25
480	-9	-6	-4	-19	-17	-14	-31	-29	-26
460	-9	-7	-4	-20	-18	-15	-33	-30	-28
440	-10	-8	-5	-21	-19	-16	-34	-31	-29
420	-11	-8	-6	-22	-19	-17	-35	-32	-30
400	-11	-8	-6	-22	-20	-17	-36	-33	-31
380	-11	-9	-6	-23	-21	-18	-36	-34	-31
360	-12	-9	-7	-24	-21	-19	-37	-34	-32
340	-12	-9	-7	-24	-21	-19	-37	-35	-32
320	-12	-9	-7	-24	-22	-19	-38	-35	-33
300	-12	-9	-7	-24	-22	-19	-38	-36	-33
280	-12	-9	-7	-25	-22	-20	-38	-36	-33
260	-11	-9	-6	-25	-22	-20	-38	-36	-33
240	-11	-9	-6	-25	-22	-20	-38	-36	-33

1. **Obtain V1, VR and V2 for the actual weight using the Dry Runway Takeoff Speeds table.**
2. **If V1(MCG) limited, set V1 = V1(MCG). If not V1(MCG) limited, enter V1 Adjustment table with the actual weight to obtain V1 speed adjustment. If adjusted V1 is less than V1(MCG), set V1 = V1(MCG). V1 not to exceed VR.**

ADVISORY INFORMATION

Slippery Runway Takeoff
No Reverse Thrust
Weight Adjustment (1000 LB)

DRY FIELD/OBSTACLE LIMIT WEIGHT (1000 LB)	REPORTED BRAKING ACTION								
	GOOD			MEDIUM			POOR		
	PRESS ALT (FT)			PRESS ALT (FT)			PRESS ALT (FT)		
	S.L.	5000	10000	S.L.	5000	10000	S.L.	5000	10000
540	-7.6	-8.6	-9.6	-50.3	-51.3	-52.3	-83.1	-84.1	-85.1
520	-9.6	-10.6	-11.6	-49.1	-50.1	-51.1	-79.1	-80.1	-81.1
500	-11.2	-12.2	-13.2	-47.8	-48.8	-49.8	-75.2	-76.2	-77.2
480	-12.6	-13.6	-14.6	-46.5	-47.5	-48.5	-71.6	-72.6	-73.6
460	-13.7	-14.7	-15.7	-45.0	-46.0	-47.0	-68.1	-69.1	-70.1
440	-14.4	-15.4	-16.4	-43.5	-44.5	-45.5	-64.8	-65.8	-66.8
420	-14.9	-15.9	-16.9	-42.0	-43.0	-44.0	-61.7	-62.7	-63.7
400	-15.0	-16.0	-17.0	-40.3	-41.3	-42.3	-58.8	-59.8	-60.8
380	-14.8	-15.8	-16.8	-38.6	-39.6	-40.6	-56.1	-57.1	-58.1
360	-14.4	-15.4	-16.4	-36.9	-37.9	-38.9	-53.5	-54.5	-55.5
340	-13.6	-14.6	-15.6	-35.0	-36.0	-37.0	-51.1	-52.1	-53.1
320	-12.5	-13.5	-14.5	-33.1	-34.1	-35.1	-48.9	-49.9	-50.9
300	-11.1	-12.1	-13.1	-31.1	-32.1	-33.1	-46.9	-47.9	-48.9
280	-9.4	-10.4	-11.4	-29.0	-30.0	-31.0	-45.1	-46.1	-47.1
260	-7.4	-8.4	-9.4	-26.9	-27.9	-28.9	-43.4	-44.4	-45.4
240	-5.1	-6.1	-7.1	-24.6	-25.6	-26.6	-41.9	-42.9	-43.9

ADVISORY INFORMATION

Slippery Runway Takeoff
No Reverse Thrust
V1(MCG) Limit Weight (1000 LB)

ADJUSTED FIELD LENGTH (FT)	REPORTED BRAKING ACTION								
	GOOD			MEDIUM			POOR		
	PRESS ALT (FT)			PRESS ALT (FT)			PRESS ALT (FT)		
	S.L.	5000	10000	S.L.	5000	10000	S.L.	5000	10000
5000	222.2								
5400	291.7								
5800	363.0	230.8							
6200	436.3	300.5							
6600	511.7	372.1	239.4						
7000		445.6	309.4						
7400		521.3	381.1	230.1					
7800			454.9	285.2					
8200			530.9	342.5					
8600				402.2	250.5				
9000				464.8	306.4				
9400				530.7	364.6	216.6			
9800					425.4	271.2			
10200					489.1	327.9			
10600					556.2	387.0			
11000						448.9	231.0		
11400						513.9	269.5		
11800							309.0		
12200							349.7	202.5	
12600							391.5	240.5	
13000							434.6	279.3	
13400							479.2	319.1	
13800							525.4	360.0	212.0
14200							572.7	402.2	250.1

1. **Enter Weight Adjustment table with reported braking action and dry field/obstacle limit weight to obtain slippery runway weight adjustment.**
2. **Adjust "Good" field length available by -100 ft/+100 ft for every 5°C above/below 4°C.**
   Adjust "Medium" field length available by -140 ft/+140 ft for every 5°C above/below 4°C.
   Adjust "Poor" field length available by -220 ft/+220 ft for every 5°C above/below 4°C.
3. **Find V1(MCG) limit weight for adjusted field length and pressure altitude.**
4. **Max allowable slippery runway limited weight is lesser of weights from 1 and 3.**

ADVISORY INFORMATION

Slippery Runway Takeoff
No Reverse Thrust
V1 Adjustment (KIAS)

WEIGHT (1000 LB)	REPORTED BRAKING ACTION								
	GOOD			MEDIUM			POOR		
	PRESS ALT (FT)			PRESS ALT (FT)			PRESS ALT (FT)		
	S.L.	5000	10000	S.L.	5000	10000	S.L.	5000	10000
500	-11	-6	-1	-26	-21	-16	-47	-42	-37
480	-12	-7	-2	-27	-22	-17	-49	-44	-39
460	-13	-8	-3	-29	-24	-19	-51	-46	-41
440	-14	-9	-4	-30	-25	-20	-52	-47	-42
420	-15	-10	-5	-31	-26	-21	-54	-49	-44
400	-15	-10	-5	-33	-28	-23	-56	-51	-46
380	-16	-11	-6	-34	-29	-24	-57	-52	-47
360	-17	-12	-7	-35	-30	-25	-59	-54	-49
340	-17	-12	-7	-36	-31	-26	-60	-55	-50
320	-18	-13	-8	-37	-32	-27	-60	-55	-50
300	-18	-13	-8	-39	-34	-29	-61	-56	-51
280	-19	-14	-9	-40	-35	-30	-61	-56	-51
260	-20	-15	-10	-41	-36	-31	-61	-56	-51
240	-20	-15	-10	-42	-37	-32	-60	-55	-50

1. **Obtain V1, VR and V2 for the actual weight using the Dry Runway Takeoff Speeds table.**
2. **If V1(MCG) limited, set V1 = V1(MCG). If not V1(MCG) limited, enter V1 Adjustment table with the actual weight to obtain V1 speed adjustment. If adjusted V1 is less than V1(MCG), set V1 = V1(MCG). V1 not to exceed VR.**

Takeoff TPR
Based on anti-ice on or off

OAT (°C)	AIRPORT PRESSURE ALTITUDE (FT)												
	-2000	-1000	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
70	49.4	50.3	51.0	50.3	49.6	48.8	48.1	47.3	46.1	45.5	44.4	43.1	41.7
60	56.4	57.6	58.7	58.1	57.5	56.9	56.4	55.8	54.7	54.3	53.4	52.1	50.8
55	60.1	61.4	62.5	62.0	61.5	60.9	60.5	60.0	58.9	58.7	57.8	56.6	55.4
50	64.0	65.4	66.7	66.2	65.6	65.0	64.6	64.2	63.2	63.1	62.3	61.2	60.0
45	67.4	69.2	70.9	70.4	69.9	69.3	68.9	68.5	67.5	67.5	66.7	65.7	64.5
40	70.6	72.7	74.5	74.3	74.1	73.7	73.4	73.0	72.0	72.0	71.2	70.2	69.1
35	74.0	76.2	78.3	78.1	77.8	77.6	77.6	77.6	76.6	76.7	75.9	74.9	73.7
30	74.9	78.5	82.1	81.8	81.6	81.3	81.4	81.5	80.7	81.2	80.7	79.7	78.6
25	75.1	78.7	82.3	83.4	84.4	84.9	85.0	85.1	84.7	85.1	84.9	84.2	83.6
20	75.3	78.9	82.6	83.6	84.7	85.7	87.2	88.6	88.3	88.7	88.5	88.0	87.5
15	75.5	79.1	82.8	83.9	84.9	86.0	87.4	88.9	89.7	91.3	91.8	91.3	90.8
10	75.7	79.4	83.0	84.1	85.1	86.2	87.7	89.1	90.0	91.6	92.6	93.3	94.0
5	75.9	79.6	83.2	84.3	85.4	86.4	87.9	89.3	90.2	91.8	92.8	93.5	94.3
0	76.1	79.8	83.5	84.5	85.6	86.7	88.1	89.6	90.4	92.1	93.1	93.8	94.5
-10	76.5	80.2	83.9	85.0	86.0	87.1	88.6	90.1	90.9	92.6	93.6	94.3	95.0
-20	76.9	80.6	84.3	85.4	86.5	87.6	89.1	90.5	91.4	93.1	94.1	94.8	95.5
-30	77.3	81.0	84.8	85.9	87.0	88.1	89.5	91.0	91.9	93.6	94.6	95.3	96.0
-40	77.7	81.5	85.2	86.3	87.4	88.5	90.0	91.5	92.4	94.1	95.1	95.8	96.5
-50	78.1	81.9	85.7	86.8	87.9	89.0	90.5	92.0	92.9	94.5	95.6	96.3	97.1

Minimum Allowable TPR for Reduced Thrust
Based on 25% thrust reduction

MAX TAKEOFF TPR FOR ACTUAL OAT	MIN TAKEOFF TPR ALLOWED
40.0	32.4
45.0	36.2
50.0	39.9
55.0	43.5
60.0	47.2
65.0	50.9
70.0	54.6
75.0	58.2
80.0	61.8
85.0	65.2
90.0	68.4
95.0	71.3
100.0	73.6

Go-Around TPR

Based on anti-ice on or off

REPORTED OAT		TAT (°C)	AIRPORT PRESSURE ALTITUDE (1000 FT)												
°C	°F		-2	-1	0	1	2	3	4	5	6	7	8	9	10
66	150	70	51.2	52.2	53.1	52.5	51.8	51.1	50.5	49.9	48.6	48.2	47.2	45.9	44.6
56	133	60	58.1	59.3	60.5	60.0	59.5	58.9	58.5	58.0	56.8	56.7	55.8	54.6	53.4
51	124	55	61.8	63.2	64.4	63.9	63.3	62.8	62.5	62.1	61.0	60.9	60.1	59.0	57.8
46	115	50	65.2	67.0	68.5	68.0	67.5	66.9	66.6	66.2	65.1	65.1	64.4	63.4	62.2
41	106	45	68.5	70.4	72.1	72.0	71.7	71.2	71.0	70.6	69.4	69.4	68.7	67.7	66.6
36	97	40	71.7	73.8	75.7	75.6	75.5	75.2	75.2	75.1	73.9	74.0	73.3	72.1	71.0
31	88	35	73.3	76.7	79.3	79.3	79.2	78.9	79.0	79.0	78.1	78.5	77.9	76.9	75.7
26	79	30	73.5	76.9	80.4	81.7	82.7	82.5	82.6	82.7	81.9	82.5	82.2	81.5	80.5
21	70	25	73.7	77.1	80.6	81.9	83.1	84.2	85.7	86.3	85.9	86.4	86.1	85.5	84.8
16	61	20	73.9	77.4	80.8	82.1	83.3	84.4	85.9	87.4	88.3	89.8	89.6	89.1	88.5
11	53	15	74.1	77.6	81.0	82.3	83.5	84.6	86.1	87.6	88.6	90.2	91.2	91.9	91.8
7	44	10	74.3	77.8	81.2	82.5	83.7	84.9	86.4	87.8	88.8	90.4	91.4	92.1	92.8
2	35	5	74.5	78.0	81.4	82.8	84.0	85.1	86.6	88.1	89.0	90.7	91.7	92.4	93.0
-3	26	0	74.7	78.2	81.6	83.0	84.2	85.3	86.8	88.3	89.3	90.9	91.9	92.6	93.3
-13	8	-10	75.1	78.6	82.1	83.4	84.6	85.8	87.3	88.8	89.7	91.4	92.4	93.1	93.8
-23	-10	-20	75.5	79.0	82.5	83.9	85.1	86.2	87.7	89.2	90.2	91.9	92.9	93.6	94.3
-33	-27	-30	75.9	79.4	82.9	84.3	85.5	86.7	88.2	89.7	90.7	92.4	93.4	94.1	94.8
-43	-45	-40	76.3	79.8	83.4	84.7	86.0	87.1	88.6	90.2	91.2	92.8	93.9	94.6	95.3
-53	-63	-50	76.6	80.2	83.8	85.2	86.4	87.6	89.1	90.6	91.6	93.3	94.3	95.1	95.8

Max Climb TPR

Based on anti-ice on or off

TAT (°C)	PRESSURE ALTITUDE (1000 FT) / SPEED (KIAS OR MACH)									
	0	5	10	15	20	25	30	35	40	43
	310	310	310	310	310	310	310	0.85	0.85	0.85
60	48.9	49.0	51.2	55.6	58.0	61.8	66.2	73.7	71.4	70.2
50	55.6	55.2	54.2	55.6	58.0	61.8	66.2	73.7	71.4	70.2
40	62.0	62.8	61.6	61.0	59.2	61.8	66.2	73.7	71.4	70.2
30	63.7	70.0	69.4	69.9	67.9	67.1	67.3	73.7	71.4	70.2
20	64.0	70.3	75.7	78.4	77.2	76.2	76.2	76.2	71.9	70.7
15	64.2	70.5	75.9	82.1	81.3	80.9	80.8	80.4	76.3	75.2
10	64.4	70.7	76.1	82.3	85.8	85.3	85.5	84.7	80.7	79.6
5	64.5	70.9	76.3	82.5	87.2	89.6	89.8	89.1	85.3	84.1
0	64.7	71.0	76.5	82.7	87.4	91.8	93.9	93.5	89.8	88.6
-5	64.9	71.2	76.6	82.9	87.6	92.0	96.3	97.6	94.3	93.2
-10	65.0	71.4	76.8	83.1	87.8	92.2	96.5	101.9	98.8	97.9
-15	65.2	71.6	77.0	83.3	88.0	92.5	96.7	103.2	102.1	101.2
-20	65.3	71.8	77.2	83.5	88.3	92.7	96.9	103.4	102.3	101.5
-25	65.5	71.9	77.4	83.7	88.5	92.9	97.2	103.6	102.5	101.7
-30	65.7	72.1	77.6	84.0	88.7	93.1	97.4	103.9	102.8	101.9
-35	65.8	72.3	77.8	84.2	88.9	93.4	97.6	104.1	103.0	102.2
-40	66.0	72.5	78.0	84.4	89.1	93.6	97.9	104.4	103.3	102.4

Flight With Unreliable Airspeed / Turbulent Air Penetration

Altitude and/or vertical speed indications may also be unreliable.

Climb

Flaps Up, Set Max Climb Thrust

PRESSURE ALTITUDE (FT) (SPEED)		WEIGHT (1000 LB) 300	350	400	450	500
40000 (.85M)	**PITCH ATT**	**3.5**	**3.5**	**3.5**	**3.5**	
	V/S (FT/MIN)	1300	1000	600	100	
30000 (310 KIAS)	**PITCH ATT**	**3.5**	**3.5**	**3.5**	**3.5**	**3.5**
	V/S (FT/MIN)	2000	1700	1300	1100	900
20000 (290 KIAS)	**PITCH ATT**	**6.5**	**6.0**	**6.0**	**6.0**	**6.0**
	V/S (FT/MIN)	3500	2900	2400	2000	1700
10000 (290 KIAS)	**PITCH ATT**	**9.0**	**8.5**	**8.0**	**7.5**	**7.5**
	V/S (FT/MIN)	4600	3900	3300	2900	2500
SEA LEVEL (290 KIAS)	**PITCH ATT**	**11.5**	**10.5**	**9.5**	**9.0**	**9.0**
	V/S (FT/MIN)	5400	4500	3900	3400	3000

Cruise

Flaps Up, Set Thrust for Level Flight

PRESSURE ALTITUDE (FT) (SPEED)		WEIGHT (1000 LB) 300	350	400	450	500
40000 (.85M)	**PITCH ATT**	**1.5**	**1.5**	**2.0**		
	TPR	64.8	69.0	77.0		
35000 (310 KIAS)	**PITCH ATT**	**1.0**	**1.0**	**1.5**	**2.0**	**2.0**
	TPR	58.8	62.0	64.9	68.5	74.0
30000 (310 KIAS)	**PITCH ATT**	**0.5**	**1.0**	**1.5**	**1.5**	**2.0**
	TPR	54.1	56.0	58.5	61.1	63.9
25000 (310 KIAS)	**PITCH ATT**	**0.5**	**1.0**	**1.5**	**1.5**	**2.0**
	TPR	47.7	48.9	50.7	52.8	55.1
20000 (290 KIAS)	**PITCH ATT**	**1.0**	**1.5**	**2.0**	**2.5**	**2.5**
	TPR	39.4	40.9	42.6	44.7	47.1
15000 (290 KIAS)	**PITCH ATT**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**
	TPR	35.1	36.3	37.6	39.3	41.1

Descent

Flaps Up, Set Idle Thrust

PRESSURE ALTITUDE (FT) (SPEED)		WEIGHT (1000 LB) 300	350	400	450	500
40000 (.85M)	**PITCH ATT**	**-2.0**	**-1.0**	**-1.0**	**-0.5**	**0.0**
	V/S (FT/MIN)	-2700	-2500	-2500	-2600	-2900
30000 (310 KIAS)	**PITCH ATT**	**-2.5**	**-2.0**	**-1.5**	**-1.0**	**-0.5**
	V/S (FT/MIN)	-2600	-2300	-2100	-2000	-1900
20000 (290 KIAS)	**PITCH ATT**	**-2.0**	**-1.5**	**-0.5**	**0.0**	**0.5**
	V/S (FT/MIN)	-2100	-1900	-1800	-1700	-1600
10000 (290 KIAS)	**PITCH ATT**	**-2.5**	**-1.5**	**-1.0**	**-0.5**	**0.5**
	V/S (FT/MIN)	-2000	-1800	-1600	-1500	-1500
SEA LEVEL (290 KIAS)	**PITCH ATT**	**-2.5**	**-1.5**	**-1.0**	**-0.5**	**0.0**
	V/S (FT/MIN)	-1800	-1600	-1500	-1400	-1300

Flight With Unreliable Airspeed / Turbulent Air Penetration
Altitude and/or vertical speed indications may also be unreliable.
Holding
Flaps Up, Set Thrust for Level Flight

PRESSURE ALTITUDE (FT)		WEIGHT (1000 LB)				
		300	350	400	450	500
10000	**PITCH ATT**	**4.0**	**4.0**	**4.5**	**4.0**	**4.0**
	TPR	24.6	27.3	29.9	32.5	35.1
	KIAS	206	217	226	240	259
5000	**PITCH ATT**	**4.0**	**4.0**	**4.5**	**4.5**	**4.5**
	TPR	21.7	24.1	26.3	28.6	30.9
	KIAS	206	216	225	235	249

Terminal Area (5000 FT)
Set Thrust for Level Flight

FLAP POSITION (VREF + INCREMENT)		WEIGHT (1000 LB)				
		300	350	400	450	500
FLAPS UP	**PITCH ATT**	**4.5**	**5.0**	**5.0**	**5.5**	**6.0**
GEAR UP	TPR	21.4	23.7	26	28.4	30.8
VREF30+80	KIAS	206	217	226	235	241
FLAPS 1	**PITCH ATT**	**6.0**	**6.5**	**6.5**	**7.0**	**7.5**
GEAR UP	TPR	22.5	25.1	27.6	30.2	32.8
VREF30+60	KIAS	186	197	206	215	222
FLAPS 5	**PITCH ATT**	**3.5**	**3.5**	**4.0**	**4.0**	**4.5**
GEAR UP	TPR	23.1	25.9	28.6	31.3	34.1
VREF30+40	KIAS	166	177	186	195	202
FLAPS 15	**PITCH ATT**	**4.5**	**5.0**	**5.0**	**5.0**	**5.5**
GEAR UP	TPR	24.2	27.3	30.3	33.4	36.6
VREF30+20	KIAS	146	157	166	175	182
FLAPS 20	**PITCH ATT**	**3.0**	**3.5**	**3.5**	**3.5**	**4.0**
GEAR DOWN	TPR	34.6	39.1	43.6	48.2	52.5
VREF30+20	KIAS	146	157	166	175	182

Final Approach (1500 FT)
Gear Down, Set Thrust for 3° Glideslope

FLAP POSITION (VREF + INCREMENT)		WEIGHT (1000 LB)				
		300	350	400	450	500
FLAPS 20 VREF20+10	**PITCH ATT**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
	TPR	15.8	17.4	19.0	20.6	22.1
	KIAS	138	149	158	168	177
FLAPS 25 VREF25+10	**PITCH ATT**	**1.5**	**1.5**	**2.0**	**2.0**	**2.0**
	TPR	17.1	18.9	20.6	22.4	24.1
	KIAS	137	148	157	166	175
FLAPS 30 VREF30+10	**PITCH ATT**	**1.5**	**1.5**	**2.0**	**2.0**	**2.0**
	TPR	18.9	21.0	23.0	25.1	27.1
	KIAS	135	144	154	163	171

Performance Inflight — Chapter PI
All Engine — Section 11

Long Range Cruise Maximum Operating Altitude
Max Climb Thrust
ISA + 10°C and Below

WEIGHT (1000 LB)	OPTIMUM ALT (FT)	TAT (°C)	MARGIN TO INITIAL BUFFET 'G' (BANK ANGLE)		
			1.30 (39°)	1.40 (44°)	1.50 (48°)
500	35000	-11	37100	35700	34300
480	35900	-13	38000	36500	35100
460	36700	-14	38900	37400	36000
440	37700	-14	39600	38100	36700
420	38600	-14	40200	38700	37200
400	39600	-14	40700	39200	37800
380	40700	-14	41400	39900	38400
360	41800	-14	42300	40700	39200
340	43000	-14	43100	41600	40100
320	43100	-14	43100	42500	41100
300	43100	-14	43100	43100	42100
280	43100	-14	43100	43100	43100

ISA + 15°C

WEIGHT (1000 LB)	OPTIMUM ALT (FT)	TAT (°C)	MARGIN TO INITIAL BUFFET 'G' (BANK ANGLE)		
			1.30 (39°)	1.40 (44°)	1.50 (48°)
500	35000	-6	37000*	35700	34300
480	35900	-8	37800*	36500	35100
460	36700	-8	38600*	37400	36000
440	37700	-8	39400*	38100	36700
420	38600	-8	40100*	38700	37200
400	39600	-8	40700	39200	37800
380	40700	-8	41400	39900	38400
360	41800	-8	42300	40700	39200
340	43000	-8	43100	41600	40100
320	43100	-8	43100	42500	41100
300	43100	-8	43100	43100	42100
280	43100	-8	43100	43100	43100

ISA + 20°C

WEIGHT (1000 LB)	OPTIMUM ALT (FT)	TAT (°C)	MARGIN TO INITIAL BUFFET 'G' (BANK ANGLE)		
			1.30 (39°)	1.40 (44°)	1.50 (48°)
500	35000	0	36300*	35700	34300
480	35900	-2	37000*	36500	35100
460	36700	-2	37800*	37400	36000
440	37700	-2	38600*	38100	36700
420	38600	-2	39300*	38700	37200
400	39600	-2	40000*	39200	37800
380	40700	-2	40800*	39900	38400
360	41800	-2	41700*	40700	39200
340	43000	-2	42500*	41600	40100
320	43100	-2	43100	42500	41100
300	43100	-2	43100	43100	42100
280	43100	-2	43100	43100	43100

***Denotes altitude thrust limited in level flight, 300 fpm residual rate of climb.**

Long Range Cruise Control

WEIGHT (1000 LB)		PRESSURE ALTITUDE (1000 FT)									
		25	27	29	31	33	35	37	39	41	43
500	TPR	55.7	58.8	62.4	66.0	69.5	73.9	80.8			
	MACH	.753	.777	.809	.850	.855	.849	.843			
	KIAS	316	314	314	318	306	291	275			
	FF/ENG	6552	6527	6577	6663	6464	6275	6271			
460	TPR	52.9	55.7	58.9	62.6	66.1	69.8	74.8	82.8		
	MACH	.730	.754	.778	.813	.852	.854	.848	.842		
	KIAS	306	304	301	303	305	293	277	262		
	FF/ENG	6052	6020	5997	6053	6101	5917	5788	5869		
420	TPR	50.0	52.7	55.6	58.8	62.6	66.1	70.2	75.8	86.1	
	MACH	.708	.729	.754	.778	.814	.853	.854	.848	.841	
	KIAS	296	293	291	289	290	292	279	265	250	
	FF/ENG	5566	5521	5491	5467	5520	5556	5423	5346	5579	
380	TPR	47.1	49.6	52.3	55.2	58.4	62.2	66.1	70.7	77.3	
	MACH	.685	.705	.727	.751	.776	.811	.852	.854	.848	
	KIAS	286	282	280	277	275	276	279	267	253	
	FF/ENG	5108	5038	4995	4965	4940	4979	5051	4977	4978	
340	TPR	44.2	46.4	48.9	51.5	54.5	57.7	61.5	65.9	71.1	77.9
	MACH	.659	.680	.700	.722	.746	.771	.804	.848	.855	.849
	KIAS	274	272	269	266	263	261	261	265	255	242
	FF/ENG	4648	4587	4516	4473	4443	4418	4450	4573	4570	4582
300	TPR	40.9	43.1	45.4	47.8	50.4	53.3	56.7	60.7	65.2	70.8
	MACH	.621	.649	.672	.692	.714	.737	.764	.792	.835	.856
	KIAS	258	259	257	254	251	249	247	245	248	244
	FF/ENG	4127	4117	4066	4003	3955	3925	3927	3955	4066	4149
260	TPR	37.2	39.4	41.6	44.0	46.3	48.9	51.9	55.5	59.3	63.7
	MACH	.579	.605	.633	.659	.681	.702	.725	.751	.777	.813
	KIAS	239	240	241	241	239	236	233	231	229	230
	FF/ENG	3601	3584	3577	3552	3502	3446	3433	3452	3469	3535
220	TPR	33.4	35.3	37.3	39.6	41.9	44.3	47.0	50.1	53.6	57.3
	MACH	.535	.558	.582	.609	.638	.664	.686	.708	.732	.758
	KIAS	220	221	221	221	222	222	219	217	214	213
	FF/ENG	3102	3068	3049	3034	3029	3000	2970	2964	2976	2994

Shaded area approximates optimum altitude.

Long Range Cruise Enroute Fuel and Time - Low Altitudes

Ground to Air Miles Conversion

AIR DISTANCE (NM)					GROUND DISTANCE (NM)	AIR DISTANCE (NM)				
HEADWIND COMPONENT (KTS)						TAILWIND COMPONENT (KTS)				
100	80	60	40	20		20	40	60	80	100
284	262	243	226	213	200	192	184	176	169	163
572	528	489	455	426	400	382	366	351	337	325
861	794	734	683	639	600	573	549	526	505	486
1151	1061	980	912	853	800	764	732	701	673	648
1443	1328	1227	1141	1067	1000	956	914	876	841	809
1735	1597	1474	1370	1281	1200	1146	1096	1051	1009	971
2029	1866	1721	1599	1494	1400	1337	1279	1226	1177	1132
2323	2136	1970	1830	1708	1600	1528	1461	1400	1344	1293
2619	2406	2218	2059	1922	1800	1719	1643	1574	1511	1454
2916	2678	2468	2290	2137	2000	1909	1825	1748	1678	1614

Reference Fuel And Time Required at Check Point

AIR DIST (NM)	PRESSURE ALTITUDE (1000 FT)									
	10		14		20		24		28	
	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)
200	6.1	0:39	5.4	0:37	4.6	0:34	4.0	0:32	3.6	0:31
400	12.7	1:16	11.5	1:11	10.0	1:05	9.1	1:02	8.3	0:59
600	19.1	1:53	17.5	1:46	15.3	1:37	14.1	1:31	12.9	1:28
800	25.6	2:30	23.4	2:21	20.6	2:09	19.0	2:01	17.6	1:57
1000	32.0	3:08	29.3	2:57	25.9	2:41	24.0	2:31	22.2	2:25
1200	38.3	3:46	35.2	3:33	31.2	3:13	28.9	3:02	26.7	2:54
1400	44.6	4:24	41.0	4:09	36.4	3:46	33.7	3:32	31.3	3:23
1600	50.8	5:03	46.8	4:45	41.6	4:18	38.5	4:03	35.8	3:52
1800	57.0	5:42	52.5	5:21	46.7	4:51	43.3	4:33	40.2	4:22
2000	63.2	6:21	58.2	5:58	51.9	5:25	48.1	5:04	44.7	4:51

Fuel Required Adjustment (1000 LB)

REFERENCE FUEL REQUIRED (1000 LB)	WEIGHT AT CHECK POINT (1000 LB)							
	220	260	300	340	380	420	460	500
5	-0.6	-0.4	-0.3	-0.1	0.0	0.1	0.3	0.4
10	-1.5	-1.1	-0.7	-0.4	0.0	0.4	0.9	1.3
15	-2.4	-1.8	-1.2	-0.6	0.0	0.7	1.5	2.2
20	-3.2	-2.4	-1.6	-0.8	0.0	1.0	2.1	3.1
25	-4.1	-3.1	-2.1	-1.0	0.0	1.3	2.7	4.0
30	-5.0	-3.7	-2.5	-1.3	0.0	1.6	3.3	4.9
35	-5.8	-4.4	-2.9	-1.5	0.0	1.9	3.9	5.8
40	-6.7	-5.0	-3.4	-1.7	0.0	2.2	4.5	6.7
45	-7.6	-5.7	-3.8	-1.9	0.0	2.5	5.0	7.6
50	-8.4	-6.3	-4.2	-2.1	0.0	2.8	5.6	8.5
55	-9.3	-7.0	-4.7	-2.4	0.0	3.1	6.2	9.4
60	-10.2	-7.6	-5.1	-2.6	0.0	3.4	6.8	10.2
65	-11.0	-8.3	-5.5	-2.8	0.0	3.7	7.4	11.1

Long Range Cruise Enroute Fuel and Time - High Altitudes

Ground to Air Miles Conversion

AIR DISTANCE (NM)					GROUND DISTANCE (NM)	AIR DISTANCE (NM)				
HEADWIND COMPONENT (KTS)						TAILWIND COMPONENT (KTS)				
100	80	60	40	20		20	40	60	80	100
518	490	464	440	419	400	384	368	354	342	330
1036	979	927	881	839	800	768	739	712	687	663
1556	1470	1392	1321	1258	1200	1153	1109	1069	1031	996
2078	1962	1857	1763	1678	1600	1538	1480	1425	1375	1329
2601	2456	2323	2204	2098	2000	1922	1850	1782	1719	1661
3126	2950	2790	2647	2518	2400	2307	2219	2138	2062	1993
3652	3446	3257	3089	2939	2800	2691	2589	2493	2405	2324
4180	3942	3725	3532	3359	3200	3075	2957	2848	2747	2654
4709	4439	4194	3976	3780	3600	3458	3326	3203	3088	2983
5239	4938	4663	4420	4201	4000	3842	3694	3556	3429	3312
5771	5437	5134	4864	4622	4400	4225	4062	3910	3769	3640
6305	5938	5605	5309	5043	4800	4608	4429	4262	4109	3967
6840	6440	6077	5754	5465	5200	4991	4796	4615	4448	4295
7376	6943	6549	6200	5887	5600	5374	5164	4968	4787	4621
7915	7448	7023	6646	6309	6000	5757	5530	5320	5125	4947
8455	7953	7497	7093	6731	6400	6140	5897	5671	5463	5272
8998	8461	7972	7541	7154	6800	6522	6263	6022	5800	5597
9544	8970	8449	7989	7577	7200	6904	6628	6373	6137	5921
10093	9482	8927	8438	8000	7600	7286	6994	6723	6473	6244
10644	9996	9407	8888	8424	8000	7668	7359	7073	6808	6567

Reference Fuel And Time Required at Check Point

AIR DIST (NM)	PRESSURE ALTITUDE (1000 FT)									
	31		33		35		37		39	
	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)
400	8.2	0:56	8.0	0:55	7.7	0:54	7.5	0:51	7.3	0:53
800	16.8	1:53	16.3	1:50	15.8	1:47	15.4	1:42	15.0	1:42
1200	25.4	2:49	24.7	2:45	24.0	2:40	23.3	2:34	22.7	2:31
1600	34.0	3:45	33.0	3:40	32.1	3:34	31.2	3:25	30.5	3:20
2000	42.6	4:41	41.4	4:34	40.2	4:27	39.1	4:16	38.2	4:09
2400	50.9	5:39	49.4	5:30	48.0	5:22	46.7	5:09	45.6	4:59
2800	59.2	6:36	57.5	6:27	55.9	6:16	54.4	6:01	53.1	5:49
3200	67.4	7:34	65.4	7:23	63.6	7:11	61.9	6:55	60.4	6:39
3600	75.4	8:33	73.2	8:20	71.2	8:07	69.2	7:49	67.6	7:31
4000	83.4	9:32	81.0	9:18	78.7	9:03	76.6	8:43	74.8	8:22
4400	91.1	10:32	88.5	10:16	86.0	10:00	83.7	9:38	81.7	9:15
4800	98.9	11:32	96.0	11:15	93.3	10:57	90.8	10:33	88.7	10:09
5200	106.5	12:32	103.4	12:14	100.5	11:54	97.8	11:29	95.5	11:02
5600	114.0	13:34	110.6	13:14	107.6	12:53	104.7	12:25	102.2	11:56
6000	121.5	14:35	117.9	14:13	114.6	13:51	111.6	13:21	108.9	12:51
6400	128.7	15:38	124.9	15:15	121.4	14:50	118.2	14:19	115.4	13:46
6800	135.9	16:41	131.9	16:16	128.2	15:50	124.8	15:17	121.8	14:42
7200	143.0	17:46	138.8	17:17	134.9	16:50	131.4	16:15	128.2	15:38
7600	150.0	18:51	145.6	18:20	141.4	17:51	137.7	17:14	134.5	16:34
8000	157.0	19:56	152.3	19:23	148.0	18:52	144.1	18:13	140.7	17:31

Long Range Cruise Enroute Fuel and Time - High Altitudes

Fuel Required Adjustment (1000 LB)

REFERENCE FUEL REQUIRED (1000 LB)	WEIGHT AT CHECK POINT (1000 LB)							
	220	260	300	340	380	420	460	500
10	-1.9	-1.4	-1.0	-0.5	0.0	0.7	1.7	4.3
20	-4.4	-3.3	-2.2	-1.1	0.0	1.5	3.3	6.9
30	-6.9	-5.1	-3.4	-1.7	0.0	2.2	4.8	9.4
40	-9.4	-7.0	-4.7	-2.4	0.0	2.9	6.3	11.9
50	-11.9	-8.8	-5.9	-3.0	0.0	3.7	7.9	14.4
60	-14.4	-10.6	-7.1	-3.6	0.0	4.4	9.3	16.7
70	-16.8	-12.5	-8.3	-4.2	0.0	5.1	10.8	19.0
80	-19.3	-14.4	-9.5	-4.8	0.0	5.8	12.2	21.2
90	-21.8	-16.2	-10.8	-5.4	0.0	6.5	13.6	23.4
100	-24.2	-18.1	-12.0	-6.0	0.0	7.2	15.0	25.4
110	-26.7	-19.9	-13.2	-6.7	0.0	7.8	16.4	27.4
120	-29.1	-21.8	-14.5	-7.3	0.0	8.5	17.7	29.4
130	-31.6	-23.7	-15.7	-7.9	0.0	9.2	19.0	31.3
140	-34.0	-25.6	-17.0	-8.5	0.0	9.8	20.3	33.1
150	-36.4	-27.4	-18.2	-9.1	0.0	10.5	21.6	34.8
160	-38.9	-29.3	-19.5	-9.7	0.0	11.1	22.8	36.5

Long Range Cruise Wind-Altitude Trade

PRESSURE ALTITUDE (1000 FT)	CRUISE WEIGHT (1000 LB)							
	500	460	420	380	340	300	260	220
43			69	17	0	7	31	60
41		65	19	1	4	22	48	75
39	56	17	1	3	17	40	64	87
37	13	1	2	15	34	57	78	96
35	0	3	14	31	52	72	89	101
33	4	15	30	49	67	84	97	104
31	16	31	47	64	80	93	102	105
29	32	47	63	78	90	100	105	
27	48	63	76	88	98	103	105	
25	63	76	87	96	102	105		

The above wind factor table is for calculation of wind required to maintain present range capability at new pressure altitude, i.e., break-even wind.

Method:

1. **Read wind factors for present and new altitudes from table.**
2. **Determine difference (new altitude wind factor minus present altitude wind factor); This difference may be negative or positive.**
3. **Break-even wind at new altitude is present altitude wind plus difference from step 2.**

Descent at .85/310/250 KIAS

PRESSURE ALT (1000 FT)	25	27	29	31	33	35	37	39	41	43
DISTANCE (NM)	90	97	104	111	117	123	128	135	141	148
TIME (MINUTES)	19	20	21	22	23	23	24	25	26	27

Holding

Flaps Up

WEIGHT (1000 LB)		PRESSURE ALTITUDE (FT)									
		1500	5000	10000	15000	20000	25000	30000	35000	40000	43000
500	TPR	28.3	30.9	35.1	40.2	46.5	53.6	62.5	74.2		
	KIAS	244	249	259	266	269	271	275	279		
	FF/ENG	6190	6090	6030	6020	6030	6040	6140	6420		
460	TPR	26.7	29.1	33.0	37.9	43.7	50.5	59.0	69.7		
	KIAS	236	237	244	256	258	260	263	267		
	FF/ENG	5760	5640	5540	5540	5570	5520	5600	5800		
420	TPR	25.0	27.3	31.0	35.5	40.9	47.2	55.2	64.8	79.1	
	KIAS	229	230	230	239	245	247	250	254	251	
	FF/ENG	5360	5220	5080	5050	5110	5000	5070	5180	5490	
380	TPR	23.4	25.4	28.9	33.0	38.2	43.8	51.3	60.4	72.8	
	KIAS	222	222	223	223	233	235	237	240	244	
	FF/ENG	4950	4820	4660	4590	4660	4510	4550	4630	4910	
340	TPR	21.7	23.6	26.7	30.6	35.2	40.4	47.3	55.7	66.9	76.0
	KIAS	214	215	215	215	216	221	223	226	230	232
	FF/ENG	4550	4440	4260	4200	4170	4030	4040	4090	4290	4540
300	TPR	20.1	21.7	24.6	28.1	32.2	37.0	43.1	50.8	61.2	68.8
	KIAS	206	206	206	207	207	208	209	211	214	216
	FF/ENG	4170	4050	3870	3820	3740	3570	3550	3580	3730	3880
260	TPR	18.4	20.0	22.5	25.7	29.3	33.5	39.0	45.8	55.2	62.0
	KIAS	198	198	198	198	198	198	198	198	198	200
	FF/ENG	3800	3670	3500	3430	3330	3160	3110	3100	3190	3300
220	TPR	16.7	18.0	20.3	23.2	26.5	30.2	35.0	40.9	49.2	55.2
	KIAS	188	188	188	188	188	188	188	188	188	188
	FF/ENG	3410	3270	3130	3050	2940	2810	2720	2680	2750	2810

This table includes 5% additional fuel for holding in a racetrack pattern.

Holding
Flaps 1

WEIGHT (1000 LB)		PRESSURE ALTITUDE (FT)				
		1500	5000	10000	15000	20000
500	TPR	29.8	32.6	37.4	43.2	50.6
	KIAS	226	226	227	229	233
	FF/ENG	6460	6360	6270	6230	6250
460	TPR	27.9	30.5	35.0	40.4	47.3
	KIAS	220	220	220	222	226
	FF/ENG	5990	5880	5780	5720	5820
420	TPR	26.0	28.5	32.6	37.6	43.8
	KIAS	211	211	211	212	214
	FF/ENG	5520	5390	5280	5230	5350
380	TPR	24.2	26.4	30.1	34.8	40.4
	KIAS	201	201	201	201	203
	FF/ENG	5070	4930	4790	4760	4810
340	TPR	22.4	24.3	27.6	32.0	37.0
	KIAS	191	192	192	192	193
	FF/ENG	4630	4500	4340	4310	4290
300	TPR	20.5	22.3	25.2	29.1	33.7
	KIAS	183	183	183	184	184
	FF/ENG	4210	4090	3910	3880	3810
260	TPR	18.7	20.2	22.8	26.2	30.2
	KIAS	175	175	175	175	175
	FF/ENG	3800	3680	3500	3440	3340
220	TPR	16.8	18.2	20.5	23.3	26.8
	KIAS	165	165	165	165	165
	FF/ENG	3410	3270	3100	3000	2890

This table includes 5% additional fuel for holding in a racetrack pattern.

Intentionally
Blank

Performance Inflight — Chapter PI

Advisory Information — Section 12

ADVISORY INFORMATION

Normal Configuration Landing Distance

Flaps 30

Dry Runway

	LANDING DISTANCE AND ADJUSTMENTS (FT)											
	REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS		SLOPE ADJ PER 1%		TEMP ADJ PER 10°C		VREF ADJ	REVERSE THRUST ADJ	
BRAKING CONFIGURATION	370000 LB LANDING WEIGHT	PER 10000 LB ABOVE / BELOW 370000 LB	PER 1000 FT STD/ HIGH*	HEAD WIND	TAIL WIND	DOWN HILL	UP HILL	ABV ISA	BLW ISA	PER 10 KTS ABOVE VREF30	ONE REV	NO REV
MAX MANUAL	2910	70/-40	60/80	-110	400	30	-30	60	-60	210	50	120
MAX AUTO	3940	70/-50	90/130	-170	570	0	0	90	-100	400	0	0
AUTOBRAKE 4	5100	100/-80	130/180	-240	820	10	-10	140	-140	560	10	10
AUTOBRAKE 3	6010	130/-110	170/220	-290	1010	30	-90	160	-160	530	70	80
AUTOBRAKE 2	6710	150/-130	200/270	-330	1140	120	-150	170	-180	490	380	400
AUTOBRAKE 1	7390	170/-150	230/320	-380	1330	220	-220	190	-200	490	830	1160

Good Reported Braking Action

MAX MANUAL	4000	70/-60	100/140	-190	680	90	-80	90	-100	300	230	540
MAX AUTO	4340	80/-60	110/150	-200	690	50	-40	100	-100	400	210	560
AUTOBRAKE 4	5100	100/-80	140/180	-240	830	20	-10	140	-140	560	30	90
AUTOBRAKE 3	6010	130/-110	170/220	-290	1010	30	-90	160	-160	530	70	80

Medium Reported Braking Action

MAX MANUAL	5340	120/-100	160/220	-290	1080	210	-170	140	-140	380	640	1630
MAX AUTO	5570	120/-100	160/230	-290	1070	200	-150	140	-140	430	640	1650
AUTOBRAKE 4	5770	120/-90	170/230	-300	1110	140	-100	150	-150	560	480	1530
AUTOBRAKE 3	6270	130/-120	190/250	-330	1190	130	-140	170	-170	530	310	1060

Poor Reported Braking Action

MAX MANUAL	6770	160/-140	240/320	-420	1620	460	-320	180	-190	440	1330	3860
MAX AUTO	7100	160/-140	230/320	-420	1600	460	-320	180	-190	440	1350	3910
AUTOBRAKE 4	7100	170/-130	240/330	-420	1610	450	-280	190	-190	530	1350	3910
AUTOBRAKE 3	7290	170/-140	240/330	-430	1650	380	-290	200	-200	530	1120	3720

Reference distance is for sea level, standard day, no wind or slope, VREF30 approach speed and 2 engine maximum reverse thrust.
Actual (unfactored) distances are shown.
Includes distance from 50 ft above threshold (1000 ft of air distance).

Max manual braking data valid for auto speedbrakes. Autobrake data valid for both auto and manual speedbrakes.
For max manual braking and manual speedbrakes, increase reference landing distance by 260 ft.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft,**
Adjustment = STD*8+HIGH*((Press Alt/1000)-8).

ADVISORY INFORMATION

Normal Configuration Landing Distance
Flaps 25
Dry Runway

BRAKING CONFIGURATION	REF DIST: 370000 LB LANDING WEIGHT	WT ADJ: PER 10000 LB ABOVE / BELOW 370000 LB	ALT ADJ: PER 1000 FT STD/ HIGH*	WIND ADJ PER 10 KTS: HEAD WIND	WIND ADJ PER 10 KTS: TAIL WIND	SLOPE ADJ PER 1%: DOWN HILL	SLOPE ADJ PER 1%: UP HILL	TEMP ADJ PER 10°C: ABV ISA	TEMP ADJ PER 10°C: BLW ISA	VREF ADJ: PER 10 KTS ABOVE VREF25	REVERSE THRUST ADJ: ONE REV	REVERSE THRUST ADJ: NO REV
MAX MANUAL	2970	70/-40	60/80	-120	400	30	-30	60	-60	210	60	130
MAX AUTO	4070	70/-60	100/130	-170	590	0	0	100	-100	410	0	0
AUTOBRAKE 4	5280	100/-90	140/190	-250	840	10	-10	140	-140	580	10	10
AUTOBRAKE 3	6230	130/-120	180/240	-300	1020	50	-100	170	-170	530	130	140
AUTOBRAKE 2	6880	150/-140	210/280	-340	1150	130	-160	170	-180	480	510	530
AUTOBRAKE 1	7520	180/-160	250/330	-380	1330	230	-230	190	-200	480	980	1390

Good Reported Braking Action

MAX MANUAL	4080	80/-70	110/140	-190	680	90	-80	100	-100	300	250	590
MAX AUTO	4440	80/-70	110/150	-200	700	50	-30	110	-110	410	200	590
AUTOBRAKE 4	5280	100/-90	140/190	-250	850	20	-10	140	-140	580	30	90
AUTOBRAKE 3	6230	130/-120	180/240	-300	1020	50	-100	170	-170	530	130	140

Medium Reported Braking Action

MAX MANUAL	5440	120/-110	170/230	-290	1080	210	-170	140	-140	380	690	1810
MAX AUTO	5680	120/-100	170/230	-290	1070	200	-150	140	-140	420	690	1820
AUTOBRAKE 4	5930	120/-110	170/240	-310	1120	130	-90	160	-160	580	470	1640
AUTOBRAKE 3	6480	140/-130	200/260	-340	1200	140	-150	180	-180	530	360	1160

Poor Reported Braking Action

MAX MANUAL	6890	170/-150	240/330	-420	1620	460	-320	190	-190	440	1420	4250
MAX AUTO	7230	170/-150	240/330	-420	1600	460	-320	190	-190	440	1440	4300
AUTOBRAKE 4	7230	170/-140	240/340	-420	1610	440	-260	190	-200	550	1420	4280
AUTOBRAKE 3	7480	170/-160	250/340	-430	1650	390	-290	200	-210	530	1180	4060

Reference distance is for sea level, standard day, no wind or slope, VREF25 approach speed and 2 engine maximum reverse thrust.
Actual (unfactored) distances are shown.
Includes distance from 50 ft above threshold (1000 ft of air distance).

Max manual braking data valid for auto speedbrakes. Autobrake data valid for both auto and manual speedbrakes.
For max manual braking and manual speedbrakes, increase reference landing distance by 270 ft.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft,**
Adjustment = STD*8+HIGH*((Press Alt/1000)-8).

ADVISORY INFORMATION

Non-Normal Configuration Landing Distance

Dry Runway

		LANDING DISTANCE AND ADJUSTMENT (FT)								
		REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS	SLOPE ADJ PER 1%	TEMP ADJ PER 10°C	APP SPEED ADJ	REVERSE THRUST ADJ	
EICAS MESSAGE	REF SPEED	370000 LB LDG WT	PER 10000 LB ABV/BLW 370000 LB	PER 1000 FT ABV S.L. STD/ HIGH*	HEAD/ TAIL WIND	DOWN/UP HILL	ABV/ BLW ISA	PER 10 KTS ABV VREF	ONE REV	NO REV
ANTI-ICE LEAK ENG L, R (FLAPS 20)	VREF20	3080	90/-50	70/90	-120/420	40/-40	60/-70	230	0	80
ANTI-ICE LEAK ENG L, R (FLAPS 30)	VREF30	2960	80/-50	60/80	-120/410	40/-30	60/-60	220	0	60
ANTISKID (FLAPS 25)	VREF25	5370	120/-120	170/230	-290/1080	210/-170	140/-140	380	690	1800
ANTISKID (FLAPS 30)	VREF30	5280	110/-120	160/220	-290/1080	210/-170	140/-140	380	640	1630
BRAKES (FLAPS 25)	VREF25	4050	160/-80	110/170	-190/680	90/-80	100/-100	290	250	590
BRAKES (FLAPS 30)	VREF30	3980	140/-80	100/140	-190/680	90/-80	90/-100	300	230	540
ENG FAIL L, R (FLAPS 20)	VREF20	3050	80/-50	70/90	-120/420	40/-30	60/-70	230	0	100
ENG FAIL L, R (FLAPS 30)	VREF30	2930	80/-50	60/80	-120/410	40/-30	60/-60	220	0	90
ENG LIMIT EXCEED L, R (FLAPS 20)	VREF20	3050	80/-50	70/90	-120/420	40/-30	60/-70	230	0	100
ENG LIMIT EXCEED L, R (FLAPS 30)	VREF30	2930	80/-50	60/80	-120/410	40/-30	60/-60	220	0	90
ENG OIL FILTER L, R (FLAPS 20)	VREF20	3050	80/-50	70/90	-120/420	40/-30	60/-70	230	0	100
ENG OIL FILTER L, R (FLAPS 30)	VREF30	2930	80/-50	60/80	-120/410	40/-30	60/-60	220	0	90
ENG OIL PRESS L, R (FLAPS 20)	VREF20	3050	80/-50	70/90	-120/420	40/-30	60/-70	230	0	100
ENG OIL PRESS L, R (FLAPS 30)	VREF30	2930	80/-50	60/80	-120/410	40/-30	60/-60	220	0	90

Actual (unfactored) distances are shown.
Includes distances from 50 ft above threshold (1000 ft air distance).
Assumes max manual braking and maximum available reverse thrust.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft, Adjustment = STD*8+HIGH*((Press Alt/1000)-8).**

ADVISORY INFORMATION

Non-Normal Configuration Landing Distance

Dry Runway

		LANDING DISTANCE AND ADJUSTMENT (FT)								
		REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS	SLOPE ADJ PER 1%	TEMP ADJ PER 10°C	APP SPEED ADJ	REVERSE THRUST ADJ	
EICAS MESSAGE	REF SPEED	370000 LB LDG WT	PER 10000 LB ABV/BLW 370000 LB	PER 1000 FT ABV S.L. STD/ HIGH*	HEAD/ TAIL WIND	DOWN/UP HILL	ABV/ BLW ISA	PER 10 KTS ABV VREF	ONE REV	NO REV
ENG OIL TEMP L, R (FLAPS 20)	VREF20	3050	80/-50	70/90	-120/420	40/-30	60/-70	230	0	100
ENG OIL TEMP L, R (FLAPS 30)	VREF30	2930	80/-50	60/80	-120/410	40/-30	60/-60	220	0	90
ENG SURGE L, R (FLAPS 20)	VREF20	3050	80/-50	70/90	-120/420	40/-30	60/-70	230	0	100
ENG SURGE L, R (FLAPS 30)	VREF30	2930	80/-50	60/80	-120/410	40/-30	60/-60	220	0	90
**ENG SVR DAMAGE/SEP L, R (FLAPS 20)	VREF20	3050	80/-50	70/90	-120/420	40/-30	60/-70	230	0	100
**ENG SVR DAMAGE/SEP L, R (FLAPS 30)	VREF30	2930	80/-50	60/80	-120/410	40/-30	60/-60	220	0	90
FIRE ENG L, R (FLAPS 20)	VREF20	3050	80/-50	70/90	-120/420	40/-30	60/-70	230	0	100
FIRE ENG L, R (FLAPS 30)	VREF30	2930	80/-50	60/80	-120/410	40/-30	60/-60	220	0	90
FLAP/SLAT CONTROL (FLAPS 20)	VREF20	3010	80/-50	70/90	-120/410	30/-30	60/-60	220	70	140
FLAPS DRIVE (UP < FLAPS ≤ 1)	VREF30+40	3690	130/-60	90/150	-140/480	40/-40	80/-80	240	120	270
FLAPS DRIVE (1 < FLAPS ≤ 5)	VREF30+40	3680	130/-60	90/150	-130/470	40/-40	80/-90	240	110	230
FLAPS DRIVE (5 < FLAPS < 20)	VREF30+20	3310	100/-50	70/100	-130/430	40/-30	70/-70	210	80	180
FLAPS DRIVE (FLAPS ≥ 20)	VREF20	3010	80/-50	70/90	-120/410	30/-30	60/-60	220	70	140
FLAPS PRIMARY FAIL (FLAPS 20)	VREF20	3300	80/-50	70/100	-130/440	40/-30	70/-70	250	70	160

Actual (unfactored) distances are shown.
Includes distances from 50 ft above threshold (1000 ft air distance).
Assumes max manual braking and maximum available reverse thrust.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft, Adjustment = STD*8+HIGH*((Press Alt/1000)-8).**
****Unannunciated Non-Normal Checklist condition.**

ADVISORY INFORMATION

Non-Normal Configuration Landing Distance

Dry Runway

		LANDING DISTANCE AND ADJUSTMENT (FT)								
		REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS	SLOPE ADJ PER 1%	TEMP ADJ PER 10°C	APP SPEED ADJ	REVERSE THRUST ADJ	
EICAS MESSAGE	REF SPEED	370000 LB LDG WT	PER 10000 LB ABV/BLW 370000 LB	PER 1000 FT ABV S.L. STD/ HIGH*	HEAD/ TAIL WIND	DOWN/UP HILL	ABV/ BLW ISA	PER 10 KTS ABV VREF	ONE REV	NO REV
FLIGHT CONTROL MODE (FLAPS 20)	VREF20	3350	70/-60	70/100	-130/440	40/-40	70/-70	260	80	170
FLIGHT CONTROLS (FLAPS 20)	VREF30+20	3550	80/-60	80/110	-130/460	50/-40	80/-80	260	110	250
**FUEL LEAK (FLAPS 20)	VREF20	3050	80/-50	70/90	-120/420	40/-30	60/-70	230	0	100
**FUEL LEAK (FLAPS 30)	VREF30	2930	80/-50	60/80	-120/410	40/-30	60/-60	220	0	90
FUEL QTY LOW (FLAPS 20)	VREF20	3010	80/-50	70/90	-120/410	30/-30	60/-60	220	70	140
HYD PRESS SYS C (FLAPS 20)	VREF20	3300	80/-50	70/100	-130/440	40/-30	70/-70	250	70	160
HYD PRESS SYS L (FLAPS 25)	VREF25	3060	80/-50	70/90	-120/420	40/-40	60/-70	230	0	70
HYD PRESS SYS L (FLAPS 30)	VREF30	2990	70/-50	60/80	-120/420	40/-30	60/-60	230	0	70
HYD PRESS SYS L+C (FLAPS 20)	VREF30+20	3890	90/-60	90/120	-150/500	50/-50	90/-90	300	0	130
HYD PRESS SYS L+R (FLAPS 20)	VREF30+20	3770	110/-60	90/110	-150/500	60/-60	90/-90	300	0	0
HYD PRESS SYS R (FLAPS 25)	VREF25	3100	80/-50	70/90	-120/430	40/-40	70/-70	240	0	80
HYD PRESS SYS R (FLAPS 30)	VREF30	3020	70/-50	60/80	-120/420	40/-40	60/-60	240	0	70
HYD PRESS SYS R+C (FLAPS 20)	VREF30+20	3960	90/-60	90/120	-150/510	60/-50	90/-90	310	0	140
NAV AIR DATA SYS (FLAPS 20)	VREF20	3230	80/-50	70/90	-120/430	30/-30	70/-70	230	60	140

Actual (unfactored) distances are shown.
Includes distances from 50 ft above threshold (1000 ft air distance).
Assumes max manual braking and maximum available reverse thrust.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft, Adjustment = STD*8+HIGH*((Press Alt/1000)-8).**
****Unannunciated Non-Normal Checklist condition.**

ADVISORY INFORMATION

Non-Normal Configuration Landing Distance

Dry Runway

		LANDING DISTANCE AND ADJUSTMENT (FT)								
		REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS	SLOPE ADJ PER 1%	TEMP ADJ PER 10°C	APP SPEED ADJ	REVERSE THRUST ADJ	
EICAS MESSAGE	REF SPEED	370000 LB LDG WT	PER 10000 LB ABV/BLW 370000 LB	PER 1000 FT ABV S.L. STD/ HIGH*	HEAD/ TAIL WIND	DOWN/UP HILL	ABV/ BLW ISA	PER 10 KTS ABV VREF	ONE REV	NO REV
NAV AIRSPEED DATA (FLAPS 20)	VREF20	3230	80/-50	70/90	-120/430	30/-30	70/-70	230	60	140
OVERHEAT ENG L, R (FLAPS 20)	VREF20	3050	80/-50	70/90	-120/420	40/-30	60/-70	230	0	100
OVERHEAT ENG L, R (FLAPS 30)	VREF30	2930	80/-50	60/80	-120/410	40/-30	60/-60	220	0	90
PITCH UP AUTHORITY (FLAPS ≥ 20)	VREF30+20	3400	90/-50	80/100	-130/440	40/-40	70/-80	230	90	200
PITCH UP AUTHORITY (FLAPS ≤ 15)	VREF30+40	3670	130/-60	90/150	-130/470	40/-40	80/-80	240	100	230
PRI FLIGHT COMPUTERS (FLAPS 20)	VREF20	3350	70/-60	70/100	-130/440	40/-40	70/-70	260	80	170
ROLL LEFT AUTHORITY (FLAPS 20)	VREF30+20	3350	90/-50	80/100	-130/430	40/-40	70/-70	220	90	190
ROLL RIGHT AUTHORITY (FLAPS 20)	VREF30+20	3350	90/-50	80/100	-130/430	40/-40	70/-70	220	90	190
SLATS DRIVE (FLAPS 20)	VREF30+30	3650	100/-60	90/110	-130/460	40/-40	80/-80	240	110	240
SPOILER PAIRS (FLAPS 25)	VREF25+5	3140	80/-50	70/90	-120/420	40/-30	70/-70	230	70	160
SPOILER PAIRS (FLAPS 30)	VREF30+5	3070	70/-50	70/90	-120/420	40/-30	60/-70	230	60	140
STABILIZER (FLAPS 20)	VREF30+20	3400	90/-50	80/100	-130/440	40/-40	70/-80	230	90	200

Actual (unfactored) distances are shown.
Includes distances from 50 ft above threshold (1000 ft air distance).
Assumes max manual braking and maximum available reverse thrust.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft, Adjustment = STD*8+HIGH*((Press Alt/1000)-8).**

ADVISORY INFORMATION

Non-Normal Configuration Landing Distance

Good Reported Braking Action

		LANDING DISTANCE AND ADJUSTMENT (FT)								
		REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS	SLOPE ADJ PER 1%	TEMP ADJ PER 10°C	APP SPEED ADJ	REVERSE THRUST ADJ	
EICAS MESSAGE	REF SPEED	370000 LB LDG WT	PER 10000 LB ABV/BLW 370000 LB	PER 1000 FT ABV S.L. STD/ HIGH*	HEAD/ TAIL WIND	DOWN/UP HILL	ABV/ BLW ISA	PER 10 KTS ABV VREF	ONE REV	NO REV
ANTI-ICE LEAK ENG L, R (FLAPS 20)	VREF20	4400	80/-90	120/160	-210/750	120/-100	110/-110	340	0	380
ANTI-ICE LEAK ENG L, R (FLAPS 30)	VREF30	4210	80/-80	110/140	-210/730	110/-100	100/-100	330	0	310
ANTISKID (FLAPS 25)	VREF25	5370	120/-120	170/230	-290/1080	210/-170	140/-140	380	690	1800
ANTISKID (FLAPS 30)	VREF30	5280	110/-120	160/220	-290/1080	210/-170	140/-140	380	640	1630
BRAKES (FLAPS 25)	VREF25	5370	120/-120	170/230	-290/1080	210/-170	140/-140	380	690	1800
BRAKES (FLAPS 30)	VREF30	5280	110/-120	160/220	-290/1080	210/-170	140/-140	380	640	1630
ENG FAIL L, R (FLAPS 20)	VREF20	4330	80/-90	120/160	-210/730	110/-100	110/-110	340	0	430
ENG FAIL L, R (FLAPS 30)	VREF30	4140	80/-80	110/140	-200/720	110/-90	100/-100	330	0	360
ENG LIMIT EXCEED L, R (FLAPS 20)	VREF20	4330	80/-90	120/160	-210/730	110/-100	110/-110	340	0	430
ENG LIMIT EXCEED L, R (FLAPS 30)	VREF30	4140	80/-80	110/140	-200/720	110/-90	100/-100	330	0	360
ENG OIL FILTER L, R (FLAPS 20)	VREF20	4330	80/-90	120/160	-210/730	110/-100	110/-110	340	0	430
ENG OIL FILTER L, R (FLAPS 30)	VREF30	4140	80/-80	110/140	-200/720	110/-90	100/-100	330	0	360
ENG OIL PRESS L, R (FLAPS 20)	VREF20	4330	80/-90	120/160	-210/730	110/-100	110/-110	340	0	430
ENG OIL PRESS L, R (FLAPS 30)	VREF30	4140	80/-80	110/140	-200/720	110/-90	100/-100	330	0	360

Actual (unfactored) distances are shown.
Includes distances from 50 ft above threshold (1000 ft air distance).
Assumes max manual braking and maximum available reverse thrust.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft, Adjustment = STD*8+HIGH*((Press Alt/1000)-8).**

ADVISORY INFORMATION

Non-Normal Configuration Landing Distance

Good Reported Braking Action

		LANDING DISTANCE AND ADJUSTMENT (FT)								
		REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS	SLOPE ADJ PER 1%	TEMP ADJ PER 10°C	APP SPEED ADJ	REVERSE THRUST ADJ	
EICAS MESSAGE	REF SPEED	370000 LB LDG WT	PER 10000 LB ABV/BLW 370000 LB	PER 1000 FT ABV S.L. STD/HIGH*	HEAD/TAIL WIND	DOWN/UP HILL	ABV/BLW ISA	PER 10 KTS ABV VREF	ONE REV	NO REV
ENG OIL TEMP L, R (FLAPS 20)	VREF20	4330	80/-90	120/160	-210/730	110/-100	110/-110	340	0	430
ENG OIL TEMP L, R (FLAPS 30)	VREF30	4140	80/-80	110/140	-200/720	110/-90	100/-100	330	0	360
ENG SURGE L, R (FLAPS 20)	VREF20	4330	80/-90	120/160	-210/730	110/-100	110/-110	340	0	430
ENG SURGE L, R (FLAPS 30)	VREF30	4140	80/-80	110/140	-200/720	110/-90	100/-100	330	0	360
**ENG SVR DAMAGE/SEP L, R (FLAPS 20)	VREF20	4330	80/-90	120/160	-210/730	110/-100	110/-110	340	0	430
**ENG SVR DAMAGE/SEP L, R (FLAPS 30)	VREF30	4140	80/-80	110/140	-200/720	110/-90	100/-100	330	0	360
FIRE ENG L, R (FLAPS 20)	VREF20	4330	80/-90	120/160	-210/730	110/-100	110/-110	340	0	430
FIRE ENG L, R (FLAPS 30)	VREF30	4140	80/-80	110/140	-200/720	110/-90	100/-100	330	0	360
FLAP/SLAT CONTROL (FLAPS 20)	VREF20	4120	80/-80	110/150	-190/690	90/-80	100/-100	300	270	650
FLAPS DRIVE (UP < FLAPS ≤ 1)	VREF30+40	4870	80/-90	140/180	-210/730	90/-80	120/-120	270	380	930
FLAPS DRIVE (1 < FLAPS ≤ 5)	VREF30+40	5090	90/-90	150/190	-220/750	110/-90	130/-130	290	390	940
FLAPS DRIVE (5 < FLAPS < 20)	VREF30+20	4570	80/-90	130/170	-200/720	100/-90	110/-120	300	330	790
FLAPS DRIVE (FLAPS ≥ 20)	VREF20	4120	80/-80	110/150	-190/690	90/-80	100/-100	300	270	650
FLAPS PRIMARY FAIL (FLAPS 20)	VREF20	4430	80/-90	120/160	-200/720	100/-90	100/-110	340	290	710

Actual (unfactored) distances are shown.
Includes distances from 50 ft above threshold (1000 ft air distance).
Assumes max manual braking and maximum available reverse thrust.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft,**
Adjustment = STD*8+HIGH*((Press Alt/1000)-8).
****Unannunciated Non-Normal Checklist condition.**

ADVISORY INFORMATION

Non-Normal Configuration Landing Distance

Good Reported Braking Action

		LANDING DISTANCE AND ADJUSTMENT (FT)								
		REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS	SLOPE ADJ PER 1%	TEMP ADJ PER 10°C	APP SPEED ADJ	REVERSE THRUST ADJ	
EICAS MESSAGE	REF SPEED	370000 LB LDG WT	PER 10000 LB ABV/BLW 370000 LB	PER 1000 FT ABV S.L. STD/ HIGH*	HEAD/ TAIL WIND	DOWN/UP HILL	ABV/ BLW ISA	PER 10 KTS ABV VREF	ONE REV	NO REV
FLIGHT CONTROL MODE (FLAPS 20)	VREF20	4500	90/-90	120/170	-210/730	100/-90	110/-110	350	310	760
FLIGHT CONTROLS (FLAPS 20)	VREF30+20	4890	90/-90	140/190	-220/760	120/-100	120/-130	360	410	1000
**FUEL LEAK (FLAPS 20)	VREF20	4330	80/-90	120/160	-210/730	110/-100	110/-110	340	0	430
**FUEL LEAK (FLAPS 30)	VREF30	4140	80/-80	110/140	-200/720	110/-90	100/-100	330	0	360
FUEL QTY LOW (FLAPS 20)	VREF20	4120	80/-80	110/150	-190/690	90/-80	100/-100	300	270	650
HYD PRESS SYS C (FLAPS 20)	VREF20	4430	80/-90	120/160	-200/720	100/-90	100/-110	340	290	710
HYD PRESS SYS L (FLAPS 25)	VREF25	4370	80/-90	110/150	-210/750	120/-100	110/-110	340	0	360
HYD PRESS SYS L (FLAPS 30)	VREF30	4260	80/-80	110/140	-210/740	120/-100	100/-110	340	0	320
HYD PRESS SYS L+C (FLAPS 20)	VREF30+20	5500	100/-100	150/200	-250/860	150/-130	140/-140	420	0	580
HYD PRESS SYS L+R (FLAPS 20)	VREF30+20	5810	100/-110	150/200	-270/940	210/-180	150/-160	480	0	0
HYD PRESS SYS R (FLAPS 25)	VREF25	4430	80/-90	120/150	-210/760	120/-100	110/-110	360	0	380
HYD PRESS SYS R (FLAPS 30)	VREF30	4310	80/-80	110/150	-210/740	120/-100	100/-110	350	0	330
HYD PRESS SYS R+C (FLAPS 20)	VREF30+20	5630	100/-110	150/200	-250/870	160/-140	140/-150	450	0	630
NAV AIR DATA SYS (FLAPS 20)	VREF20	4330	80/-80	110/160	-200/710	90/-80	100/-100	320	270	640

Actual (unfactored) distances are shown.
Includes distances from 50 ft above threshold (1000 ft air distance).
Assumes max manual braking and maximum available reverse thrust.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft,**
Adjustment = STD*8+HIGH*((Press Alt/1000)-8).
****Unannunciated Non-Normal Checklist condition.**

ADVISORY INFORMATION

Non-Normal Configuration Landing Distance

Good Reported Braking Action

		LANDING DISTANCE AND ADJUSTMENT (FT)								
		REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS	SLOPE ADJ PER 1%	TEMP ADJ PER 10°C	APP SPEED ADJ	REVERSE THRUST ADJ	
EICAS MESSAGE	REF SPEED	370000 LB LDG WT	PER 10000 LB ABV/BLW 370000 LB	PER 1000 FT ABV S.L. STD/ HIGH*	HEAD/ TAIL WIND	DOWN/UP HILL	ABV/ BLW ISA	PER 10 KTS ABV VREF	ONE REV	NO REV
NAV AIRSPEED DATA (FLAPS 20)	VREF20	4330	80/-80	110/160	-200/710	90/-80	100/-100	320	270	640
OVERHEAT ENG L, R (FLAPS 20)	VREF20	4330	80/-90	120/160	-210/730	110/-100	110/-110	340	0	430
OVERHEAT ENG L, R (FLAPS 30)	VREF30	4140	80/-80	110/140	-200/720	110/-90	100/-100	330	0	360
PITCH UP AUTHORITY (FLAPS ≥ 20)	VREF30+20	4650	80/-90	130/170	-210/730	100/-90	110/-120	320	350	830
PITCH UP AUTHORITY (FLAPS ≤ 15)	VREF30+40	5060	90/-90	140/190	-210/750	100/-90	130/-130	290	380	920
PRI FLIGHT COMPUTERS (FLAPS 20)	VREF20	4500	90/-90	120/170	-210/730	100/-90	110/-110	350	310	760
ROLL LEFT AUTHORITY (FLAPS 20)	VREF30+20	4600	80/-90	130/170	-210/720	100/-90	110/-120	310	330	790
ROLL RIGHT AUTHORITY (FLAPS 20)	VREF30+20	4600	80/-90	130/170	-210/720	100/-90	110/-120	310	330	790
SLATS DRIVE (FLAPS 20)	VREF30+30	5000	90/-90	140/190	-220/760	110/-100	130/-130	320	390	950
SPOILER PAIRS (FLAPS 25)	VREF25+5	4310	80/-80	120/160	-200/710	100/-90	100/-110	320	300	700
SPOILER PAIRS (FLAPS 30)	VREF30+5	4210	80/-80	110/150	-200/700	100/-90	100/-100	320	270	620
STABILIZER (FLAPS 20)	VREF30+20	4650	80/-90	130/170	-210/730	100/-90	110/-120	320	350	830

Actual (unfactored) distances are shown.
Includes distances from 50 ft above threshold (1000 ft air distance).
Assumes max manual braking and maximum available reverse thrust.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft, Adjustment = STD*8+HIGH*((Press Alt/1000)-8).**

ADVISORY INFORMATION

Non-Normal Configuration Landing Distance

Medium Reported Braking Action

		LANDING DISTANCE AND ADJUSTMENT (FT)								
		REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS	SLOPE ADJ PER 1%	TEMP ADJ PER 10°C	APP SPEED ADJ	REVERSE THRUST ADJ	
EICAS MESSAGE	REF SPEED	370000 LB LDG WT	PER 10000 LB ABV/BLW 370000 LB	PER 1000 FT ABV S.L. STD/ HIGH*	HEAD/ TAIL WIND	DOWN/UP HILL	ABV/ BLW ISA	PER 10 KTS ABV VREF	ONE REV	NO REV
ANTI-ICE LEAK ENG L, R (FLAPS 20)	VREF20	6190	140/-140	190/260	-350/1270	320/-250	160/-170	460	0	1220
ANTI-ICE LEAK ENG L, R (FLAPS 30)	VREF30	5920	130/-130	180/230	-340/1240	310/-240	160/-160	440	0	1000
ANTISKID (FLAPS 25)	VREF25	6740	170/-160	240/330	-420/1620	460/-320	190/-190	440	1420	4250
ANTISKID (FLAPS 30)	VREF30	6660	160/-160	240/320	-420/1620	460/-320	180/-190	440	1330	3860
BRAKES (FLAPS 25)	VREF25	6740	170/-160	240/330	-420/1620	460/-320	190/-190	440	1420	4250
BRAKES (FLAPS 30)	VREF30	6660	160/-160	240/320	-420/1620	460/-320	180/-190	440	1330	3860
ENG FAIL L, R (FLAPS 20)	VREF20	6050	140/-140	190/260	-340/1220	300/-240	170/-170	450	0	1340
ENG FAIL L, R (FLAPS 30)	VREF30	5780	130/-130	170/230	-330/1200	290/-230	160/-160	440	0	1120
ENG LIMIT EXCEED L, R (FLAPS 20)	VREF20	6050	140/-140	190/260	-340/1220	300/-240	170/-170	450	0	1340
ENG LIMIT EXCEED L, R (FLAPS 30)	VREF30	5780	130/-130	170/230	-330/1200	290/-230	160/-160	440	0	1120
ENG OIL FILTER L, R (FLAPS 20)	VREF20	6050	140/-140	190/260	-340/1220	300/-240	170/-170	450	0	1340
ENG OIL FILTER L, R (FLAPS 30)	VREF30	5780	130/-130	170/230	-330/-1200	290/-230	160/-160	440	0	1120
ENG OIL PRESS L, R (FLAPS 20)	VREF20	6050	140/-140	190/260	-340/1220	300/-240	170/-170	450	0	1340
ENG OIL PRESS L, R (FLAPS 30)	VREF30	5780	130/-130	170/230	-330/1200	290/-230	160/-160	440	0	1120

Actual (unfactored) distances are shown.
Includes distances from 50 ft above threshold (1000 ft air distance).
Assumes max manual braking and maximum available reverse thrust.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft, Adjustment = STD*8+HIGH*((Press Alt/1000)-8).**

ADVISORY INFORMATION

Non-Normal Configuration Landing Distance

Medium Reported Braking Action

EICAS MESSAGE	REF SPEED	REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS	SLOPE ADJ PER 1%	TEMP ADJ PER 10°C	APP SPEED ADJ	REVERSE THRUST ADJ	
		LANDING DISTANCE AND ADJUSTMENT (FT)								
		370000 LB LDG WT	PER 10000 LB ABV/BLW 370000 LB	PER 1000 FT ABV S.L. STD/ HIGH*	HEAD/ TAIL WIND	DOWN/UP HILL	ABV/ BLW ISA	PER 10 KTS ABV VREF	ONE REV	NO REV
ENG OIL TEMP L, R (FLAPS 20)	VREF20	6050	140/-140	190/260	-340/1220	300/-240	170/-170	450	0	1340
ENG OIL TEMP L, R (FLAPS 30)	VREF30	5780	130/-130	170/230	-330/1200	290/-230	160/-160	440	0	1120
ENG SURGE L, R (FLAPS 20)	VREF20	6050	140/-140	190/260	-340/1220	300/-240	170/-170	450	0	1340
ENG SURGE L, R (FLAPS 30)	VREF30	5780	130/-130	170/230	-330/1200	290/-230	160/-160	440	0	1120
**ENG SVR DAMAGE/SEP L, R (FLAPS 20)	VREF20	6050	140/-140	190/260	-340/1220	300/-240	170/-170	450	0	1340
**ENG SVR DAMAGE/SEP L, R (FLAPS 30)	VREF30	5780	130/-130	170/230	-330/1200	290/-230	160/-160	440	0	1120
FIRE ENG L, R (FLAPS 20)	VREF20	6050	140/-140	190/260	-340/1220	300/-240	170/-170	450	0	1340
FIRE ENG L, R (FLAPS 30)	VREF30	5780	130/-130	170/230	-330/1200	290/-230	160/-160	440	0	1120
FLAP/SLAT CONTROL (FLAPS 20)	VREF20	5460	120/-120	180/240	-300/1090	220/-180	140/-150	380	730	1950
FLAPS DRIVE (UP < FLAPS ≤ 1)	VREF30+40	6440	130/-130	210/280	-310/1140	220/-180	170/-180	340	980	2690
FLAPS DRIVE (1 < FLAPS ≤ 5)	VREF30+40	6750	140/-140	220/300	-330/1180	240/-200	180/-190	370	1000	2680
FLAPS DRIVE (5 < FLAPS < 20)	VREF30+20	6070	130/-130	200/260	-310/1140	230/-190	160/-170	390	870	2330
FLAPS DRIVE (FLAPS ≥ 20)	VREF20	5460	120/-120	180/240	-300/1090	220/-180	140/-150	380	730	1950
FLAPS PRIMARY FAIL (FLAPS 20)	VREF20	5790	130/-130	180/250	-310/1130	230/-180	150/-150	420	790	2120

Actual (unfactored) distances are shown.
Includes distances from 50 ft above threshold (1000 ft air distance).
Assumes max manual braking and maximum available reverse thrust.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft, Adjustment = STD*8+HIGH*((Press Alt/1000)-8).**
****Unannunciated Non-Normal Checklist condition.**

ADVISORY INFORMATION

Non-Normal Configuration Landing Distance

Medium Reported Braking Action

		LANDING DISTANCE AND ADJUSTMENT (FT)								
		REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS	SLOPE ADJ PER 1%	TEMP ADJ PER 10°C	APP SPEED ADJ	REVERSE THRUST ADJ	
EICAS MESSAGE	REF SPEED	370000 LB LDG WT	PER 10000 LB ABV/BLW 370000 LB	PER 1000 FT ABV S.L. STD/ HIGH*	HEAD/ TAIL WIND	DOWN/UP HILL	ABV/ BLW ISA	PER 10 KTS ABV VREF	ONE REV	NO REV
FLIGHT CONTROL MODE (FLAPS 20)	VREF20	5890	130/-130	190/260	-320/1140	240/-190	150/-160	440	830	2280
FLIGHT CONTROLS (FLAPS 20)	VREF30+20	6420	140/-140	210/290	-330/1190	260/-210	170/-180	440	1020	2800
**FUEL LEAK (FLAPS 20)	VREF20	6050	140/-140	190/260	-340/1220	300/-240	170/-170	450	0	1340
**FUEL LEAK (FLAPS 30)	VREF30	5780	130/-130	170/230	-330/1200	290/-230	160/-160	440	0	1120
FUEL QTY LOW (FLAPS 20)	VREF20	5460	120/-120	180/240	-300/1090	220/-180	140/-150	380	730	1950
HYD PRESS SYS C (FLAPS 20)	VREF20	5790	130/-130	180/250	-310/1130	230/-180	150/-150	420	790	2120
HYD PRESS SYS L (FLAPS 25)	VREF25	6160	130/-140	190/250	-350/1270	320/-250	160/-170	460	0	1180
HYD PRESS SYS L (FLAPS 30)	VREF30	6000	130/-130	180/240	-340/1250	320/-240	160/-160	460	0	1040
HYD PRESS SYS L+C (FLAPS 20)	VREF30+20	7630	160/-160	240/320	-400/1410	400/-310	210/-210	550	0	1750
HYD PRESS SYS L+R (FLAPS 20)	VREF30+20	9050	170/-180	260/340	-490/1720	690/-500	250/-250	680	0	0
HYD PRESS SYS R (FLAPS 25)	VREF25	6260	140/-140	190/260	-350/1280	330/-260	170/-170	480	0	1240
HYD PRESS SYS R (FLAPS 30)	VREF30	6080	130/-130	180/240	-350/1270	330/-250	160/-160	470	0	1080
HYD PRESS SYS R+C (FLAPS 20)	VREF30+20	7830	160/-170	250/330	-410/1440	420/-330	210/-220	580	0	1910
NAV AIR DATA SYS (FLAPS 20)	VREF20	5650	120/-120	180/240	-300/1110	210/-170	140/-150	400	730	1930

Actual (unfactored) distances are shown.
Includes distances from 50 ft above threshold (1000 ft air distance).
Assumes max manual braking and maximum available reverse thrust.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft,**
Adjustment = STD*8+HIGH*((Press Alt/1000)-8).
****Unannunciated Non-Normal Checklist condition.**

ADVISORY INFORMATION

Non-Normal Configuration Landing Distance

Medium Reported Braking Action

		LANDING DISTANCE AND ADJUSTMENT (FT)								
		REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS	SLOPE ADJ PER 1%	TEMP ADJ PER 10°C	APP SPEED ADJ	REVERSE THRUST ADJ	
EICAS MESSAGE	REF SPEED	370000 LB LDG WT	PER 10000 LB ABV/BLW 370000 LB	PER 1000 FT ABV S.L. STD/ HIGH*	HEAD/ TAIL WIND	DOWN/UP HILL	ABV/ BLW ISA	PER 10 KTS ABV VREF	ONE REV	NO REV
NAV AIRSPEED DATA (FLAPS 20)	VREF20	5650	120/-120	180/240	-300/1110	210/-170	140/-150	400	730	1930
OVERHEAT ENG L, R (FLAPS 20)	VREF20	6050	140/-140	190/260	-340/1220	300/-240	170/-170	450	0	1340
OVERHEAT ENG L, R (FLAPS 30)	VREF30	5780	130/-130	170/230	-330/1200	290/-230	160/-160	440	0	1120
PITCH UP AUTHORITY (FLAPS ≥ 20)	VREF30+20	6090	130/-130	200/270	-320/1140	230/-190	160/-170	390	860	2310
PITCH UP AUTHORITY (FLAPS ≤ 15)	VREF30+40	6690	140/-140	220/300	-330/1180	240/-200	180/-190	360	970	2590
PRI FLIGHT COMPUTERS (FLAPS 20)	VREF20	5890	130/-130	190/260	-320/1140	240/-190	150/-160	440	830	2280
ROLL LEFT AUTHORITY (FLAPS 20)	VREF30+20	6060	130/-130	200/260	-310/1140	230/-190	160/-170	380	850	2260
ROLL RIGHT AUTHORITY (FLAPS 20)	VREF30+20	6060	130/-130	200/260	-310/1140	230/-190	160/-170	380	850	2260
SLATS DRIVE (FLAPS 20)	VREF30+30	6540	140/-140	220/290	-330/1180	250/-200	180/-180	390	960	2580
SPOILER PAIRS (FLAPS 25)	VREF25+5	5710	130/-130	180/250	-310/1120	230/-190	150/-160	400	780	2080
SPOILER PAIRS (FLAPS 30)	VREF30+5	5590	120/-120	180/240	-300/1110	230/-190	150/-150	400	720	1850
STABILIZER (FLAPS 20)	VREF30+20	6090	130/-130	200/270	-320/1140	230/-190	160/-170	390	860	2310

Actual (unfactored) distances are shown.
Includes distances from 50 ft above threshold (1000 ft air distance).
Assumes max manual braking and maximum available reverse thrust.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft, Adjustment = STD*8+HIGH*((Press Alt/1000)-8).**

ADVISORY INFORMATION

Non-Normal Configuration Landing Distance

Poor Reported Braking Action

		LANDING DISTANCE AND ADJUSTMENT (FT)								
		REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS	SLOPE ADJ PER 1%	TEMP ADJ PER 10°C	APP SPEED ADJ	REVERSE THRUST ADJ	
EICAS MESSAGE	REF SPEED	370000 LB LDG WT	PER 10000 LB ABV/BLW 370000 LB	PER 1000 FT ABV S.L. STD/ HIGH*	HEAD/ TAIL WIND	DOWN/UP HILL	ABV/ BLW ISA	PER 10 KTS ABV VREF	ONE REV	NO REV
ANTI-ICE LEAK ENG L, R (FLAPS 20)	VREF20	8340	200/-200	290/400	-540/2060	820/-520	230/-230	560	0	3070
ANTI-ICE LEAK ENG L, R (FLAPS 30)	VREF30	7990	190/-190	270/360	-530/2030	800/-510	220/-220	540	0	2530
ANTISKID (FLAPS 25)	VREF25	8790	250/-240	380/520	-660/2770	1670/-670	260/-270	490	3390	15310
ANTISKID (FLAPS 30)	VREF30	8700	250/-230	370/510	-660/2760	1670/-680	260/-270	500	3220	14080
BRAKES (FLAPS 25)	VREF25	8010	220/-210	320/440	-560/2270	950/-510	230/-240	480	2450	8720
BRAKES (FLAPS 30)	VREF30	7920	210/-200	310/430	-560/2270	960/-520	230/-240	480	2310	7960
ENG FAIL L, R (FLAPS 20)	VREF20	8050	200/-200	290/390	-510/1940	730/-480	240/-240	550	0	3320
ENG FAIL L, R (FLAPS 30)	VREF30	7700	190/-190	260/350	-500/1900	710/-460	220/-230	530	0	2770
ENG LIMIT EXCEED L, R (FLAPS 20)	VREF20	8050	200/-200	290/390	-510/1940	730/-480	240/-240	550	0	3320
ENG LIMIT EXCEED L, R (FLAPS 30)	VREF30	7700	190/-190	260/350	-500/1900	710/-460	220/-230	530	0	2770
ENG OIL FILTER L, R (FLAPS 20)	VREF20	8050	200/-200	290/390	-510/1940	730/-480	240/-240	550	0	3320
ENG OIL FILTER L, R (FLAPS 30)	VREF30	7700	190/-190	260/350	-500/1900	710/-460	220/-230	530	0	2770
ENG OIL PRESS L, R (FLAPS 20)	VREF20	8050	200/-200	290/390	-510/1940	730/-480	240/-240	550	0	3320
ENG OIL PRESS L, R (FLAPS 30)	VREF30	7700	190/-190	260/350	-500/1900	710/-460	220/-230	530	0	2770

Actual (unfactored) distances are shown.
Includes distances from 50 ft above threshold (1000 ft air distance).
Assumes max manual braking and maximum available reverse thrust.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft, Adjustment = STD*8+HIGH*((Press Alt/1000)-8).**

ADVISORY INFORMATION

Non-Normal Configuration Landing Distance

Poor Reported Braking Action

		LANDING DISTANCE AND ADJUSTMENT (FT)								
		REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS	SLOPE ADJ PER 1%	TEMP ADJ PER 10°C	APP SPEED ADJ	REVERSE THRUST ADJ	
EICAS MESSAGE	REF SPEED	370000 LB LDG WT	PER 10000 LB ABV/BLW 370000 LB	PER 1000 FT ABV S.L. STD/HIGH*	HEAD/TAIL WIND	DOWN/UP HILL	ABV/BLW ISA	PER 10 KTS ABV VREF	ONE REV	NO REV
ENG OIL TEMP L, R (FLAPS 20)	VREF20	8050	200/-200	290/390	-510/1940	730/-480	240/-240	550	0	3320
ENG OIL TEMP L, R (FLAPS 30)	VREF30	7700	190/-190	260/350	-500/1900	710/-460	220/-230	530	0	2770
ENG SURGE L, R (FLAPS 20)	VREF20	8050	200/-200	290/390	-510/1940	730/-480	240/-240	550	0	3320
ENG SURGE L, R (FLAPS 30)	VREF30	7700	190/-190	260/350	-500/1900	710/-460	220/-230	530	0	2770
**ENG SVR DAMAGE/SEP L, R (FLAPS 20)	VREF20	8050	200/-200	290/390	-510/1940	730/-480	240/-240	550	0	3320
**ENG SVR DAMAGE/SEP L, R (FLAPS 30)	VREF30	7700	190/-190	260/350	-500/-1900	710/-460	220/-230	530	0	2770
FIRE ENG L, R (FLAPS 20)	VREF20	8050	200/-200	290/390	-510/1940	730/-480	240/-240	550	0	3320
FIRE ENG L, R (FLAPS 30)	VREF30	7700	190/-190	260/350	-500/1900	710/-460	220/-230	530	0	2770
FLAP/SLAT CONTROL (FLAPS 20)	VREF20	6840	170/-170	250/350	-430/1630	460/-320	190/-200	440	1500	4570
FLAPS DRIVE (UP < FLAPS ≤ 1)	VREF30+40	8010	180/-180	300/410	-440/1690	450/-330	230/-230	400	1910	6090
FLAPS DRIVE (1 < FLAPS ≤ 5)	VREF30+40	8410	200/-200	320/430	-460/1750	500/-360	240/-250	430	1950	5980
FLAPS DRIVE (5 < FLAPS < 20)	VREF30+20	7600	180/-180	280/380	-450/1690	490/-350	210/-220	450	1740	5380
FLAPS DRIVE (FLAPS ≥ 20)	VREF20	6840	170/-170	250/350	-430/1630	460/-320	190/-200	440	1500	4570
FLAPS PRIMARY FAIL (FLAPS 20)	VREF20	7190	180/-170	260/360	-440/1670	480/-340	200/-200	480	1600	4970

Actual (unfactored) distances are shown.
Includes distances from 50 ft above threshold (1000 ft air distance).
Assumes max manual braking and maximum available reverse thrust.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft, Adjustment = STD*8+HIGH*((Press Alt/1000)-8).**
****Unannunciated Non-Normal Checklist condition.**

ADVISORY INFORMATION

Non-Normal Configuration Landing Distance

Poor Reported Braking Action

		LANDING DISTANCE AND ADJUSTMENT (FT)								
		REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS	SLOPE ADJ PER 1%	TEMP ADJ PER 10°C	APP SPEED ADJ	REVERSE THRUST ADJ	
EICAS MESSAGE	REF SPEED	370000 LB LDG WT	PER 10000 LB ABV/BLW 370000 LB	PER 1000 FT ABV S.L. STD/ HIGH*	HEAD/ TAIL WIND	DOWN/UP HILL	ABV/ BLW ISA	PER 10 KTS ABV VREF	ONE REV	NO REV
FLIGHT CONTROL MODE (FLAPS 20)	VREF20	7310	180/-180	270/380	-450/1690	500/-350	250/-210	500	1680	5330
FLIGHT CONTROLS (FLAPS 20)	VREF30+20	7960	190/-190	300/410	-460/1740	530/-380	230/-230	490	1950	6190
**FUEL LEAK (FLAPS 20)	VREF20	8050	200/-200	290/390	-510/1940	730/-480	240/-240	550	0	3320
**FUEL LEAK (FLAPS 30)	VREF30	7700	190/-190	260/350	-500/1900	710/-460	220/-230	530	0	2770
FUEL QTY LOW (FLAPS 20)	VREF20	6840	170/-170	250/350	-430/1630	460/-320	190/-200	440	1500	4570
HYD PRESS SYS C (FLAPS 20)	VREF20	7190	180/-170	260/360	-440/1670	480/-340	200/-200	480	1600	4970
HYD PRESS SYS L (FLAPS 25)	VREF25	8310	200/-200	290/380	-540/2060	830/-520	230/-230	560	0	2970
HYD PRESS SYS L (FLAPS 30)	VREF30	8090	190/-190	270/370	-540/2040	820/-520	230/-230	550	0	2630
HYD PRESS SYS L+C (FLAPS 20)	VREF30+20	10090	230/-230	360/480	-600/2250	980/-620	290/-290	640	0	4200
HYD PRESS SYS L+R (FLAPS 20)	VREF30+20	13810	260/-270	400/530	-860/3170	2480/-1290	380/-350	860	0	0
HYD PRESS SYS R (FLAPS 25)	VREF25	8450	200/-200	290/390	-550/2090	860/-540	240/-240	580	0	3130
HYD PRESS SYS R (FLAPS 30)	VREF30	8210	190/-200	280/370	-540/2060	840/-530	230/-230	570	0	2750
HYD PRESS SYS R+C (FLAPS 20)	VREF30+20	10380	240/-240	370/500	-620/2290	1030/-660	290/-300	680	0	4600
NAV AIR DATA SYS (FLAPS 20)	VREF20	7020	170/-170	250/350	-430/1650	460/-320	190/-200	460	1490	4540

Actual (unfactored) distances are shown.
Includes distances from 50 ft above threshold (1000 ft air distance).
Assumes max manual braking and maximum available reverse thrust.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft, Adjustment = STD*8+HIGH*((Press Alt/1000)-8).**
****Unannunciated Non-Normal Checklist condition.**

ADVISORY INFORMATION

Non-Normal Configuration Landing Distance

Poor Reported Braking Action

		LANDING DISTANCE AND ADJUSTMENT (FT)								
		REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS	SLOPE ADJ PER 1%	TEMP ADJ PER 10°C	APP SPEED ADJ	REVERSE THRUST ADJ	
EICAS MESSAGE	REF SPEED	370000 LB LDG WT	PER 10000 LB ABV/BLW 370000 LB	PER 1000 FT ABV S.L. STD/ HIGH*	HEAD/ TAIL WIND	DOWN/UP HILL	ABV/ BLW ISA	PER 10 KTS ABV VREF	ONE REV	NO REV
NAV AIRSPEED DATA (FLAPS 20)	VREF20	7020	170/-170	250/350	-430/1650	460/-320	190/-200	460	1490	4540
OVERHEAT ENG L, R (FLAPS 20)	VREF20	8050	200/-200	290/390	-510/1940	730/-480	240/-240	550	0	3320
OVERHEAT ENG L, R (FLAPS 30)	VREF30	7700	190/-190	260/350	-500/1900	710/-460	220/-230	530	0	2770
PITCH UP AUTHORITY (FLAPS ≥ 20)	VREF30+20	7540	180/-180	280/380	-440/1690	480/-340	210/-220	440	1670	5080
PITCH UP AUTHORITY (FLAPS ≤ 15)	VREF30+40	8320	190/-190	310/420	-460/1730	490/-350	240/-250	420	1890	5750
PRI FLIGHT COMPUTERS (FLAPS 20)	VREF20	7310	180/-180	270/380	-450/1690	500/-350	200/-210	500	1680	5330
ROLL LEFT AUTHORITY (FLAPS 20)	VREF30+20	7530	180/-180	280/380	-440/1680	480/-340	210/-220	440	1670	5060
ROLL RIGHT AUTHORITY (FLAPS 20)	VREF30+20	7530	180/-180	280/380	-440/1680	480/-340	210/-220	440	1670	5060
SLATS DRIVE (FLAPS 20)	VREF30+30	8060	190/-190	300/410	-460/1730	500/-360	230/-240	440	1830	5570
SPOILER PAIRS (FLAPS 25)	VREF25+5	7140	180/-170	260/360	-440/1660	480/-340	200/-210	460	1580	4810
SPOILER PAIRS (FLAPS 30)	VREF30+5	7020	170/-170	250/340	-440/1660	490/-340	200/-200	460	1460	4290
STABILIZER (FLAPS 20)	VREF30+20	7540	180/-180	280/380	-440/1690	480/-340	210/-220	440	1670	5080

Actual (unfactored) distances are shown.
Includes distances from 50 ft above threshold (1000 ft air distance).
Assumes max manual braking and maximum available reverse thrust.

***Altitude adjustment - Use STD up to 8000 ft pressure altitude, above 8000 ft, Adjustment = STD*8+HIGH*((Press Alt/1000)-8).**

ADVISORY INFORMATION

Recommended Brake Cooling Schedule

Reference Brake Energy (Millions of Foot Pounds)

		BRAKES ON SPEED (KIAS)																	
		80			100			120			140			160			180		
WEIGHT (1000 LB)	OAT (°C)	PRESSURE ALTITUDE (1000 FT)																	
		0	5	10	0	5	10	0	5	10	0	5	10	0	5	10	0	5	10
500	0	20.8	23.9	27.8	30.4	35.1	40.8	41.5	48.0	55.9	53.9	62.5	72.9	67.1	78.0	91.2	80.3	93.7	109.6
	10	21.5	24.7	28.7	31.5	36.3	42.3	42.9	49.7	57.9	55.7	64.7	75.5	69.3	80.7	94.3	82.9	96.8	113.4
	15	21.8	25.1	29.2	32.0	36.9	43.0	43.6	50.5	58.9	56.7	65.8	76.8	70.5	82.1	95.9	84.3	98.4	115.2
	20	22.1	25.5	29.6	32.5	37.5	43.7	44.4	51.3	59.8	57.6	66.8	78.0	71.6	83.4	97.5	85.6	99.9	117.0
	30	22.7	26.1	30.3	33.3	38.5	44.8	45.6	52.8	61.5	59.2	68.7	80.2	73.6	85.8	100.3	88.0	102.8	120.5
	40	23.0	26.5	30.8	34.0	39.2	45.6	46.5	53.8	62.7	60.5	70.2	82.0	75.3	87.8	102.7	90.2	105.4	123.5
460	0	19.4	22.4	26.0	28.4	32.7	38.1	38.6	44.7	52.0	50.1	58.0	67.7	62.4	72.5	84.7	74.9	87.3	102.2
	10	20.1	23.1	26.9	29.3	33.9	39.4	40.0	46.2	53.8	51.8	60.1	70.0	64.5	75.1	87.7	77.5	90.3	105.7
	15	20.4	23.5	27.3	29.8	34.4	40.0	40.6	47.0	54.7	52.7	61.1	71.2	65.6	76.3	89.2	78.7	91.8	107.4
	20	20.7	23.8	27.7	30.3	35.0	40.7	41.3	47.8	55.6	53.5	62.1	72.4	66.7	77.5	90.6	79.9	93.3	109.1
	30	21.2	24.4	28.3	31.1	35.9	41.7	42.4	49.1	57.2	55.0	63.8	74.5	68.5	79.8	93.2	82.2	95.9	112.3
	40	21.5	24.8	28.8	31.6	36.5	42.5	43.2	50.1	58.3	56.2	65.2	76.1	70.1	81.6	95.4	84.2	98.3	115.1
420	0	18.1	20.9	24.2	26.3	30.3	35.3	35.7	41.3	48.0	46.2	53.5	62.3	57.6	66.9	78.0	69.3	80.7	94.3
	10	18.7	21.5	25.0	27.2	31.4	36.5	37.0	42.7	49.7	47.8	55.4	64.5	59.6	69.2	80.8	71.7	83.5	97.6
	15	19.0	21.9	25.4	27.7	31.9	37.1	37.6	43.4	50.6	48.6	56.3	65.6	60.6	70.4	82.2	72.8	84.8	99.2
	20	19.3	22.2	25.8	28.1	32.4	37.7	38.2	44.1	51.4	49.4	57.2	66.7	61.5	71.5	83.5	74.0	86.2	100.8
	30	19.7	22.7	26.4	28.8	33.2	38.6	39.2	45.3	52.8	50.7	58.8	68.6	63.3	73.5	85.9	76.1	88.7	103.7
	40	20.0	23.0	26.8	29.3	33.8	39.3	40.0	46.2	53.8	51.8	60.0	70.0	64.7	75.2	87.8	77.9	90.8	106.3
380	0	16.8	19.3	22.5	24.3	27.9	32.5	32.8	37.8	44.0	42.2	48.8	56.9	52.6	61.0	71.1	63.4	73.7	86.1
	10	17.3	19.9	23.2	25.1	28.9	33.6	33.9	39.1	45.6	43.7	50.6	58.9	54.4	63.1	73.6	65.6	76.3	89.1
	15	17.6	20.3	23.5	25.5	29.4	34.1	34.5	39.8	46.3	44.4	51.4	59.9	55.3	64.2	74.9	66.7	77.5	90.6
	20	17.8	20.5	23.8	25.9	29.8	34.7	35.0	40.5	47.1	45.1	52.3	60.9	56.2	65.2	76.1	67.7	78.8	92.1
	30	18.2	21.0	24.4	26.5	30.6	35.5	35.9	41.5	48.3	46.4	53.7	62.6	57.8	67.1	78.3	69.6	81.0	94.7
	40	18.5	21.3	24.7	27.0	31.1	36.2	36.6	42.3	49.3	47.3	54.8	63.9	59.0	68.6	80.0	71.2	82.9	97.0
340	0	15.5	17.8	20.7	22.2	25.5	29.7	29.8	34.3	39.9	38.2	44.1	51.4	47.4	54.9	64.0	57.2	66.4	77.5
	10	16.0	18.4	21.3	22.9	26.4	30.7	30.8	35.5	41.3	39.5	45.7	53.2	49.1	56.9	66.3	59.2	68.7	80.2
	15	16.2	18.6	21.6	23.3	26.8	31.2	31.3	36.1	42.0	40.2	46.5	54.1	49.9	57.8	67.4	60.2	69.9	81.6
	20	16.4	18.9	21.9	23.6	27.2	31.6	31.8	36.7	42.7	40.8	47.2	55.0	50.7	58.8	68.5	61.1	71.0	82.9
	30	16.8	19.3	22.4	24.2	27.9	32.4	32.6	37.7	43.8	41.9	48.5	56.5	52.1	60.4	70.5	62.8	73.0	85.3
	40	17.0	19.6	22.7	24.6	28.4	33.0	33.2	38.4	44.6	42.7	49.5	57.6	53.2	61.7	72.0	64.2	74.7	87.2
300	0	14.2	16.3	18.9	20.1	23.1	26.8	26.7	30.8	35.8	34.1	39.3	45.8	42.1	48.7	56.7	50.7	58.8	68.5
	10	14.6	16.8	19.5	20.7	23.9	27.7	27.6	31.9	37.0	35.2	40.7	47.4	43.5	50.4	58.7	52.5	60.8	71.0
	15	14.8	17.0	19.8	21.1	24.2	28.2	28.1	32.4	37.7	35.8	41.4	48.2	44.3	51.3	59.7	53.3	61.9	72.2
	20	15.0	17.3	20.0	21.4	24.6	28.6	28.5	32.9	38.3	36.4	42.1	49.0	45.0	52.1	60.7	54.2	62.9	73.4
	30	15.3	17.6	20.5	21.9	25.2	29.3	29.2	33.7	39.2	37.4	43.2	50.3	46.2	53.5	62.4	55.7	64.6	75.4
	40	15.5	17.9	20.7	22.2	25.6	29.7	29.8	34.3	39.9	38.1	44.0	51.3	47.2	54.6	63.7	56.9	66.0	77.1

To correct for wind, enter table with the brakes on speed minus one half the headwind or plus 1.5 times the tailwind.
If groundspeed is used for brakes on speed, ignore wind and enter table with sea level, 15°C.

ADVISORY INFORMATION

Recommended Brake Cooling Schedule

Event Adjusted Brake Energy (Millions of Foot Pounds)

No Reverse Thrust

		REFERENCE BRAKE ENERGY PER BRAKE (MILLIONS OF FOOT POUNDS)												
EVENT		10	20	30	40	50	60	70	80	90	100	110	120	130
RTO MAX MAN		10	20	30	40	50	60	70	80	90	100	110	120	130
LANDING	MAX MAN	6.7	15.9	25.3	34.9	44.6	54.5	64.6	74.7	85.0	95.5	105.9	116.3	126.8
LANDING	MAX AUTO	6.1	14.6	23.1	31.8	40.8	50.0	59.5	69.4	79.8	90.6	101.6	112.6	123.7
LANDING	AUTOBRAKE 4	5.6	13.6	21.5	29.5	37.6	46.0	54.8	63.9	73.5	83.7	94.0	104.4	114.7
LANDING	AUTOBRAKE 3	5.4	12.9	20.3	27.7	35.1	42.8	50.8	59.1	68.0	77.6	87.3	97.0	106.7
LANDING	AUTOBRAKE 2	5.0	12.1	18.9	25.7	32.5	39.4	46.6	54.2	62.3	71.1	80.1	89.0	98.0
LANDING	AUTOBRAKE 1	4.2	10.6	16.7	22.8	28.9	35.1	41.5	48.3	55.5	63.3	71.2	79.2	87.1

2 Engine Reverse Thrust

		REFERENCE BRAKE ENERGY PER BRAKE (MILLIONS OF FOOT POUNDS)												
EVENT		10	20	30	40	50	60	70	80	90	100	110	120	130
RTO MAX MAN		10	20	30	40	50	60	70	80	90	100	110	120	130
LANDING	MAX MAN	6.2	14.5	23.0	31.8	40.8	49.8	58.9	68.1	77.3	86.3	95.4	104.4	113.5
LANDING	MAX AUTO	4.1	10.2	16.6	23.4	30.6	38.2	46.3	54.9	64.0	73.6	83.4	93.2	103.0
LANDING	AUTOBRAKE 4	2.2	6.5	11.1	16.2	21.7	27.7	34.2	41.3	49.1	57.5	66.2	74.8	83.4
LANDING	AUTOBRAKE 3	1.2	4.3	7.5	11.2	15.2	19.6	24.7	30.4	36.8	44.1	51.6	59.0	66.5
LANDING	AUTOBRAKE 2	0.6	2.9	5.2	7.7	10.5	13.7	17.4	21.7	26.7	32.5	38.6	44.7	50.8
LANDING	AUTOBRAKE 1	0.1	1.8	3.5	5.3	7.2	9.3	11.8	14.7	18.2	22.2	26.5	30.7	34.9

Cooling Time (Minutes)

	EVENT ADJUSTED BRAKE ENERGY (MILLIONS OF FOOT POUNDS)									
	16 & BELOW	17	18	22	26	30	34	35	36 TO 44	45 & ABOVE
GEAR DOWN INFLIGHT	NO SPECIAL PROCEDURE REQUIRED	1	2	3	5	6	7	7	CAUTION	FUSE PLUG MELT ZONE
GROUND		12	18	35	49	60	72	73		
BRAKE TEMPERATURE INDICATION	UP TO 2.4	2.4	2.6	3.1	3.7	4.3	4.8	4.9	5.0 TO 6.2	6.3 & ABOVE

Observe maximum quick turnaround limit.
Table shows energy per brake added by a single stop with all brakes operating. Energy is assumed to be equally distributed among the operating brakes. Total energy is the sum of residual energy plus energy added.
Add 1.0 million foot pounds for each taxi mile.
For one brake deactivated, increase brake energy by 13 percent.
For two brakes deactivated, increase brake energy by 25 percent.

When in caution zone, wheel fuse plugs may melt. Delay takeoff and inspect after one hour. If overheat occurs after takeoff, extend gear soon for at least 8 minutes.

When in fuse plug melt zone, clear runway immediately. Unless required, do not set parking brake. Do not approach gear or attempt taxi for one hour. Tire, wheel and brake replacement may be required. If overheat occurs after takeoff, extend gear soon for at least 12 minutes.

Brake temperature indication on Multifunction Display may be used 10 to 15 minutes after airplane has come to a complete stop, or inflight with gear retracted, to determine recommended cooling schedule.

ADVISORY INFORMATION

Landing Climb Limit Weight

Valid for approach with flaps 20 and landing with flaps 30
Based on anti-ice off

AIRPORT OAT		LANDING CLIMB LIMIT WEIGHT (1000 LB)						
		AIRPORT PRESSURE ALTITUDE (FT)						
°C	°F	-2000	0	2000	4000	6000	8000	10000
54	129	411.5	399.0					
52	126	421.7	409.3					
50	122	431.8	419.5	383.6				
48	118	441.3	429.6	393.5				
46	115	450.1	439.6	403.3	369.5			
44	111	458.7	449.0	413.1	378.9			
42	108	467.5	457.6	422.6	388.4	352.1		
40	104	481.4	466.1	431.5	397.5	361.1		
38	100	492.9	478.3	439.8	406.6	369.8	339.8	
36	97	501.7	491.8	448.1	415.0	378.5	348.2	
34	93	510.5	500.4	456.0	422.6	387.0	356.4	320.6
32	90	510.8	508.8	463.9	430.1	394.7	364.5	328.6
30	86	511.0	517.2	472.2	437.4	401.7	372.6	336.3
28	82	511.2	517.4	487.5	444.6	408.7	379.9	344.0
26	79	511.4	517.5	494.8	451.5	416.0	386.7	351.6
24	75	511.5	517.7	495.0	458.4	423.2	393.3	358.4
22	72	511.7	517.8	495.1	464.7	430.2	399.7	364.8
20	68	511.9	518.0	495.3	464.9	436.6	405.9	370.9
18	64	512.1	518.1	495.5	465.0	442.6	411.4	376.1
16	61	512.3	518.3	495.6	465.2	442.8	416.3	381.3
14	57	512.5	518.5	495.8	465.3	442.9	420.7	386.2
12	54	512.7	518.7	495.9	465.4	443.0	420.7	390.4
10	50	512.9	518.8	496.1	465.6	443.2	420.8	394.1
-40	-40	517.9	523.3	500.1	469.3	446.3	423.1	396.4

With engine anti-ice on, decrease weight by 1100 lb.
With engine and wing anti-ice on, decrease weight by 1100 lb.
When operating in icing conditions during any part of the flight with forecast landing temperature below 10°C, decrease weight by 37500 lb.

ADVISORY INFORMATION

Landing Climb Limit Weight

Valid for approach with flaps 20 and landing with flaps 25
Based on anti-ice off

AIRPORT OAT		LANDING CLIMB LIMIT WEIGHT (1000 LB)						
		AIRPORT PRESSURE ALTITUDE (FT)						
°C	°F	-2000	0	2000	4000	6000	8000	10000
54	129	413.7	401.2					
52	126	423.9	411.5					
50	122	434.1	421.8	385.7				
48	118	443.7	431.9	395.6				
46	115	452.5	442.0	405.5	371.5			
44	111	461.2	451.5	415.3	381.0			
42	108	470.2	460.0	424.9	390.5	354.0		
40	104	487.6	468.7	433.8	399.7	363.0		
38	100	496.4	486.2	442.0	408.7	371.8	341.6	
36	97	505.3	494.9	450.1	417.0	380.5	350.0	
34	93	514.1	503.4	458.1	424.6	389.1	358.4	322.3
32	90	514.4	512.0	466.1	432.2	396.8	366.5	330.3
30	86	514.6	520.4	475.6	439.6	403.9	374.6	338.1
28	82	514.8	520.6	490.5	446.9	410.9	382.0	345.9
26	79	514.9	520.7	497.9	453.9	418.2	388.8	353.5
24	75	515.1	520.9	498.1	460.7	425.5	395.4	360.4
22	72	515.3	521.1	498.2	467.3	432.5	402.0	366.8
20	68	515.4	521.2	498.4	467.5	439.1	408.2	373.0
18	64	515.6	521.4	498.5	467.7	445.3	413.8	378.3
16	61	515.8	521.5	498.7	467.8	445.4	418.8	383.6
14	57	516.1	521.7	498.8	467.9	445.5	423.2	388.5
12	54	516.3	521.9	499.0	468.1	445.6	423.3	392.8
10	50	516.5	522.1	499.2	468.2	445.8	423.4	396.5
-40	-40	521.4	526.6	503.3	472.0	449.0	425.6	398.8

With engine anti-ice on, decrease weight by 400 lb.
With engine and wing anti-ice on, decrease weight by 400 lb.
When operating in icing conditions during any part of the flight with forecast landing temperature below 10°C, decrease weight by 39800 lb.

ADVISORY INFORMATION

Fuel Heating Schedule

		TO BE SUPPLIED					

Intentionally
Blank

ENGINE INOP

Initial Max Continuous TPR

Based on .85M and anti-ice on or off

TAT (°C)	PRESSURE ALTITUDE (1000 FT)								
	27	29	31	33	35	37	39	41	43
20	76.7	77.0	77.2	77.0	76.2	73.6	72.3	71.5	70.7
15	80.7	81.1	81.3	81.5	80.4	77.9	76.7	75.9	75.2
10	84.9	85.3	85.5	85.7	84.7	82.2	81.1	80.4	79.6
5	87.7	89.6	90.0	89.9	89.1	86.6	85.7	84.9	84.2
0	87.9	92.0	94.2	94.7	93.5	91.1	90.3	89.6	88.8
-5	88.1	92.2	96.1	98.6	97.6	95.4	94.8	94.1	93.4
-10	88.3	92.5	96.4	100.0	101.9	99.9	99.5	99.2	98.8
-15	88.5	92.7	96.6	100.2	103.2	103.6	103.6	103.7	103.8
-20	88.7	92.9	96.8	100.5	103.4	103.9	103.8	103.9	104.1
-25	88.9	93.1	97.0	100.7	103.7	104.1	104.1	104.2	104.3
-30	89.1	93.3	97.3	100.9	103.9	104.4	104.3	104.4	104.6
-35	89.3	93.6	97.5	101.2	104.2	104.6	104.5	104.7	104.8
-40	89.5	93.8	97.7	101.4	104.4	104.9	104.8	104.9	105.0

ENGINE INOP

Max Continuous TPR

Based on anti-ice on or off

37000 FT to 27000 FT Pressure Altitudes

37000 FT PRESS ALT		TAT (°C)											
KIAS	M	-50	-45	-40	-35	-30	-25	-20	-15	-10	-5	0	5
280	0.86	104.8	104.5	104.3	104.0	103.8	103.6	103.3	103.1	99.8	95.4	91.1	86.5
240	0.74	105.5	105.3	105.0	104.8	104.5	104.3	102.9	98.5	94.1	89.4	84.6	80.1
200	0.63	105.9	105.7	105.4	105.1	104.9	102.0	97.7	93.0	88.0	83.2	78.5	74.9
35000 FT PRESS ALT		TAT (°C)											
KIAS	M	-50	-45	-40	-35	-30	-25	-20	-15	-10	-5	0	5
280	0.82	104.9	104.6	104.4	104.2	103.9	103.7	103.4	103.2	100.1	95.9	91.6	87.2
240	0.71	105.5	105.2	104.9	104.7	104.4	104.2	103.1	98.8	94.5	89.8	85.2	80.7
200	0.60	105.9	105.6	105.4	105.1	104.8	102.7	98.6	94.0	89.0	84.1	79.5	75.3
33000 FT PRESS ALT		TAT (°C)											
KIAS	M	-50	-45	-40	-35	-30	-25	-20	-15	-10	-5	0	5
320	0.89	98.3	98.1	97.9	97.6	97.4	97.2	97.0	96.7	96.5	96.3	93.3	89.1
280	0.79	103.0	102.7	102.5	102.2	102.0	101.8	101.5	101.3	100.0	96.0	91.5	87.0
240	0.68	103.7	103.4	103.2	102.9	102.7	102.4	102.2	99.0	94.6	90.2	85.6	81.0
200	0.58	104.5	104.2	103.9	103.7	103.4	103.2	98.8	94.3	89.6	84.9	80.3	75.7
31000 FT PRESS ALT		TAT (°C)											
KIAS	M	-45	-40	-35	-30	-25	-20	-15	-10	-5	0	5	10
320	0.85	97.5	97.3	97.0	96.8	96.6	96.4	96.1	95.9	95.7	94.0	89.8	85.4
280	0.76	100.6	100.4	100.1	99.9	99.7	99.4	99.2	98.9	95.4	91.2	86.8	82.2
240	0.66	101.4	101.1	100.9	100.6	100.4	100.1	99.1	94.8	90.5	85.8	81.0	76.3
200	0.55	102.0	101.7	101.5	101.2	100.9	99.1	94.8	90.3	85.4	80.6	75.9	71.3
29000 FT PRESS ALT		TAT (°C)											
KIAS	M	-40	-35	-30	-25	-20	-15	-10	-5	0	5	10	15
320	0.82	96.4	96.1	95.9	95.7	95.5	95.2	95.0	94.8	94.6	89.9	85.6	81.4
280	0.73	99.5	99.2	99.0	98.7	98.5	98.3	98.0	95.9	91.2	86.9	82.4	77.9
240	0.63	100.7	100.4	100.2	99.9	99.7	99.4	95.9	91.2	86.7	82.0	77.2	72.2
200	0.53	101.2	100.9	100.7	100.4	100.2	96.0	91.3	86.6	81.8	77.0	72.3	69.6
27000 FT PRESS ALT		TAT (°C)											
KIAS	M	-40	-35	-30	-25	-20	-15	-10	-5	0	5	10	15
360	0.88	86.5	86.3	86.1	85.9	85.7	85.5	85.3	85.1	84.9	84.7	84.1	79.9
320	0.79	97.8	97.5	97.3	97.1	96.8	96.6	96.4	96.2	95.9	91.7	85.8	81.6
280	0.70	100.3	100.1	99.8	99.6	99.3	99.1	98.9	98.6	93.0	88.3	83.9	79.5
240	0.60	102.1	101.8	101.6	101.3	101.1	100.8	99.7	92.6	88.1	83.5	79.0	74.0
200	0.51	102.4	102.1	101.8	101.6	101.3	99.8	92.8	88.4	83.6	78.8	74.1	69.3

ENGINE INOP

Max Continuous TPR

Based on anti-ice on or off

25000 FT to 18000 FT Pressure Altitudes

25000 FT PRESS ALT		TAT (°C)											
KIAS	M	-35	-30	-25	-20	-15	-10	-5	0	5	10	15	20
360	0.85	85.3	85.1	84.9	84.7	84.5	84.3	84.1	83.9	83.7	83.5	80.3	76.2
320	0.76	96.5	96.3	96.0	95.8	95.6	95.3	95.1	94.9	93.6	86.4	82.1	78.1
280	0.67	99.6	99.4	99.2	98.9	98.7	98.4	98.2	95.3	89.3	84.9	80.6	76.2
240	0.58	101.4	101.2	100.9	100.7	100.4	100.2	95.8	89.7	85.2	80.7	76.1	71.1
200	0.49	100.7	100.5	100.2	100.0	99.7	95.5	89.5	85.0	80.4	75.7	70.9	67.4
24000 FT PRESS ALT		TAT (°C)											
KIAS	M	-35	-30	-25	-20	-15	-10	-5	0	5	10	15	20
360	0.83	86.4	86.2	86.0	85.8	85.6	85.4	85.2	85.0	84.8	84.6	81.6	76.9
320	0.75	95.4	95.2	95.0	94.8	94.5	94.3	94.1	93.9	93.6	87.5	82.8	78.7
280	0.66	98.8	98.6	98.3	98.1	97.8	97.6	97.4	96.2	89.9	85.6	81.3	77.0
240	0.57	100.1	99.8	99.6	99.3	99.1	98.8	96.8	90.3	85.9	81.4	77.0	72.0
200	0.48	98.8	98.6	98.3	98.1	97.8	96.2	89.9	85.4	80.9	76.3	71.6	67.0
22000 FT PRESS ALT		TAT (°C)											
KIAS	M	-30	-25	-20	-15	-10	-5	0	5	10	15	20	25
360	0.80	88.7	88.5	88.2	88.0	87.8	87.6	87.4	87.2	87.0	85.8	79.5	75.6
320	0.72	93.5	93.2	93.0	92.8	92.6	92.3	92.1	91.9	89.4	84.5	80.4	76.4
280	0.63	97.3	97.0	96.8	96.5	96.3	96.1	95.8	92.2	87.4	83.2	78.9	74.4
240	0.55	96.4	96.2	95.9	95.7	95.5	95.2	91.5	86.7	82.3	78.0	73.4	68.6
200	0.46	95.0	94.7	94.5	94.3	94.0	91.0	86.2	81.8	77.4	72.9	68.4	65.4
20000 FT PRESS ALT		TAT (°C)											
KIAS	M	-30	-25	-20	-15	-10	-5	0	5	10	15	20	25
360	0.77	87.2	87.0	86.8	86.6	86.3	86.1	85.9	85.7	85.5	85.3	82.2	78.3
320	0.69	92.0	91.8	91.5	91.3	91.1	90.9	90.6	90.4	90.2	86.4	82.4	78.4
280	0.61	95.8	95.6	95.3	95.1	94.8	94.6	94.4	93.8	90.0	85.9	81.7	77.4
240	0.53	95.2	95.0	94.7	94.5	94.2	94.0	93.4	88.6	84.2	80.0	75.7	70.9
200	0.44	95.8	95.5	95.3	95.0	94.8	94.5	89.7	85.3	80.9	76.5	71.7	66.8
18000 FT PRESS ALT		TAT (°C)											
KIAS	M	-25	-20	-15	-10	-5	0	5	10	15	20	25	30
360	0.75	84.1	83.9	83.7	83.5	83.3	83.1	82.9	82.7	82.5	81.5	78.1	74.4
320	0.67	89.8	89.5	89.3	89.1	88.9	88.7	88.4	88.2	86.2	82.2	78.2	74.4
280	0.59	92.9	92.7	92.4	92.2	92.0	91.7	91.5	89.5	85.7	81.6	77.5	73.3
240	0.51	92.0	91.8	91.5	91.3	91.1	90.8	89.1	85.1	80.9	76.8	72.5	67.6
200	0.42	94.3	94.1	93.9	93.6	93.4	92.0	87.5	83.2	78.9	74.5	69.6	64.8

ENGINE INOP

Max Continuous TPR
Based on anti-ice on or off
16000 FT to 5000 FT Pressure Altitudes

16000 FT PRESS ALT		TAT (°C)											
KIAS	M	-25	-20	-15	-10	-5	0	5	10	15	20	25	30
360	0.72	81.5	81.3	81.1	80.9	80.7	80.5	80.3	80.1	79.9	79.7	76.9	73.6
320	0.64	87.6	87.4	87.1	86.9	86.7	86.5	86.3	86.1	85.9	82.1	78.1	74.4
280	0.57	90.3	90.0	89.8	89.6	89.4	89.1	88.9	88.7	84.7	80.6	76.6	72.7
240	0.49	91.3	91.0	90.8	90.6	90.3	90.1	89.9	85.9	81.6	77.5	73.5	69.0
200	0.41	93.3	93.0	92.8	92.6	92.3	92.1	88.9	84.2	80.0	75.8	71.4	66.5
14000 FT PRESS ALT		TAT (°C)											
KIAS	M	-20	-15	-10	-5	0	5	10	15	20	25	30	35
360	0.69	79.5	79.3	79.1	78.9	78.7	78.5	78.3	78.2	78.0	76.9	74.0	70.6
320	0.62	84.9	84.7	84.5	84.3	84.1	83.9	83.7	83.5	81.8	77.9	74.2	70.6
280	0.54	88.0	87.8	87.6	87.3	87.1	86.9	86.7	84.8	80.2	76.3	72.5	68.7
240	0.47	90.2	89.9	89.7	89.5	89.3	89.0	87.8	82.3	78.3	74.4	70.5	65.8
200	0.39	92.1	91.9	91.7	91.4	91.2	90.9	85.5	81.2	77.1	73.0	68.4	63.7
12000 FT PRESS ALT		TAT (°C)											
KIAS	M	-15	-10	-5	0	5	10	15	20	25	30	35	40
360	0.67	75.4	75.2	75.0	74.8	74.7	74.5	74.3	74.1	73.9	72.8	70.2	67.0
320	0.60	82.7	82.5	82.3	82.1	81.9	81.7	81.5	81.2	77.8	74.0	70.5	67.0
280	0.52	86.2	86.0	85.8	85.6	85.4	85.1	84.9	80.8	76.4	72.7	69.1	65.0
240	0.45	89.1	88.9	88.6	88.4	88.2	87.9	84.4	79.1	75.2	71.4	67.4	62.9
200	0.38	91.4	91.1	90.9	90.7	90.4	88.8	82.3	78.3	74.4	70.3	65.7	61.2
10000 FT PRESS ALT		TAT (°C)											
KIAS	M	-15	-10	-5	0	5	10	15	20	25	30	35	40
360	0.65	71.7	71.5	71.4	71.2	71.0	70.8	70.7	70.5	70.3	69.5	67.3	65.3
320	0.58	79.4	79.2	79.0	78.8	78.6	78.4	78.2	78.0	76.7	72.7	69.2	65.8
280	0.51	82.5	82.3	82.1	81.9	81.7	81.5	81.3	80.6	76.6	72.9	69.4	65.9
240	0.43	85.2	85.0	84.8	84.6	84.4	84.1	83.9	80.3	76.4	72.7	69.0	64.8
200	0.36	86.9	86.7	86.5	86.3	86.0	85.8	83.9	80.2	76.3	72.4	68.3	63.7
5000 FT PRESS ALT		TAT (°C)											
KIAS	M	-10	-5	0	5	10	15	20	25	30	35	40	45
360	0.59	64.9	64.8	64.6	64.5	64.3	64.1	64.0	63.8	63.7	63.5	62.3	60.1
320	0.53	71.8	71.6	71.4	71.3	71.1	70.9	70.7	70.5	70.4	67.8	64.7	61.7
280	0.46	76.4	76.2	76.0	75.8	75.6	75.4	75.2	75.0	72.7	68.9	65.6	62.3
240	0.40	79.2	79.0	78.8	78.6	78.4	78.2	78.0	77.1	72.9	69.4	66.0	62.6
200	0.33	80.9	80.7	80.5	80.3	80.1	79.9	79.6	76.7	72.9	69.4	66.0	62.0

ENGINE INOP

MAX CONTINUOUS THRUST

Driftdown Speed/Level Off Altitude

100 ft/min residual rate of climb

Includes APU fuel burn

WEIGHT (1000 LB)		OPTIMUM DRIFTDOWN SPEED (KIAS)	LEVEL OFF PRESSURE ALTITUDE (FT)		
START DRIFT DOWN	LEVEL OFF		ISA + 10°C & BELOW	ISA + 15°C	ISA + 20°C
500	482	266	19100	17600	15500
480	463	261	20300	18900	17000
460	444	255	21500	20100	18400
440	425	250	22700	21100	19700
420	406	245	24000	22200	20800
400	388	239	25500	23400	21900
380	369	234	26600	24800	23300
360	349	227	27600	26200	24800
340	330	221	28800	27600	26400
320	310	214	30000	29000	27900
300	290	208	31600	30600	29400
280	271	201	33300	32300	31200
260	252	195	34900	34100	33000
240	233	188	36500	35900	35000

ENGINE INOP

MAX CONTINUOUS THRUST

Driftdown/LRC Cruise Range Capability

Ground to Air Miles Conversion

AIR DISTANCE (NM)					GROUND DISTANCE (NM)	AIR DISTANCE (NM)				
HEADWIND COMPONENT (KTS)						TAILWIND COMPONENT (KTS)				
100	80	60	40	20		20	40	60	80	100
136	127	119	112	105	100	94	90	86	82	78
273	255	238	224	211	200	189	180	172	164	157
411	382	358	336	317	300	284	270	258	246	236
548	510	477	448	422	400	379	360	344	328	314
686	638	597	560	528	500	474	451	430	410	393
823	766	716	673	634	600	569	541	515	492	471
961	894	836	785	740	700	663	631	601	574	550
1099	1022	956	897	846	800	758	721	687	656	628
1236	1150	1075	1010	951	900	853	811	773	738	707
1374	1278	1195	1122	1057	1000	948	901	859	820	785
1512	1407	1315	1234	1163	1100	1043	991	945	902	864
1650	1535	1435	1347	1269	1200	1137	1081	1031	984	942
1788	1663	1554	1459	1375	1300	1232	1171	1116	1066	1021
1926	1791	1674	1571	1480	1400	1327	1262	1202	1148	1099
2064	1919	1794	1684	1586	1500	1422	1352	1288	1230	1177
2202	2048	1914	1796	1692	1600	1517	1442	1374	1312	1256
2340	2176	2033	1908	1798	1700	1611	1532	1460	1394	1334
2477	2304	2153	2021	1904	1800	1706	1622	1546	1476	1413

Driftdown/Cruise Fuel and Time

AIR DIST (NM)	FUEL REQUIRED (1000 LB)								TIME (HR:MIN)
	WEIGHT AT START OF DRIFTDOWN (1000 LB)								
	220	260	300	340	380	420	460	500	
100	1.4	1.4	1.5	1.6	1.7	1.8	2.0	2.1	0:16
200	3.0	3.2	3.5	3.7	4.0	4.4	4.8	5.1	0:32
300	4.7	5.2	5.7	6.1	6.7	7.3	7.9	8.5	0:49
400	6.5	7.3	7.9	8.6	9.5	10.4	11.2	12.1	1:05
500	8.1	9.1	10.2	11.1	12.3	13.5	14.6	15.7	1:21
600	9.7	11.0	12.3	13.5	14.9	16.5	17.9	19.3	1:38
700	11.2	12.8	14.4	15.8	17.5	19.3	21.0	22.6	1:54
800	12.8	14.6	16.4	18.1	20.0	22.1	24.0	25.9	2:11
900	14.4	16.4	18.5	20.4	22.5	24.9	27.0	29.1	2:27
1000	15.9	18.2	20.5	22.6	25.0	27.6	30.0	32.4	2:44
1100	17.4	20.0	22.5	24.9	27.5	30.3	33.0	35.6	3:00
1200	18.9	21.7	24.5	27.1	30.0	33.1	35.9	38.8	3:17
1300	20.5	23.5	26.5	29.3	32.5	35.8	38.9	41.9	3:33
1400	22.0	25.2	28.4	31.5	34.9	38.4	41.8	45.1	3:50
1500	23.4	26.9	30.4	33.7	37.3	41.1	44.7	48.2	4:06
1600	24.9	28.6	32.3	35.9	39.7	43.8	47.6	51.4	4:23
1700	26.4	30.3	34.3	38.1	42.1	46.4	50.4	54.5	4:39
1800	27.9	32.0	36.2	40.2	44.5	49.0	53.3	57.6	4:55

Includes APU fuel burn.
Driftdown at optimum driftdown speed and cruise at Long Range Cruise speed.

ENGINE INOP

MAX CONTINUOUS THRUST

Long Range Cruise Altitude Capability

100 ft/min residual rate of climb

WEIGHT (1000 LB)	PRESSURE ALTITUDE (FT)		
	ISA + 10°C & BELOW	ISA + 15°C	ISA + 20°C
500	16800	14200	9300
480	18300	16300	12200
460	19700	18300	14800
440	21000	19800	17500
420	22300	21000	19400
400	23700	22100	20800
380	25100	23300	21900
360	26400	24500	23200
340	27500	25900	24500
320	28600	27300	26000
300	29900	28800	27600
280	31600	30500	29300
260	33400	32400	31100
240	35200	34400	33200
220	36900	36200	35300

With anti-ice on, no altitude capability adjustment is required.

ENGINE INOP

MAX CONTINUOUS THRUST

Long Range Cruise Control

WEIGHT (1000 LB)		PRESSURE ALTITUDE (1000 FT)									
		10	15	17	19	21	23	25	27	29	31
500	TPR	67.5	77.2	82.5							
	MACH	.552	.586	.604							
	KIAS	306	296	294							
	FF/ENG	12847	12566	12643							
460	TPR	63.6	72.8	76.9	82.2	89.1					
	MACH	.535	.573	.585	.603	.630					
	KIAS	297	290	285	283	284					
	FF/ENG	11865	11648	11521	11595	11998					
420	TPR	59.7	68.2	72.2	76.2	81.6	88.5				
	MACH	.517	.556	.572	.584	.602	.627				
	KIAS	287	281	278	273	271	271				
	FF/ENG	10896	10692	10622	10486	10541	10890				
380	TPR	55.5	63.5	67.1	71.1	75.1	80.3	86.8			
	MACH	.496	.536	.553	.569	.581	.598	.623			
	KIAS	275	271	268	266	261	258	258			
	FF/ENG	9893	9724	9647	9601	9468	9485	9733			
340	TPR	51.0	58.8	62.0	65.6	69.5	73.6	78.3	84.8		
	MACH	.473	.515	.531	.547	.564	.577	.592	.615		
	KIAS	261	259	257	255	253	249	245	244		
	FF/ENG	8879	8772	8687	8611	8570	8471	8421	8607		
300	TPR	46.5	53.6	56.8	60.0	63.5	67.3	71.4	75.9	81.9	90.0
	MACH	.446	.488	.505	.522	.539	.556	.572	.585	.605	.634
	KIAS	247	246	245	243	241	239	236	232	230	231
	FF/ENG	7872	7774	7734	7667	7598	7554	7490	7410	7496	7831
260	TPR	41.8	48.1	51.1	54.2	57.5	60.8	64.4	68.5	72.8	78.0
	MACH	.418	.458	.475	.492	.510	.527	.544	.562	.576	.592
	KIAS	231	230	230	229	228	226	224	222	219	215
	FF/ENG	6877	6772	6747	6711	6668	6609	6548	6509	6443	6427
220	TPR	37.1	42.5	45.1	47.9	50.8	54.0	57.3	60.7	64.6	68.9
	MACH	.387	.424	.440	.457	.475	.493	.511	.529	.546	.565
	KIAS	213	213	212	212	212	211	210	208	207	205
	FF/ENG	5900	5776	5809	5787	5701	5663	5626	5574	5527	5498

ENGINE INOP

MAX CONTINUOUS THRUST

Long Range Cruise Diversion Fuel and Time

Ground to Air Miles Conversion

AIR DISTANCE (NM) HEADWIND COMPONENT (KTS)					GROUND DISTANCE (NM)	AIR DISTANCE (NM) TAILWIND COMPONENT (KTS)				
100	80	60	40	20		20	40	60	80	100
289	266	245	228	213	200	191	182	174	167	161
582	535	493	458	427	400	381	363	347	332	319
877	805	741	687	641	600	571	544	519	497	477
1173	1076	990	917	855	800	761	725	692	661	634
1470	1347	1239	1148	1070	1000	951	905	864	826	792
1768	1619	1488	1378	1284	1200	1141	1086	1035	990	949
2067	1892	1738	1609	1499	1400	1330	1266	1207	1154	1106
2367	2166	1989	1840	1713	1600	1520	1446	1379	1318	1263
2669	2441	2240	2072	1928	1800	1709	1626	1550	1481	1419

Reference Fuel and Time Required at Check Point

AIR DIST (NM)	PRESSURE ALTITUDE (1000 FT)									
	10		14		18		22		26	
	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)
200	6.1	0:40	5.4	0:38	4.9	0:37	4.4	0:35	4.1	0:33
400	12.5	1:19	11.5	1:15	10.5	1:11	9.8	1:09	9.4	1:05
600	18.8	1:57	17.4	1:51	16.1	1:46	15.1	1:43	14.5	1:37
800	25.1	2:36	23.3	2:28	21.7	2:22	20.3	2:17	19.7	2:09
1000	31.4	3:15	29.2	3:05	27.2	2:57	25.6	2:51	24.7	2:42
1200	37.6	3:55	35.0	3:43	32.7	3:33	30.7	3:25	29.7	3:14
1400	43.7	4:35	40.8	4:20	38.1	4:09	35.8	4:00	34.6	3:47
1600	49.8	5:15	46.5	4:58	43.5	4:45	40.9	4:34	39.5	4:20
1800	55.8	5:55	52.2	5:36	48.8	5:21	46.0	5:09	44.3	4:54

Fuel Required Adjustment (1000 LB)

REFERENCE FUEL REQUIRED (1000 LB)	WEIGHT AT CHECK POINT (1000 LB)							
	220	260	300	340	380	420	460	500
5	-0.8	-0.6	-0.4	-0.2	0.0	0.4	0.7	1.1
10	-1.9	-1.4	-0.9	-0.5	0.0	0.9	1.9	2.8
15	-2.9	-2.2	-1.4	-0.7	0.0	1.5	3.1	4.6
20	-4.0	-3.0	-2.0	-1.0	0.0	2.0	4.2	6.3
25	-5.0	-3.8	-2.5	-1.2	0.0	2.5	5.3	8.0
30	-6.1	-4.6	-3.0	-1.5	0.0	3.0	6.4	9.7
35	-7.2	-5.4	-3.5	-1.8	0.0	3.5	7.4	11.3
40	-8.2	-6.1	-4.1	-2.0	0.0	4.0	8.5	12.9
45	-9.3	-6.9	-4.6	-2.3	0.0	4.5	9.5	14.5
50	-10.3	-7.7	-5.1	-2.6	0.0	4.9	10.5	16.1
55	-11.4	-8.5	-5.6	-2.8	0.0	5.4	11.5	17.7
60	-12.5	-9.3	-6.2	-3.1	0.0	5.8	12.4	19.3

Includes APU fuel burn.

ENGINE INOP

MAX CONTINUOUS THRUST

Holding

Flaps Up

WEIGHT (1000 LB)		PRESSURE ALTITUDE (FT)						
		1500	5000	10000	15000	20000	25000	30000
500	TPR	48.6	53.8	62.6	73.8	90.0		
	KIAS	244	249	259	266	269		
	FF/ENG	11520	11540	11710	12010	12820		
460	TPR	45.4	50.3	58.3	68.7	82.1		
	KIAS	236	237	244	256	258		
	FF/ENG	10600	10560	10630	10910	11330		
420	TPR	42.3	46.6	54.1	63.4	75.3	93.2	
	KIAS	229	230	230	239	245	247	
	FF/ENG	9720	9660	9630	9790	10070	10860	
380	TPR	39.1	43.1	49.9	58.2	69.0	83.1	
	KIAS	222	222	223	223	233	235	
	FF/ENG	8850	8770	8720	8730	8950	9320	
340	TPR	36.0	39.5	45.7	53.2	62.7	74.6	
	KIAS	214	215	215	215	216	221	
	FF/ENG	7990	7920	7840	7820	7890	8050	
300	TPR	32.8	36.0	41.5	48.2	56.7	67.0	81.7
	KIAS	206	206	206	207	207	208	209
	FF/ENG	7170	7080	6990	6940	7000	6980	7300
260	TPR	29.8	32.6	37.5	43.4	50.8	59.8	71.6
	KIAS	198	198	198	198	198	198	198
	FF/ENG	6400	6290	6190	6110	6150	6080	6170
220	TPR	26.6	29.1	33.4	38.7	45.2	52.9	63.0
	KIAS	188	188	188	188	188	188	188
	FF/ENG	5630	5520	5400	5360	5400	5240	5260

This table includes 5% additional fuel for holding in a racetrack pattern.

ENGINE INOP

ADVISORY INFORMATION

Gear Down Landing Rate of Climb Available

Flaps 20

TAT (°C)	RATE OF CLIMB (FT/MIN)						
	PRESSURE ALTITUDE (FT)						
	-2000	0	2000	4000	6000	8000	10000
52	230	190					
50	260	230	90				
48	300	270	130	-10			
46	340	310	170	30			
44	370	340	210	70			
42	410	380	240	110	-50		
40	440	420	280	150	-10		
38	480	460	320	180	30	-100	
36	500	490	350	210	60	-70	
34	510	530	390	250	100	-30	-200
32	510	550	420	280	130	0	-160
30	510	550	450	310	160	30	-130
20	520	560	480	390	290	170	10
10	540	580	490	390	300	190	70
0	550	590	500	410	300	200	70
-20	580	620	530	430	320	210	80
-40	620	660	560	450	340	230	90

Rate of climb capability shown is valid for 370000 lb, gear down at VREF20+5.
Decrease rate of climb 40 ft/min per 10000 lb greater than 370000 lb.
Increase rate of climb 60 ft/min per 10000 lb less than 370000 lb.

Flaps 30

TAT (°C)	RATE OF CLIMB (FT/MIN)						
	PRESSURE ALTITUDE (FT)						
	-2000	0	2000	4000	6000	8000	10000
52	50	0					
50	80	40	-100				
48	120	80	-60	-200			
46	150	120	-20	-160			
44	190	160	20	-120			
42	220	190	50	-80	-240		
40	260	230	90	-50	-200		
38	290	260	120	-10	-170	-300	
36	320	300	160	20	-130	-260	
34	320	340	190	50	-100	-230	-390
32	320	360	220	80	-70	-200	-360
30	320	360	250	110	-40	-170	-330
20	330	370	270	180	80	-40	-200
10	340	380	280	190	90	-10	-140
0	350	390	290	200	90	-10	-140
-20	370	410	310	210	100	-10	-140
-40	400	440	330	220	110	0	-140

Rate of climb capability shown is valid for 370000 lb, gear down at VREF30+5.
Decrease rate of climb 40 ft/min per 10000 lb greater than 370000 lb.
Increase rate of climb 60 ft/min per 10000 lb less than 370000 lb.

Intentionally
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ALTERNATE MODE EEC

Limit Weight

PERFORMANCE LIMIT	ALTERNATE MODE EEC LIMIT WEIGHT (1000 LB)							
	PRIMARY MODE PERFORMANCE LIMIT WEIGHT (1000 LB)							
	260	300	340	380	420	460	500	540
FIELD	256.8	295.3	333.8	372.4	410.9	449.4	488.0	526.5
CLIMB	255.6	294.3	333.0	371.7	410.4	449.1	487.8	526.5
OBSTACLE	254.3	292.8	331.4	370.0	408.5	447.1	485.7	524.2
NET LEVEL OFF WEIGHT	253.1	293.3	333.6	373.9	414.1	454.4	494.6	534.9
LANDING CLIMB	258.5	295.9	333.4	370.8	408.3	445.7	483.2	520.6

Max Takeoff %N1

Based on anti-ice on or off

AIRPORT OAT		AIRPORT PRESSURE ALTITUDE (1000 FT)												
°C	°F	-2	-1	0	1	2	3	4	5	6	7	8	9	10
70	158	81.2	81.8	82.4	81.9	81.3	80.7	80.2	79.6	78.6	78.2	77.2	76.1	74.9
60	140	84.8	85.6	86.3	85.9	85.6	85.1	84.8	84.5	83.8	83.6	82.9	82.0	81.1
55	131	86.5	87.3	88.0	87.7	87.4	87.0	86.8	86.5	85.8	85.7	85.2	84.4	83.7
50	122	88.1	89.0	89.7	89.4	89.1	88.8	88.6	88.4	87.8	87.7	87.2	86.6	85.9
45	113	89.4	90.4	91.3	91.1	90.8	90.5	90.3	90.1	89.6	89.6	89.2	88.6	87.9
40	104	90.4	91.4	92.3	92.2	92.1	91.9	91.8	91.6	91.2	91.2	90.8	90.3	89.8
35	95	91.3	92.3	93.3	93.2	93.1	93.0	93.0	93.0	92.6	92.6	92.3	91.8	91.3
30	86	91.0	92.6	94.3	94.2	94.1	94.0	94.0	94.1	93.7	94.0	93.7	93.3	92.8
25	77	90.3	91.9	93.6	94.1	94.6	94.8	94.9	94.9	94.8	95.0	94.9	94.6	94.3
20	68	89.6	91.3	92.9	93.4	93.9	94.4	95.1	95.7	95.6	95.8	95.7	95.5	95.3
15	59	88.9	90.6	92.2	92.7	93.2	93.7	94.4	95.0	95.4	96.1	96.3	96.1	95.9
10	50	88.3	89.9	91.5	92.0	92.5	93.0	93.6	94.3	94.7	95.4	95.8	96.1	96.4
5	41	87.6	89.2	90.8	91.3	91.8	92.3	92.9	93.5	93.9	94.6	95.0	95.4	95.7
0	32	86.9	88.5	90.1	90.6	91.1	91.5	92.2	92.8	93.2	93.9	94.3	94.6	94.9
-10	14	85.4	87.0	88.6	89.1	89.6	90.0	90.7	91.3	91.7	92.3	92.8	93.1	93.4
-20	-4	84.0	85.5	87.1	87.6	88.0	88.5	89.1	89.7	90.1	90.8	91.2	91.5	91.8
-30	-22	82.4	84.0	85.6	86.0	86.5	86.9	87.5	88.1	88.5	89.2	89.6	89.9	90.2
-40	-40	80.9	82.4	84.0	84.4	84.9	85.3	85.9	86.5	86.8	87.5	87.9	88.2	88.5
-50	-58	79.3	80.8	82.3	82.8	83.2	83.6	84.2	84.8	85.1	85.8	86.2	86.5	86.8

ALTERNATE MODE EEC

Max Climb %N1

Based on anti-ice on or off

TAT (°C)	PRESSURE ALTITUDE (FT) / SPEED (KIAS OR MACH)									
	0	5000	10000	15000	20000	25000	30000	35000	40000	43000
	310	310	310	310	310	310	310	.85	.85	.85
60	81.8	82.2	84.1	87.4	89.2	91.8	94.6	98.2	97.3	96.7
50	85.0	85.1	84.8	86.0	87.9	90.4	93.1	96.7	95.8	95.3
40	87.4	88.1	87.8	87.9	87.2	89.0	91.7	95.2	94.3	93.8
30	86.9	90.4	90.4	90.9	90.2	90.2	90.7	93.7	92.8	92.3
20	85.7	89.0	91.7	93.1	92.9	92.8	93.2	93.2	91.4	91.0
15	85.0	88.3	91.0	93.9	93.9	94.0	94.3	94.1	92.4	92.0
10	84.4	87.6	90.3	93.2	95.1	95.1	95.5	95.1	93.4	93.0
5	83.7	86.9	89.5	92.5	94.8	96.1	96.4	96.1	94.5	94.0
0	83.0	86.2	88.8	91.7	94.0	96.2	97.2	97.1	95.6	95.0
-5	82.4	85.5	88.1	91.0	93.3	95.4	97.4	98.0	96.6	96.1
-10	81.7	84.8	87.3	90.2	92.5	94.6	96.6	99.2	97.7	97.3
-15	81.0	84.1	86.6	89.4	91.7	93.8	95.7	99.0	98.4	98.0
-20	80.2	83.3	85.8	88.7	90.9	93.0	94.9	98.1	97.6	97.1
-25	79.5	82.6	85.0	87.9	90.1	92.1	94.1	97.3	96.7	96.3
-30	78.8	81.8	84.3	87.1	89.3	91.3	93.2	96.4	95.9	95.4
-35	78.1	81.0	83.5	86.2	88.4	90.4	92.4	95.5	95.0	94.6
-40	77.3	80.3	82.6	85.4	87.6	89.6	91.5	94.6	94.1	93.7

Max Cruise %N1

Based on anti-ice on or off

TAT (°C)	PRESSURE ALTITUDE (FT)				
	25000	30000	35000	40000	43000
30	88.4	88.9	92.0	91.0	90.5
20	90.9	91.3	91.4	89.7	89.2
15	91.9	92.3	92.1	90.7	90.2
10	92.7	93.1	92.8	91.4	91.0
5	93.4	93.8	93.5	92.2	91.8
0	93.3	94.3	94.2	92.9	92.5
-5	92.6	94.3	94.8	93.6	93.2
-10	91.8	93.5	95.4	94.3	94.0
-15	91.0	92.7	95.0	94.6	94.3
-20	90.2	91.8	94.2	93.8	93.4
-25	89.3	91.0	93.3	92.9	92.6
-30	88.5	90.2	92.5	92.1	91.8
-35	87.7	89.3	91.6	91.2	90.9

ALTERNATE MODE EEC

Go-Around %N1

Based on anti-ice on or off

AIRPORT OAT		TAT (°C)	PRESSURE ALTITUDE (FT)											
°C	°F		-2000	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
66	150	70	82.9	84.2	83.8	83.3	82.8	82.4	82.0	81.0	80.6	79.9	78.9	77.8
56	133	60	86.3	87.8	87.5	87.1	86.8	86.5	86.2	85.5	85.3	84.8	84.0	83.2
51	124	55	87.9	89.5	89.2	88.8	88.5	88.3	88.1	87.4	87.4	86.9	86.2	85.4
46	115	50	89.3	91.0	90.8	90.5	90.2	90.0	89.8	89.2	89.2	88.8	88.2	87.5
41	106	45	90.3	92.1	92.1	92.0	91.7	91.6	91.4	90.8	90.8	90.5	89.9	89.3
36	97	40	91.2	93.1	93.0	93.0	92.8	92.9	92.8	92.2	92.3	91.9	91.4	90.9
31	88	35	91.2	94.0	94.0	93.9	93.8	93.9	93.9	93.4	93.6	93.4	92.9	92.3
26	79	30	90.6	93.7	94.3	94.8	94.7	94.8	94.8	94.5	94.7	94.6	94.2	93.8
21	70	25	89.9	93.0	93.7	94.2	94.7	95.4	95.7	95.5	95.7	95.6	95.3	95.0
16	61	20	89.2	92.4	93.0	93.5	94.0	94.7	95.3	95.8	96.4	96.3	96.1	95.8
11	53	15	88.6	91.7	92.3	92.8	93.3	94.0	94.6	95.0	95.7	96.2	96.5	96.5
7	44	10	87.9	91.0	91.6	92.1	92.6	93.3	93.9	94.3	95.0	95.5	95.8	96.1
2	35	5	87.2	90.3	90.8	91.4	91.9	92.5	93.2	93.6	94.3	94.7	95.1	95.4
-3	26	0	86.5	89.5	90.1	90.7	91.1	91.8	92.4	92.8	93.5	94.0	94.3	94.6
-13	8	-10	85.1	88.1	88.6	89.2	89.7	90.3	90.9	91.3	92.0	92.5	92.8	93.1
-23	-10	-20	83.6	86.6	87.1	87.6	88.1	88.7	89.4	89.8	90.5	90.9	91.2	91.5
-33	-27	-30	82.1	85.0	85.6	86.1	86.5	87.1	87.8	88.2	88.9	89.3	89.6	89.9
-43	-45	-40	80.5	83.4	84.0	84.5	84.9	85.5	86.1	86.5	87.2	87.6	87.9	88.2
-53	-63	-50	78.9	81.8	82.3	82.8	83.2	83.8	84.4	84.8	85.5	85.9	86.2	86.5

Intentionally
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Performance Inflight — Chapter PI

Alternate Mode EEC, Engine Inoperative — Section 15

ALTERNATE MODE EEC

ENGINE INOP

Initial Max Continuous %N1

Based on .85M and anti-ice on or off

TAT (°C)	PRESSURE ALTITUDE (1000 FT)								
	27	29	31	33	35	37	39	41	43
20	93.4	93.5	93.6	93.5	93.2	92.1	91.6	91.3	91.0
15	94.2	94.4	94.5	94.6	94.1	93.1	92.6	92.3	92.0
10	95.2	95.4	95.5	95.5	95.1	94.0	93.6	93.3	93.0
5	95.5	96.3	96.5	96.5	96.1	95.1	94.7	94.4	94.0
0	94.7	96.5	97.4	97.6	97.1	96.1	95.8	95.5	95.1
-5	94.0	95.7	97.4	98.5	98.1	97.0	96.8	96.5	96.2
-10	93.2	94.9	96.6	98.3	99.3	98.2	98.0	97.9	97.7
-15	92.4	94.1	95.7	97.4	99.0	99.2	99.2	99.2	99.3
-20	91.5	93.2	94.9	96.6	98.1	98.4	98.3	98.4	98.5
-25	90.7	92.4	94.1	95.8	97.3	97.5	97.5	97.5	97.6
-30	89.9	91.6	93.2	94.9	96.4	96.6	96.6	96.7	96.7
-35	89.0	90.7	92.4	94.1	95.5	95.8	95.7	95.8	95.9
-40	88.2	89.8	91.5	93.2	94.7	94.9	94.8	94.9	95.0

ALTERNATE MODE EEC
ENGINE INOP

Max Continuous %N1
Based on anti-ice on or off

320 KIAS

TAT (°C)	AIRPORT PRESSURE ALTITUDE (1000 FT)															
	5	10	12	14	16	18	20	22	24	25	27	29	31	33	35	37
30	90.6	92.0	92.7	92.9	93.1	93.2	93.3	92.5	91.8	91.5	91.2	91.1	91.3	91.2	90.4	89.3
25	90.0	93.0	93.5	93.7	93.9	94.1	94.3	93.6	93.0	92.8	92.7	92.5	92.5	92.3	91.6	90.4
20	89.3	92.8	94.3	94.6	94.9	95.0	95.2	94.5	93.9	93.7	93.7	93.6	93.5	93.3	92.5	91.4
15	88.6	92.0	93.6	94.6	95.8	96.0	96.2	95.5	94.9	94.7	94.6	94.5	94.5	94.3	93.5	92.3
10	87.9	91.3	92.9	93.9	95.0	96.1	97.1	96.8	96.1	95.7	95.5	95.5	95.4	95.2	94.5	93.1
5	87.2	90.6	92.1	93.1	94.3	95.4	96.3	97.0	97.9	97.9	97.2	96.4	96.4	96.2	95.4	94.0
0	86.5	89.9	91.4	92.4	93.5	94.6	95.6	96.3	97.1	97.5	98.1	97.5	97.3	97.1	96.2	94.8
-5	85.8	89.1	90.6	91.6	92.8	93.8	94.8	95.5	96.3	96.7	97.3	96.7	97.2	97.5	97.1	95.6
-10	85.1	88.4	89.9	90.8	92.0	93.0	94.0	94.7	95.5	95.9	96.5	95.9	96.4	96.7	96.4	94.8
-15	84.3	87.6	89.1	90.1	91.2	92.2	93.2	93.9	94.7	95.1	95.7	95.1	95.5	95.9	95.6	93.9
-20	83.6	86.8	88.3	89.3	90.4	91.4	92.4	93.0	93.8	94.3	94.8	94.3	94.7	95.0	94.7	93.1
-25	82.8	86.0	87.5	88.5	89.6	90.6	91.5	92.2	93.0	93.5	94.0	93.4	93.9	94.2	93.9	92.3
-30	82.1	85.3	86.7	87.7	88.8	89.8	90.7	91.4	92.1	92.6	93.2	92.6	93.0	93.3	93.0	91.4
-35	81.3	84.5	85.9	86.9	88.0	89.0	89.9	90.5	91.3	91.8	92.3	91.7	92.2	92.5	92.2	90.5
-40	80.5	83.6	85.1	86.0	87.1	88.1	89.0	89.6	90.4	90.9	91.4	90.9	91.3	91.6	91.3	89.7

280 KIAS

TAT (°C)	AIRPORT PRESSURE ALTITUDE (1000 FT)															
	5	10	12	14	16	18	20	22	24	25	27	29	31	33	35	37
30	91.3	91.7	91.7	91.7	91.9	92.3	92.1	90.8	89.9	89.5	89.7	90.1	91.2	92.6	93.7	93.2
25	91.6	92.6	92.6	92.6	92.9	93.4	93.5	92.3	91.4	91.1	90.6	89.9	90.5	91.9	92.9	92.5
20	91.0	93.6	93.7	93.6	93.8	94.4	94.5	93.4	92.7	92.5	92.0	91.4	91.5	92.0	92.4	92.1
15	90.3	93.1	94.8	94.9	94.9	95.5	95.7	94.5	93.8	93.5	93.2	92.7	92.7	93.1	93.3	93.0
10	89.6	92.4	94.1	94.9	95.9	96.4	96.7	95.6	94.9	94.6	94.3	93.8	93.9	94.1	94.3	94.0
5	88.9	91.6	93.4	94.2	95.2	96.5	97.6	96.9	96.0	95.8	95.4	94.9	95.0	95.2	95.3	95.0
0	88.1	90.9	92.6	93.4	94.4	95.7	96.9	97.7	97.9	97.5	96.6	95.9	96.0	96.2	96.3	96.1
-5	87.4	90.2	91.9	92.7	93.7	94.9	96.2	96.9	97.6	98.0	98.3	97.1	96.9	97.2	97.2	97.0
-10	86.7	89.4	91.1	91.9	92.9	94.1	95.4	96.1	96.8	97.2	97.5	97.1	97.6	98.1	98.3	98.2
-15	85.9	88.6	90.3	91.1	92.1	93.3	94.6	95.3	96.0	96.4	96.7	96.3	96.8	97.9	98.9	98.9
-20	85.2	87.9	89.5	90.3	91.3	92.5	93.8	94.5	95.2	95.6	95.9	95.5	96.0	97.0	98.1	98.1
-25	84.4	87.1	88.8	89.5	90.5	91.7	92.9	93.7	94.3	94.8	95.0	94.7	95.1	96.2	97.2	97.2
-30	83.6	86.3	87.9	88.7	89.7	90.9	92.1	92.8	93.5	93.9	94.2	93.8	94.3	95.4	96.4	96.4
-35	82.8	85.5	87.1	87.9	88.8	90.0	91.3	92.0	92.6	93.1	93.3	93.0	93.4	94.5	95.5	95.5
-40	82.0	84.7	86.3	87.0	88.0	89.2	90.4	91.1	91.8	92.2	92.4	92.1	92.5	93.6	94.6	94.6

ALTERNATE MODE EEC
ENGINE INOP

Max Continuous %N1
Based on anti-ice on or off
240 KIAS

TAT (°C)	AIRPORT PRESSURE ALTITUDE (1000 FT)															
	5	10	12	14	16	18	20	22	24	25	27	29	31	33	35	37
30	91.0	91.2	90.7	90.3	89.7	89.2	88.5	88.2	89.0	89.2	89.6	90.2	91.2	92.5	93.4	93.4
25	92.2	92.1	91.7	91.4	91.1	90.7	90.1	89.1	88.5	88.5	88.9	89.4	90.4	91.8	92.7	92.6
20	91.9	93.1	92.6	92.4	92.1	91.9	91.5	90.6	90.1	89.7	88.9	88.7	89.7	91.0	91.9	91.8
15	91.2	93.9	94.2	93.4	93.1	92.9	92.6	91.8	91.5	91.2	90.4	89.7	89.5	90.2	91.1	91.1
10	90.5	93.2	95.0	95.1	94.2	94.0	93.7	92.9	92.6	92.3	91.7	91.1	90.8	91.1	91.1	91.0
5	89.7	92.5	94.3	94.8	95.3	95.0	94.8	94.1	93.8	93.5	92.9	92.3	92.0	92.1	92.1	92.1
0	89.0	91.7	93.5	94.0	94.5	94.9	96.2	95.4	95.0	94.7	94.1	93.6	93.3	93.3	93.2	93.1
-5	88.3	91.0	92.8	93.2	93.7	94.2	95.6	96.2	97.1	96.6	95.3	94.7	94.5	94.4	94.4	94.3
-10	87.6	90.2	92.0	92.5	93.0	93.4	94.8	95.4	97.1	97.8	97.7	95.9	95.5	95.5	95.5	95.4
-15	86.8	89.4	91.2	91.7	92.2	92.6	94.0	94.6	96.3	97.0	97.3	96.7	96.6	96.6	96.5	96.5
-20	86.0	88.7	90.4	90.9	91.4	91.8	93.2	93.8	95.5	96.2	96.5	95.9	96.1	97.3	97.8	97.7
-25	85.3	87.9	89.6	90.1	90.6	91.0	92.4	93.0	94.7	95.4	95.7	95.0	95.3	96.4	97.4	97.5
-30	84.5	87.1	88.8	89.3	89.8	90.2	91.6	92.2	93.8	94.6	94.9	94.2	94.5	95.6	96.6	96.6
-35	83.7	86.3	88.0	88.5	88.9	89.4	90.7	91.3	93.0	93.7	94.0	93.3	93.6	94.7	95.7	95.8
-40	82.9	85.5	87.2	87.6	88.1	88.5	89.9	90.5	92.1	92.9	93.2	92.5	92.8	93.9	94.8	94.9

200 KIAS

TAT (°C)	AIRPORT PRESSURE ALTITUDE (1000 FT)															
	5	10	12	14	16	18	20	22	24	25	27	29	31	33	35	37
30	90.7	90.6	89.7	88.9	88.0	87.3	87.6	87.8	88.6	88.9	89.7	90.3	91.2	92.4	93.3	93.3
25	91.7	91.6	90.9	90.3	89.6	88.9	87.6	87.0	87.8	88.2	88.9	89.6	90.4	91.7	92.5	92.5
20	92.2	92.6	91.9	91.4	90.9	90.4	89.2	87.8	87.2	87.5	88.2	88.8	89.7	90.9	91.7	91.7
15	91.5	93.5	92.9	92.5	92.0	91.6	90.6	89.1	88.7	88.4	87.7	88.0	88.9	90.1	90.9	90.9
10	90.8	93.5	95.0	93.6	93.1	92.7	91.8	90.3	90.0	89.7	89.1	88.4	88.1	89.3	90.1	90.1
5	90.1	92.8	94.9	95.2	94.4	93.8	92.9	91.4	91.1	91.0	90.4	89.7	89.4	89.4	89.3	89.3
0	89.4	92.1	94.1	94.5	95.0	95.0	94.1	92.6	92.3	92.2	91.7	91.0	90.6	90.5	90.3	90.0
-5	88.7	91.3	93.4	93.7	94.2	94.8	95.4	93.9	93.5	93.4	93.0	92.3	91.8	91.7	91.5	91.2
-10	87.9	90.6	92.6	92.9	93.4	94.0	94.6	94.4	95.5	95.2	94.1	93.5	93.1	92.9	92.8	92.4
-15	87.2	89.8	91.8	92.1	92.6	93.2	93.9	93.6	95.3	96.3	96.4	94.7	94.2	94.1	94.1	93.7
-20	86.4	89.0	91.0	91.4	91.9	92.4	93.1	92.8	94.5	95.5	96.3	95.8	95.3	95.3	95.3	94.9
-25	85.6	88.2	90.2	90.6	91.1	91.6	92.2	92.0	93.7	94.6	95.5	95.0	95.3	96.6	96.5	96.1
-30	84.9	87.4	89.4	89.7	90.2	90.8	91.4	91.2	92.9	93.8	94.7	94.1	94.5	95.8	96.6	96.7
-35	84.1	86.6	88.6	88.9	89.4	90.0	90.6	90.3	92.0	93.0	93.8	93.3	93.7	94.9	95.8	95.8
-40	83.3	85.8	87.8	88.1	88.6	89.1	89.7	89.5	91.2	92.2	93.0	92.4	92.8	94.1	94.9	94.9

Intentionally
Blank

GEAR DOWN

220 KIAS Max Climb TPR

TAT (°C)	PRESSURE ALTITUDE (1000 FT)														
	0	5	10	12	14	16	18	20	22	24	26	28	30	32	34
55	51.4	52.4	55.9	56.2	53.3	50.2	62.1	63.3	64.0	65.4	67.0	68.1	69.2	71.8	74.5
50	54.6	54.7	55.9	56.2	57.3	54.1	62.1	63.3	64.0	65.4	67.0	68.1	69.2	71.8	74.5
45	58.3	58.1	55.9	56.2	58.3	58.0	62.1	63.3	64.0	65.4	67.0	68.1	69.2	71.8	74.5
40	61.7	62.0	59.8	57.6	58.3	60.2	62.1	63.3	64.0	65.4	67.0	68.1	69.2	71.8	74.5
35	65.1	66.1	63.7	62.0	61.1	60.3	62.1	63.3	64.0	65.4	67.0	68.1	69.2	71.8	74.5
30	68.0	69.8	68.1	66.3	65.3	64.5	63.8	63.3	64.0	65.4	67.0	68.1	69.2	71.8	74.5
25	68.2	74.1	72.5	70.5	69.6	68.7	68.1	66.6	64.6	65.4	67.0	68.1	69.2	71.8	74.5
20	68.4	76.4	76.3	74.6	73.9	73.1	72.4	70.9	68.9	68.0	67.0	68.1	69.2	71.8	74.5
15	68.6	76.6	80.7	78.6	78.1	77.6	76.9	75.3	73.1	72.4	71.6	70.1	69.2	71.8	74.5
10	68.8	76.8	81.7	82.7	82.2	81.7	81.3	79.8	77.4	77.0	76.4	74.8	73.3	73.4	74.5
5	68.9	77.0	81.9	82.9	84.5	85.8	85.6	84.2	81.7	81.7	81.3	79.6	78.0	78.0	78.3
0	69.1	77.2	82.2	83.1	84.7	86.8	89.5	88.8	86.2	86.2	86.3	84.6	83.0	82.6	82.8
-5	69.3	77.4	82.4	83.3	85.0	87.1	89.7	91.3	91.0	90.7	90.9	89.6	88.1	87.5	87.3
-10	69.5	77.6	82.6	83.5	85.2	87.3	89.9	91.6	91.9	94.2	95.2	94.0	92.7	92.4	92.0
-15	69.7	77.8	82.8	83.7	85.4	87.5	90.1	91.8	92.1	94.5	97.0	98.1	97.0	96.7	96.4
-20	69.8	78.0	83.0	84.0	85.6	87.8	90.4	92.0	92.3	94.7	97.2	98.3	99.4	101.1	100.9

Long Range Cruise Altitude Capability
Max Climb Thrust, 300 ft/min residual rate of climb

WEIGHT (1000 LB)	PRESSURE ALTITUDE (FT)		
	ISA + 10°C & BELOW	ISA + 15°C	ISA + 20°C
500	17800	16000	13900
480	18900	17200	15300
460	19900	18400	16500
440	20900	19500	17900
420	21900	20600	19100
400	23100	21600	20300
380	24400	22900	21300
360	25800	24400	22600
340	27000	26000	24300
320	28200	27200	26100
300	29400	28500	27400
280	30800	29800	28800
260	32300	31300	30200
240	33800	32800	31800
220	35300	34500	33500

GEAR DOWN

Long Range Cruise Control

WEIGHT (1000 LB)		PRESSURE ALTITUDE (1000 FT)									
		10	15	17	19	21	23	25	27	29	31
500	TPR	58.9	70.6	76.6							
	MACH	.439	.488	.511							
	KIAS	243	246	247							
	FF/ENG	10157	10508	10784							
460	TPR	55.6	66.0	71.4	77.5						
	MACH	.430	.474	.496	.518						
	KIAS	237	238	240	241						
	FF/ENG	9457	9658	9850	10115						
420	TPR	52.0	61.4	66.0	71.1	76.8					
	MACH	.417	.459	.478	.498	.518					
	KIAS	230	231	231	231	232					
	FF/ENG	8694	8842	8933	9037	9198					
380	TPR	48.4	57.1	61.2	65.8	70.9	76.6	83.3			
	MACH	.403	.445	.463	.482	.501	.522	.543			
	KIAS	223	223	223	224	224	224	224			
	FF/ENG	7954	8064	8150	8221	8304	8448	8670			
340	TPR	44.8	52.7	56.5	60.6	65.2	70.3	75.8	82.8		
	MACH	.389	.429	.446	.465	.484	.504	.525	.547		
	KIAS	215	215	215	216	216	216	216	216		
	FF/ENG	7232	7304	7385	7453	7488	7558	7660	7907		
300	TPR	41.1	48.4	51.8	55.6	59.6	64.0	69.0	74.6	81.6	
	MACH	.374	.412	.429	.447	.465	.484	.505	.526	.548	
	KIAS	206	207	207	207	207	207	207	207	207	
	FF/ENG	6529	6563	6638	6703	6723	6738	6790	6899	7113	
260	TPR	37.6	44.1	47.2	50.5	54.1	58.0	62.3	67.3	72.8	79.6
	MACH	.359	.395	.411	.428	.445	.464	.483	.504	.525	.548
	KIAS	198	198	198	198	198	198	198	198	198	198
	FF/ENG	5855	5855	5928	5979	5983	5975	5992	6049	6140	6312
220	TPR	34.1	39.8	42.6	45.6	48.7	52.1	55.9	60.2	65.1	70.4
	MACH	.342	.376	.391	.407	.424	.442	.460	.480	.501	.522
	KIAS	188	188	188	188	188	188	188	188	188	188
	FF/ENG	5183	5199	5228	5305	5280	5243	5243	5274	5317	5389

GEAR DOWN

Long Range Cruise Enroute Fuel and Time

Ground to Air Miles Conversion

AIR DISTANCE (NM)					GROUND DISTANCE (NM)	AIR DISTANCE (NM)				
HEADWIND COMPONENT (KTS)						TAILWIND COMPONENT (KTS)				
100	80	60	40	20		20	40	60	80	100
335	297	264	239	218	200	188	176	166	157	149
677	599	532	479	437	400	374	351	330	312	296
1022	902	800	720	656	600	561	525	494	466	442
1369	1207	1069	962	875	800	747	700	658	620	588
1718	1514	1340	1204	1095	1000	934	874	821	774	734
2070	1822	1611	1446	1314	1200	1120	1048	984	928	879
2426	2132	1883	1690	1534	1400	1306	1222	1147	1081	1024
2786	2446	2158	1934	1755	1600	1493	1396	1309	1234	1169
3150	2762	2433	2179	1976	1800	1679	1569	1472	1386	1313
3518	3081	2710	2424	2196	2000	1864	1742	1633	1538	1457
3890	3402	2988	2671	2418	2200	2050	1915	1795	1690	1601
4266	3725	3268	2918	2640	2400	2235	2088	1957	1842	1745
4647	4052	3550	3166	2862	2600	2421	2260	2118	1994	1888
5034	4383	3834	3415	3084	2800	2607	2434	2280	2145	2031
5426	4717	4120	3665	3307	3000	2793	2606	2441	2296	2173
5823	5054	4407	3916	3531	3200	2978	2778	2601	2447	2316
6227	5396	4697	4169	3755	3400	3163	2950	2762	2598	2458
6636	5741	4990	4423	3979	3600	3348	3123	2923	2748	2600
7053	6090	5284	4677	4204	3800	3533	3294	3083	2898	2741
7477	6444	5580	4932	4430	4000	3718	3465	3242	3047	2882

Reference Fuel and Time Required at Check Point

AIR DIST (NM)	PRESSURE ALTITUDE (1000 FT)									
	10		14		20		24		28	
	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)
200	11.5	0:52	10.6	0:50	9.6	0:48	8.7	0:47	8.0	0:45
400	23.3	1:42	21.7	1:39	20.0	1:35	18.3	1:32	17.0	1:29
600	35.1	2:32	32.8	2:28	30.4	2:22	27.9	2:18	26.1	2:12
800	46.4	3:23	43.5	3:18	40.4	3:10	37.2	3:05	34.8	2:57
1000	57.8	4:14	54.2	4:07	50.5	3:58	46.5	3:51	43.5	3:42
1200	68.7	5:07	64.5	4:58	60.2	4:46	55.6	4:38	51.9	4:27
1400	79.6	5:59	74.8	5:48	69.9	5:34	64.6	5:25	60.4	5:12
1600	90.2	6:53	84.7	6:40	79.3	6:23	73.3	6:12	68.5	5:59
1800	100.7	7:47	94.7	7:31	88.7	7:13	82.0	7:00	76.7	6:45
2000	110.9	8:42	104.3	8:23	97.7	8:03	90.5	7:48	84.6	7:31
2200	121.0	9:37	114.0	9:16	106.8	8:52	98.9	8:37	92.5	8:18
2400	130.8	10:34	123.3	10:10	115.5	9:43	107.1	9:26	100.2	9:06
2600	140.6	11:31	132.6	11:03	124.3	10:34	115.2	10:15	107.8	9:53
2800	150.0	12:30	141.6	11:59	132.6	11:25	123.1	11:04	115.3	10:41
3000	159.4	13:28	150.6	12:54	141.0	12:17	130.9	11:54	122.7	11:29
3200	168.5	14:29	159.3	13:51	149.1	13:09	138.5	12:44	129.9	12:18
3400	177.5	15:30	168.0	14:48	157.1	14:02	146.1	13:35	137.1	13:06
3600	186.3	16:32	176.4	15:47	164.8	14:55	153.4	14:26	144.0	13:56
3800	195.0	17:35	184.8	16:45	172.6	15:49	160.7	15:18	151.0	14:45
4000	203.5	18:39	192.9	17:46	180.1	16:44	167.9	16:10	157.7	15:35

GEAR DOWN

Long Range Cruise Enroute Fuel and Time

Fuel Required Adjustment (1000 LB)

REFERENCE FUEL REQUIRED (1000 LB)	WEIGHT AT CHECK POINT (1000 LB)							
	220	260	300	340	380	420	460	500
20	-4.5	-3.4	-2.2	-1.1	0.0	1.7	4.3	7.4
40	-9.6	-7.1	-4.7	-2.3	0.0	3.3	7.8	13.6
60	-14.5	-10.9	-7.2	-3.5	0.0	4.8	11.2	19.3
80	-19.4	-14.6	-9.6	-4.8	0.0	6.3	14.3	24.4
100	-24.2	-18.2	-12.1	-6.0	0.0	7.7	17.2	28.9
120	-28.9	-21.8	-14.5	-7.2	0.0	9.0	19.9	33.0
140	-33.6	-25.4	-17.0	-8.4	0.0	10.3	22.3	36.5
160	-38.2	-29.0	-19.4	-9.7	0.0	11.6	24.5	39.4
180	-42.7	-32.5	-21.8	-10.9	0.0	12.8	26.5	41.8
200	-47.1	-35.9	-24.2	-12.1	0.0	14.0	28.3	43.7
220	-51.5	-39.4	-26.5	-13.3	0.0	15.1	29.9	45.1

Based on Long Range Cruise speed and 220 KIAS descent.

Descent at 220 KIAS

PRESSURE ALTITUDE (1000 FT)	17	19	21	23	25	27	29	31	33	35
DISTANCE (NM)	31	35	38	42	45	49	53	56	60	64
TIME (MINUTES)	10	11	12	12	13	14	14	15	16	16

Holding

Flaps Up

WEIGHT (1000 LB)		PRESSURE ALTITUDE (FT)						
		1500	5000	10000	15000	20000	25000	30000
500	TPR	44.9	50.1	58.9	70.6			
	KIAS	241	241	243	246			
	FF/ENG	10430	10490	10670	11030			
460	TPR	42.6	47.4	55.6	66.0	81.0		
	KIAS	236	237	237	238	242		
	FF/ENG	9790	9820	9930	10140	10810		
420	TPR	40.0	44.4	52.0	61.4	73.9		
	KIAS	229	230	230	231	232		
	FF/ENG	9050	9060	9130	9280	9570		
380	TPR	37.4	41.4	48.4	57.1	68.3	83.3	
	KIAS	222	222	223	223	224	224	
	FF/ENG	8330	8310	8350	8470	8670	9100	
340	TPR	34.8	38.4	44.8	52.7	62.9	75.8	
	KIAS	214	215	215	215	216	216	
	FF/ENG	7620	7590	7590	7670	7850	8040	
300	TPR	32.1	35.4	41.1	48.4	57.6	69.0	
	KIAS	206	206	206	207	207	207	
	FF/ENG	6930	6880	6860	6890	7060	7130	
260	TPR	29.5	32.5	37.6	44.1	52.3	62.3	76.0
	KIAS	198	198	198	198	198	198	198
	FF/ENG	6270	6190	6150	6150	6290	6290	6520
220	TPR	26.8	29.5	34.1	39.8	47.2	55.9	67.6
	KIAS	188	188	188	188	188	188	188
	FF/ENG	5610	5510	5440	5460	5570	5510	5620

This table includes 5% additional fuel for holding in a racetrack pattern.

GEAR DOWN
ENGINE INOP

MAX CONTINUOUS THRUST

Driftdown Speed/Level Off Altitude

100 ft/min residual rate of climb
Includes APU fuel burn

WEIGHT (1000 LB)		OPTIMUM DRIFTDOWN SPEED (KIAS)	LEVEL OFF ALTITUDE (FT)		
START DRIFT DOWN	LEVEL OFF		ISA + 10°C & BELOW	ISA + 15°C	ISA + 20°C
460	441	222	1900		
440	423	218	4100	900	
420	404	213	6000	3900	1000
400	385	209	8000	6200	4100
380	366	204	10100	8400	6400
360	349	199	12300	10400	8800
340	330	194	13900	12100	10800
320	310	188	15600	14100	12700
300	291	183	17300	16100	14800
280	272	177	19200	18100	17000
260	252	171	20900	20000	19000
240	232	165	23000	21800	20900

Long Range Cruise Altitude Capability

100 ft/min residual rate of climb

WEIGHT (1000 LB)	PRESSURE ALTITUDE (FT)		
	ISA + 10°C & BELOW	ISA + 15°C	ISA + 20°C
400	2700		
380	4900	1100	
360	6800	4300	800
340	8700	6600	4200
320	10900	8800	6600
300	12800	10700	9000
280	14200	12300	10900
260	15700	14100	12600
240	17300	16000	14500
220	19100	17900	16600

GEAR DOWN
ENGINE INOP

MAX CONTINUOUS THRUST

Long Range Cruise Control

WEIGHT (1000 LB)		PRESSURE ALTITUDE (1000 FT) 5	7	9	11	13	15	17
380	TPR	75.6						
	MACH	.367						
	KIAS	222						
	FF/ENG	15785						
360	TPR	72.4	77.8					
	MACH	.361	.375					
	KIAS	218	219					
	FF/ENG	14991	15170					
340	TPR	69.3	74.3	80.1				
	MACH	.355	.368	.382				
	KIAS	215	215	215				
	FF/ENG	14230	14352	14559				
320	TPR	66.2	71.0	76.3	82.5			
	MACH	.348	.361	.375	.389			
	KIAS	211	211	211	211			
	FF/ENG	13483	13576	13719	13981			
300	TPR	63.2	67.6	72.6	78.2	85.0		
	MACH	.341	.354	.367	.382	.397		
	KIAS	206	206	206	206	207		
	FF/ENG	12735	12822	12920	13089	13415		
280	TPR	60.2	64.4	69.0	74.2	80.2	87.7	
	MACH	.334	.347	.360	.374	.388	.404	
	KIAS	202	202	202	202	202	202	
	FF/ENG	12011	12089	12173	12288	12482	12882	
260	TPR	57.2	61.2	65.5	70.3	75.7	82.1	
	MACH	.327	.339	.352	.365	.380	.395	
	KIAS	198	198	198	198	198	198	
	FF/ENG	11292	11362	11435	11521	11649	11881	
240	TPR	54.2	57.9	62.0	66.5	71.5	77.2	84.1
	MACH	.319	.331	.344	.357	.371	.386	.401
	KIAS	193	193	193	193	193	193	193
	FF/ENG	10584	10645	10713	10786	10876	11016	11291
220	TPR	51.1	54.6	58.4	62.6	67.2	72.4	78.5
	MACH	.311	.323	.335	.348	.362	.376	.391
	KIAS	188	188	188	188	188	188	188
	FF/ENG	9864	9911	9971	10037	10109	10207	10366

GEAR DOWN
ENGINE INOP
MAX CONTINUOUS THRUST

Long Range Cruise Diversion Fuel and Time
Ground to Air Miles Conversion

AIR DISTANCE (NM)					GROUND DISTANCE (NM)	AIR DISTANCE (NM)				
HEADWIND COMPONENT (KTS)						TAILWIND COMPONENT (KTS)				
100	80	60	40	20		20	40	60	80	100
179	156	136	122	110	100	93	86	80	75	71
364	316	275	245	221	200	185	171	159	149	140
550	476	414	368	331	300	277	256	238	223	210
737	637	554	491	442	400	368	341	316	296	279
925	799	694	615	553	500	461	426	395	369	347
1113	961	833	738	664	600	552	510	473	442	416
1303	1124	974	862	775	700	645	595	552	516	485
1493	1287	1115	986	885	800	736	680	630	588	554
1685	1452	1256	1110	997	900	828	765	709	662	623
1877	1616	1397	1234	1108	1000	920	849	787	735	691

Reference Fuel and Time Required at Check Point

AIR DIST (NM)	PRESSURE ALTITUDE (1000 FT)									
	6		8		10		12		14	
	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)	FUEL (1000 LB)	TIME (HR:MIN)
100	6.2	0:30	5.9	0:29	5.7	0:29	5.4	0:29	5.2	0:28
200	12.6	0:57	12.1	0:56	11.7	0:56	11.3	0:56	11.1	0:55
300	18.9	1:25	18.3	1:24	17.8	1:23	17.3	1:23	16.9	1:22
400	25.2	1:53	24.5	1:51	23.7	1:51	23.1	1:50	22.6	1:49
500	31.4	2:21	30.5	2:19	29.7	2:18	28.9	2:17	28.3	2:16
600	37.6	2:49	36.5	2:47	35.5	2:45	34.6	2:45	33.9	2:43
700	43.7	3:18	42.5	3:15	41.3	3:13	40.3	3:12	39.5	3:11
800	49.7	3:46	48.3	3:43	47.0	3:40	45.9	3:39	45.0	3:38
900	55.6	4:15	54.1	4:11	52.7	4:08	51.4	4:07	50.4	4:05
1000	61.5	4:44	59.9	4:39	58.3	4:36	56.9	4:34	55.7	4:33

Fuel Required Adjustment (1000 LB)

REFERENCE FUEL REQUIRED (1000 LB)	WEIGHT AT CHECK POINT (1000 LB)							
	220	260	300	340	380	420	460	500
10	-2.4	-1.8	-1.2	-0.6	0.0	1.0	2.4	3.7
15	-3.7	-2.8	-1.9	-0.9	0.0	1.6	3.6	5.7
20	-5.0	-3.7	-2.5	-1.2	0.0	2.1	4.8	7.6
25	-6.3	-4.7	-3.2	-1.6	0.0	2.5	5.9	9.5
30	-7.7	-5.7	-3.8	-1.9	0.0	3.0	7.0	11.3
35	-9.0	-6.7	-4.5	-2.2	0.0	3.5	8.0	13.0
40	-10.3	-7.6	-5.1	-2.6	0.0	3.9	9.0	14.7
45	-11.6	-8.6	-5.8	-2.9	0.0	4.3	9.9	16.3
50	-12.9	-9.6	-6.4	-3.2	0.0	4.7	10.8	17.8
55	-14.2	-10.6	-7.1	-3.5	0.0	5.1	11.7	19.3
60	-15.5	-11.6	-7.7	-3.9	0.0	5.4	12.5	20.7
65	-16.8	-12.5	-8.3	-4.2	0.0	5.7	13.2	22.0

Includes APU fuel burn.

GEAR DOWN
ENGINE INOP
MAX CONTINUOUS THRUST

Holding
Flaps Up

WEIGHT (1000 LB)		PRESSURE ALTITUDE (FT) 1500	5000	10000	15000
420	TPR	72.5			
	KIAS	229			
	FF/ENG	17960			
400	TPR	69.8			
	KIAS	226			
	FF/ENG	17150			
380	TPR	67.1	75.6		
	KIAS	222	222		
	FF/ENG	16340	16570		
360	TPR	64.4	72.4		
	KIAS	218	218		
	FF/ENG	15550	15740		
340	TPR	61.7	69.3	83.4	
	KIAS	214	215	215	
	FF/ENG	14770	14940	15470	
320	TPR	59.1	66.2	79.2	
	KIAS	210	211	211	
	FF/ENG	14000	14160	14510	
300	TPR	56.4	63.2	75.3	
	KIAS	206	206	206	
	FF/ENG	13230	13370	13640	
280	TPR	53.8	60.2	71.5	87.7
	KIAS	202	202	202	202
	FF/ENG	12490	12610	12830	13530
260	TPR	51.1	57.2	67.8	82.1
	KIAS	198	198	198	198
	FF/ENG	11760	11860	12050	12480
240	TPR	48.5	54.2	64.2	77.2
	KIAS	193	193	193	193
	FF/ENG	11040	11110	11290	11570
220	TPR	45.7	51.1	60.4	72.4
	KIAS	188	188	188	188
	FF/ENG	10290	10360	10500	10720

This table includes 5% additional fuel for holding in a racetrack pattern.

Performance Inflight — Chapter PI

Text — Section 18

Introduction

This chapter contains information to supplement performance data from the Flight Management Computer. In addition, sufficient inflight data is provided to complete a flight with the FMC inoperative. In the event of conflict between data presented in this chapter and that contained in the Approved Flight Manual, the Flight Manual shall always take precedence.

General

Takeoff Speeds

The speeds presented in the Takeoff Speeds table can be used for all performance conditions except where adjustments must be made to V1 for clearway, stopway, brake deactivation, improved climb, contaminated runway situations, unbalanced for brake energy or obstacle clearance with unbalanced V1. These speeds may be used for weights less than or equal to the performance limited weight.

Normal takeoff speeds, V1, VR, and V2 are read from the dry or wet table by entering with takeoff flap setting and brake release weight. Use the tables provided to correct takeoff speeds for altitude and actual temperature or assumed temperature for reduced thrust takeoffs. Slope and wind corrections to V1 are obtained by entering the Slope and Wind V1 Adjustment Table.

Clearway and Stopway V1 Adjustments

Takeoff speed corrections are to be applied to V1 when using takeoff weights based on the use of clearway and stopway.

Adjust V1 by the amount shown in the table. The adjusted V1 must not exceed VR. If V1 is greater than VR, VR may be increased to equal V1. The resultant V2 will be increased by the same amount that VR was increased.

Maximum allowable clearway limits are provided for guidance when more precise data is not available.

Stabilizer Trim Setting

To find takeoff stabilizer trim setting, enter Stabilizer Trim Setting table with anticipated brake release weight and center of gravity (C.G. % MAC) and read required stabilizer trim units.

VREF Speeds

This table contains flaps 30, 25 and 20 reference speeds for a given weight.

Flap Maneuver Speeds

This table provides the flap speed schedule for recommended maneuver speeds. During flap retraction/extension, selecting the next flap setting should be initiated when reaching the maneuver speed for the existing flap position.

Slush/Standing Water

Experience has shown that aircraft performance may deteriorate significantly on runways covered with snow, slush, standing water or ice. Therefore, reductions in runway/obstacle limited takeoff weight and revised takeoff speeds are necessary. The tables are intended for guidance in accordance with advisory material and assume an engine failure at the critical point during the takeoff.

The entire runway is assumed to be completely covered by a contaminant of uniform thickness and density. Therefore this information is conservative when operating under typical colder weather conditions where patches of slush exist and some degree of sanding is common. Takeoffs in slush depths greater than 0.5 inches (13 mm) are not recommended because of possible airplane damage as a result of slush impingement on the airplane structure. The use of assumed temperature for reduced thrust is not allowed on contaminated runways. Interpolation for slush/standing water depths between the values shown is permitted.

Takeoff weight is determined as follows:

(1) Determine the dry field/obstacle limit weight for the takeoff flap setting.

(2) Enter the Weight Adjustment table with the dry field/obstacle limit weight to obtain the weight reduction for the slush/standing water depth and airport pressure altitude.

(3) Adjust field length available for temperature by the amount provided in the notes below the V1(MCG) limit weight table.

(4) Enter the V1(MCG) Limit Weight table with the adjusted field length and pressure altitude to obtain the slush/standing water limit weight with respect to minimum field length required for V1(MCG) speed.

The maximum allowable takeoff weight in slush/standing water is the lesser of the limit weights found in steps 2 and 4.

Takeoff speed determination:

(1) Determine takeoff speeds V1, VR and V2 for actual brake release weight using Takeoff Speeds tables in this section.

(2) If V1(MCG) limited, set V1=V1(MCG). If not limited by V1(MCG) considerations, enter the V1 Adjustment table with actual brake release weight to determine the V1 reduction to apply to V1 speed. If the adjusted V1 is less than V1(MCG), set V1=V1(MCG).

Slippery Runway

Airplane braking action is reported as good, medium or poor, depending on existing runway conditions. If braking action is reported as good, conditions should not be expected to be as good as on clean, dry runways. The value "good" is comparative and is intended to mean that airplanes should not experience braking or directional control difficulties when stopping. Good reported braking action denotes wet runway conditions or runways covered by compact snow. Similarly, poor braking action denotes runways covered with wet ice. Performance is based on reversers operating and a 15 ft screen height at the end of the runway. The tables provided are used in the same manner as the Slush/Standing Water tables.

Minimum Control Speeds

Regulations prohibit scheduling takeoff with a V1 less than minimum V1 for control on the ground, V1(MCG), and VR less than minimum VR, (1.05) VMCA. It is therefore necessary to compare the adjusted V1 and VR to V1(MCG) and Minimum VR respectively. To find V1(MCG) and Minimum VR, enter the V1(MCG), Minimum VR table with the airport pressure altitude and actual OAT. If the adjusted V1 is less than V1(MCG), set V1 equal to V1(MCG). If the adjusted VR is less than Min VR, set VR equal to Min VR and determine a new V2 by adding the difference between the normal VR and Min VR to the normal V2. No takeoff weight adjustment is necessary provided that the field length available exceeds the minimum field length shown in the Field and Climb Limit Weight table in Performance Dispatch chapter.

Takeoff TPR

To find Max Takeoff TPR based on anti-ice on or off enter Max Takeoff TPR Table with airport pressure altitude and airport OAT and read TPR.

Regulations permit the use of up to 25% takeoff thrust reduction for operation with assumed temperature reduced thrust. Use of reduced thrust is not allowed on runways contaminated with water, ice, slush or snow. Use of assumed temperature reduced thrust is not recommended if potential windshear conditions exist. The assumed temperature reduced takeoff TPR is read from the Max Takeoff TPR table at the assumed temperature. The minimum allowable TPR for reduced thrust, based on 25% takeoff thrust reduction, is read by entering Minimum Allowable TPR for Reduced Thrust Table with the maximum allowable TPR for the actual OAT.

Go-Around TPR

To find Go-Around TPR based on anti-ice on or off, enter the Go-Around TPR table with airport pressure altitude and reported OAT or TAT and read TPR.

Max Climb TPR

This table shows Max Climb TPR for a 310/.85 climb speed schedule and anti-ice on or off. Enter the table with airport pressure altitude and TAT and read TPR.

Flight with Unreliable Airspeed / Turbulent Air Penetration

Body attitude and average TPR information is provided for use in all phases of flight in the event of unreliable airspeed/Mach indications resulting from blocking or freezing of the pitot system. Loss of radome may also cause unreliable airspeed/Mach indications. Climb, cruise and descent information is based on the recommended turbulent air penetration speed schedule: 290 knots below 25000 feet, 310 knots or .85 Mach whichever is lower at 25000 feet and above; maintain a minimum speed of 15 knots above the minimum maneuvering speed when below .82 Mach. This schedule provides ample protection from stall and high speed buffet, while also providing protection from exceeding structural limits.

Pitch attitude is shown in bold type for emphasis since altitude and/or vertical speed may also be unreliable.

All Engines

Long Range Cruise Maximum Operating Altitude

These tables provide the maximum operating altitude in the same manner as the FMC. Maximum altitudes are shown for a given cruise weight and maneuver capability. Note that these tables consider both thrust and buffet limits, providing the more limiting of the two. Any data that is thrust limited is denoted by an asterisk and represents only a thrust limited condition in level flight with 300 ft/min residual rate of climb. Flying above these altitudes with sustained banks in excess of approximately 20° may cause the airplane to lose speed and/or altitude. The altitudes shown in the table are limited to the maximum certified altitude of 43100 ft.

Long Range Cruise Control

These tables provide target TPR, Long Range Cruise Mach number, IAS and standard day fuel flow per engine for the airplane weight and pressure altitude. As indicated by the shaded area, at optimum altitude, .85 Mach approximates the Long Range Cruise Mach schedule.

APU Operation During Flight

For APU operation during flight, increase fuel flow according to the table in the Engine Inoperative text section.

Long Range Cruise Enroute Fuel and Time

Long Range Cruise Enroute Fuel and Time tables are provided to determine remaining time and fuel required to destination. The data is based on Long Range Cruise and .85/310/250 descent. Tables are presented for low altitudes for shorter trip distances and high altitudes for longer trip distances.

To determine remaining fuel and time required, first enter the Ground to Air Miles Conversion table to convert ground distance and enroute wind to an equivalent still air distance for use with the Reference Fuel and Time tables. Next, enter the Reference Fuel and Time table with air distance from the Ground to Air Miles Conversion table and the desired altitude and read Reference Fuel and Time Required. Lastly, enter the Fuel Required Adjustment table with the Reference Fuel and the actual weight at checkpoint to obtain fuel required to destination.

Long Range Cruise Wind-Altitude Trade

Wind is a factor which may justify operations considerably below optimum altitude. For example, a favorable wind component may have an effect on ground speed which more than compensates for the loss in air range.

Using this table, it is possible to determine the break-even wind (advantage necessary or disadvantage that can be tolerated) to maintain the same range at another altitude and long range cruise speed. The tables make no allowance for climb or descent time, fuel or distance, and are based on comparing ground fuel mileage.

Descent at .85/310/250

Distance and time for descent are shown for a .85/310/250 descent speed schedule. Enter the table with top of descent pressure altitude and read distance in nautical miles and time in minutes. Data is based on flight idle thrust descent in zero wind. Allowances are included for a straight-in approach with gear down and landing Flaps 30 at the outer marker.

Holding

Target TPR, indicated airspeed and fuel flow per engine information is tabulated for holding with flaps up based on the FMC optimum holding speed schedule. This is the higher of the maximum endurance speed and the maneuvering speed for the selected flap setting. Small variations in airspeed will not appreciably affect the overall endurance time. Enter the table with weight and pressure altitude to read TPR, IAS and fuel flow per engine.

Advisory Information

Normal Configuration Landing Distance

Tables are provided as advisory information for normal configuration landing distances on dry runways and slippery runways with good, medium, and poor reported braking action. These values are actual landing distances and do not include the 1.67 regulatory factor. Therefore, they cannot be used to determine the dispatch required landing field length.

To use these tables, determine the reference landing distance for the selected braking configuration. Then adjust the reference distance for landing weight, altitude, wind, slope, temperature, approach speed, and the number of operative thrust reversers to obtain the actual landing distance.

When landing on slippery runways or runways contaminated with ice, snow, slush, or standing water, the reported braking action must be considered. If the surface is affected by water, snow, or ice, and the braking action is reported as "good", conditions should not be expected to be as good as on clean, dry runways. The value "good" is comparative and is intended to mean that airplanes should not experience braking or directional control difficulties when landing. The performance level used to calculate the "good" data is consistent with wet runway testing done on early Boeing jets. The performance level used to calculate "poor" data reflects runways covered with wet ice.

Use of the autobrake system commands the airplane to a constant deceleration rate. In some conditions, such as a runway with "poor" braking action, the airplane may not be able to achieve these deceleration rates. In these cases, runway slope and inoperative reversers influence the stopping distance. Since it cannot be determined quickly when this becomes a factor, it is appropriate to add the effects of slope and inoperative reversers when using the autobrake system.

Non-Normal Configuration Landing Distance

Advisory information is provided to support non-normal configurations that affect landing performance of the airplane. Landing distances and adjustments are provided for dry runways and runways with good, medium, and poor reported braking action.

Enter the table with the applicable non-normal configuration and read the normal approach speed. The reference landing distance is a reference distance from 50 ft above the threshold to stop based on a reference landing weight and speed at sea level, zero wind, and zero slope. Subsequent columns provide corrections for off-reference landing weight, altitude, wind, slope, temperature, speed and reverser conditions. Each corrections is independently added to the reference landing distance. The Reference landing distance includes the effects of max manual braking and reverse thrust.

For an engine inoperative landing, check the rate of climb capability shown in Gear Down Landing Rate of Climb Available tables to ensure adequate climb performance.

Recommended Brake Cooling Schedule

Advisory information is provided to assist in avoiding problems associated with hot brakes. For normal operation, most landings are at weights below the AFM quick turnaround limit weight.

Use of the recommended cooling schedule will help avoid brake overheat and fuse plug problems that could result from repeated landings at short time intervals or a rejected takeoff.

Enter the Recommended Brake Cooling Schedule table with the airplane weight and brakes on speed, adjusted for wind, at the appropriate temperature and altitude condition. Instructions for applying wind adjustments are included below the table. Linear interpolation may be used to obtain intermediate values. The resulting number is the reference brake energy per brake in millions of foot-pounds, and represents the amount of energy absorbed by each brake during a rejected takeoff.

To determine the energy per brake absorbed during landing, enter the appropriate Event Adjusted Brake Energy Table (No Reverse Thrust or 2 Engine Reverse) with the reference brake energy per brake and the type of braking used during landing (Max Manual, Max Auto, or Autobrake). The resulting number is the adjusted brake energy per brake and represents the energy absorbed in each brake during the landing. The recommended cooling time is found in the final table by entering with the adjusted brake energy per brake. Times are provided for ground cooling and inflight gear down cooling.

Brake temperature indications on Multifunction Display are also shown. The hottest brake indication 10 to 15 minutes after the airplane has come to a complete stop, or inflight with gear retracted, may be used to determine recommended cooling schedule by entering at the bottom of the chart. An EICAS advisory message, BRAKE TEMP, will appear when any brake registers 5.0 or higher on the EICAS indication and disappear as the hottest brake cools with an EICAS indication of 3.5. Note that even without an EICAS advisory message, brake cooling is recommended.

Landing Climb Limit Weight

In the event an overweight landing is necessary and the fuel dump system is unavailable, landing climb limits should be checked if a Flaps 25 or 30 landing is planned. Enter the table with airport OAT and pressure altitude to read landing climb limit weight. Apply the noted adjustments as required. At weights exceeding those shown, plan a Flaps 20 landing.

Fuel Heating Schedule

To Be Supplied.

Engine Inoperative

Initial Max Continuous TPR

The Initial Max Continuous TPR setting for use following an engine failure is shown. The table is based on the typical all engine cruise Mach number of .85 to provide a target TPR setting at the start of driftdown. Once driftdown is established, the Max Continuous TPR table should be used to determine TPR for the given conditions.

Max Continuous TPR

Power setting is based on one engine operating with anti-ice on or off. Enter the table with pressure altitude and IAS or Mach to read TPR.

It is desirable to maintain engine thrust level within the limits of the Max Cruise thrust rating. However, where thrust level in excess of Max Cruise rating is required, such as for meeting terrain clearance, ATC altitude assignments, or to attain maximum range capability, it is permissible to use the thrust needed up to the Max Continuous thrust rating. The Max Continuous thrust rating is intended primarily for emergency use at the discretion of the pilot and is the maximum thrust that may be used continuously.

Driftdown Speed/Level Off Altitude

The table shows optimum driftdown speed as a function of cruise weight at start of driftdown. Also shown are the approximate weight and pressure altitude at which the airplane will level off considering 100 ft/min residual rate of climb.

The level off altitude is dependent on air temperature (ISA deviation).

Driftdown/Cruise Range Capability

This table shows the range capability from the start of driftdown. Driftdown is continued to level off altitude. As weight decreases due to fuel burn, the airplane is accelerated to long range cruise speed. Cruise is continued at level off altitude and long range cruise speed.

To determine fuel required, enter the Ground to Air Miles Conversion table with the desired ground distance and correct for anticipated winds to obtain air distance to destination. Then enter the Driftdown/Cruise Fuel and Time table with air distance and weight at start of driftdown to determine fuel and time required. If altitudes other than the level off altitude is used, fuel and time required may be obtained by using the Engine Inoperative Long Range Cruise Diversion Fuel and Time table.

Long Range Cruise Altitude Capability

Table show the maximum altitude that can be maintained at a given weight and air temperature (ISA deviation), based on LRC speed, Max Continuous thrust, and 100 ft/min residual rate of climb.

Long Range Cruise Control

The table provides target TPR, engine inoperative Long Range Cruise Mach number, IAS and fuel flow for the airplane weight and pressure altitude. The fuel flow values in this table reflect single engine fuel burn.

APU Operation During Flight

For APU operation during flight, increase fuel flow according to the following table. These increments include the APU fuel flow and the effect of increased drag from the APU door.

PRESSURE ALTITUDE (1000 FT)	APU FUEL FLOW PENALTY (LB/HR)				
	GROSS WEIGHT (1000 LB)				
	700	600	500	400	300
43				360	310
39			420	360	310
35		470	420	380	300
31	520	500	450	370	310
25	510	490	440	380	340
20	520	520	460	410	360
15	520	520	480	440	400
10	540	520	510	490	440
5	590	590	570	530	480

Long Range Cruise Diversion Fuel and Time

Tables are provided for crews to determine the fuel and time required to proceed to an alternate airfield with one engine inoperative. The data is based on single engine Long Range Cruise speed and .85/310/250 descent. Enter with Air Distance as determined from the Ground to Air Miles Conversion Table and read Fuel and Time required at the cruise pressure altitude. Adjust the fuel obtained for deviation from the reference weight at checkpoint as required by entering the off reference fuel corrections table with the fuel required for the reference weight and the actual weight at checkpoint. Read fuel and time required for the actual weight.

Holding

Single engine holding data is provided in the same format as the all engine holding data and is based on the same assumptions.

Gear Down Landing Rate of Climb Available

Rate of climb data is provided as guidance information in the event an engine inoperative landing is planned. The tables show gear down rate of climb available for Flaps 20 and Flaps 30. Enter the table with TAT and pressure altitude to read rate of climb available. Apply adjustments shown to correct for weight.

Alternate Mode EEC

No takeoff speed adjustments are required for operation of EEC in the alternate mode.

Limit Weight

A simplified method which conservatively accounts for the effects of EEC in the alternate mode is to reduce the normal mode performance limited weights. The Limit Weight table provides takeoff field, climb, obstacle, net level off and landing climb weights. To determine limit weights for operations with the EEC in the alternate mode, enter the table with the limit weights for normal mode EEC operation and read the associated limit weight for each performance condition. The most limiting of the takeoff weights must be used. The alternate mode EEC Landing Climb limit must be compared to the Landing Field Length limit and the more limiting of the two must be used as the landing limit weight. Analysis from the Airplane Flight Manual - Digital Performance Information may yield less restrictive limit weights.

Max Takeoff %N1

Takeoff power settings are presented for anti-ice on or off. Max Takeoff %N1 may be read directly from the tables for the desired pressure altitude and airport OAT.

The EEC alternate mode schedule provides equal or greater thrust than the normal mode for the same lever position. Thrust protection is not provided in the alternate mode and maximum rated thrust is reached at a thrust lever position less than full forward. As a result, thrust overboost can occur at full forward thrust lever positions.

Max Climb %N1

This table shows Max Climb %N1 for a 310/.85 climb speed schedule with anti-ice off. Enter the table with pressure altitude and TAT to read Max Climb %N1.

Max Cruise %N1

Maximum Cruise %N1 is presented for .85M, which approximates Long Range Cruise speed. Enter the table with pressure altitude and TAT to read Max Cruise %N1.

Go-Around %N1

Go-Around power setting for alternate mode EEC operation is presented for normal engine bleed for packs on. Go-Around %N1 may be read directly from the tables for the desired pressure altitude and airport OAT.

The alternate mode EEC schedule provides equal or greater thrust than the normal mode for the same lever position. Thrust protection is not provided in the alternate mode and maximum rated thrust is reached at a thrust lever position less than full forward. As a result, thrust overboost can occur at full forward thrust lever positions.

Alternate Mode EEC, Engine Inoperative

Initial Max Continuous %N1

Initial Max Continuous %N1 settings for use following an engine failure are presented. The table is based on the typical all engine cruise Mach number of .85 to provide a target %N1 setting at the start of driftdown. Once driftdown is established, the Max Continuous %N1 table should be used to determine %N1 for the given conditions.

Max Continuous %N1

Max Continuous %N1 settings are presented as a function of pressure altitude and TAT for engine inoperative speeds of 320, 280, 240, and 200 KIAS. Power settings may be interpolated for intermediate airspeeds.

Gear Down

This section contains performance for airplane operation with the landing gear extended for all phases of flight.

Note: The Flight Management Computer System (FMCS) does not contain special provisions for operation with landing gear extended. As a result, the FMCS will generate inaccurate enroute speed schedules, display non-conservative predictions of fuel burn, estimated time of arrival (ETA), maximum altitude, and compute overly shallow descent path. An accurate estimated time of arrival is available if current speed or Mach is entered into the VNAV cruise page. Estimates of fuel remaining at waypoints or the destination may be computed by the crew based upon current fuel flow indications, but should be updated frequently.

Tables for gear down performance in this section are identical in format and used in the same manner as tables for the gear up configuration previously described.

Airplane General, Emergency Equipment, Doors, Windows — Chapter 1

Table of Contents — Section 0

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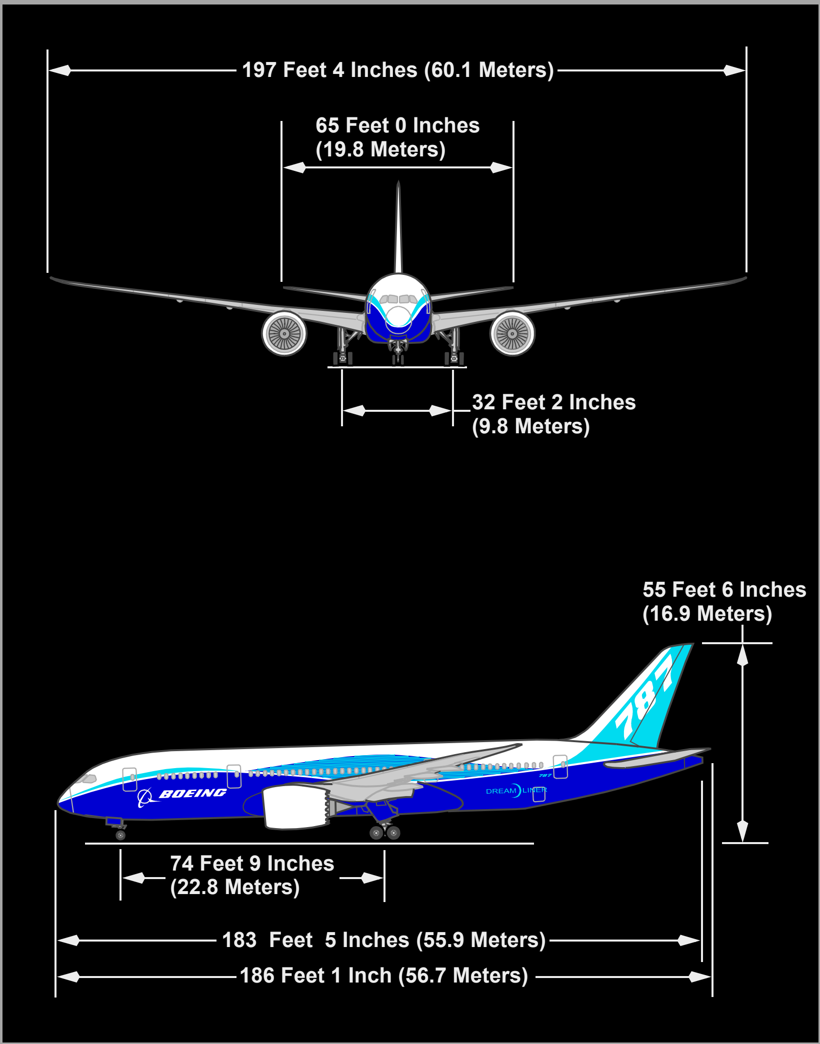
Airplane General, Emergency Equipment, Doors, Windows — Chapter 1
Dimensions — Section 10

Principal Dimensions
[Option – 787-8]

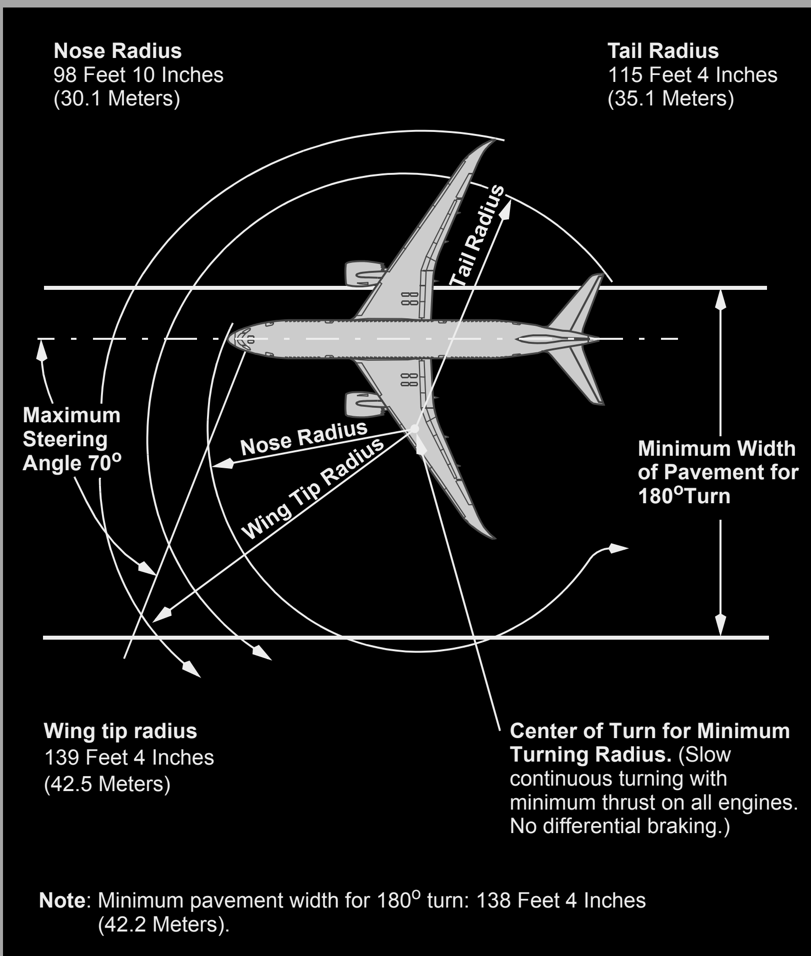


787-8

Turning Radius

The wing tip swings the largest while turning and determines the minimum obstruction clearance path. All other portions of the airplane structure remain within this arc.

[Option – 787-8]



787-8

CAUTION: Do not attempt to make a turn away from an obstacle within 15 feet (4.6 m) of the wing tip, or within 55 feet (16.8 m) of the nose.

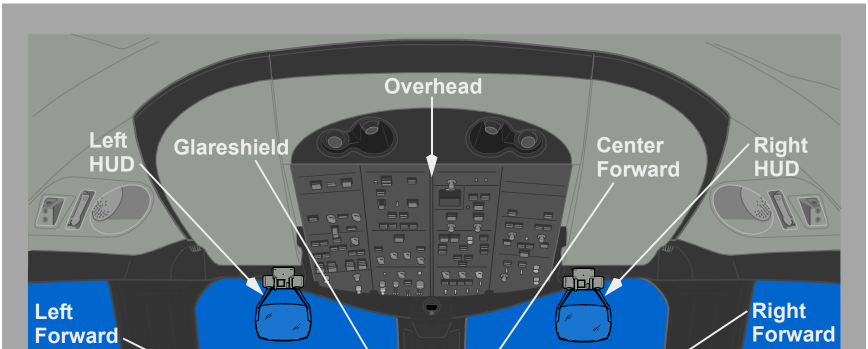
Airplane General, Emergency Equipment, Doors, Windows — Chapter 1

Flight Deck Panels — Section 20

Introduction

The panels shown in this illustration are representative of installed units and may not exactly match the latest configuration. Refer to the appropriate chapter system descriptions for the most current information.

Flight Deck Panels



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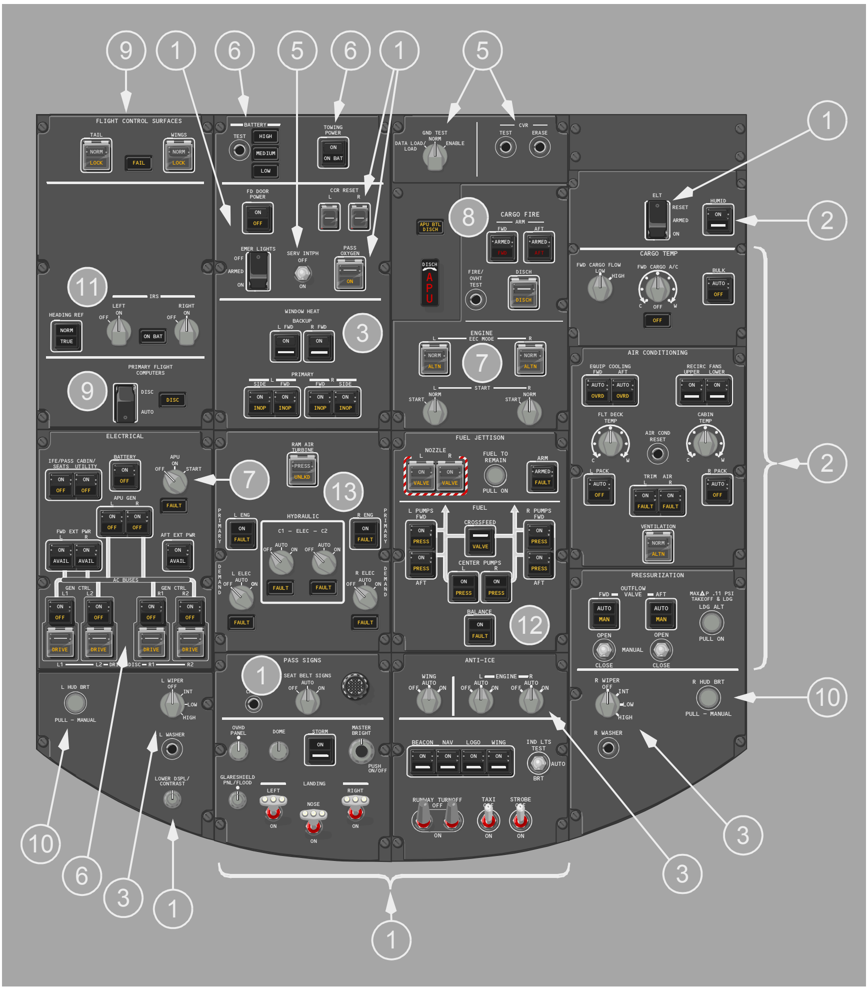
Airplane General, Emergency Equipment, Doors, Windows — Chapter 1
Overhead Panel — Section 21

Introduction

The numbered callouts for each item refer to the relevant chapter where individual panel layouts and detailed system description information can be found.

Overhead Panel

[Option – ELT, FD humidity, Forward cargo A/C]



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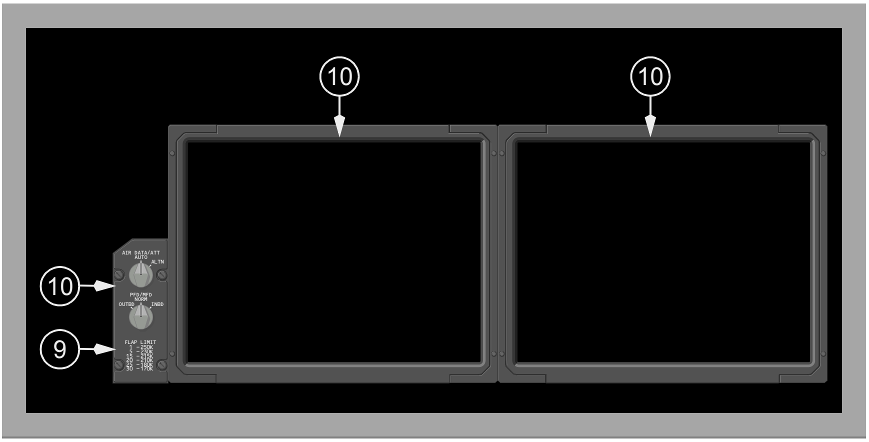
Airplane General, Emer. Equip., Doors, Windows — Chapter 1
Forward Panels — Section 22

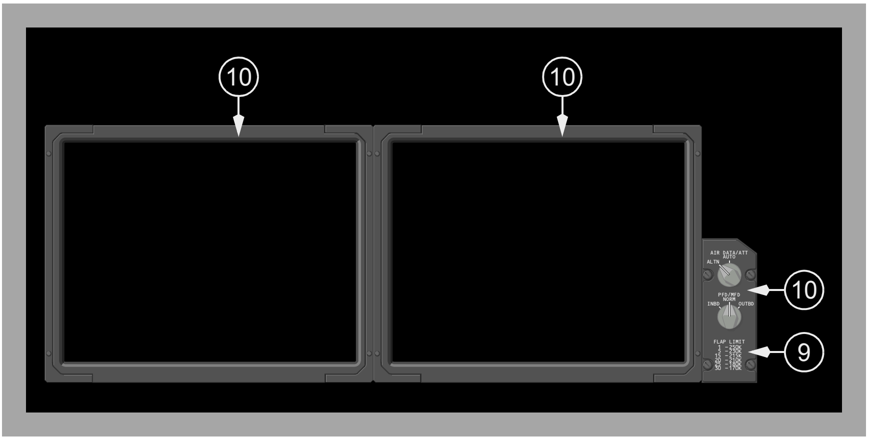
Introduction

The numbered callouts for each item refer to the relevant chapter where individual panel layouts and detailed system description information can be found.

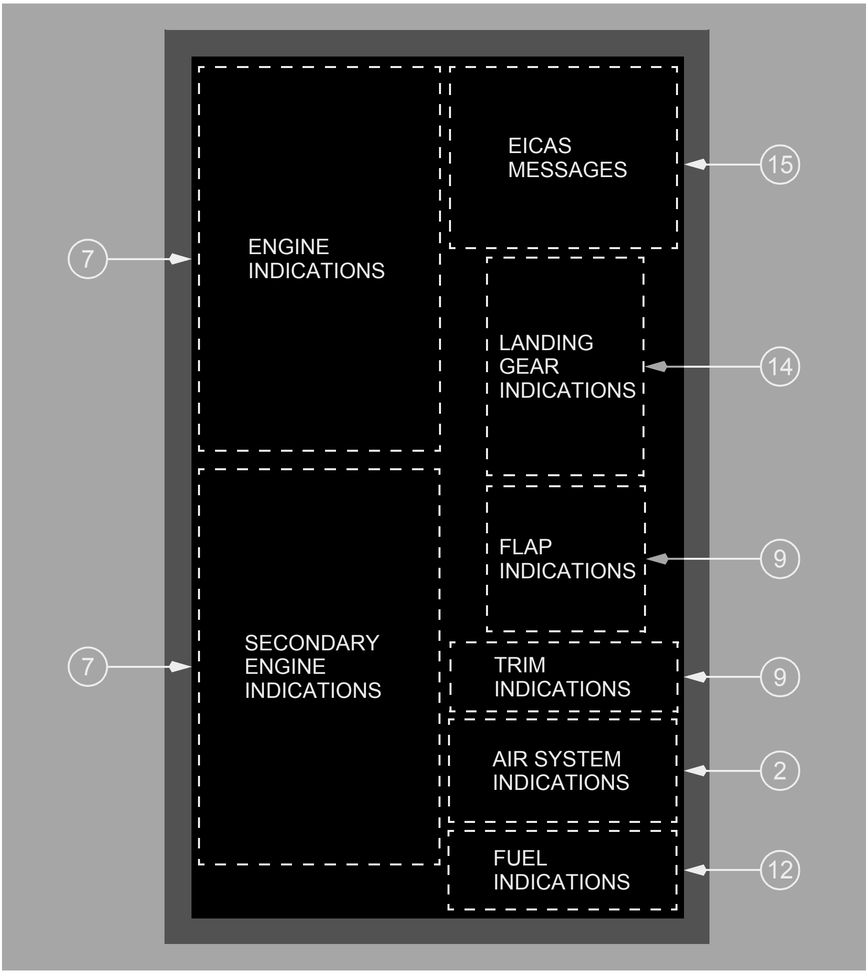
Left Forward Panel



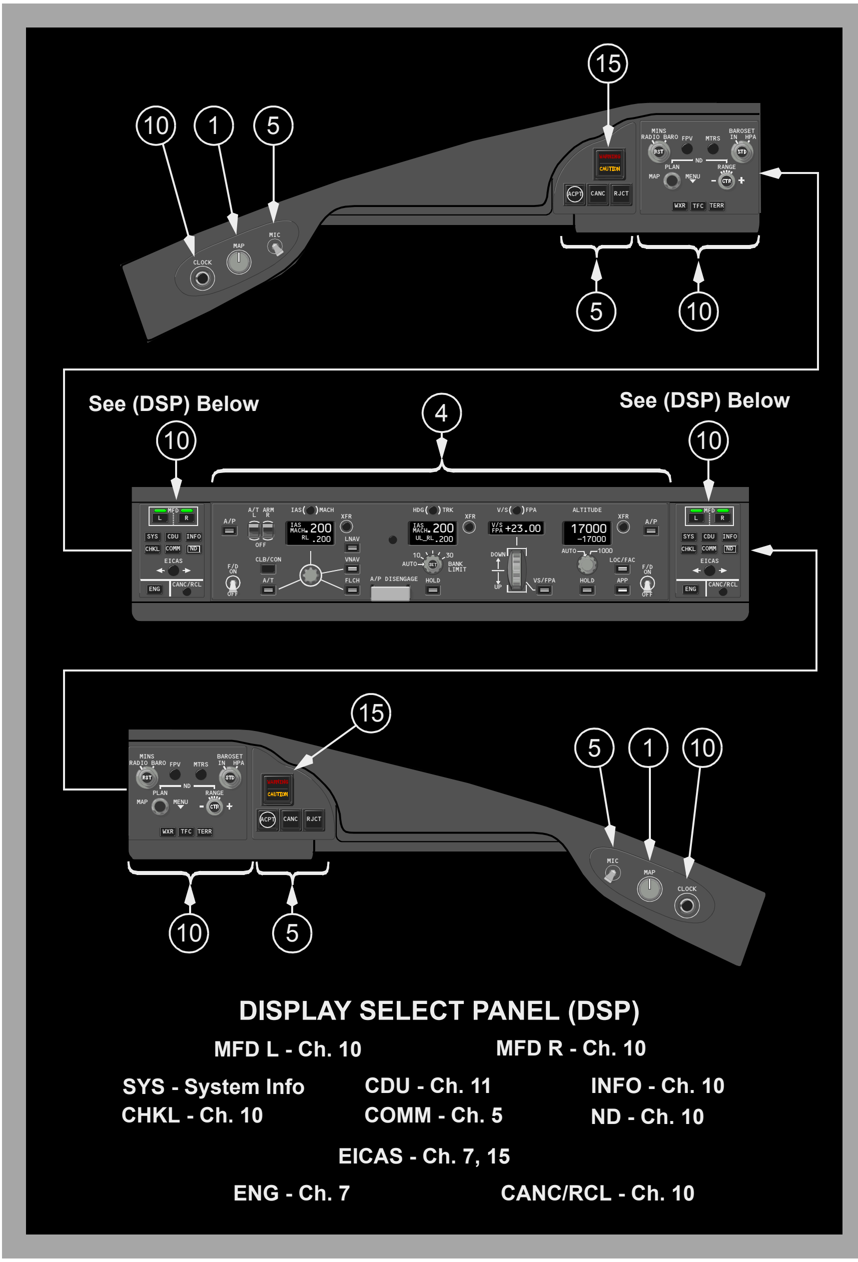
Right Forward Panel



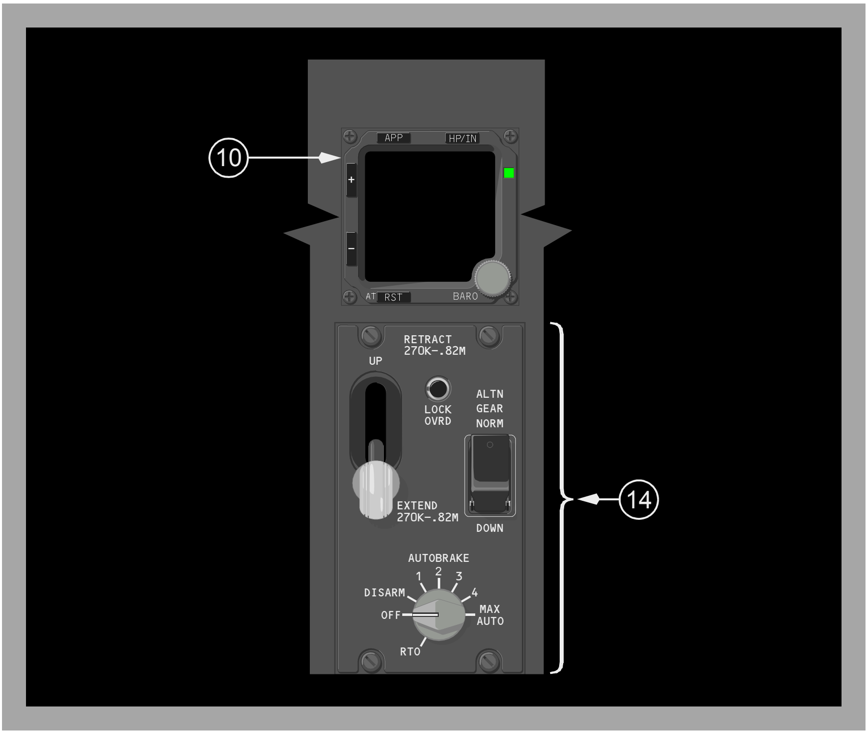
EICAS Display



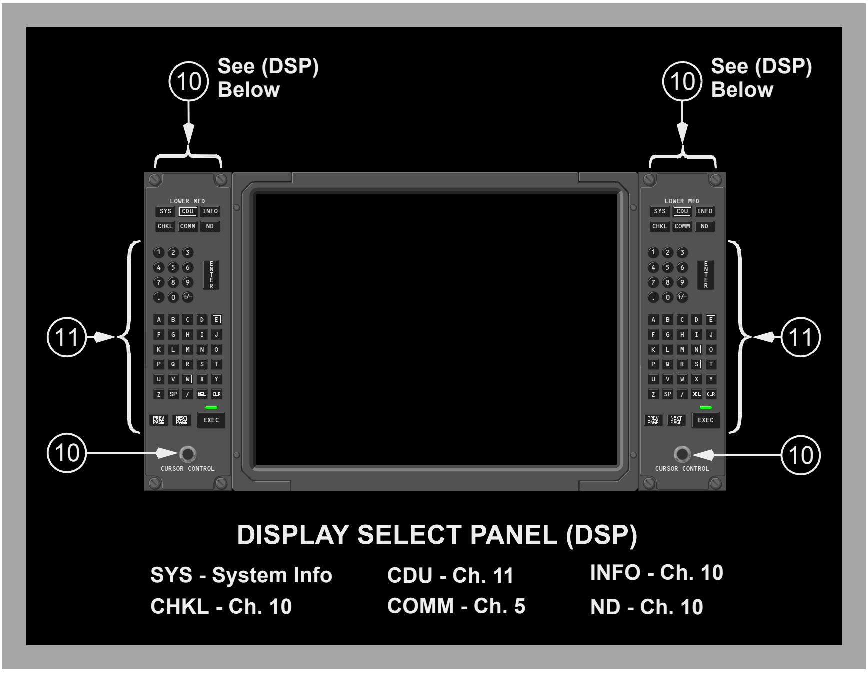
Glareshield Panel



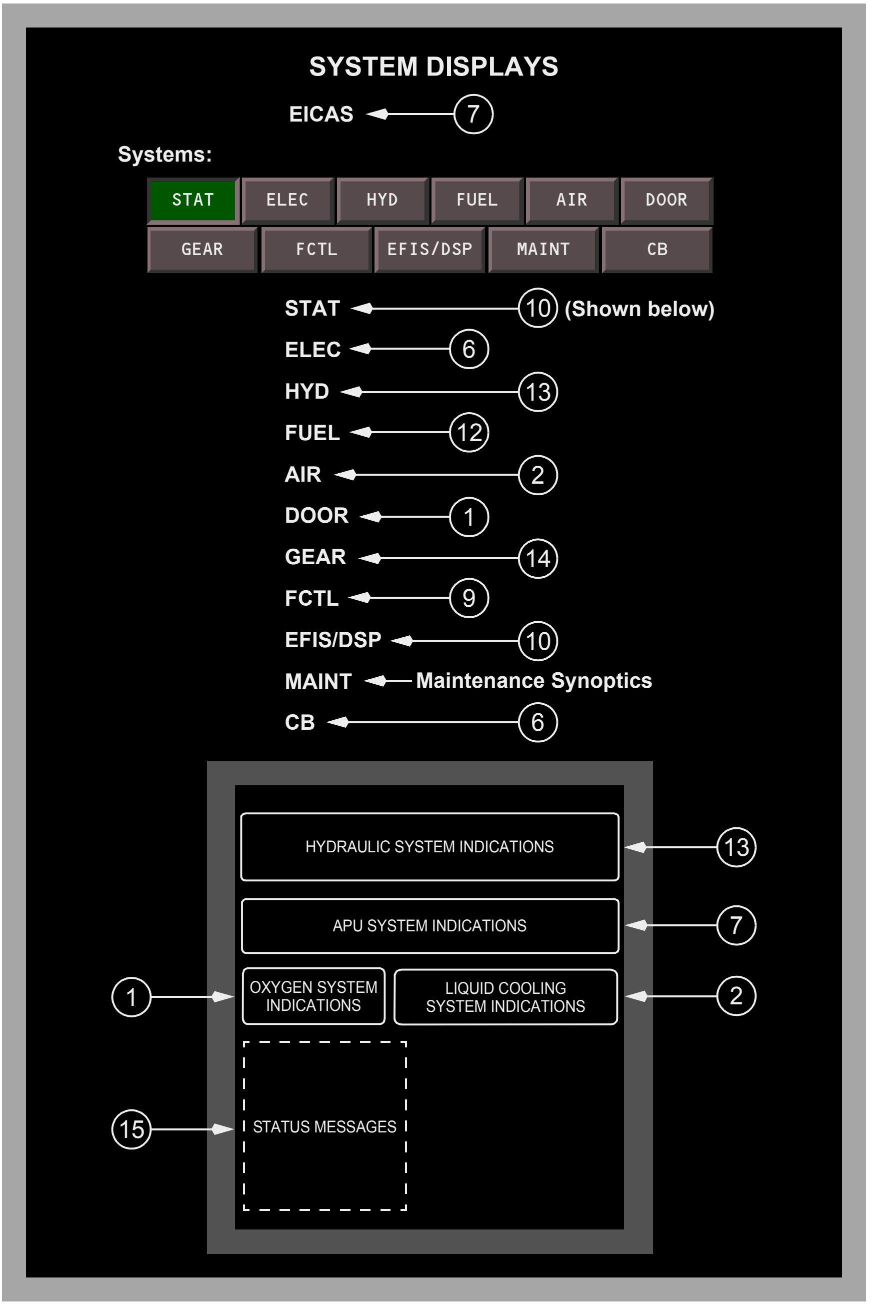
Center Forward Panel



Forward Aisle Stand



System Displays

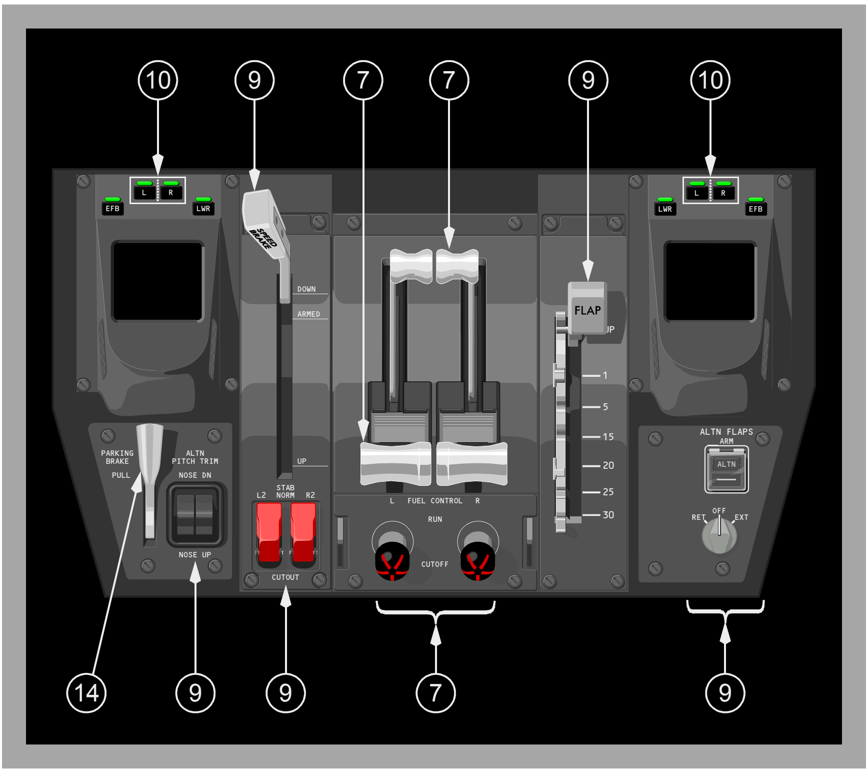


Airplane General, Emergency Equipment, Doors, Windows — Chapter 1
Aft and Side Panels — Section 23

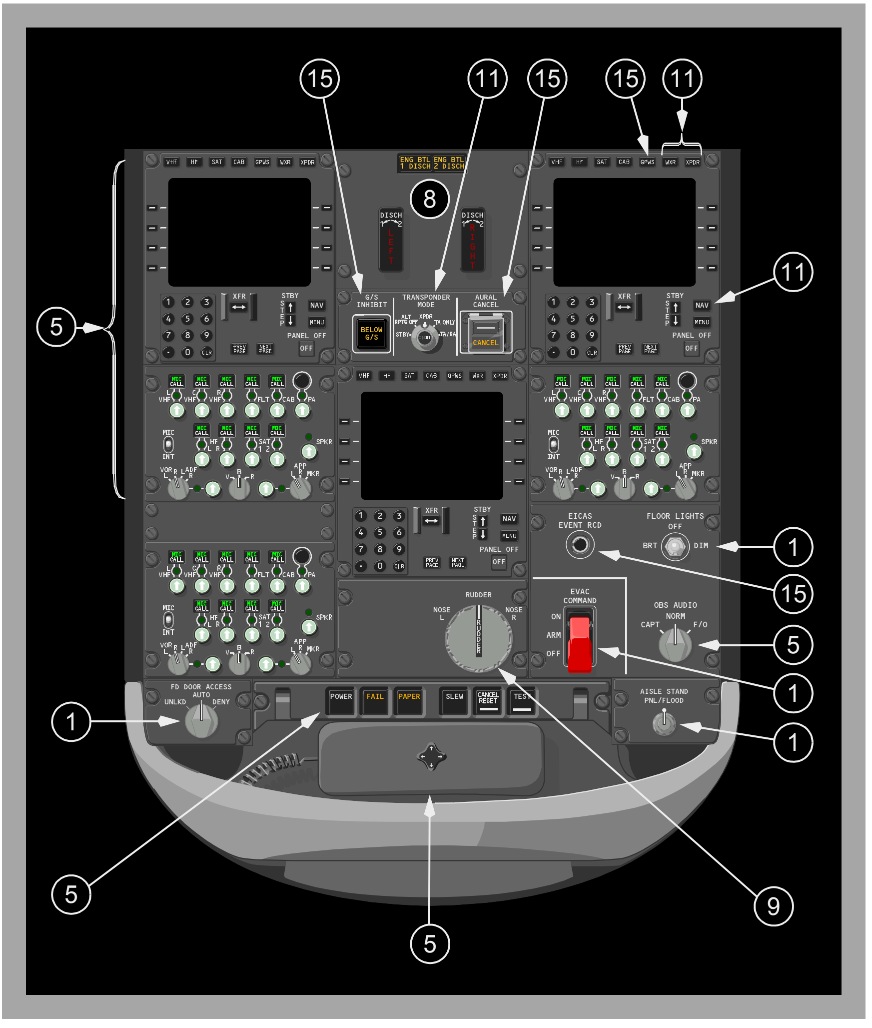
Introduction

The numbered callouts for each item refer to the relevant chapter where individual panel layouts and detailed system description information can be found.

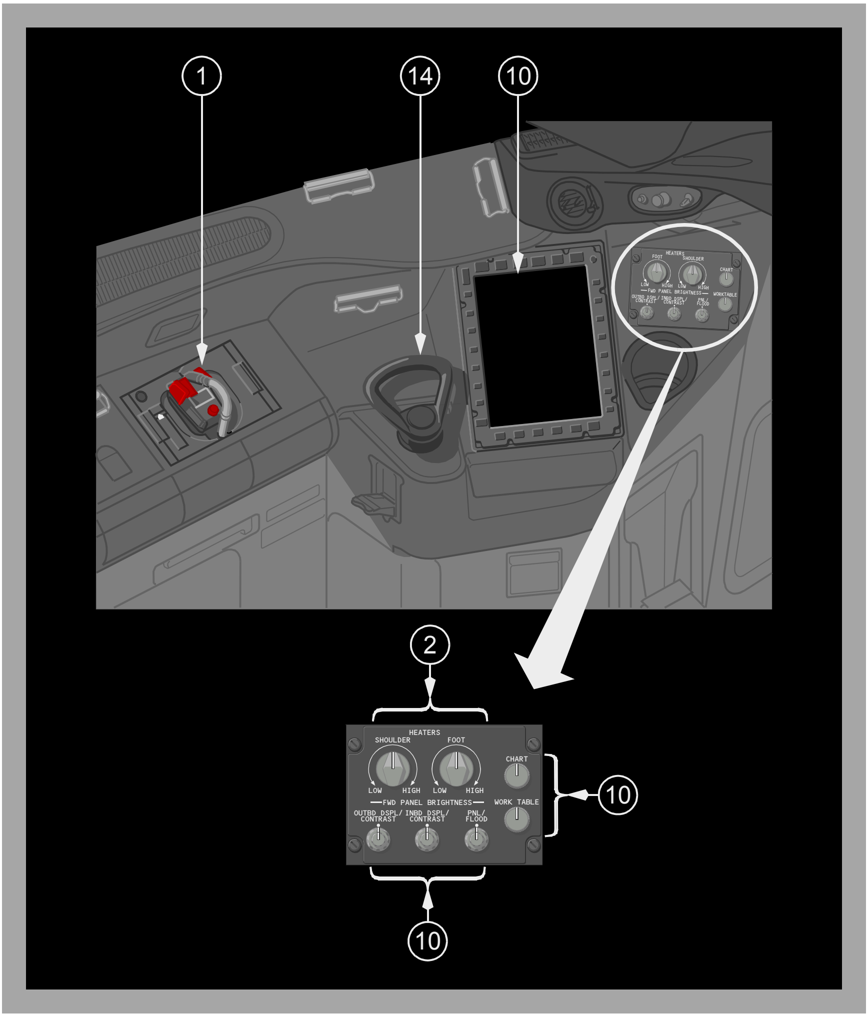
Control Stand



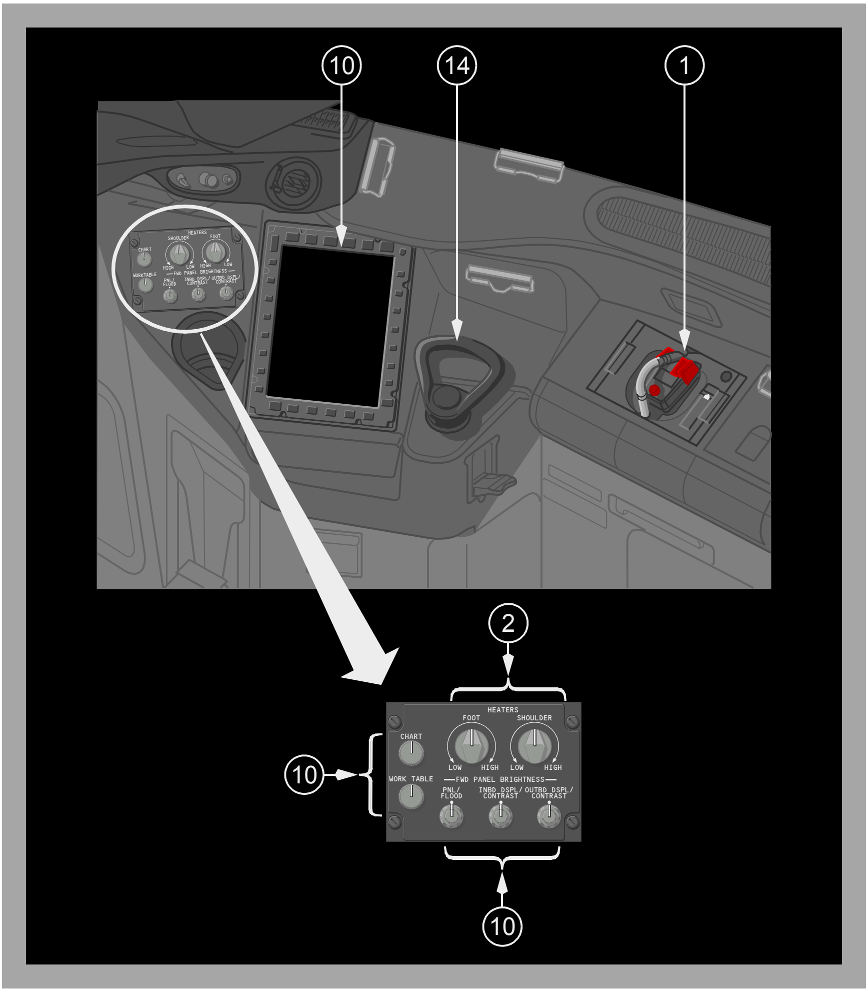
Aft Aisle Stand



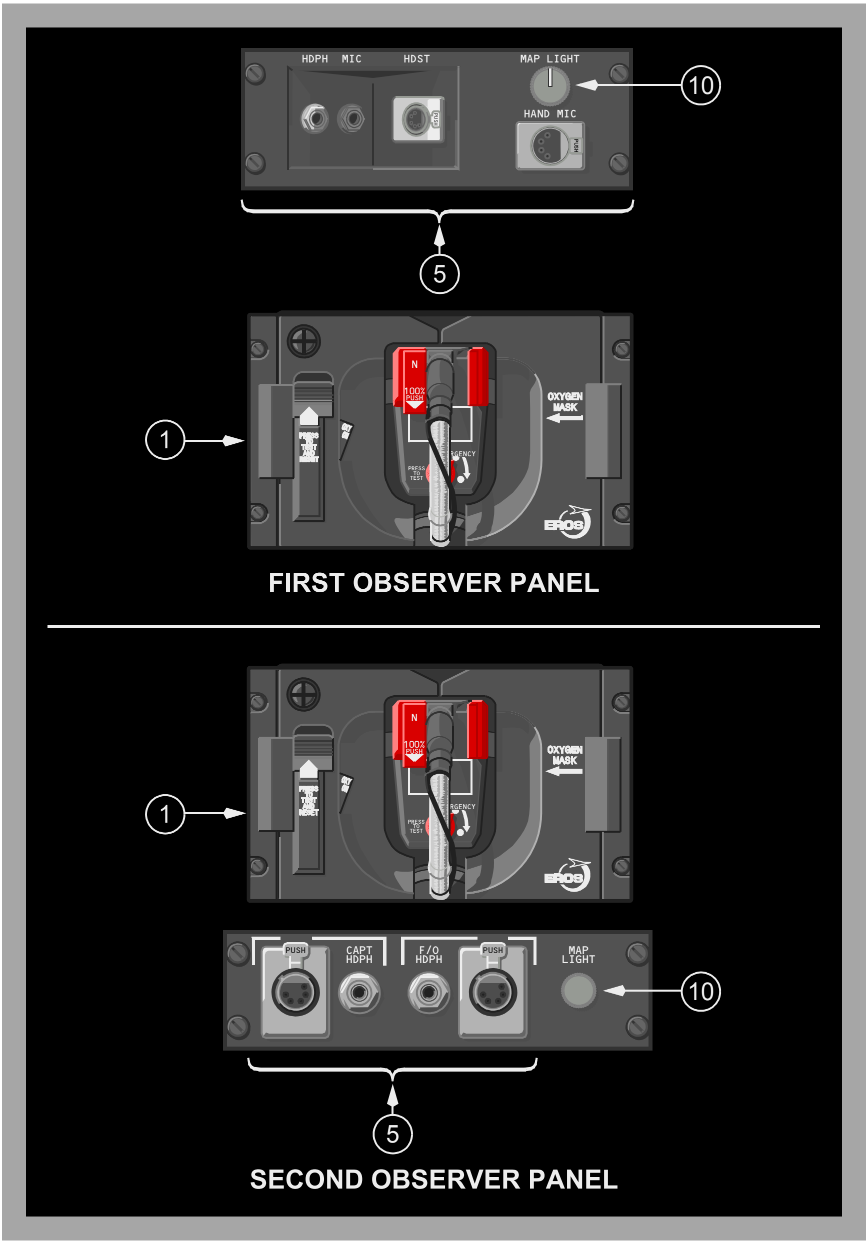
Left Sidewall



Right Sidewall



First and Second Observer Panels



Intentionally
Blank

Airplane General, Emergency Equipment, Doors, Windows — Chapter 1
Controls and Indicators — Section 30

Push–Button Switches

The airplane has two types of push–button switches: alternate action and momentary action. Both types direct crew attention to system status and faults.

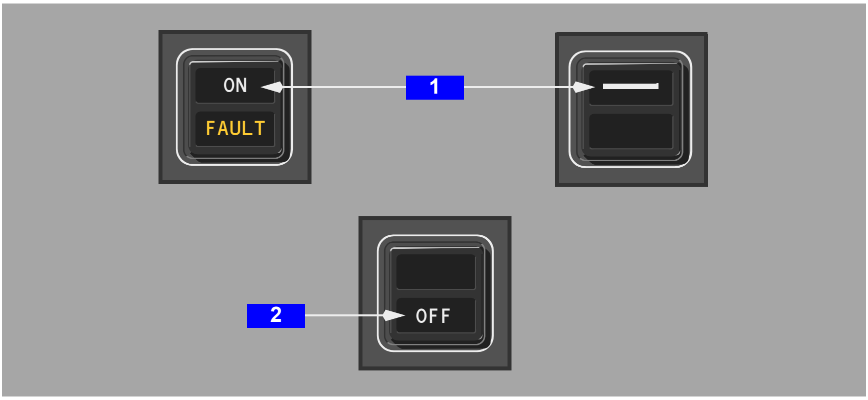
Note: Maintenance personnel should change switch lights. Changing the light requires changing the entire switch cap.

Alternate Action Switches

Alternate action switches have two positions: on and off.

When pushed in and flush with the panel, the switch is on. The switch indicates the system is on by displaying an operative word or flow bar.

When pushed out and extended, the switch is off. The switch indicates the system is off by displaying the word OFF, removing the flow bar, or becoming blank.



1 Switch is ON

ON, AUTO, or flow bar visible.

For some switches, system status (FAULT, MAN, OFF, VALVE) may be shown in the lower half of the switch.

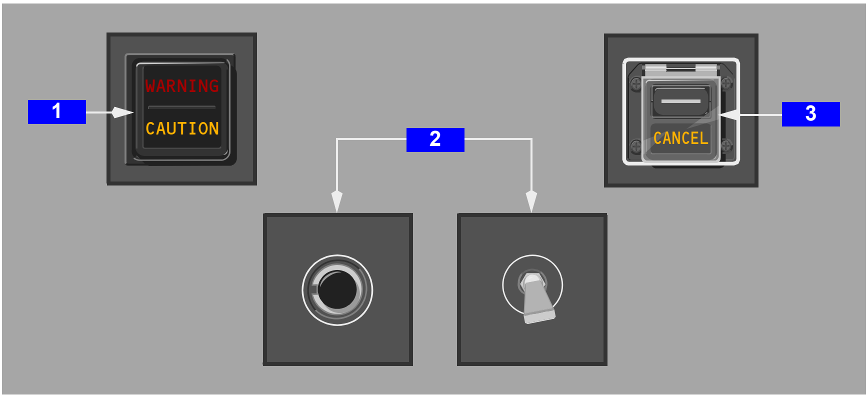
2 Switch is OFF

OFF or a line is visible –

- the top of the switch is blank
- a line indicates no label in this portion of the switch

Momentary Action Switches

Momentary action switches are spring loaded to the extended position. They are used to activate or deactivate systems or to reset system logic. The switch display indicates system status.



1 Push to Reset

Push – the switch resets the master lights and aural alerts.

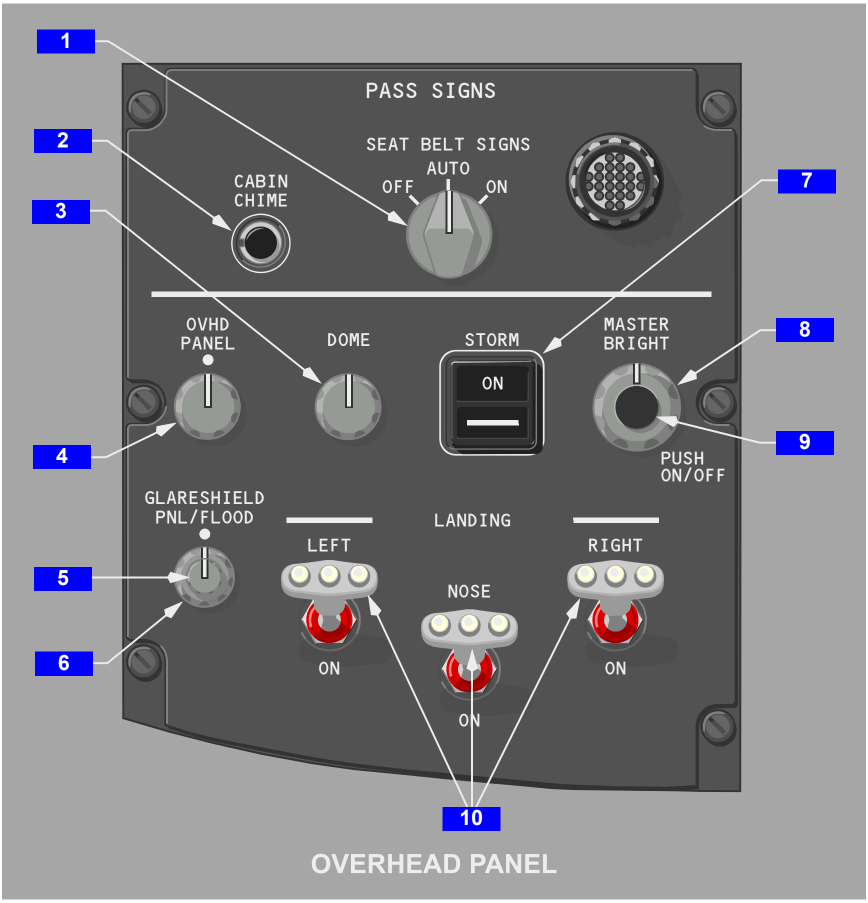
2 System Operation

Push – activates the system. Push and hold keeps some systems activated.

3 System Selection

Push – activates or deactivates the system.

Seat Belt Signs and Lighting



1 SEAT BELT SIGNS Selector

OFF – the fasten seat belt and return to seat signs are not illuminated.

AUTO – the fasten seat belt and return to seat signs are illuminated or extinguished automatically with reference to airplane altitude and system configuration (refer to Passenger Cabin Signs, Chapter 1, Section 40, for automatic system operation).

ON – the fasten seat belt and return to seat signs are illuminated.

Note: Any time passenger oxygen is deployed, the fasten seat belts signs illuminate automatically, regardless of the selector position.

2 **CABIN CHIME Switch**

Push - rings chime in cabin.

3 **DOME Light Control**

Rotate – controls overhead dome light brightness.

4 **Overhead (OVHD) PANEL Light Control**

Rotate – controls overhead panel light brightness.

5 **GLARESHIELD Panel (PNL) Light Control (outer)**

Rotate – controls glareshield panel light brightness.

6 **GLARESHIELD FLOOD Light Control (inner)**

Rotate – controls glareshield flood light brightness.

7 **STORM Light Switch**

ON – overrides normal controls and illuminates the following lights:

- all illuminated indicator lights
- glareshield flood lights
- instrument panel flood lights
- aisle stand flood lights
- forward dome light

8 **MASTER BRIGHTNESS Control (outer)**

Rotate (when the MASTER BRIGHTNESS switch is pushed on) -

- controls the brightness of all panel lights and displays (does not control: dome lights, flood lights, HUD, standby compass and annunciators)
- overrides individual brightness control settings
- limits adjustment range of individual brightness controls
- has full adjustment range of all lights when all individual brightness controls are set to the center detent

9 **MASTER BRIGHTNESS Control (inner)**

A black ring on the side of the inner switch is visible when the switch is out (OFF).

Push ON (in) – the MASTER BRIGHTNESS control is on.

Push OFF (out) – the MASTER BRIGHTNESS control is off.

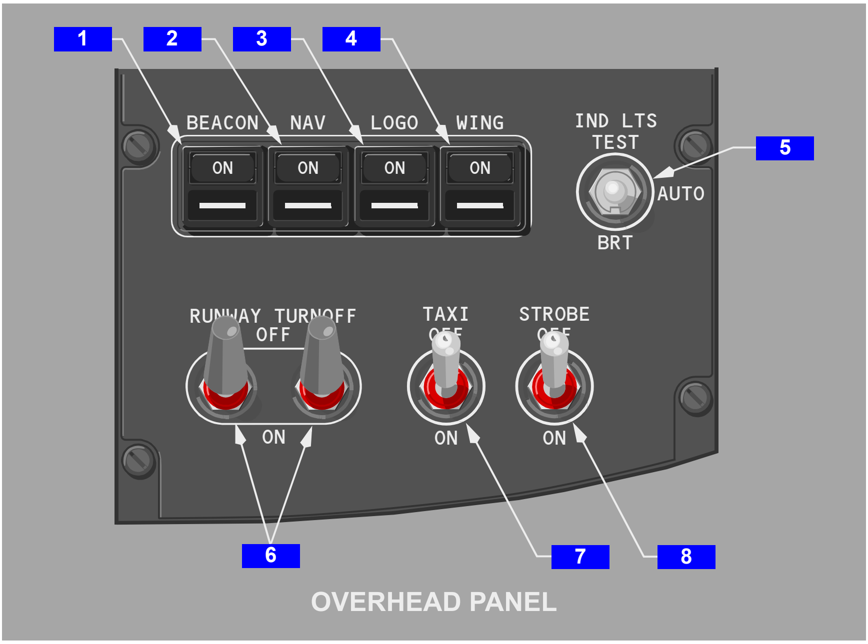
10 **LANDING Light Switches**

OFF – the landing light is not illuminated.

ON – the landing light is illuminated.

Note: The nose gear landing lights cannot illuminate when the nose landing gear is not down and locked.

Lighting Panel



1 BEACON Light Switch

ON – the red anticollision beacon lights on the top and bottom of the fuselage operate.

2 Navigation (NAV) Light Switch

ON – the red, green, and white navigation position lights are illuminated.

3 LOGO Light Switch

ON – the stabilizer mounted logo lights illuminate the airline logo on the vertical tail surface.

4 WING Light Switch

ON – the wing leading edge illumination lights are illuminated.

5 Indicator Lights (IND LTS) Switch

TEST (spring–loaded) –

While the switch is being held in the TEST position:

- illuminates all annunciator lights to full brightness for 10 seconds to check the bulbs, then dims the lights for the next 10 seconds. If the switch is held longer than 30 seconds all annunciator lights return to full brightness
- all liquid crystal displays on the MCP blink on for 2 seconds, then off for 1 second and repeat until the TEST switch is released

AUTO – sets all illuminated annunciator lights to full brightness when the forward field of view light sensors reach the high ambient lighting limit and returns to normal when the reset lighting intensity level is reached.

BRT (Bright) – sets all illuminated annunciator lights to full bright (overrides the automatic system operation).

6 RUNWAY TURNOFF Light Switches

OFF – the runway turnoff light is extinguished.

ON – the runway turnoff light is illuminated.

7 TAXI Light Switch

OFF – the taxi lights are extinguished.

ON – the taxi lights are illuminated.

Note: The taxi lights do not illuminate when the nose landing gear is not down and locked.

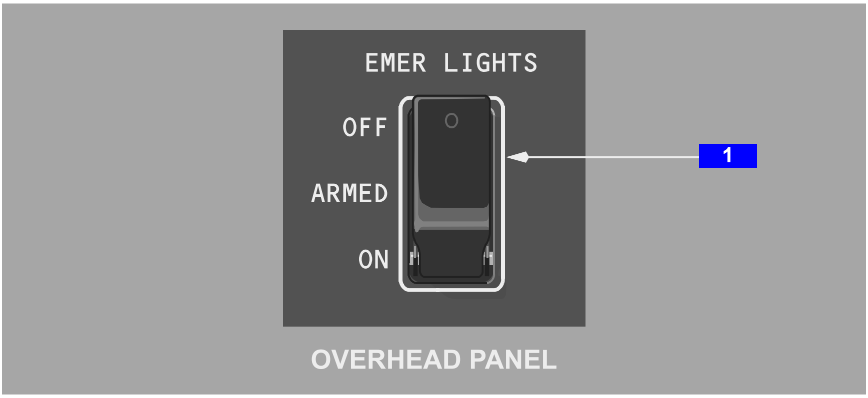
8 STROBE Light Switch

OFF – the white anticollision strobe lights on the tips of each wing and the tail cone are off.

ON – the strobe lights operate.

Miscellaneous Lighting Controls

Flight Deck Emergency Lights Switch



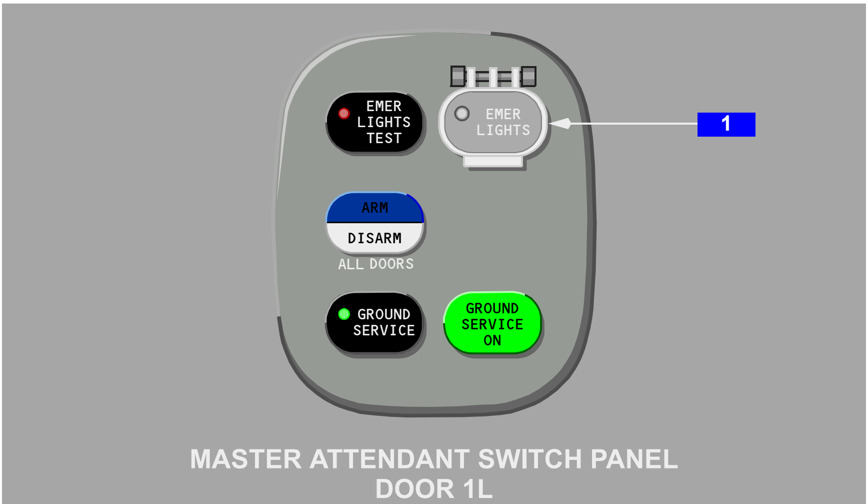
1 Emergency (EMER) LIGHTS Switch

OFF – prevents emergency lights system operation if airplane electrical power fails or is turned off.

ARMED – all emergency lights illuminate automatically if airplane electrical power fails or is turned off.

ON – all emergency lights illuminate.

Passenger Cabin Emergency Lights Switch



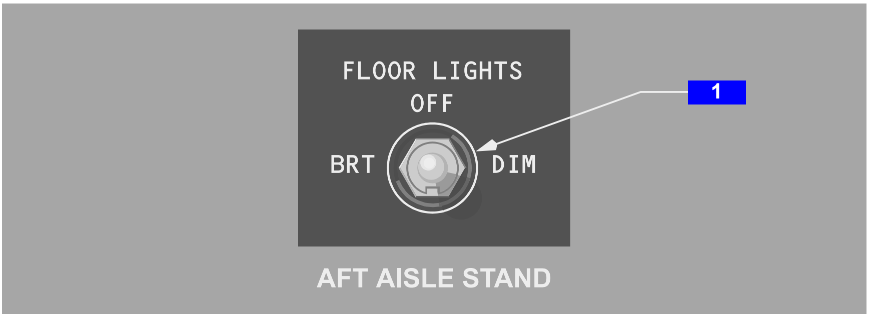
PRELIMINARY

1 **Passenger Cabin Emergency (EMER) LIGHTS Switch**

Push –

- Illuminated (red):
  - all passenger cabin and exterior emergency lights illuminate
  - bypasses the flight deck emergency lights switch
- Extinguished:
  - all passenger cabin and exterior emergency lights extinguish

Floor Lights Switch



1 **FLOOR LIGHTS Switch**

OFF – the flight deck floor lights are not illuminated.

BRT – the floor lights are illuminated bright.

DIM – the floor lights are illuminated dim.

Aisle Stand Panel/Flood Light Control

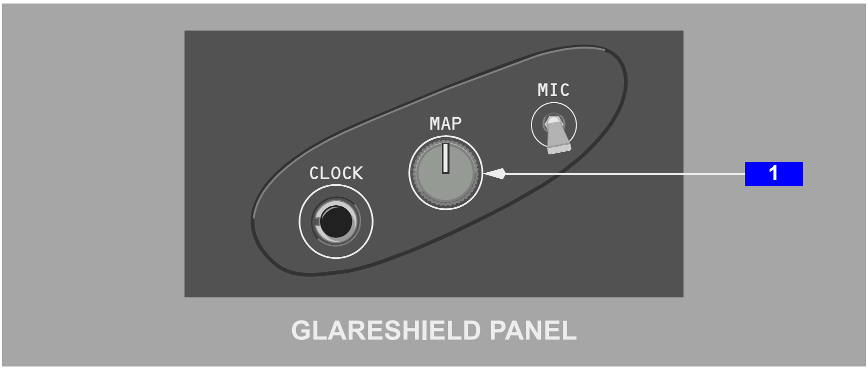
1 **AISLE STAND Panel (PNL) Light Control (outer)**

Rotate – controls the aisle stand instrument panel light brightness.

2 **AISLE STAND FLOOD Light Control (inner)**

Rotate – controls the aisle stand flood light brightness.

Map Light Control



1 MAP Light Control

Pull – on.

Push – off.

Rotate – adjusts map light brightness.

Forward Panel Brightness Controls

Note: The displays, HUD, and weather radar brightness controls are described in Chapter 10, Flight Instruments, Displays.

1 Forward Panel (PNL) Light Control (outer)

Rotate – controls forward panel lights brightness.

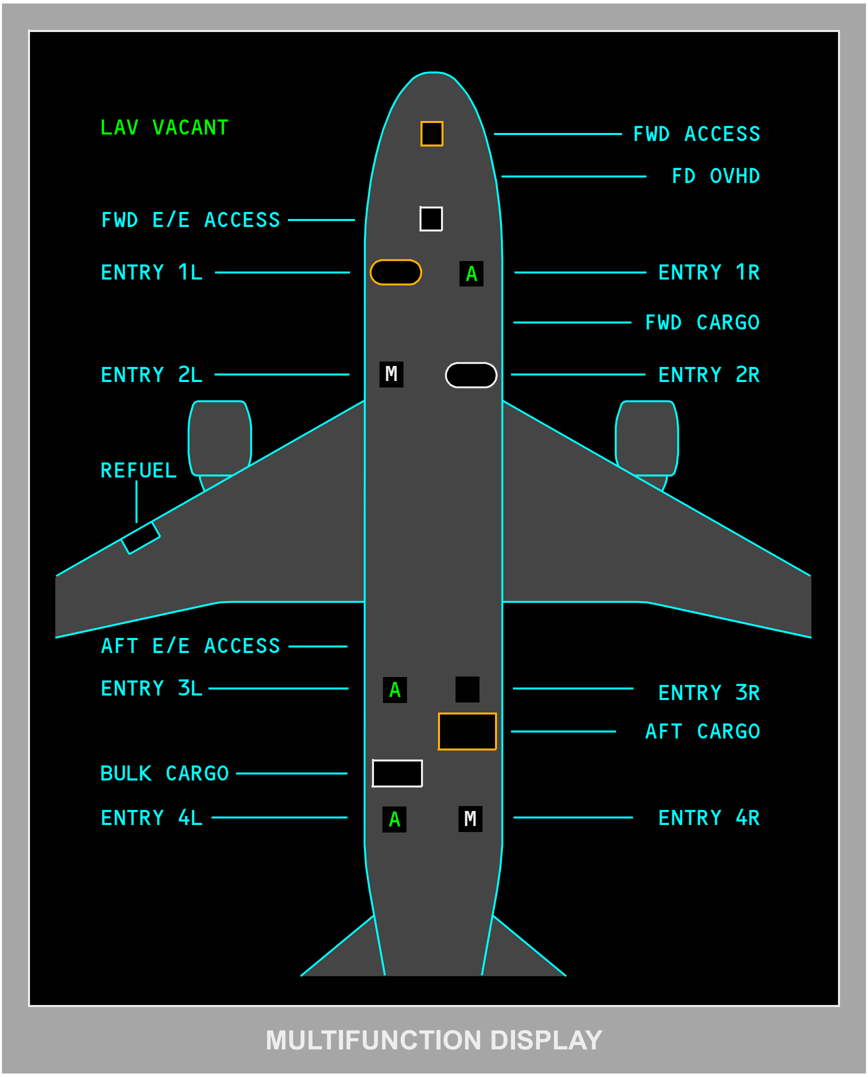
2 Forward Panel FLOOD Light Control (inner)

Rotate – controls forward panel flood light brightness.

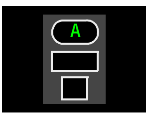
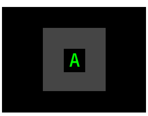
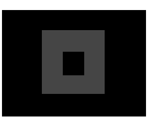
Doors and Windows

Door Synoptic Display

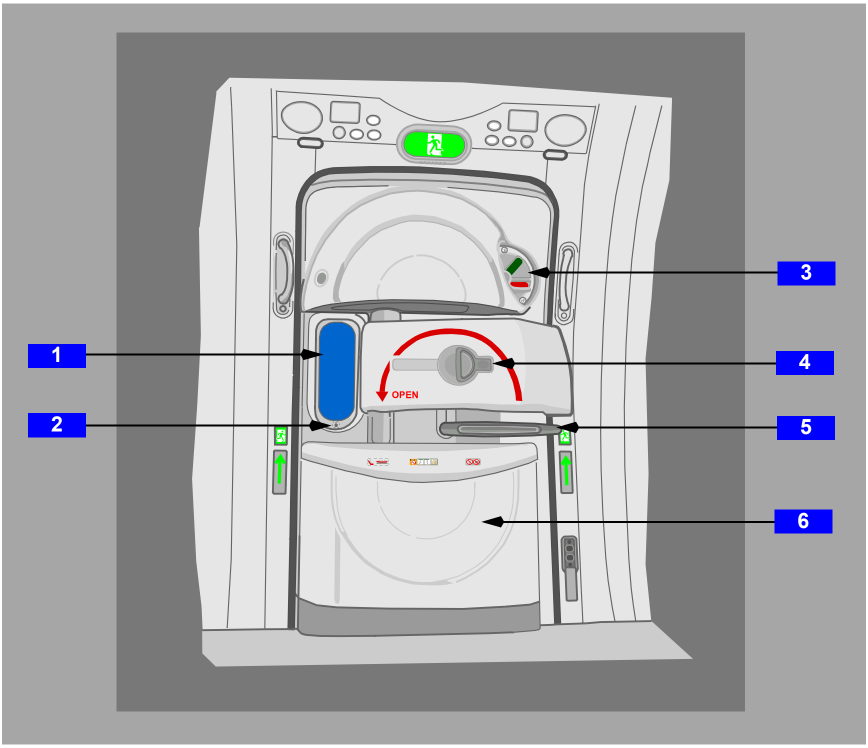
The doors synoptic is displayed by pushing the systems (SYS) display switch on the display select panel, and then selecting the DOOR synoptic key from the menu page. Display select panel operation is described in Chapter 10, Flight Instruments, Displays.



Door Synoptic Indications

Symbol	Indication	Description
	Door symbol blank	Large cargo door is closed, latched, and locked. Flight deck overhead door, bulk cargo door, or an access door is closed and latched.
	Door symbol amber	Passenger entry or large cargo door is NOT closed, latched, and locked. Flight deck overhead door, bulk cargo door, or an access door is NOT closed and latched.
	Door symbol white	Door signal is invalid or unknown. Door position is unknown. Slide indication will display if valid.
	Green letter A	Passenger door is closed, latched, and locked; and the slide in the automatic mode.
	White letter M	Passenger door is closed, latched, and locked; and the slide in the manual mode.
	Slide mode blank	Passenger door is closed, latched and locked; and the slide mode is unknown.
	Lavatory availability	LAV VACANT – lavatory is available. LAV OCCUPIED – lavatory is unavailable. Indication is blank – availability is unknown.

Passenger Entry Door



1 Viewing Window

Allows observation outside the airplane.

2 Closed, Latched and Locked Indicator

Indicates the current state of the door. The indication displays either an open symbol; or a closed, latched and locked symbol.

3 Door Mode Select Panel

See the detailed Door Mode Select Panel description in the next graphic.

4 Gust Lock Release Handle

Grab and pull inward to release the gust lock and move the door inward.

5 Door Operating Handle

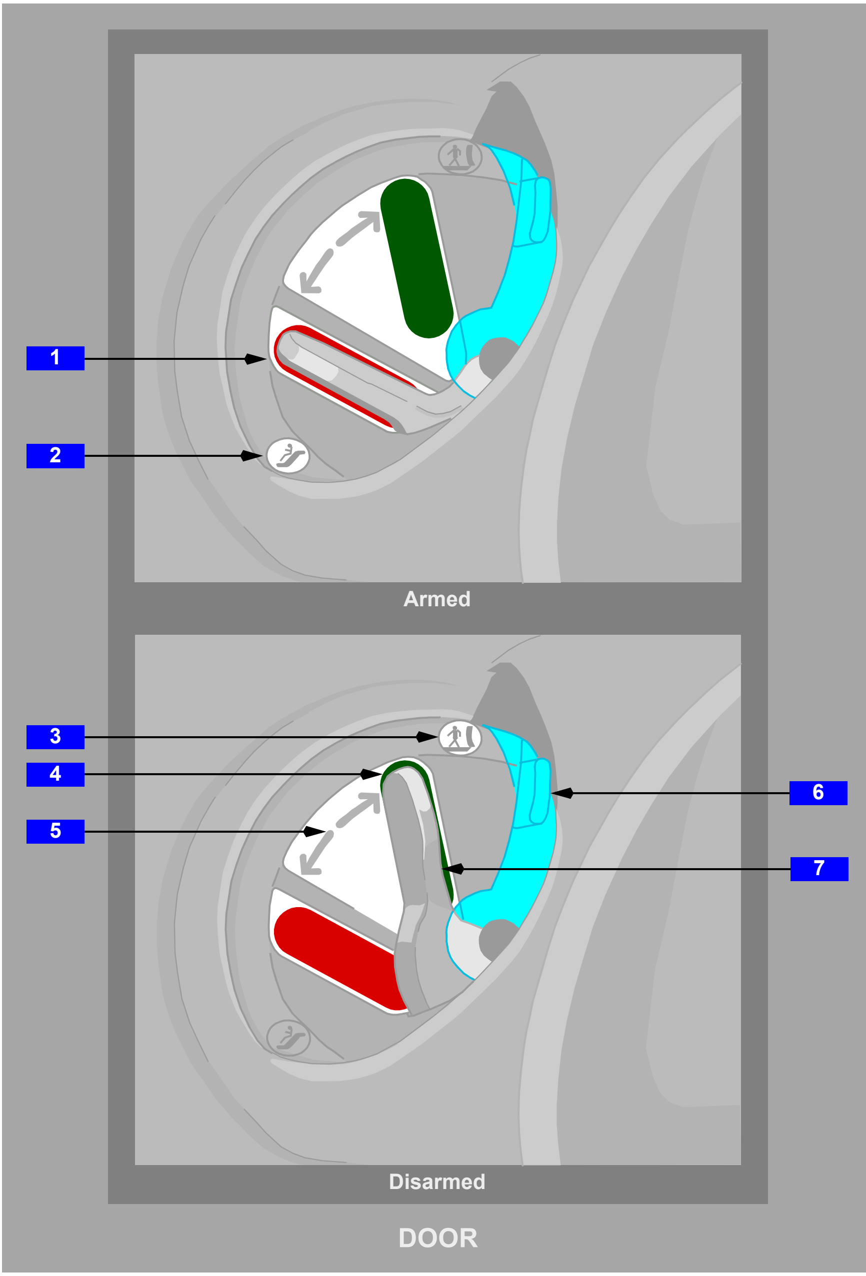
To open the door – rotate in the direction of the arrow.

To close the door – rotate in the opposite direction of the arrow.

6 Slide/Raft

The bustle contains the slide/raft.

Door Mode Select Panel



1 Armed

Red band.

Door is armed if the mode select lever is on top of the red band and the appropriate door armed indications are present. See items 2 and 3 below.

When the door operating handle is moved to the OPEN position:

- the door is powered open
- the slide/raft deploys

Note: If the door is opened from the outside, the mode select lever mechanically moves to the disarmed position.

2 Armed symbolic indicator

Indication light, symbolic of emergency slide use, is illuminated when the door mechanism has reached the fully armed position actuated by the door mode select lever. If the door is not fully armed both armed and disarmed indicators flash.

CAUTION: Do not rely on the symbolic indication as a means of determining if the door is armed. Ensure the door mode selector is directly on top of the red band, the armed symbolic indicator is illuminated, and the disarmed symbolic indicator is not illuminated.

3 Disarmed symbolic indicator

Indication light, symbolic of normal disembarkation, is illuminated when the door mechanism has reached the fully disarmed position actuated by the door mode select lever. If the door is not fully disarmed both armed and disarmed indicators flash.

CAUTION: Do not rely on the symbolic indication as a means of determining if the door is disarmed. Ensure the door mode selector is directly on top of the green band, the disarmed symbolic indicator is illuminated, and the armed symbolic indicator is not illuminated.

4 Disarmed

Green band.

Door is disarmed if the mode select lever is on top of the green band and the appropriate door disarmed indications are present. See items 2 and 3 above.

Moving the door operating handle to the OPEN position disables:

- power assist for door opening
- automatic slide/raft deployment

5 **Unsafe area**

If the mode select lever is not fully on top of the green or red band, or the armed/disarmed symbolic indicators are flashing, the door mode is unknown.

6 **Door Mode Select Lever cover**

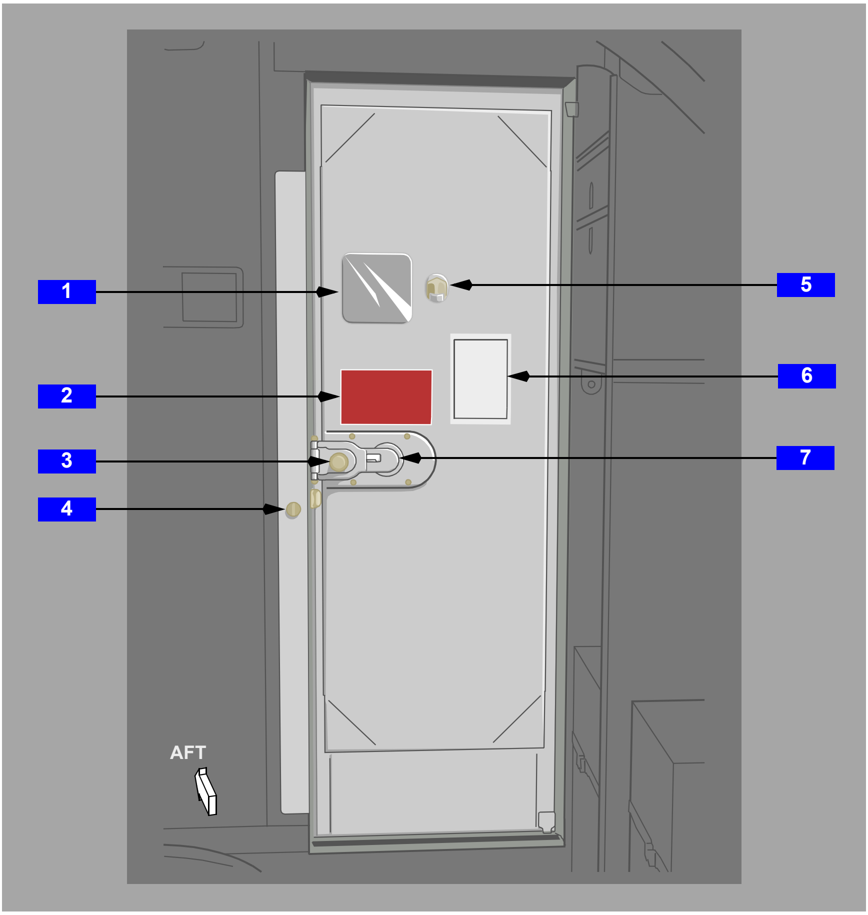
Slide closed to protect the mode select lever against inadvertent movement.

7 **Door Mode Select Lever**

Used to select the required mode; armed for flight or disarmed for arrival.

CAUTION: Ensure the door mode is properly selected by positioning the door mode select lever directly over the red or green band and ensuring that the appropriate symbolic indicator is illuminated steady and not flashing.

Flight Deck Door



1 **Mirror**

2 **Deadbolt Positions Placard**

Describes the status of the lock; unlocked, locked by key from the cabin, or locked from the flight deck.

Placard states, "CAUTION FOR GROUND USE ONLY".

3 **Door Handle**

4 **Deadbolt Knob/Indicator**

The deadbolt retracts and engages using a key on the cabin side and/or by knob on the flight deck side. Access from the cabin using the key is inhibited when the deadbolt is locked from the flight deck.

5 **Viewing Port**

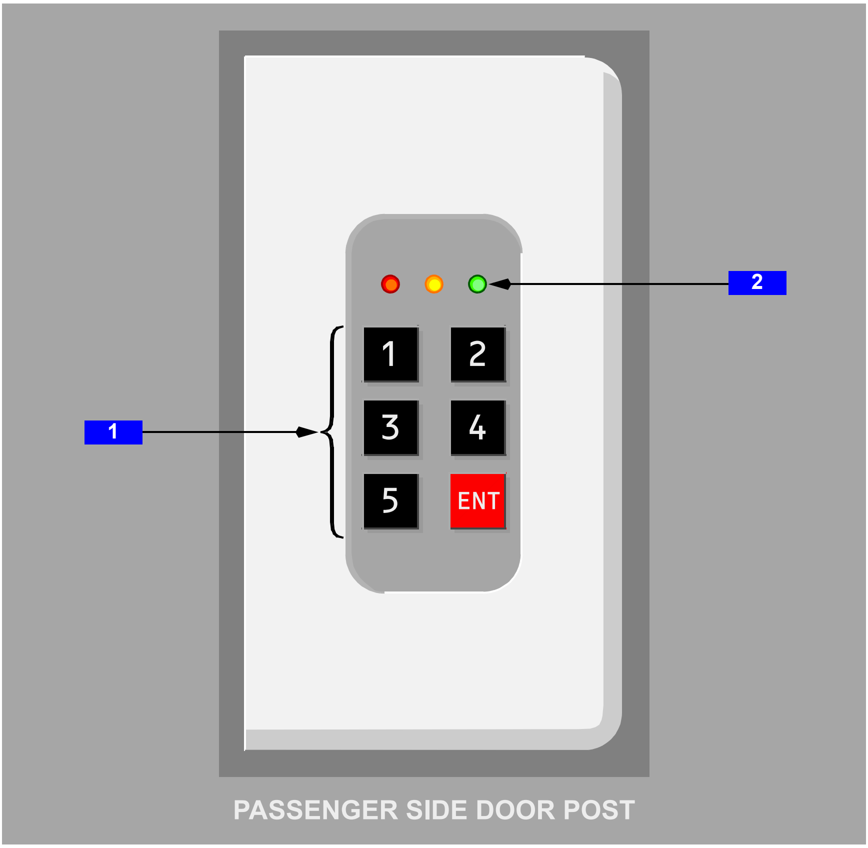
Allows viewing of persons in the immediate area outside the flight deck door.

6 **Decompression Latch Instruction Placard**

7 **Decompression Latch Override**

Allows the flight crew to manually trigger the decompression latch which opens the decompression panel to aid in egress should the door become jammed.

Flight Deck Access Keypad



1 Keypad

Push –

- enter the predefined 3 to 8 digit emergency access code by pressing the numeric sequence followed by the ENT key. Entry of the correct emergency access code produces a warning level alert to the flight crew and illuminates the amber light on the keypad
- enter 1 then ENT to activate the optional doorbell function. A hi-low chime and EICAS message alert the flight crew to the access request

2 Access Lights

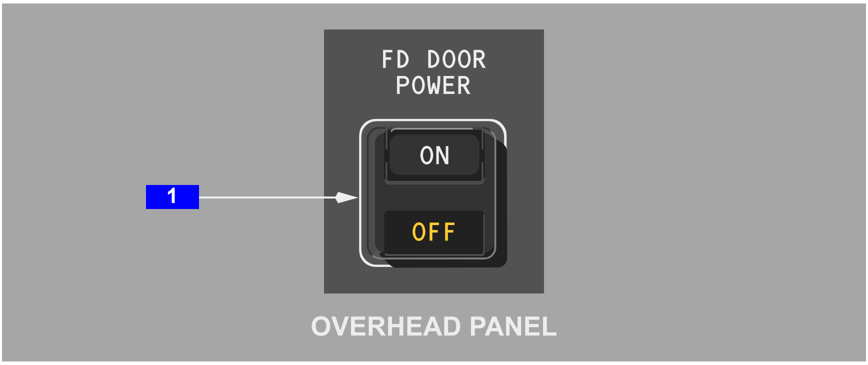
Illuminated (red) – door lock is powered and the door is locked when closed.

Note: When the FD DOOR POWER switch is OFF, the red LED is illuminated. In this condition, the door is unlocked when closed.

Illuminated (amber) – correct emergency access code has been entered.

Illuminated (green) – door is unlocked.

Flight Deck Door Power Switch

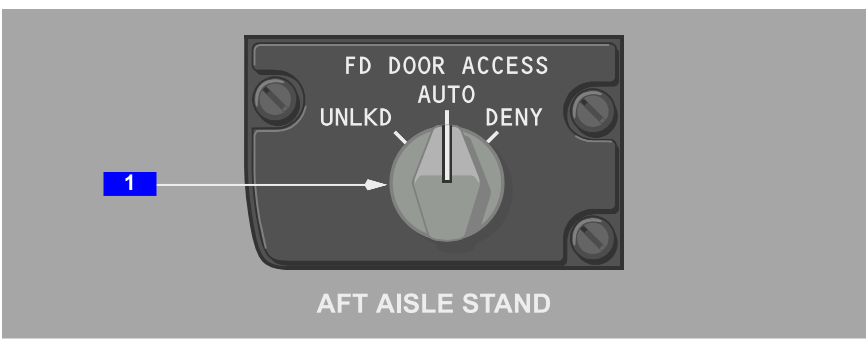


1 Flight Deck (FD) DOOR POWER Switch

ON (Normal) – flight deck door lock is powered. Door is locked when closed.

OFF (ON not visible) – removes electrical power from door lock. Door is unlocked when closed.

Flight Deck Door Access Panel



1 Flight Deck (FD) DOOR ACCESS Selector

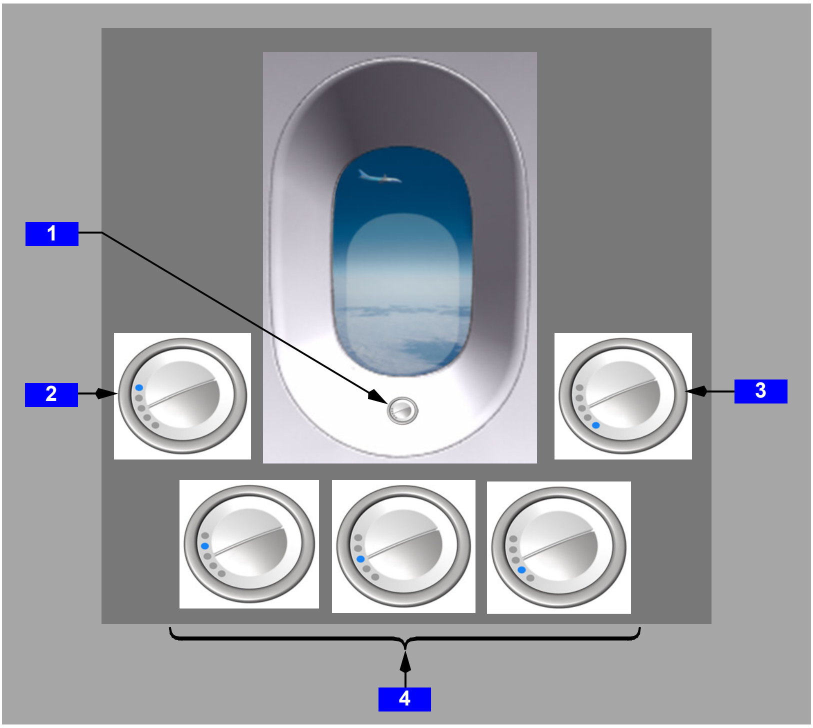
Spring loaded to AUTO. Selector must be pushed in to rotate from AUTO to UNLKD. Selector freely rotates from AUTO to DENY.

UNLKD – door unlocked while selector is held in this position.

AUTO – door locked when closed. Door unlocks after entry of emergency access code and expiration of timer, unless crew intervenes.

DENY - rejects emergency access request and prevents further emergency access code entries for a specified time period.

Passenger Cabin Window



1 Window Dimming Control Switch

Individual window dimming is controlled by using this switch. Push the upper part to lighten the window. Push the lower part to darken the window. Blue LEDs indicate the level of dimming.

The individual control feature can be partially overridden at the Cabin Attendant Panel. Only the two darker settings are available while in the cabin attendant override mode.

When the switch is not in use, the LED turns off. Selecting the control again illuminates the LED at the last position.

2 Clear

This indicates a clear window (no dimming) has been selected.

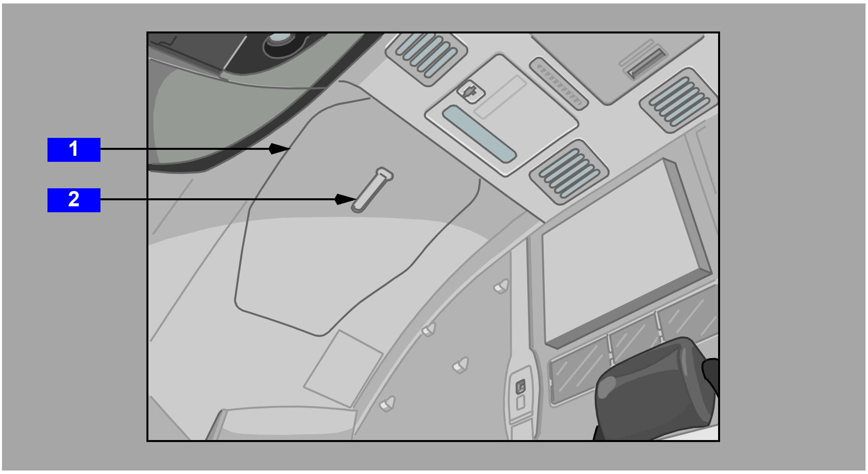
3 Dark

This indicates a dark window (full dimming) has been selected.

4 Intermediate Levels

One of these three indications is displayed when an intermediate level (partial dimming) has been selected.

Flight Deck Overhead Door and Vent

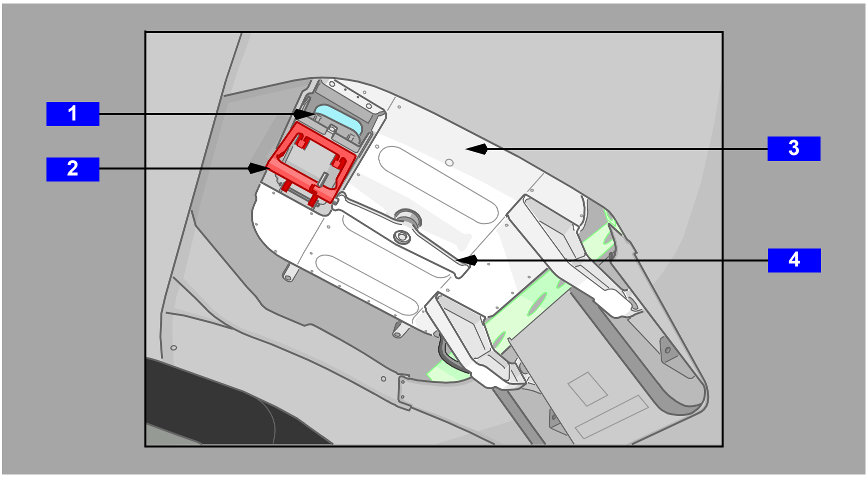


1 Flight Deck Overhead Door Panel

The door panel serves only as a cover for the overhead flight deck door and vent.

2 Flight Deck Overhead Door Panel Handle

To remove the door panel and access the overhead door and vent, release and rotate the handle in the direction of the arrow.



1 Flight Deck Overhead Vent Door

Ventilation door that, when open, allows cooling of the flight deck in non-normal conditions.

CAUTION: The vent should only be opened if the plane is depressurized and in association with a non-normal checklist procedure.

2 Flight Deck Overhead Vent Handle

The vent handle is used to open and close the vent door. Vent handle operation is described later in this section.

3 Flight Deck Overhead Door

The overhead door allows egress from the flight deck should the flight deck door become impassable. Refer to Flight Deck Overhead Door and Inertial Reels, Chapter 1, Section 40, for details on overhead door use in an emergency.

4 Flight Deck Overhead Door Handle

To open the door, rotate the handle in the direction of the arrow.

CAUTION: The flight deck overhead door is hinged to fall inward when opened. Care should be taken to avoid injury when opening the overhead door.

To close the door, lift the door into position and rotate the handle in the opposite direction of the arrow.

Flight Deck Overhead Door Vent Operation

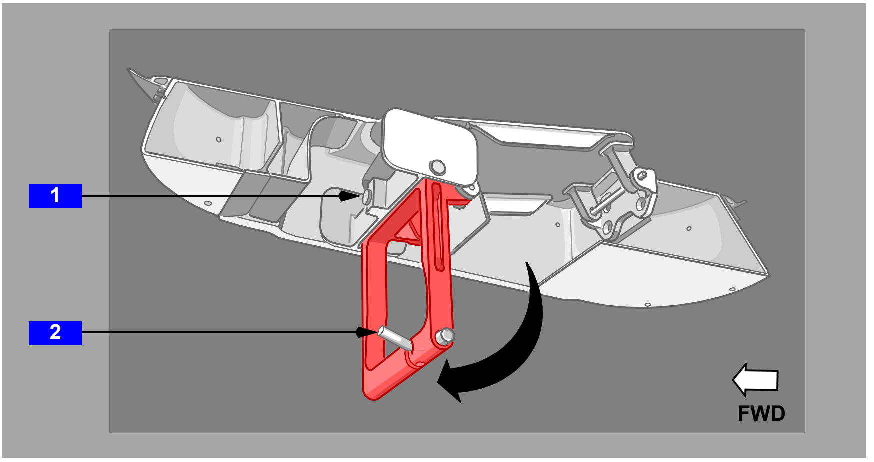
To open the vent:

- remove the vent panel cover by pulling down on the cover handles
- release the safety pin on the vent handle sliding it over and pointing down
- pull the vent handle down 90 degrees
- the handle locks in place with a spring loaded locking pin

To close the vent:

- pull out on the spring loaded locking pin at the base of the handle
- push the handle up 90 degrees
- replace the safety pin on the vent handle moving up and sliding it over
- replace the vent panel cover by pushing it securely in place

Note: The vent panel cover does not fit if the safety pin is not properly in place.



1 Locking Pin

Pull – temporarily unlocks the handle to allow closure of the vent.

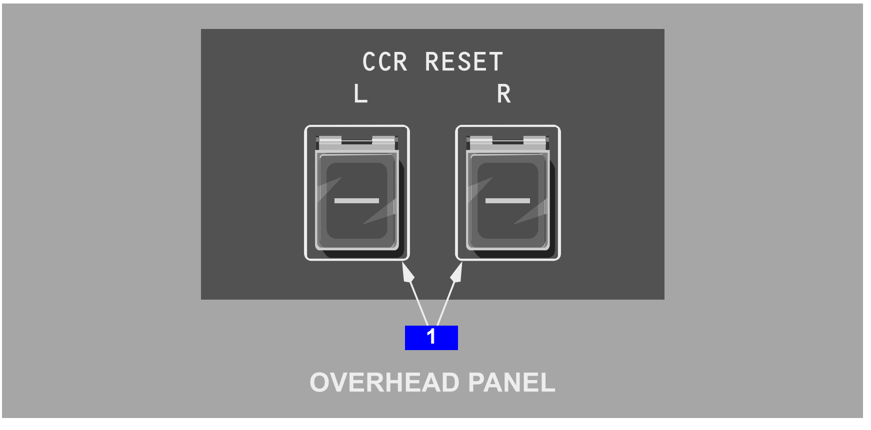
The vent handle is locked open using this spring-loaded locking pin when the handle is moved 90 degrees from closed.

2 Safety Pin

Pull and rotate – unlocks the handle to allow opening of the vent.

The vent handle is locked in the closed using this spring-loaded safety pin.

Common Computing Resource (CCR) Reset Switches



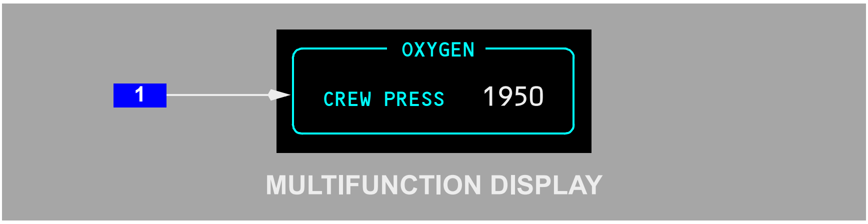
1 **CCR RESET Switches**

Push –

- temporarily removes all power from the related CCR causing a restart within the associated system
- restart cycle takes approximately 1 minute for the CCR to begin running
- restart attempts to recover a blanking condition of the forward displays

Oxygen Systems

Oxygen Indications

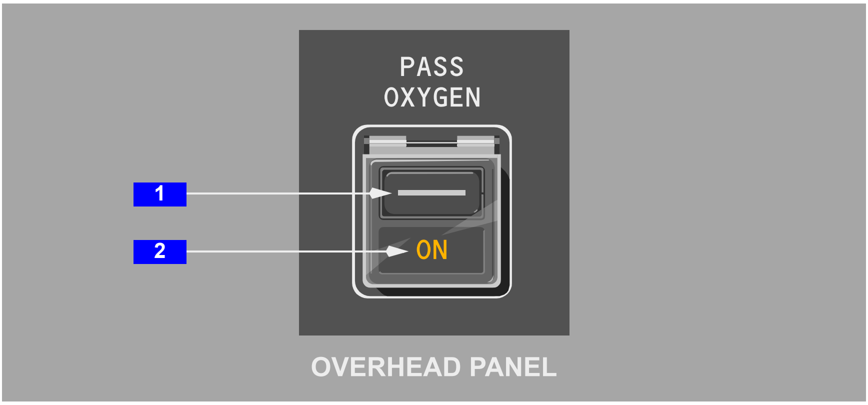


1 **Oxygen Pressure Display**

Displays crew oxygen cylinder pressure (PSI).

Note: Oxygen indication is displayed by pushing the system (SYS) display switch on the display select panel, and then selecting the status (STAT) synoptic key from the menu page.

Passenger Oxygen Switch



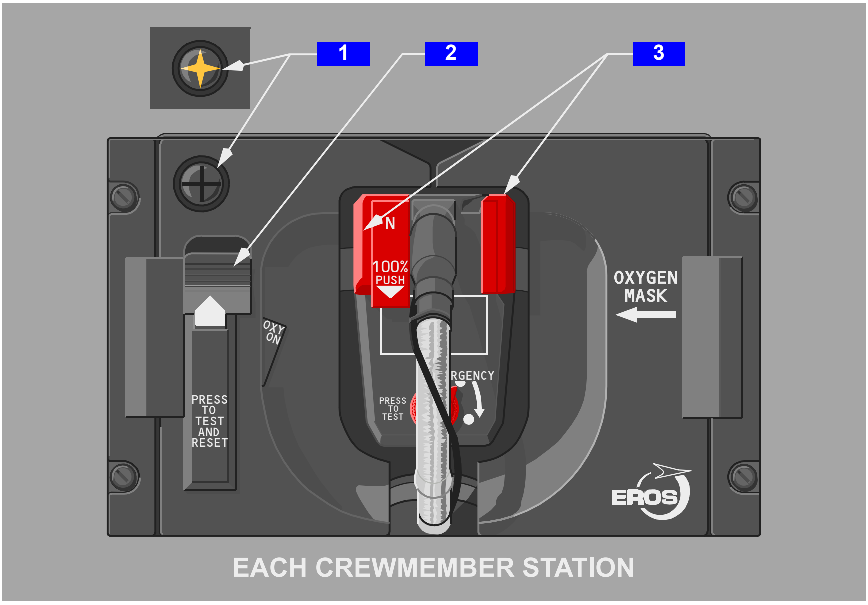
1 **PASSENGER OXYGEN Switch**

Push – the passenger cabin oxygen masks drop.

2 **Passenger Oxygen ON Light**

Illuminated (amber) – the passenger oxygen system is operating and the masks have dropped.

Oxygen Mask Panel



1 **Oxygen Flow Indicator**

Shows a yellow cross when oxygen is flowing.

2 **RESET/TEST Switch**

Push –

- with the left oxygen panel door closed and the OXY ON not displayed, turns oxygen on momentarily to test the regulator
- with the left oxygen panel door closed and the OXY ON flag displayed:
  - turns oxygen off and deactivates the mask microphone
  - reactivates the boom microphone

3 **Oxygen Mask Release Levers**

Squeeze and pull –

- opens oxygen panel doors and starts the flow of oxygen
- inflates the mask harness
- selects the mask microphone (the boom microphone is deselected)

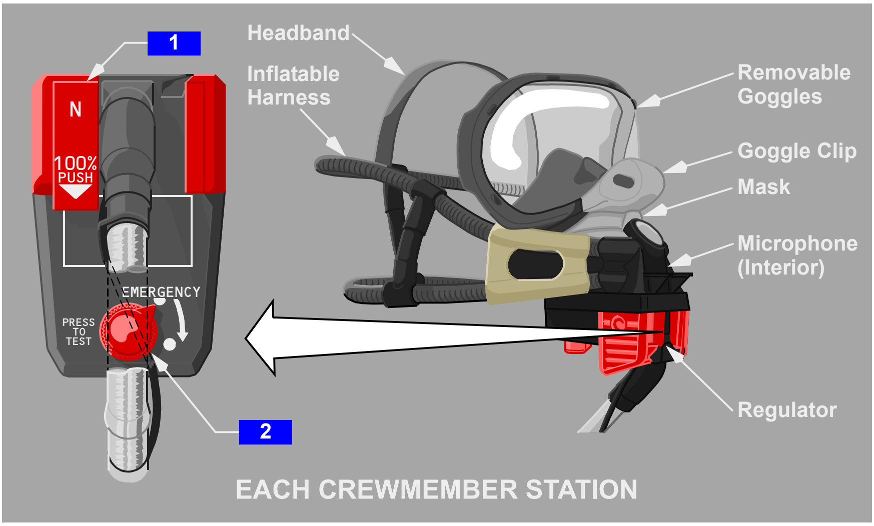
Squeeze (right lever) – inflates the mask harness.

Release (right lever) – deflates the mask harness into position on back of head.

Oxygen Mask and Regulator

The oxygen mask has a removable pair of smoke goggles attached just above the regulator. To remove the goggles:

- firmly grasp each side of the goggle clip
- depress the tabs to unlock the clip mechanism
- pull the goggles away from the mask



1 **NORMAL/100% Switch**

N (normal) – supplies an air/oxygen mixture on demand (the ratio depends on cabin altitude).

100% – supplies 100% oxygen on demand (not an air/oxygen mixture).

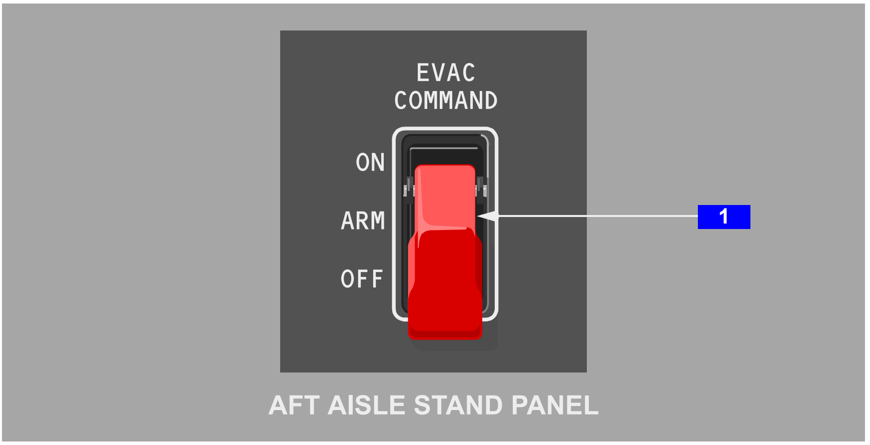
2 **Oxygen Mask Emergency/Test Selector**

Normal (non-emergency) position - supplies air/oxygen mixture or 100% oxygen on demand, depending upon the position of the Normal/100% switch. Automatically supplies 100% oxygen under positive pressure when cabin altitude is above a preset value.

EMERGENCY position (rotate in the direction of the arrow) – supplies 100% oxygen under positive pressure at all cabin altitudes (protects against smoke and harmful vapors).

PRESS TO TEST– tests the positive pressure supply to the regulator.

Emergency Evacuation Panel



1 Evacuation (EVAC) COMMAND Switch

ON –

- the EVAC COMMAND EICAS message (flight deck) is illuminated and the EVAC lights (flight attendant panels) flash
- an audio horn sounds at each flight attendant panel

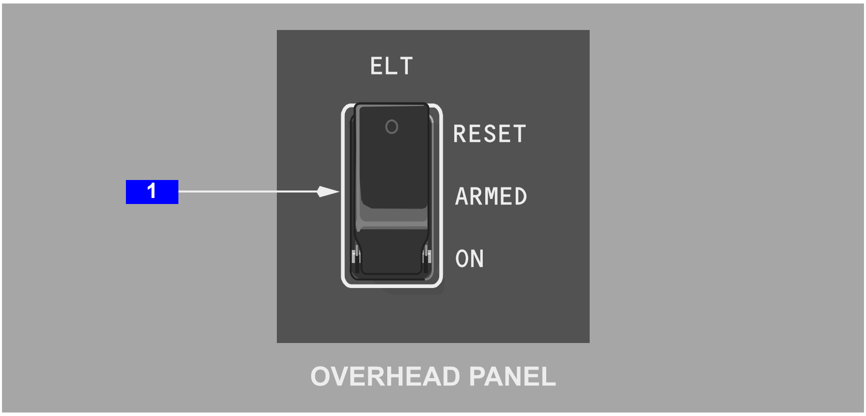
ARM – the evacuation signals can be activated at the flight attendant panels.

OFF – the evacuation signals can not be activated at the flight attendant panels.

[Option – Fixed ELT]

Fuselage Mounted Emergency Locator Transmitter

Emergency Locator Transmitter Control Panel



1 Emergency Locator Transmitter (ELT) Switch

RESET (spring–loaded) – push and hold approximately one second:

- stops ELT transmission if transmitting
- starts ELT self–test if not transmitting

ARMED – ELT starts transmitting if high deceleration is sensed.

ON – ELT transmits continuously.

Intentionally
Blank

Airplane General, Emergency Equipment, Doors, Windows — Chapter 1
Systems Description — Section 40

Introduction

This section describes miscellaneous airplane systems, including:

- lighting systems
- common core system (CCS)
- oxygen systems
- doors
- flight deck seats

Lighting Systems

Lighting systems described in this chapter include:

- exterior lighting
- flight deck lighting
- passenger cabin lighting
- emergency lighting

Exterior Lighting

Exterior lighting consists of these lights:

- landing
- runway turnoff
- taxi
- strobe
- beacon
- navigation (position)
- logo
- wing leading edge illumination

Landing Lights

The landing lights consist of the left, right, and nose gear landing lights. The left and right landing lights are located in the left and right wing root. These lights are optimized for flare and ground roll. The two nose gear–located landing lights are optimized for approach.

Runway Turnoff Lights

Runway turnoff lights are installed in the left and right wing roots. The lights illuminate the area in front of the main gear.

Taxi Lights

Taxi lights are installed on the non–steerable portion of the nose strut. They are inoperative when the nose landing gear is not down and locked.

Strobe Lights

The strobe lights are white anticollision strobe lights located on each forward wing tip and on the tail cone.

Beacon Lights

The beacon lights are red anticollision strobe lights located on the top and bottom of the fuselage.

Navigation (Position) Lights

The navigation lights are the standard red (left forward wingtip), green (right forward wingtip), and white (aft tip of both wings and tailcone) position lights.

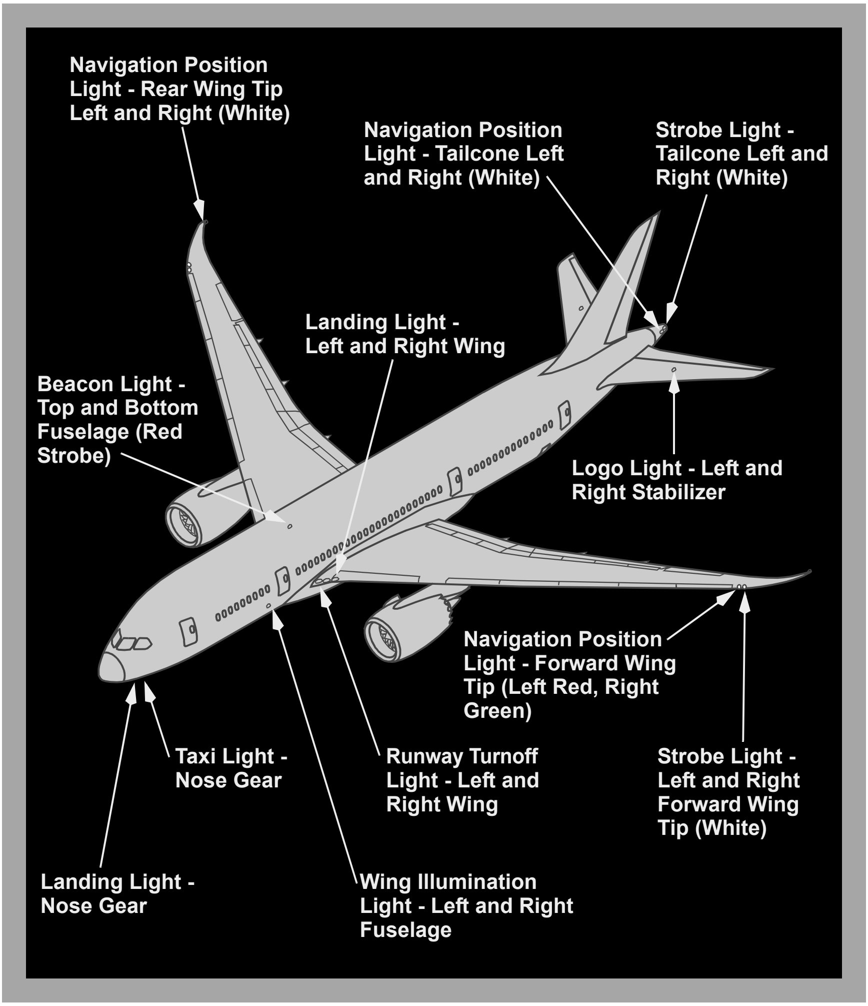
Logo Lights

Logo lights are located on the stabilizer to illuminate the airline logo on the vertical tail surface.

Wing Leading Edge Illumination

Wing lights are installed on the fuselage and illuminate the leading edge of the wing.

Exterior Lighting Locations



Flight Deck Lighting

Flight deck lighting is provided for panel illumination, area lighting and localized illumination. Flood lights and light plates provide panel illumination. Dome lights provide flight deck area lighting. Map lights and a single utility light provide localized illumination.

Panel and flood lights illuminate the forward panels, glareshield and aisle stand panels. When the storm light switch is ON, the left and right forward panel flood lights, glare shield flood lights, aisle stand flood light, and forward dome light all illuminate to a bright intensity, and all annunciator lights illuminate at full brightness.

If normal electrical power is lost, standby electrical power is automatically provided to the primary displays. The aisle stand, left and right forward panel and glareshield flood lights, and the dome lights illuminate automatically at a fixed brightness.

Master Brightness Control System

The MASTER BRIGHTNESS control provides the means of controlling panel and display lighting brightness with the use of one control. The control is turned on when the MASTER BRIGHTNESS switch is pushed on.

Lighting controlled through the master brightness system are:

- display units
- clocks
- ISFD
- digital displays
- overhead panel
- glareshield panel
- forward panels (left, center, and right)
- aisle stand panels (forward and aft)
- side panels (left and right)

The individual lighting controls for the above displays and panels have a center detent position identified by a white dot at the mid–range adjustment position, and physical stops at the minimum and maximum levels.

Individual controls can be used for dimming individual displays and panels. The individual controls have limited adjustment capability when the MASTER BRIGHTNESS switch is on, and should be centered in the detent when first adjusting the MASTER BRIGHTNESS control. They have full range of brightness control when the MASTER BRIGHTNESS switch is off.

Passenger Cabin Lighting

Passenger cabin lighting near the flight deck entry door is automatically dimmed or extinguished when the flight deck door is opened while an engine is operating. This reduces the light level entering the flight deck at night.

Passenger Cabin Signs

The fasten seat belt signs are controlled by an overhead panel selector. The signs automatically illuminate when the SEAT BELT SIGNS switch is in the AUTO position and:

- landing gear not up and locked, or
- flap lever not up, or
- airplane altitude below an airline defined altitude, or

- cabin altitude above 10,000 feet, or
- passenger oxygen on

The fasten seat belt signs can be controlled manually by positioning the SEAT BELT SIGNS selector to ON or OFF. When the SEAT BELT SIGNS selector is in the OFF position, and oxygen is ON, the fasten seat belt signs illuminate.

Return to seat signs are illuminated with the fasten seat belt signs, except when oxygen is deployed.

When the fasten seat belt signs illuminate or extinguish, a low tone sounds over the PA system.

The no smoking signs are permanently illuminated.

Emergency Lighting

The emergency lighting system is powered by remote batteries. Battery charge is maintained by the airplane electrical system. A fully charged battery provides at least 15 minutes of operation.

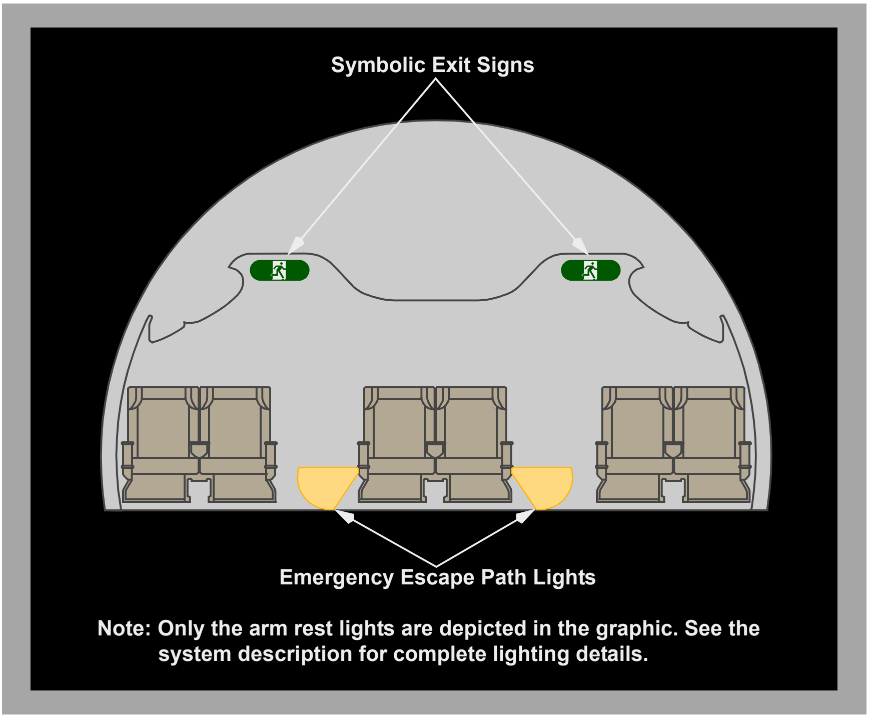
Emergency lighting is controlled by the emergency lights (EMER LIGHTS) switch on the overhead panel. The switch can be used to manually activate or arm the system for automatic operation. The system monitors airplane power and automatic operation occurs when required power fails or is turned off with the system armed. The emergency lighting system can also be activated by the EMER LIGHTS switch on a main flight attendant switch panel.

When the emergency lights switch in the flight deck is armed, and the door mode select lever is in the armed position, moving the door handle to the open position causes the interior emergency lights at that door to illuminate.

The EICAS advisory message EMER LIGHTS is displayed when:

- the emergency lights switch is not in the ARMED position, or
- the emergency lights are on

Interior Emergency Lighting

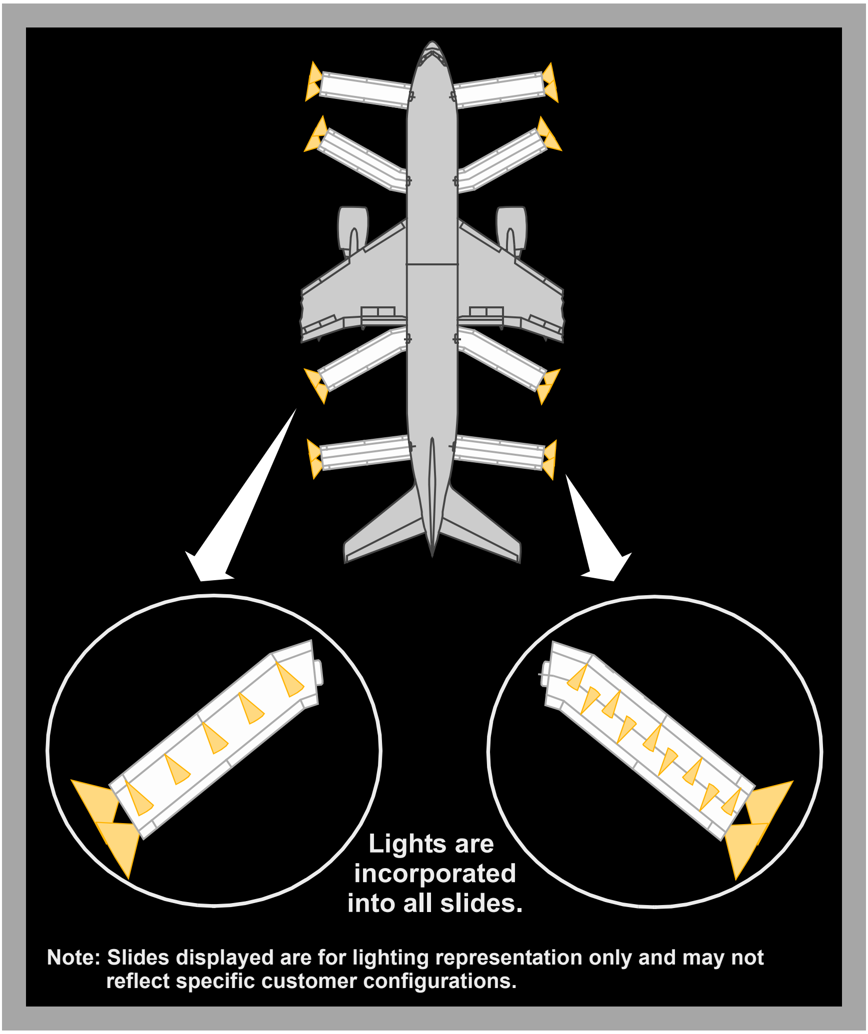


Interior emergency lighting consists of door, aisle, cross–aisle, escape path, exit lights, and luminous symbolic exit signs.

Escape path lighting consists of lights installed in the arm rest of the center passenger seats, center galleys, lavatories, closets and partitions spaced at intervals in the aisles and cross–aisles. When illuminated, escape path lighting provides visual guidance for emergency evacuation if all sources of lighting more than four feet above the aisle floor are obscured by smoke.

Luminous symbolic exit signs are located at each cabin exit door.

Exterior Emergency Lighting



Exterior emergency lighting consists of integrated escape slide lighting. Each slide has several lights built into the sliding lane and at the base near the landing area. When the slide is deployed, the lights turn on automatically to illuminate the slide and the landing area.

Common Core System

The Common Core System (CCS) provides a set of shared computing, data bus, and input/output resources to support the computing and system interface needs on the airplane. The CCS main element is the Common Computing Resource (CCR) which contains a left and right partition.

The CCS has three start-up modes depending on application of an available power source; battery only, external power, and battery start interrupted by application of external power.

Battery power only start-up sequence:

- the BATTERY switch is pushed and the left CCR starts a power up cycle which takes approximately 50 seconds
- the left CCR is on-line when the lower display unit displays the default format (CDU pages)

Note: This applies only when no external power is, or becomes, available.

External power start-up sequence:

- when external power becomes available (AVAIL is displayed on either forward EXT PWR switch), both CCR sides start a power up cycle which takes approximately 3 minutes
- the entire CCR (left and right sides) is on-line when all the display units and the HUD display their default formats

Note: This applies only when external power is available prior to application of the BATTERY switch.

Battery then external power start-up sequence occurs when:

- the left CCR has begun a start cycle on battery power but is not yet on-line and external power becomes available:
  - the left CCR stops its start cycle and the entire CCR begins a new start cycle which takes approximately 3 minutes from the moment of external power availability
  - the entire CCR is on-line when all the display units and the HUD display their default formats
- the left CCR is on-line and external/APU power becomes available:
  - the right CCR begins a start cycle which takes approximately 3 minutes from the moment of external/APU power availability
  - the left CCR remains on-line, the lower display unit blanks, and the upper display units display their default formats
  - the entire CCR is on-line when all the display units and the HUD display their default formats

In the event of a software anomaly affecting the CCS, system processing may halt and the five forward and two HUD displays blank. If this occurs, crews are required to follow the unannunciated non-normal checklist procedure; Loss Of All Displays. This checklist attempts to restart the CCS using the CCR RESET switches located on the overhead panel. After the restart, the CCS reverts to a start up configuration but only the four forward displays are regained. The lower forward and both HUD displays remain blank.

Oxygen Systems

Two independent oxygen systems are provided, one for the flight deck and one for the passenger cabin. Portable oxygen cylinders are located throughout the airplane for emergency use.

Flight Deck Oxygen System

The flight deck oxygen system uses quick–donning masks and regulators located at each of the flight crew and observer stations. System oxygen pressure is displayed on the MFD STATUS display.

Flight crew and observer masks and regulators are installed behind oxygen mask panels near each seat. Squeezing the red oxygen mask release levers and pulling the unit outward releases the mask from stowage and:

- inflates the mask harness
- starts the flow of oxygen to the mask
- selects the mask microphone (the boom microphone is deselected)

The boom microphone can be reselected by closing the left oxygen panel door and pushing and releasing the reset/test switch. This also shuts off oxygen to the mask. The oxygen flow can be restored by opening the left oxygen panel door.

Crew Oxygen Mask Microphone Test

The oxygen mask microphone can be tested without removing it from the storage box using the following procedure:

- select the FLIGHT interphone transmitter and set the speaker volume as desired
- push and hold a MIC switch on either the audio control panel or the glare shield
- push both the oxygen mask RESET/TEST switch and the EMERGENCY/TEST selector

The sound of oxygen flowing is heard through the speaker, verifying microphone operation.

Passenger Cabin Oxygen System

The passenger cabin oxygen system is supplied by gaseous oxygen stored in small high pressure cylinders. The passenger and flight attendant oxygen masks and gaseous oxygen cylinders are located throughout the cabin in passenger service units (PSUs) fitted to the ceiling panels. Oxygen flows from a PSU cylinder when any mask hanging from that PSU is placed over the nose and mouth. Normal breathing initiates the oxygen flow. The system regulates the pressure and distributes oxygen to the masks by providing small pulses of oxygen to the user during inhalation. The oxygen cylinders are single use devices and once activated, provides oxygen until the cylinder is depleted.

The masks automatically drop from the PSUs prior to the cabin altitude reaching the greater of:

- 15,000 feet, or
- origin airfield altitude +2000 feet, or
- destination airfield altitude +2000 feet

The passenger cabin masks can be manually deployed from the flight deck by pushing the PASS OXYGEN switch on the overhead panel to the ON position.

The passenger cabin system provides oxygen to the main seating area, galleys, flight attendant stations, and lavatories.

The passenger cabin system provides oxygen to the main seating area, galleys, flight attendant stations, overhead crew rest areas, and lavatories.

Overhead Crew Rest Oxygen System

[Option – Overhead crew rest]

The overhead crew rest oxygen system is considered part of the passenger cabin oxygen system and its operation is identical. See Passenger Cabin Oxygen System description in this section.

Portable Oxygen Bottles

Portable oxygen bottles are stowed in various locations in the passenger cabin. The bottles are fitted with disposable masks and are used for first aid purposes or as walk–around units. All bottles are identical in size and capacity.

Doors

The airplane has eight passenger cabin entry doors, a flight deck door, and two large cargo doors. It also has a bulk cargo door, an overhead door in the flight deck ceiling, one equipment access door located forward of the nose gear, and two electrical and electronic (E/E) equipment access doors, one aft of the nose gear and one aft of the wing box.

An EICAS message is displayed when the flight deck door, a passenger cabin door, or large cargo door is not closed, latched, and locked. Likewise, an EICAS message is displayed when the bulk cargo door, overhead flight deck door, or an access door is not closed and latched (there are no locks on these doors).

Flight Deck Door

[Option – Video surveillance]

The flight deck door and aft wall meet requirements for resistance to ballistic penetration and intruder entrance. The door opens into the cabin. When closed, the door locks when electrical power is available and unlocks when electrical power is removed. A security camera system in the EFB allows observation of the cabin area immediately outside the flight deck door. The door can be manually opened from the flight deck at anytime by turning the door handle.

The flight deck door features an inset decompression panel that allows air to vent from the passenger cabin into the flight deck in the event of a rapid decompression in the flight deck. The inset decompression panel is hinged along the left hand side, allowing it to swing open from right to left. The panel uses a mechanical decompression latch that senses the onset of a rapid decompression, thereby allowing it to open. The decompression latch contains features that make it tamper and ballistic resistant from the passenger cabin side. In the event of a passenger cabin decompression, the entire flight deck door is allowed to open permitting flight deck air to vent into the passenger cabin.

The decompression panel also features an escape mechanism that allows the flight crew to open it should the door become jammed. This feature allows for egress from the flight deck to the passenger cabin. The escape mechanism is integrated into the decompression latch allowing the flight crew to manually trigger the latch to open the decompression panel. Instructions for using the latch are placarded on the interior of the flight deck door.

The flight deck access system incorporates a check to verify the flight deck door is properly closed and locked. Activation of the EICAS advisory message FD DOOR OPEN indicates the door lock pin is seated while the door sensor is indicating the door is open.

The pull-handle design on the passenger side of the door has no key, is not physically part of the latch, and is designed to limit the amount of pulling force that can be applied to the door. If this load is exceeded, the handle separates from the flight deck door but the door remains closed and locked.

Flight Deck Access System

The flight deck access system consists of a flight deck access keypad, a flight deck door access selector, a flight deck door power switch, and EICAS messages.

The flight deck access keypad includes a six button keypad along with red, amber, and green LED lights. The red light illuminates to indicate the door is locked. When the correct emergency access code is entered, the amber light illuminates. The green light illuminates to indicate the door is unlocked.

Note: The red light also illuminates when the FD DOOR POWER switch is OFF. In this condition, the door is unlocked when closed.

A three position rotary door access selector is located on the aft aisle stand. This selector is used to allow or deny access to the flight deck. The EICAS advisory message FD DOOR LOCK FAIL indicates the door lock has failed or the door power switch is in the OFF position.

Pressing the 1 and then ENT keys on the flight deck access keypad sounds the flight deck chime and set the EICAS COMM message FD DOOR CALL to be displayed. The door remains locked unless pilot action is taken.

The emergency access code is used to gain access to the flight deck in case of pilot incapacitation. Activation of the EICAS warning message FD DOOR AUTO UNLOCK, the master warning lights, and master warning siren indicate the correct emergency access code has been entered and the door is programmed to unlock after a time delay. Selecting the DENY position on the door access selector denies entry and prevents any further keypad entries for a customer defined time period. During an emergency access request, the UNLKD position on the door access selector is inhibited. To allow entry, the selector must first be turned to the DENY position and then to the UNLKD position which unlocks the door while held in that position. Or, if the pilot takes no action during the emergency access request, the door unlocks after expiration of the customer defined time delay.

Dead Bolt Lock

The door incorporates a deadbolt with keyed access from the cabin. The keyed deadbolt is primarily used to secure the flight deck when power is not available to the locking system. The locking bolt retracts and engages using the key and/or inside flight deck knob only. The deadbolt is placarded, "CAUTION FOR GROUND USE ONLY".

The deadbolt has a lockout feature in the flight deck so that an intruder with the key would not be able to unlock the door. The knob clearly indicates the status of the lock whether it is unlocked, has been locked with a key from the passenger cabin, or the passenger side key function has been locked out from the flight deck.

Flight Deck Overhead Door and Inertial Reels

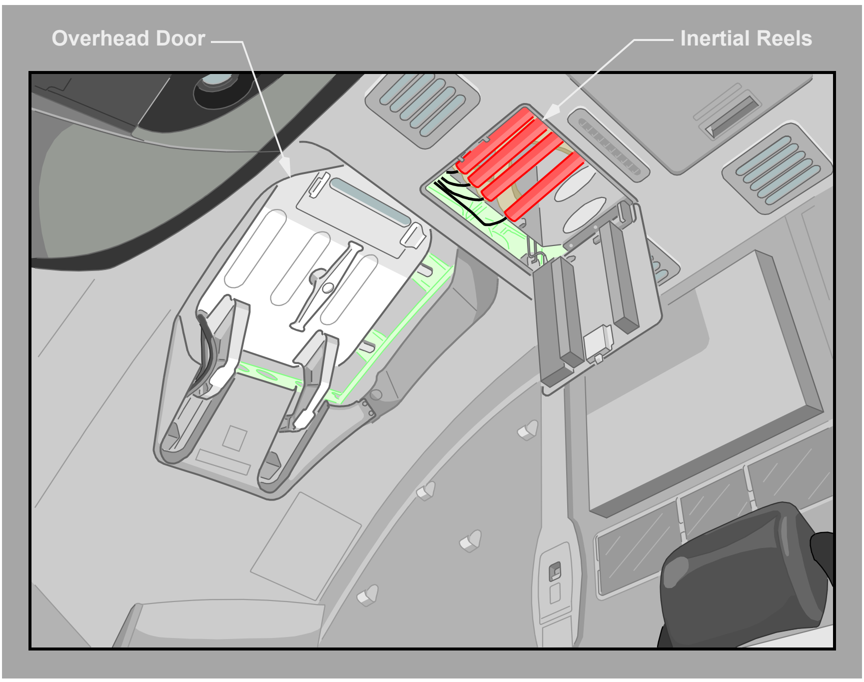
The flight deck overhead door can be opened only on the ground with the plane depressurized. To open the door:

- pull and rotate the door lock lever to the open position
- the door opens inside the flight deck and hangs from the ceiling on hinges

CAUTION: The flight deck overhead door is hinged to fall inward when opened. Care should be taken to avoid injury when opening the overhead door.

The overhead door is used for emergency egress in combination with the installed inertial reels. To access these reels:

- rotate the reel stowage lever to the open position
- retrieve the inertial reels from the compartment



The EICAS advisory message DOOR FD OVHD is displayed if the door is not closed, latched and locked.

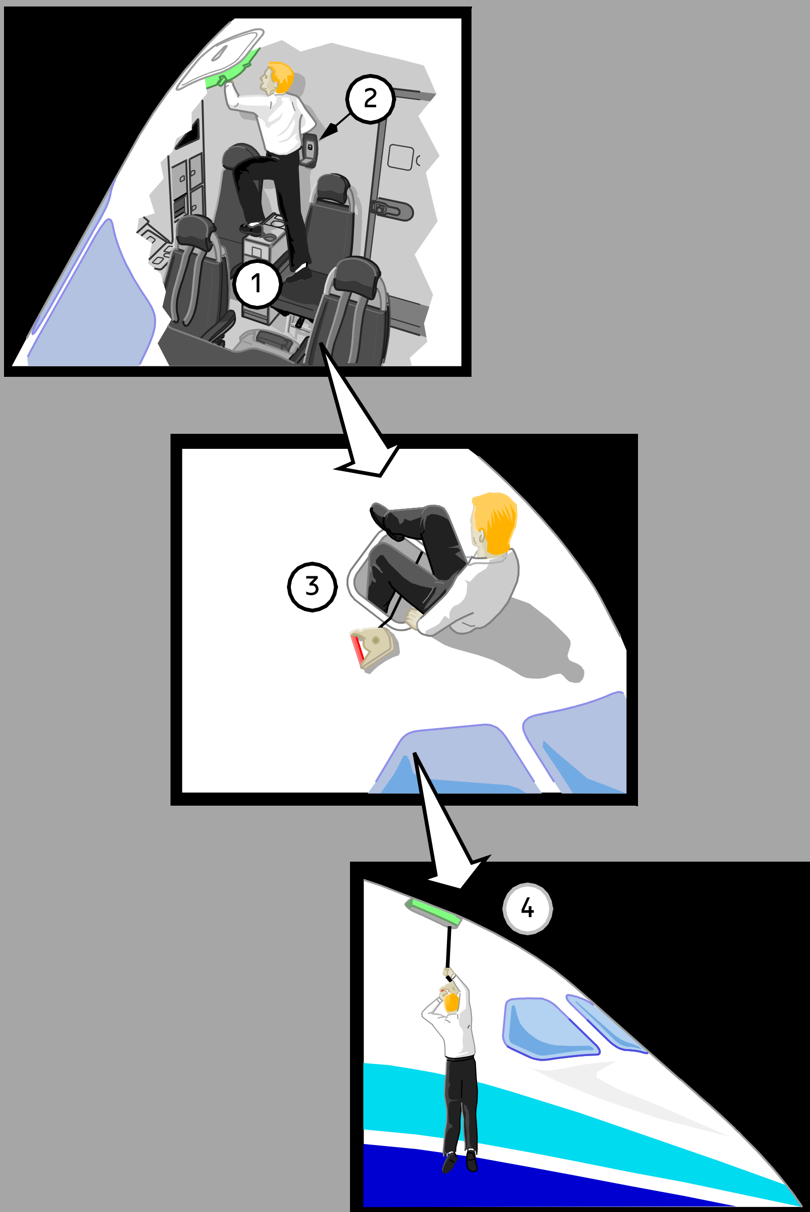
Flight Deck Overhead Door Emergency Egress

If the flight deck overhead door must be used for emergency egress, use the following procedure:

- open the upper door
- open the inertial reel stowage door (next to door in the flight deck ceiling)
- remove the inertial reel and pull on the cable to ensure it is securely attached to the airplane
- throw reel out of hatch (reel stays within safe reach on top of the airplane)

- climb out the door (see the following illustration) using the first observer’s seat, the observer’s console (1), the fold-down step in the bulkhead (2), and the door sill (3)
- lie on stomach, grasp reel in both hands, ease over the airplane side (4)
- the inertial reel slowly extends and lowers you to the ground

CAUTION: Ensure the reel is securely fastened to the airplane.



FLIGHT DECK OVERHEAD DOOR EGRESS PATH

Passenger Entry Doors

The passenger entry doors are used to enter and exit the airplane, and also serve as emergency exits. There are no other passenger cabin exits. The eight passenger entry doors are paired along the airplane fuselage. The doors are identified 1 through 4 left, and 1 through 4 right. The passenger entry doors can be opened or closed manually from inside or outside of the airplane.

The entry doors are translating, plug–type doors. During opening, the door first moves inward and upward, then translates outward and forward. Each door is held in the open position by a gust lock. The gust lock drops into a latch as the door nears its forward limit of travel. A window in each door allows observation outside of the airplane.

Each door has a vent panel connected to the door handle. The vent is designed to prevent pressurization to an unsafe level if the door is not fully closed, latched, and locked. Forward rotation of the door handle past the latched position closes the vent. Initial aft door handle rotation opens the vent to equalize cabin and ambient pressure. At low differential pressure, the door handle can be rotated to allow the door to open fully. At high differential pressure, the vent can be partially opened; however, a mechanical interlock prevents door opening until the differential pressure is reduced. At very high differential pressure, the vent cannot be opened.

Flight Lock

Each door handle is automatically locked when groundspeed is greater than 80 knots. The flight lock allows limited door handle rotation sufficient to partially open the door vent, but prevents door opening. If electrical power is removed or fails, the flight lock is spring–loaded to the unlocked position.

Emergency System Operation

[Option – Rafts at every door]

Emergency evacuation slide/raft and pneumatic door opening systems are contained in each passenger entry door. Each door system has enough power to open the door unassisted, even if the airplane is not level because of any landing gear collapse condition. A bustle in the lower face of the door contains the slide/raft.

[Option – Rafts at every door]

The pneumatic door opening system is armed when the mode select lever is in the armed position. This engages the door girt bar and arms both the slide/raft and the pneumatic door opening systems. Once armed, moving the interior door handle to the open position operates the pneumatic opening actuator. The actuator drives the door open, and the slide/raft automatically deploys and inflates.

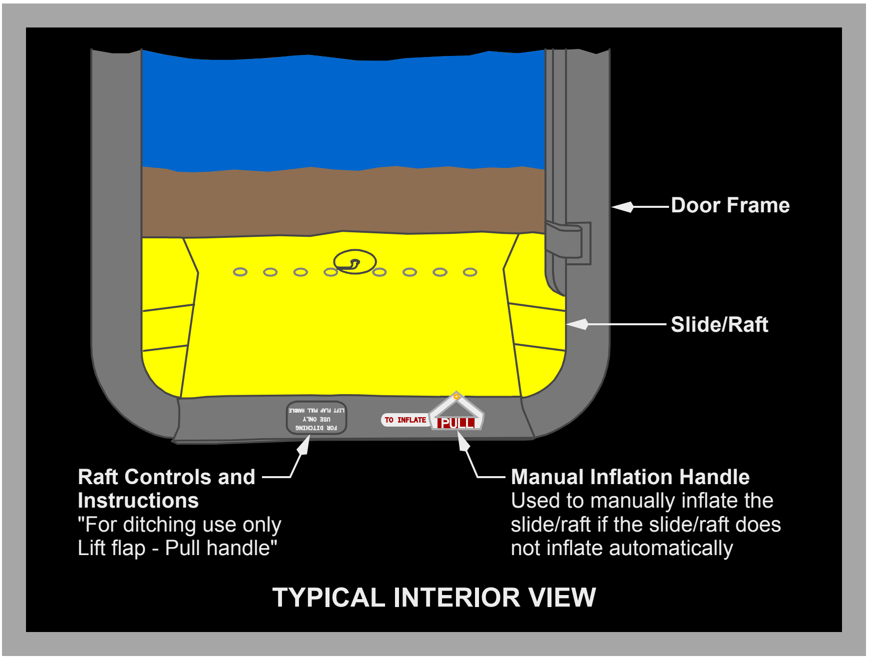
[Option – Rafts at every door]

The pneumatic door opening system and the slide/raft are automatically disarmed when the door is opened from the outside. If the mode select lever is in the armed position and the door is opened using the exterior door handle, the mode select lever automatically moves to the disarmed position and the door opens without slide/raft deployment.

[Option – Rafts]

Slide/Raft Deployed

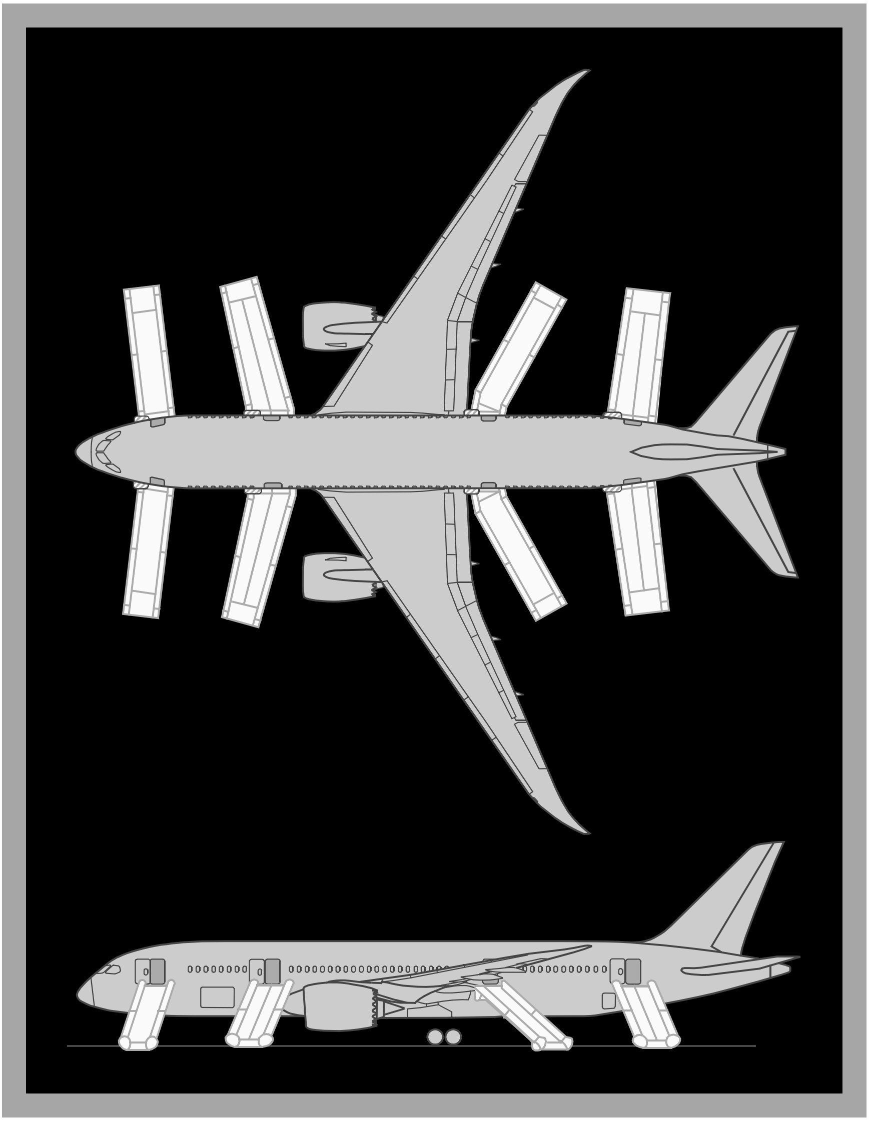
[Option – Rafts]



[Option – Rafts]

Evacuation Slides/Rafts

[Option – Baseline, C-A-C-A door slides]



Cargo Doors

There are three cargo doors; one forward, one aft, and one bulk. The forward and aft cargo doors are located on the right side of the airplane while the bulk cargo door is on the left side. The cargo doors all open upward. The forward and aft cargo doors open outward and the bulk cargo door opens inward.

Both forward and aft cargo doors are normally operated electrically from an exterior or interior fuselage mounted control panel located with each door. A control panel light indicates cargo door latching. Forward and aft cargo door locking is accomplished manually. If necessary, the forward and aft cargo doors may be operated manually.

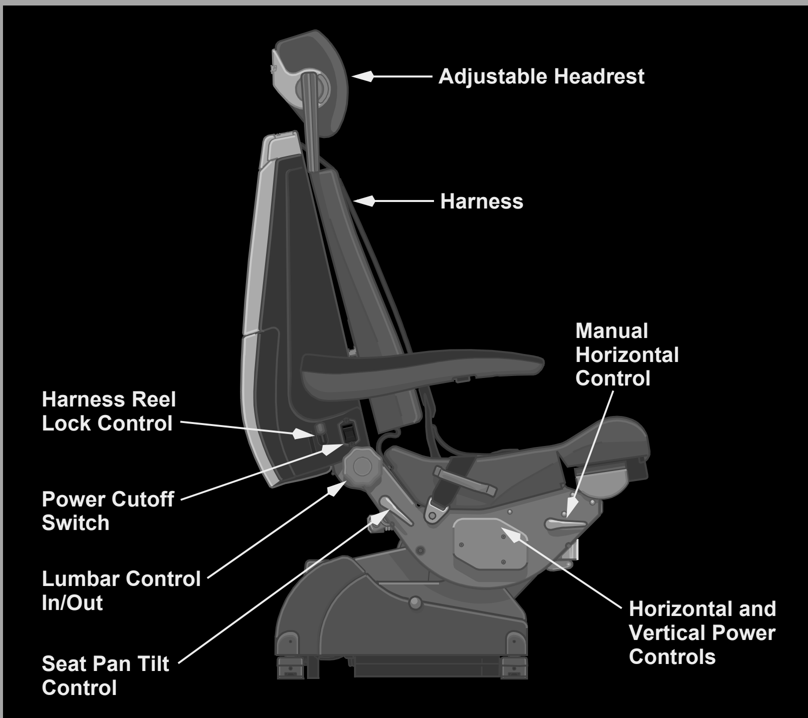
The bulk cargo door is manually opened and closed, and is counterbalanced for ease of operation.

Flight Deck Seats

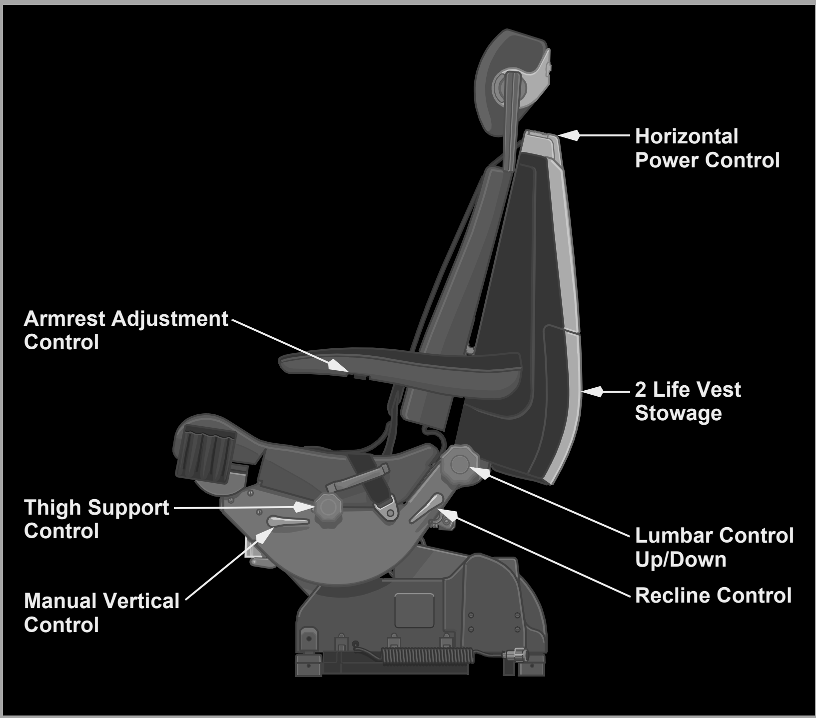
The flight deck has three seat types:

- pilot seats (captain and first officer)
- first observer seat
- second observer seat

Pilot Seats



CAPTAIN'S SEAT – INBOARD SIDE VIEW



CAPTAIN'S SEAT – OUTBOARD SIDE VIEW

The pilot seats:

- recline
- adjust vertically
- adjust forward and aft
- adjust for thigh support
- adjust for lumbar support
- adjust for seat pan tilt angle

WARNING: Seat pan tilt must be rotated fully forward during takeoff and landing.

The seats also have:

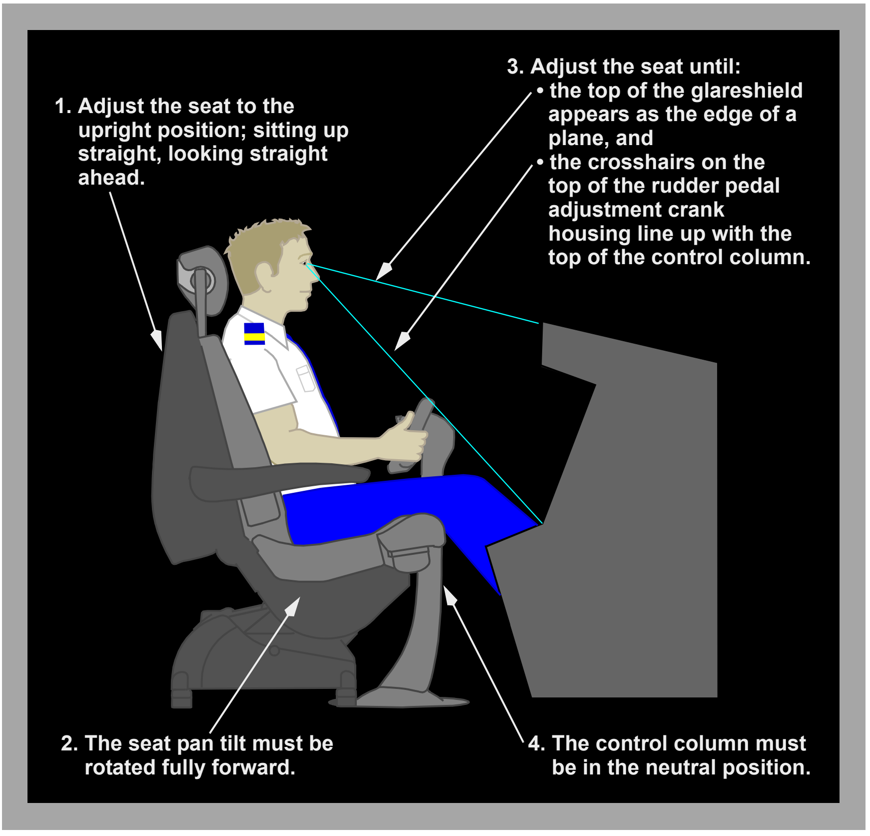
- adjustable armrests
- crotch straps
- inertial–reel shoulder harnesses with manual locks
- lap belts
- adjustable headrests

The seats move outboard during the last two inches of aft travel. Electric and manual controls provide forward, aft, and vertical adjustment. A guarded secondary fore/aft power control is provided in the upper seat back near the headrest for easier seat access. Manual levers provide other adjustments.

Lumbar and thigh pad support can be adjusted using the manual control wheels. Armrest pitch can be adjusted using the control knob under the armrest. The armrests can be stowed vertically for easier seat access. The headrest can be adjusted vertically by pulling up or pushing down. The headrest angle can be adjusted by moving the cushion to the right and rotating it.

Adjust the seat to obtain the optimum eye position as shown on the following illustration.

Pilot Seat Adjustment



Observer Seats

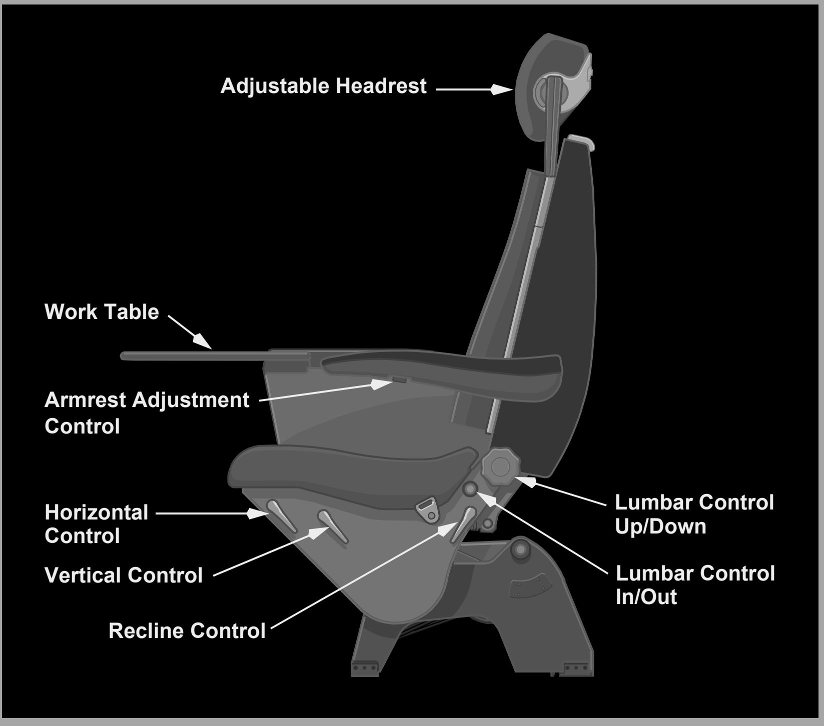
The first observer seat is track mounted. The seat:

- adjusts vertically
- adjusts forward and aft
- reclines
- adjusts for lumbar support

The seat also has:

- a folding arm rest on the left side
- crotch strap
- inertial–reel shoulder harness with manual locks
- lap belt
- adjustable headrest

The lumbar support can be adjusted using the manual control wheel and the push-button on the left side of the seat. The left side armrest pitch can be adjusted using the control knob under the armrest and can be stowed vertically for easier seat access. The headrest can be adjusted vertically by pulling up or pushing down. The headrest angle can be adjusted by moving the cushion to the right and rotating it.



FIRST OBSERVER'S SEAT – PORT SIDE VIEW

The second observer seat is not adjustable. The seat has:

- folding arm rests
- crotch strap
- inertial reel shoulder harness
- lap belt
- adjustable headrest
- folding seat cushion access to under seat stowage

Airplane General, Emergency Equipment, Doors, Windows — Chapter 1

Emergency Equipment — Section 45

Introduction

Emergency equipment described in this chapter includes:

- emergency evacuation signal system
- emergency locator transmitters (ELTs)
- escape reels
- fire extinguishers
- portable flight deck emergency equipment locations
- portable passenger cabin emergency equipment locations

Emergency Evacuation Signal System

The emergency evacuation signal system alerts the flight attendants to evacuate the passenger cabin. Evacuation command switches are located on the flight deck and at the flight attendant panels.

Placing the flight deck EVAC COMMAND switch to ON activates the evacuation signals on the flight deck and on the flight attendant panels. With the flight deck EVAC COMMAND switch in ARM, pressing an EVAC COMMAND switch on a flight attendant panel activates the evacuation signals on the flight deck and on the flight attendant panels. With the flight deck EVAC COMMAND switch in the OFF position, all emergency evacuation panels are disabled.

Emergency Locator Transmitter (ELT)

Passenger Cabin

ELTs are installed in the passenger cabin, as shown in the Emergency Equipment Locations – Passenger Cabin diagram.

[Option – Fixed ELT]

Fuselage Mounted Emergency Locator Transmitter (ELT)

An ELT is mounted to the top of the fuselage in the passenger cabin area.

The ELT automatically transmits distress signals on 121.5 MHZ, 243 MHZ, and 406 MHZ if a deceleration is sensed, or if the ELT switch is positioned to ON.

The EICAS alert message ELT ON is displayed if the transmitter is activated. The ELT can be deactivated by placing the ELT switch to RESET momentarily, then ARMED.

Escape Reels

Escape reels are attached to the airplane structure in the flight deck ceiling. The reels are stowed in a compartment near the flight deck overhead door. The reels are used to lower the flight deck occupants to the ground when exiting through the flight deck overhead door.

Fire Extinguishers

Halon and water fire extinguishers are located throughout the passenger cabin and on the flight deck.

Halon Fire Extinguishers

Halon fire extinguishers contain a liquefied gas agent under pressure. The extinguisher pressure indicator shows three pressure ranges:

- acceptable
- recharge
- overcharged

A safety pin with a pull ring prevents accidental trigger movement. When released, the liquefied gas agent vaporizes and extinguishes the fire. The extinguisher is effective on all types of fires, but is used primarily on electrical, fuel, and grease fires.

WARNING: If a halon fire extinguisher is to be discharged in the flight deck area, all flight crew members must wear oxygen masks and use 100% oxygen with emergency selected.

CAUTION: For electrical fires, remove the power source as soon as possible. Avoid discharging directly on persons due to possibility of suffocating effects. Do not discharge too close to fire as the discharge stream may scatter the fire. As with any fire, keep away from the fuel source. Avoid breathing vapors, fumes and heated smoke as much as possible.

Halon Fire Extinguisher Operation

To use the halon fire extinguisher:

- pull ring pin from lever and handle
- hold extinguisher upright with hand under handle and thumb on top of lever
- from a distance of 6 to 10 feet, direct the nozzle towards the base of the fire source

  Note: The extinguisher stream can shoot over a 10 foot distance.

- squeeze the lever downward with thumb
- spray at the base of the flame in quick side-to-side motion

Water Fire Extinguishers

Water fire extinguishers contain a solution of water mixed with antifreeze. Water fire extinguishers are to be used on fabric or paper fires only. They are not to be used on electrical or grease fires.

WARNING: Antifreeze compound has been added to the water which makes it unfit for drinking.

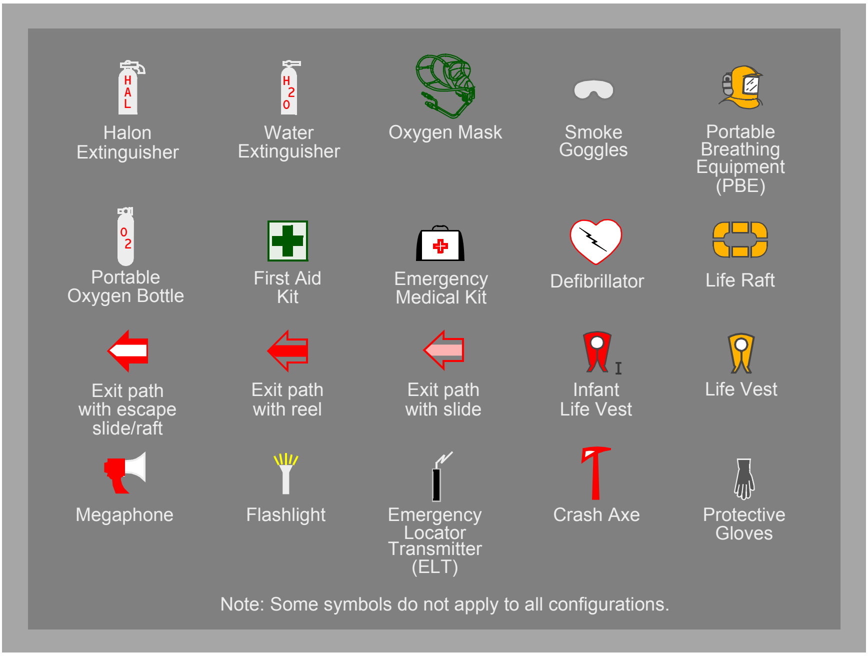
CAUTION: Do not use on electrical or grease type fires.

Water Fire Extinguisher Operation

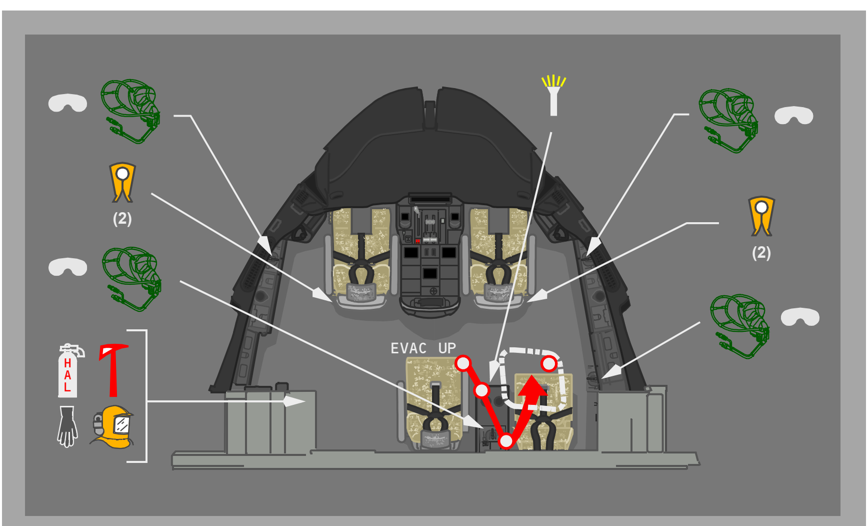
To use the water fire extinguisher:

- remove it from stowage
- turn handle clockwise as far as possible (charges bottle with CO2)
- hold bottle upright
- direct nozzle at base of fire
- press trigger to discharge

Emergency Equipment Symbols

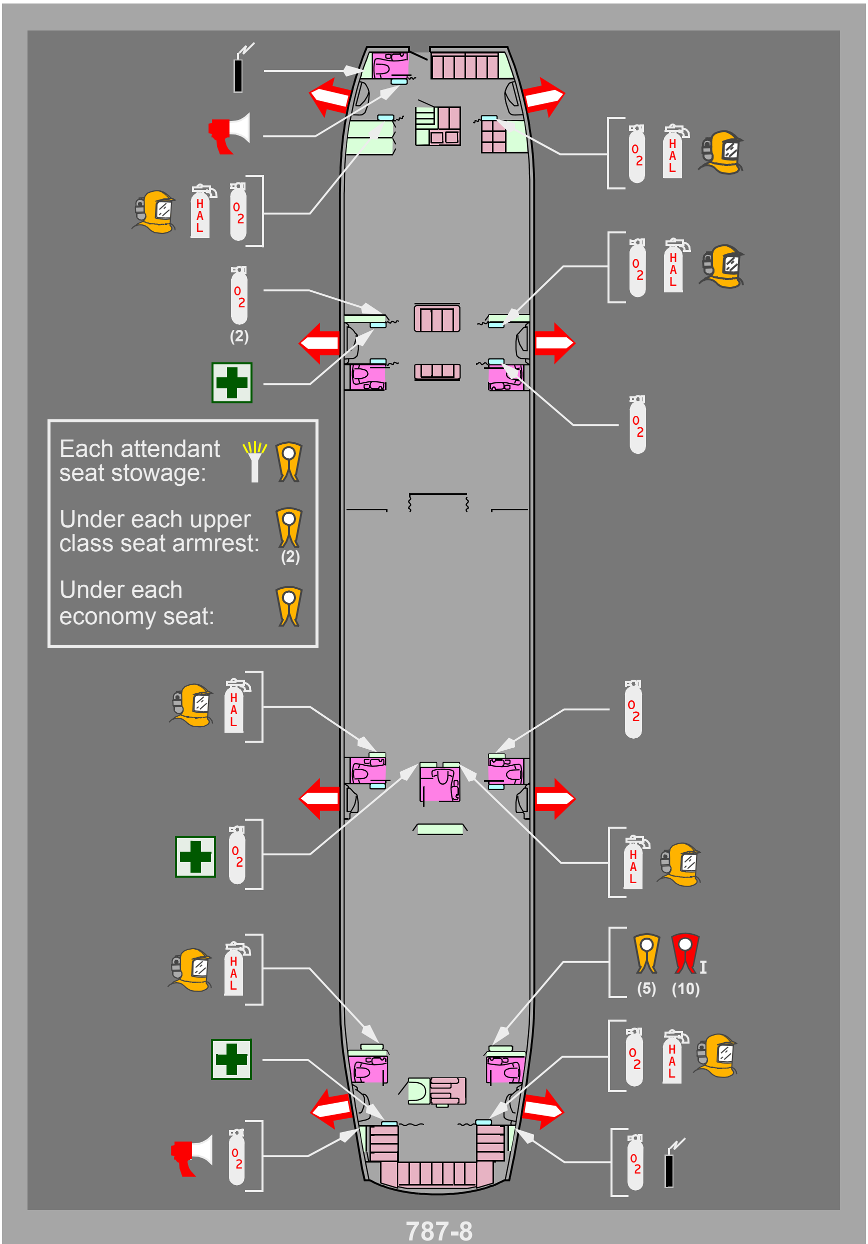


Emergency Equipment Locations - Flight Deck



Emergency Equipment Locations – Passenger Cabin

[Option – 787-8]



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Airplane General, Emergency Equipment, Doors, Windows — Chapter 1
Flight Crew Rest — Section 46

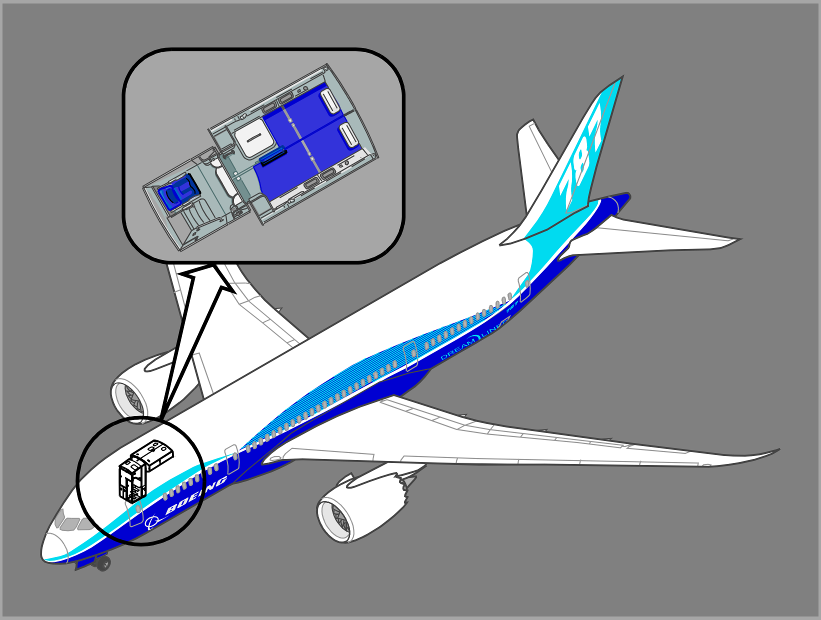
[Option – Any Overhead Flight Crew Rest Config]

Overhead Flight Crew Rest

An overhead flight crew rest is located in the forward part of the airplane in the overhead area between door 1L and 1R. Access to the area is through an enclosure located in the passenger cabin near door 1L.

The area has its own smoke detection system but no fire extinguishing system.

[Option – Single seat]



OVERHEAD FLIGHT CREW REST

Occupancy

The overhead flight crew rest is to be occupied by flight crew members trained in the use of the crew rest evacuation routes, fire fighting and depressurization procedures.

Note: A placard is installed indicating any overhead flight crew rest occupancy restrictions.

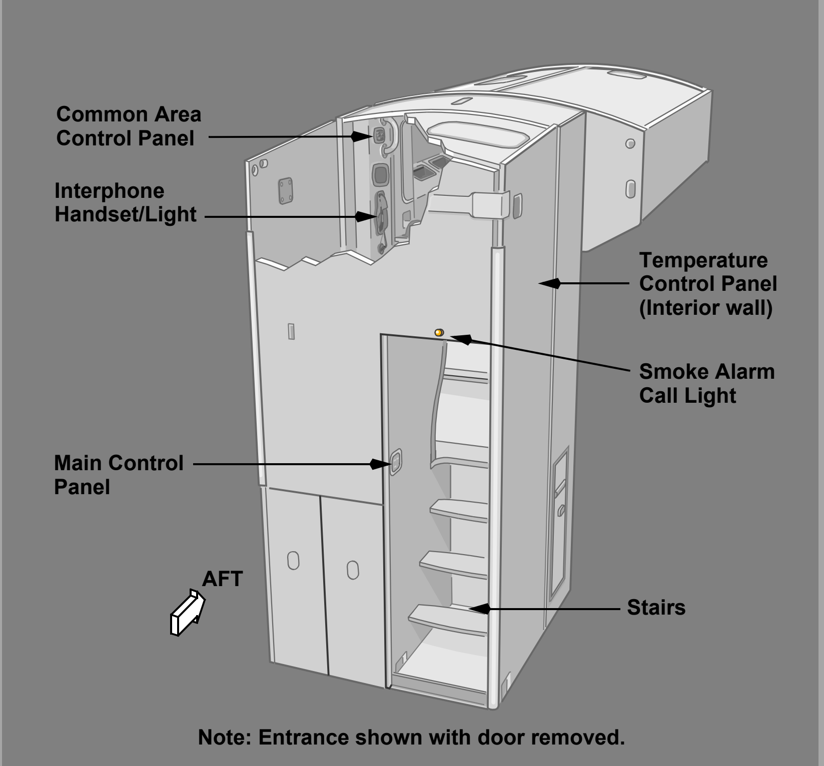
Note: The overhead flight crew rest may be occupied during taxi, takeoff, or landing operations but this applies only to the seat and not the bunks.

Entrance Enclosure

The entrance to the overhead flight crew rest is an enclosure located in the passenger cabin near door 1L and has the same external appearance as a lavatory, but is placarded for crew use and utilizes a cipher lock for security.

The door should remain closed and locked at all times.

The entrance enclosure contains lighting and a warning horn shutoff switch.



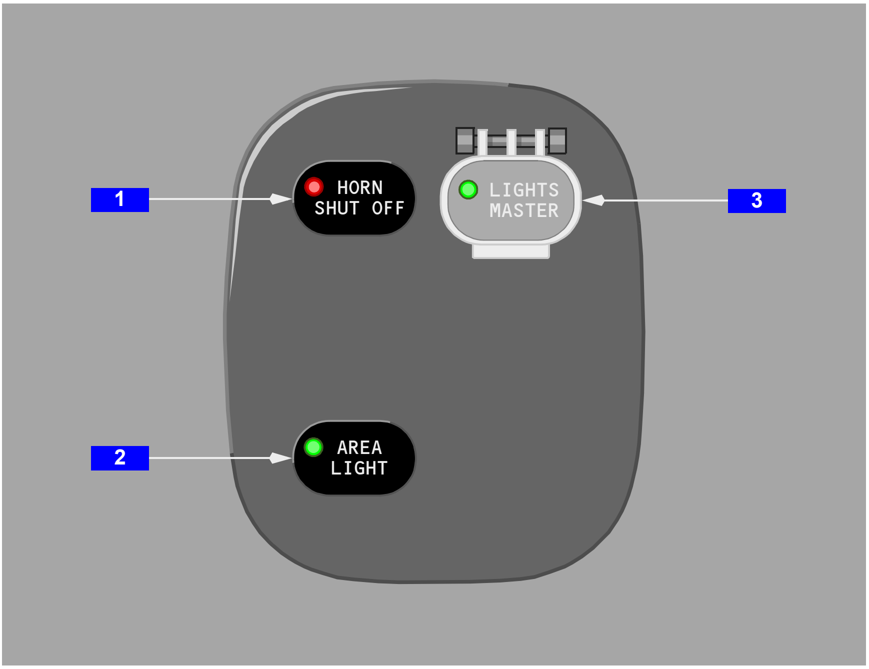
Note: Entrance shown with door removed.

An amber smoke alarm/call light is mounted on the exterior wall above the entrance door. When smoke is detected in the crew rest area, the light flashes. The light illuminates steady when the attendant call button on a crew rest PCU has been pushed.

Conditioned air is used to provide temperature control and ventilation to the overhead flight crew rest. This air is regulated using the temperature control panel in the common area.

Main Control Panel

The overhead flight crew rest main control panel is located inside the entrance enclosure.



1 HORN SHUT OFF Switch

Illuminated (red) during an airplane decompression or overhead flight crew rest smoke detection.

Push – silences the decompression/smoke alert horn (light remains red).

2 AREA LIGHT switch

Push –

- turns entrance enclosure light on (green light illuminated)
- second push turns entrance enclosure light off (green light extinguished)

3 LIGHTS MASTER Switch

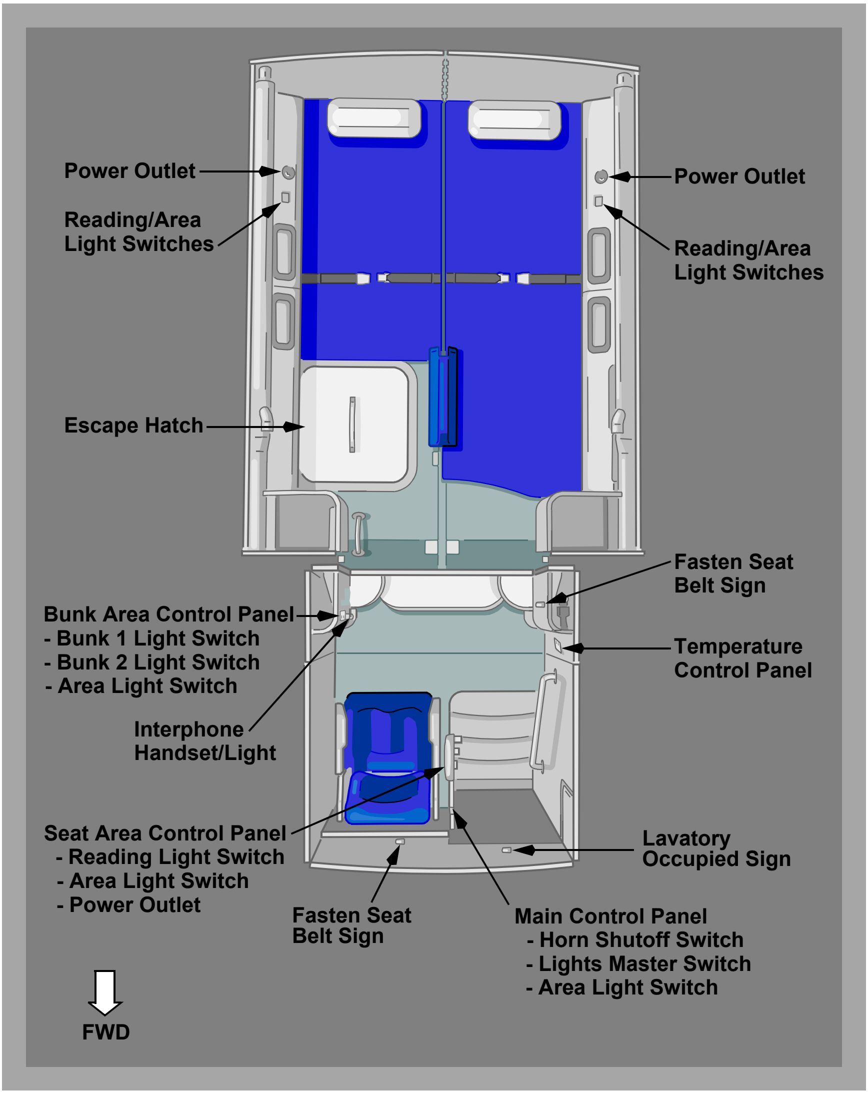
Guarded switch.

Push –

- over-rides individual lighting controls and turns all the lights in the overhead flight crew rest on (green light illuminated)
- second push returns individual control and all overhead flight crew rest lights return to the previous state (green light extinguished)

Layout

[Option – Single seat]



The overhead flight crew rest contains the following:

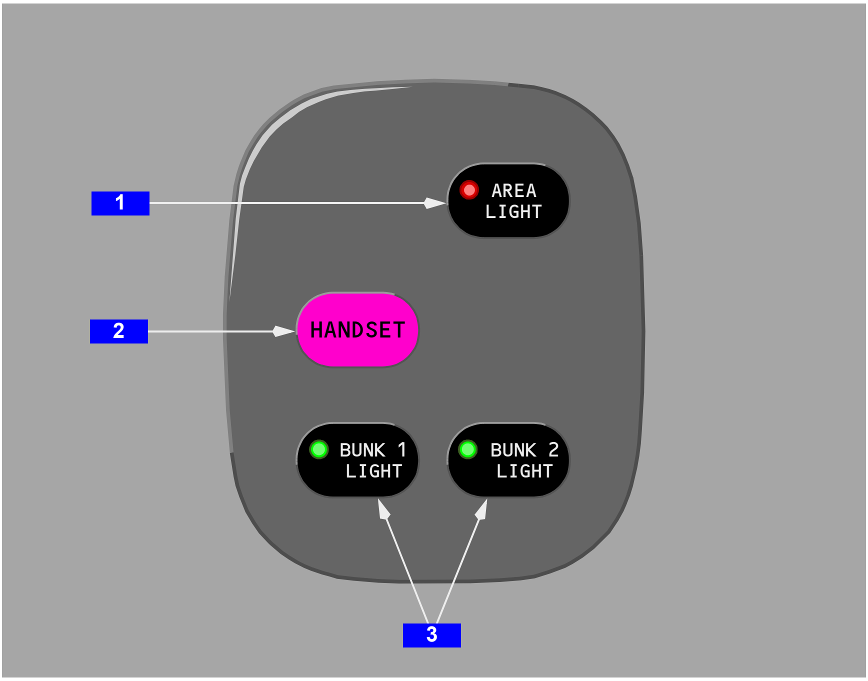
[Option – Single seat]

- an entrance and common area containing:
  - lights master switch
  - area lighting switches

    - horn shut off switch
    - temperature control panel
    - interphone handset/light
    - passenger information signs
    - emergency horn
    - smoke detector
    - flashlight
    - service power outlet
    - coat hooks, mirror, stowage
- a curtained off seat area containing:
    - 1 seat
    - control/lighting panel
    - PSU
    - smoke detector
    - emergency equipment
- an individually curtained off bunk area containing:
    - sleeping bunks (2)
    - control/lighting panels (2)
    - PSUs (2)
    - smoke detectors (2)
    - emergency equipment
    - emergency egress hatch
    - stowage

Bunk Area Control Panel

A bunk area control panel is located on the common wall.



1 AREA LIGHT Switch

Push –

- turns common area light on (green light illuminated)
- second push turns common area light off (green light extinguished)

2 HANDSET Light

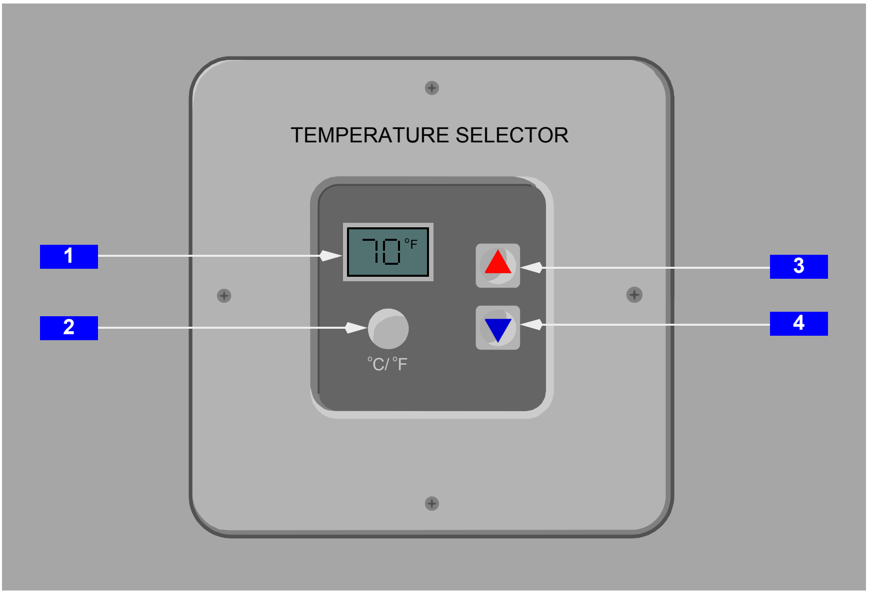
Illuminated (magenta) – the handset is in use.

3 BUNK LIGHT Switches

Push –

- turns associated bunk light on (green light illuminated)
- second push turns associated bunk light off (green light extinguished)

Temperature Control Panel



1 Temperature Display

Displays:

- current selected air temperature in degrees F or C
- a momentary flashing selected temperature after warmer or cooler arrows are pushed

Note: If temperature display is continuously flashing, and not associated with a recent temperature setting change, the system has failed.

2 Units Selector

Push – toggles between degrees F and degrees C for display and temperature selection.

3 Warmer Arrow

Push – to increase temperature setting for the overhead flight crew rest.

4 Cooler Arrow

Push – to decrease temperature setting for the overhead flight crew rest.

Temperature Control System

[Option – Single seat]

The temperature in the overhead flight crew rest is controlled by the temperature controller located on the wall in the entrance enclosure. The temperature can be set between 59 degrees F (14 degrees C) and 80 degrees F (27 degrees C) by selecting the warmer or cooler arrows on the panel. The seat and each bunk has an individual air flow outlet to help control individual temperatures in those areas.

Oxygen System

The overhead flight crew rest oxygen system is considered part of the passenger cabin oxygen system and its operation is identical. Refer to Passenger Cabin Oxygen System, Chapter 1, Section 40, for system description.

Note: When the oxygen masks deploy, the green oxygen indicator light in the common area illuminates.

Decompression

If a cabin decompression occurs during cruise, a decompression (continuous) horn sounds in the main area and the entrance enclosure. The green oxygen indicator light also illuminates.

Overhead flight crew rest occupants should immediately don one of the oxygen masks, move to an unoccupied position, and fasten the seat/bunk lap belt.

WARNING: It is acceptable to reach over a seat/bunk occupant to obtain an open/unused oxygen mask to prevent oxygen deprivation / light-headedness when moving to an unoccupied position.

Evacuate the overhead flight crew rest when directed by the flight crew.

Note: Prior to evacuating the overhead flight crew rest, push the HORN SHUT OFF switch (located in the entrance area). This silences the decompression alarm horns in the overhead flight crew rest.

Smoke Detection System

Smoke detection is annunciated by a smoke alarm horn (pulsating) sounding in the main overhead flight crew rest and the entrance enclosure.

[Option – Single seat]

A total of four (4) smoke detectors are installed in the overhead flight crew rest. There is one smoke detector in the common area, one in the seat area, and one in each bunk area.

If smoke is detected in the overhead flight crew rest:

- on the flight deck:
  - the master caution light illuminates
  - an aural caution alarm sounds
- in the flight crew rest area:
  - the smoke detector alarm indicator light will illuminate
  - all area lights will illuminate
  - the pulsating smoke detection system alarm horns sound in the overhead flight crew rest
  - the overhead flight crew rest air supply valves are closed and the area exhaust valves are opened
- at the entrance main control panel:
  - an alarm horn will sound
- in the passenger cabin:
  - the amber light above the entrance enclosure door flashes
  - a continuous chime sounds in the passenger cabin at door 1L, door 1 cross-aisle, door 1R, door 2L, and door 2R
  - the cabin attendant master call lights flash
  - a SMOKE DETECTED DR1 UPR REST message appears on the cabin management system control panels

Once the smoke clears, the red alarm indicator light extinguishes and the smoke detector is sensitive to smoke again. Continue to monitor the area until the red alarm indicator light extinguishes.

Note: When the smoke detector has been activated by smoke, lingering smoke in the detector sensor may cause reactivation. Blowing air into the detector sensor (the small screen cutout on the side of the cube extending from the unit) may clear lingering smoke.

Emergency Equipment

Overhead flight crew rest emergency equipment includes:

- halon fire extinguishers (2)

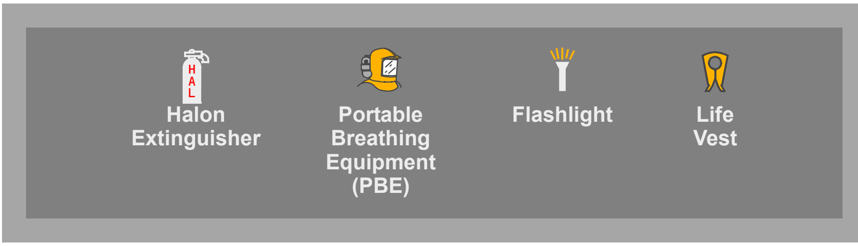
[Option – Single seat]

- protective breathing equipment (PBE) (2)

[Option – Single seat]

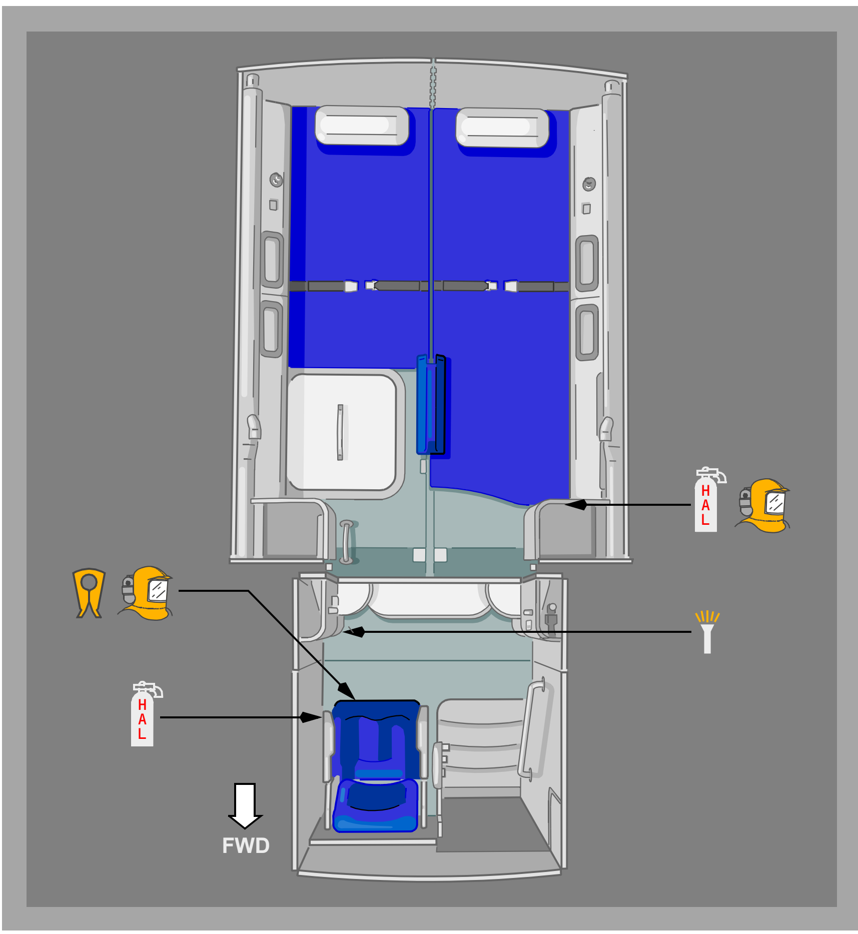
- life vest (1)
- flashlight (1)

Emergency Equipment Symbols



Emergency Equipment Location

[Option – Single seat]

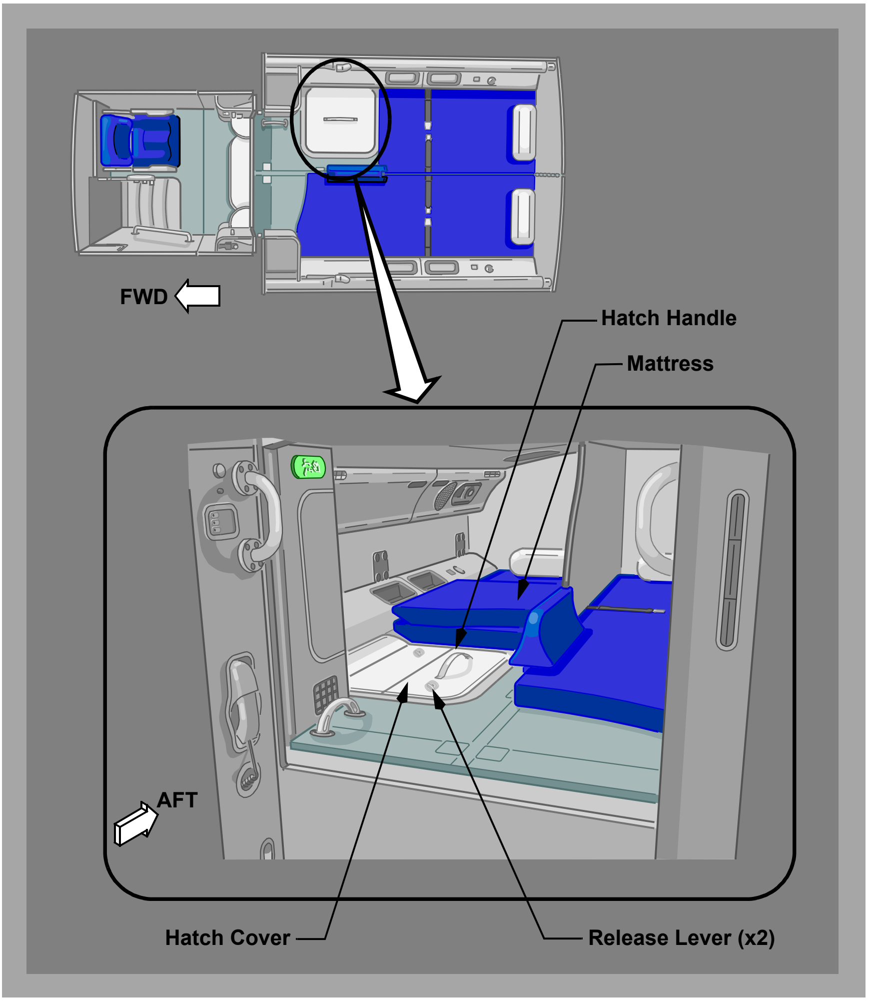


Evacuation

The primary evacuation route is down the entrance stairway through the entrance enclosure.

If the main entrance is unusable, evacuation is possible through the emergency hatch located at the bunk on the right side.

[Option – Single seat]



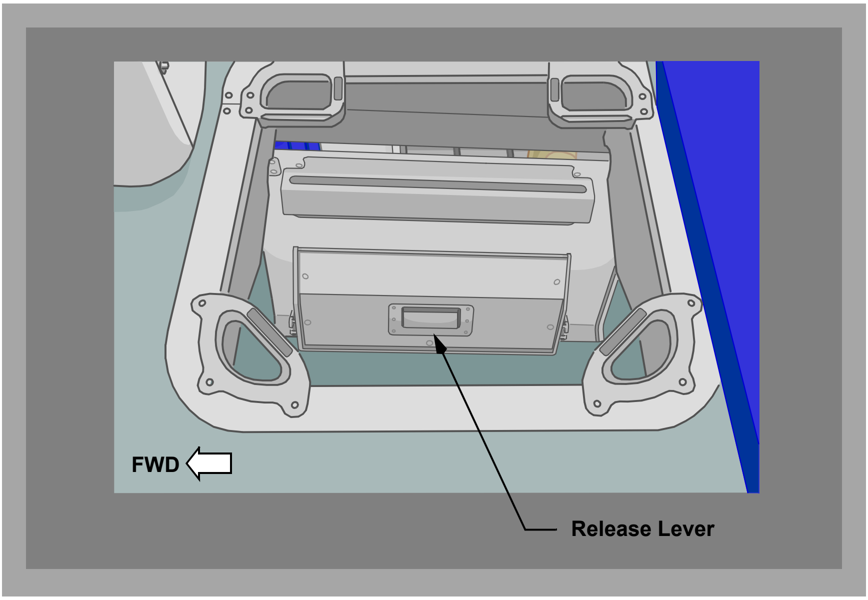
For egress:

- lift and remove the mattress pad

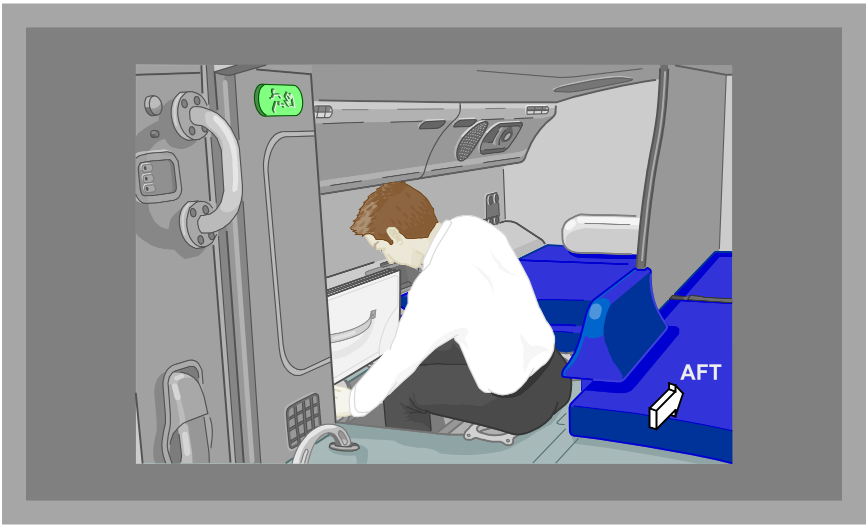
  Note: Stow the mattress pad where it does not obstruct the emergency hatch.

- unlatch the cover using the two release levers
- pull up on hatch handle to open the cover
- make sure to open the hatch fully to lock the cover in place

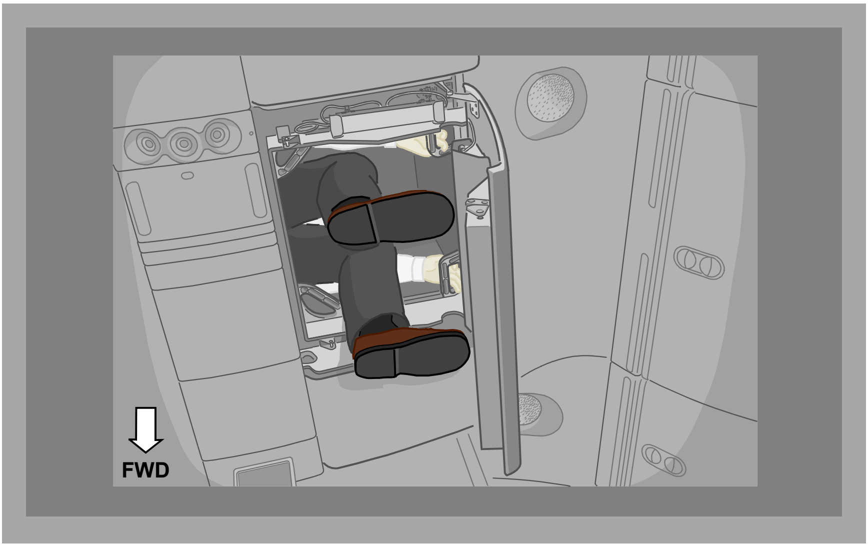
  WARNING: Failure to ensure the hatch cover is locked in position may allow the hatch to unexpectedly close causing injury.



- unlatch lower hatch
  - push the lower hatch release lever
- command passengers in immediate area to move clear of evacuation area



- sit on bench facing the right side of the aircraft
- lower legs into hatch opening



- grasp the handholds keeping elbows tucked inward

- use the lower hatch to slide/swing down and drop to main deck
  - use the seat armrest to assist in maintaining balance as necessary

CAUTION: During exit to the main deck, stepping on the seat back may cause the seat back to fold. If this occurs, the crew member may lose balance and hand grip resulting in personal injury.

- close the lower hatch when evacuation is complete

WARNING: The lower evacuation hatch must be closed to help prevent the spread of smoke or fire.

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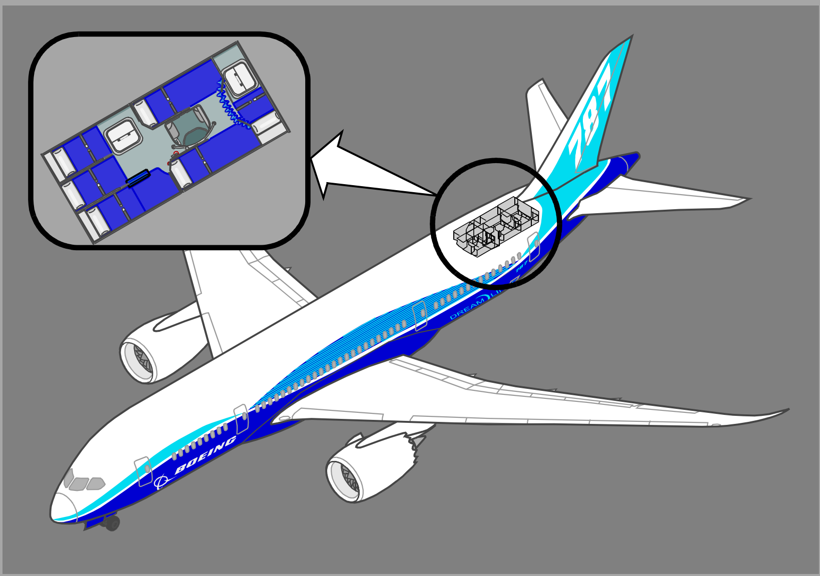
Airplane General, Emergency Equipment, Doors, Windows — Chapter 1
Flight Attendant Rest — Section 47

[Option – Overhead Flight Attendant Rest]

Overhead Flight Attendant Rest

An overhead flight attendant rest is located in the aft part of the airplane in the overhead area between door 4L and 4R. Access to the area is through an enclosure located in the passenger cabin near door 4L.

The area has its own smoke detection system but no fire extinguishing system.



OVERHEAD FLIGHT ATTENDANT REST

Occupancy

The overhead flight attendant rest is to be occupied by crew members trained in the use of the crew rest evacuation routes, fire fighting procedures and depressurization procedures.

Note: A placard is installed indicating any overhead flight attendant rest occupancy restrictions.

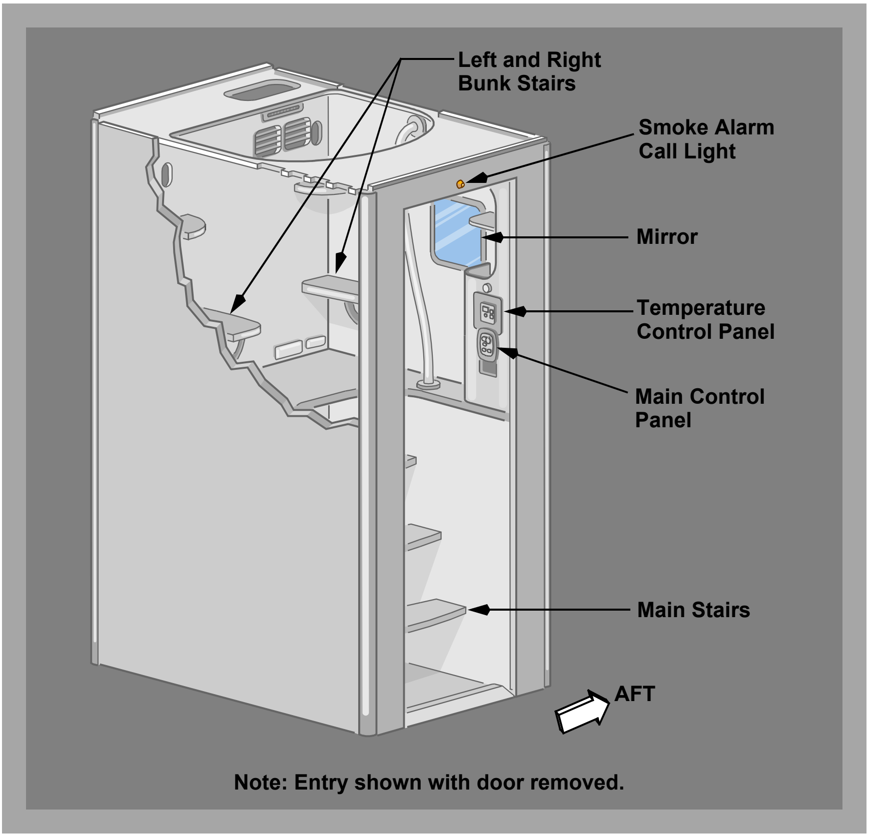
Note: The overhead flight attendant rest is not to be occupied during taxi, takeoff or landing operations.

Entrance Enclosure

The entrance to the overhead flight attendant rest is an enclosure located in the passenger cabin across from door 4L and has the same external appearance as a lavatory, but is placarded for crew use only and utilizes a cipher lock for security.

The door should remain closed and locked at all times.

The entrance enclosure contains lighting and temperature controls, and a warning horn shutoff switch.



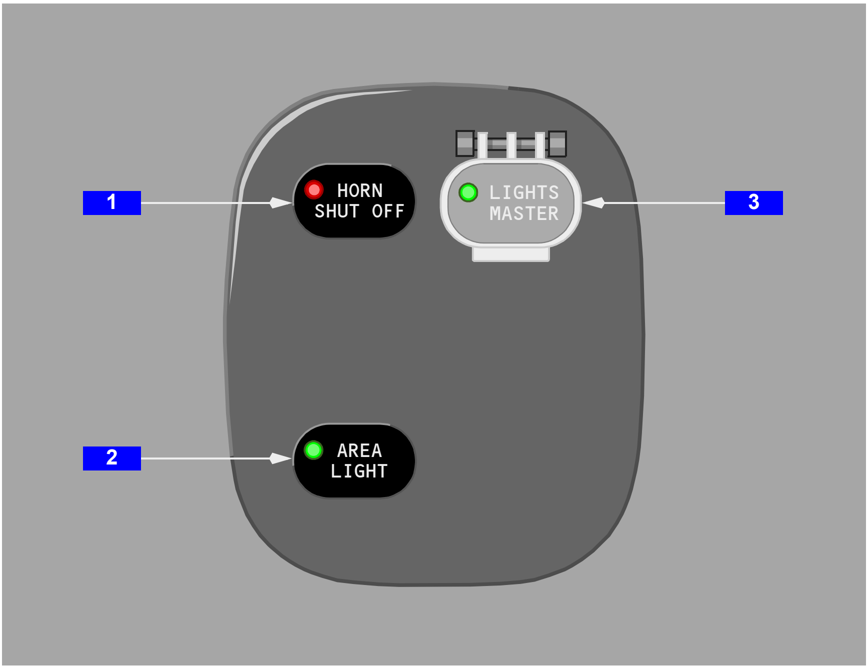
An amber smoke alarm/call light is mounted on the exterior wall above the entrance door. When smoke is detected in the overhead flight attendant rest, the light flashes. The light illuminates steady when the attendant call button on a crew rest PCU has been pushed.

Conditioned air is used to provide temperature control and ventilation to the overhead flight attendant rest. This air is regulated using the temperature control panel in the entrance enclosure.

Entrance Enclosure Control Panels

The overhead flight attendant rest main control and temperature control panels are located inside the entrance enclosure.

Main Control Panel



1 HORN SHUT OFF Switch

Illuminated (red) during an airplane decompression or overhead flight attendant rest smoke detection.

Push – silences the decompression/smoke alert horn (light remains red).

2 AREA LIGHT switch

Push –

- turns entrance enclosure light on (green light illuminated)
- second push turns entrance enclosure light off (green light extinguished)

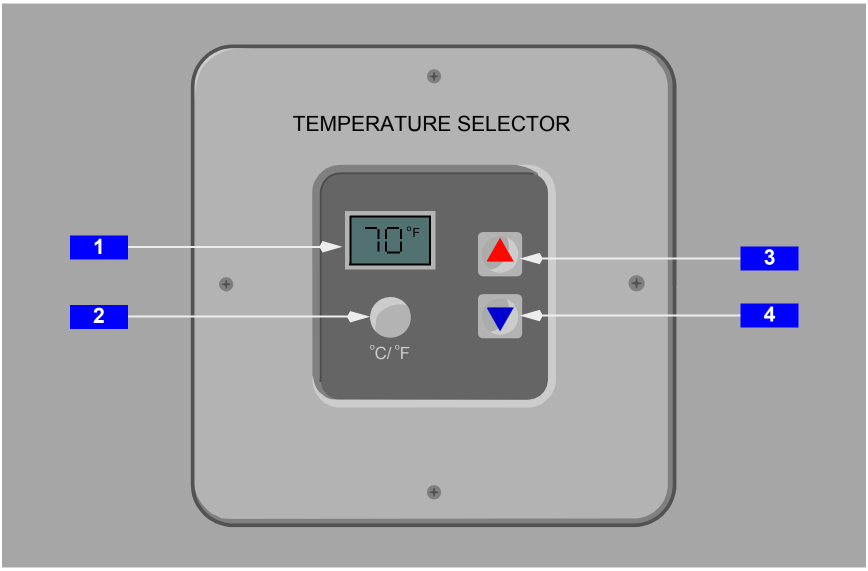
3 LIGHTS MASTER Switch

Guarded switch.

Push –

- over-rides individual lighting controls and turns all the lights in the overhead flight attendant rest on (green light illuminated)
- second push returns individual control and all overhead flight attendant rest lights return to the previous state (green light extinguished)

Temperature Control Panel



1 Temperature Display

Displays:

- current selected air temperature in degrees F or C
- a momentary flashing selected temperature after warmer or cooler arrows are pushed

Note: If temperature display is continuously flashing, and not associated with a recent temperature setting change, the system has failed.

2 Units Selector

Push – toggles between degrees F and degrees C for display and temperature selection.

3 Warmer Arrow

Push – to increase temperature setting for the overhead flight attendant rest.

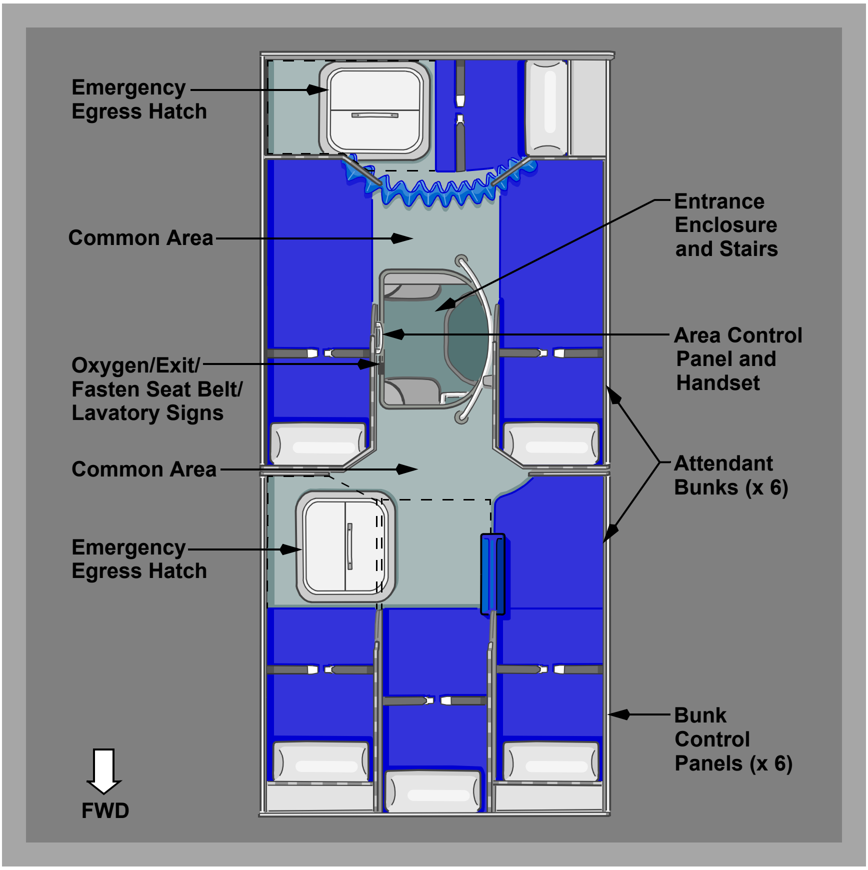
4 Cooler Arrow

Push – to decrease temperature settingfor the overhead flight attendant rest.

Temperature Control System

The temperature in the overhead flight attendant rest is controlled by the temperature controller located on the wall in the entrance enclosure. The temperature can be set between 59 degrees F (14 degrees C) and 80 degrees F (27 degrees C) by selecting the warmer or cooler arrows on the panel. Each bunk has an individual air flow outlet to help control individual temperatures in those areas.

Layout



The overhead flight attendant rest contains the following:

- an entrance and common area containing:
  - lights master switch
  - area lighting switches
  - horn shut off switch
  - temperature control panel

- interphone handset/light
- passenger information signs
- emergency horn
- smoke detectors (2)
- emergency equipment
- coat hooks, mirror, stowage

- an individually curtained off bunk area containing:
  - sleeping bunks (6)
  - control/lighting panels
  - PSUs (6)
  - smoke detectors (6)
  - emergency equipment
  - emergency egress hatches (2)
  - power outlet (6)
  - stowage

Oxygen System

The overhead flight attendant rest oxygen system is considered part of the passenger cabin oxygen system and its operation is identical. Refer to Passenger Cabin Oxygen System, Chapter 1, Section 40, for system description.

Note: When the oxygen masks deploy, the green oxygen indicator light in the common area illuminates.

Decompression

If a cabin decompression occurs during cruise, a decompression (continuous) horn sounds in the main crew rest area and the entrance enclosure. The green oxygen indicator light also illuminates.

Overhead flight attendant rest occupants should immediately don one of the oxygen masks, move to an unoccupied position, and fasten the bunk lap belt.

WARNING: It is acceptable to reach over a bunk occupant to obtain an open/unused oxygen mask to prevent oxygen depravation / light-headedness when moving to an unoccupied position.

Evacuate the overhead flight attendant rest when directed by the flight crew.

Note: Prior to evacuating the overhead flight attendant rest, push the HORN SHUT OFF switch (located at the entrance on the main control panel). This silences the decompression alarm horns in the overhead flight attendant rest.

Smoke Detection System

Smoke detection is annunciated by a smoke alarm horn (pulsating) sounding in the main crew rest area and the entrance enclosure.

A total of eight (8) smoke detectors are installed in the overhead flight attendant rest. There are two smoke detectors in the common area and one in each bunk area.

If smoke is detected in the overhead flight attendant rest:

- on the flight deck:
  - the master caution light illuminates
  - an aural caution alarm sounds
  - a SMOKE REST UPR DR 4 EICAS caution message is displayed
- in the crew rest area:
  - the smoke detector alarm indicator light will illuminate
  - all area lights will illuminate
  - the pulsating smoke detection system alarm horn sounds
  - the air supply valves are closed and the area exhaust valves are opened
- at the entrance main control panel:
  - the pulsating smoke detection system alarm horn sounds
- in the passenger cabin:
  - the amber light above the entrance enclosure door flashes
  - a continuous chime sounds in the passenger cabin at door 3L, door 3 cross-aisle, door 3R, door 4L, and door 4R
  - the cabin attendant master call lights flash
  - a SMOKE DETECTED DR4 UPR REST message appears on the cabin management system control panels

Once the smoke clears, the red alarm indicator light extinguishes and the smoke detector is sensitive to smoke again. Continue to monitor the area until the red alarm indicator light extinguishes.

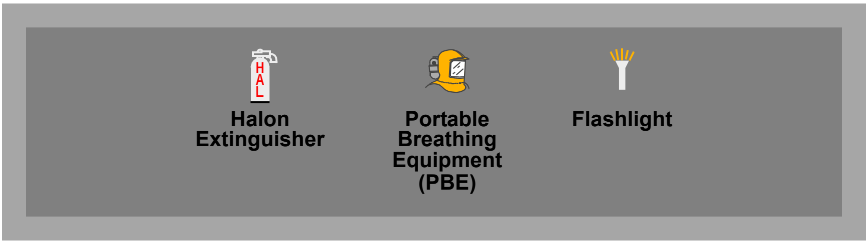
Note: When the smoke detector has been activated by smoke, lingering smoke in the detector sensor may cause reactivation. Blowing air into the detector sensor (the small screen cutout on the side of the cube extending from the unit) may clear lingering smoke.

Emergency Equipment

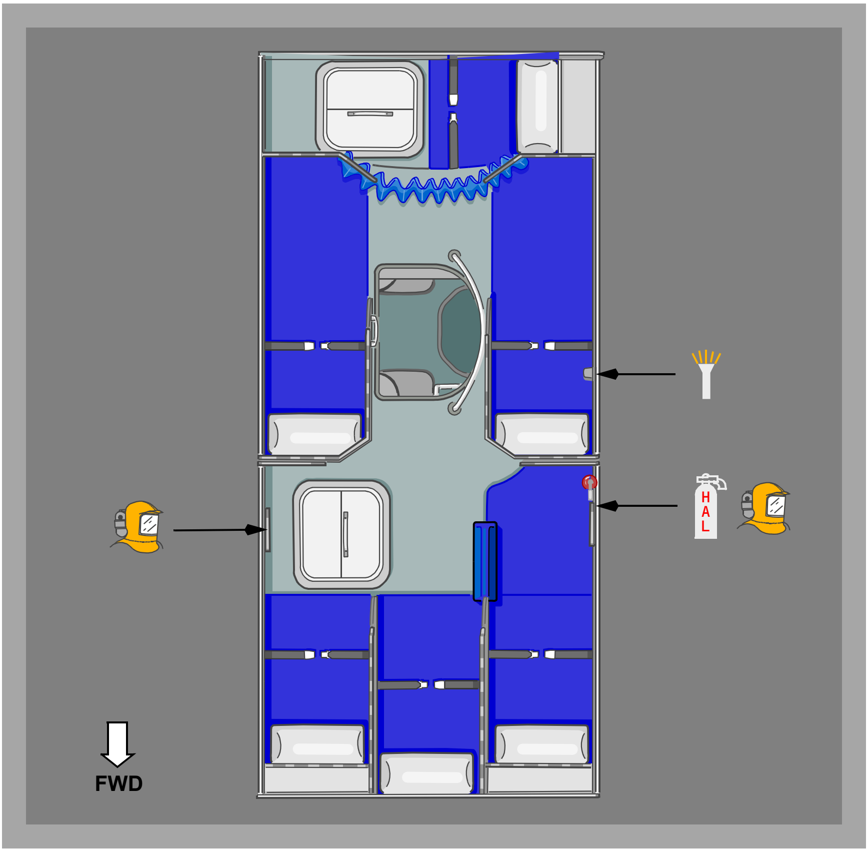
The overhead flight attendant rest emergency equipment includes:

- halon fire extinguisher
- portable breathing equipment (PBE) (2)
- flashlight

Emergency Equipment Symbols



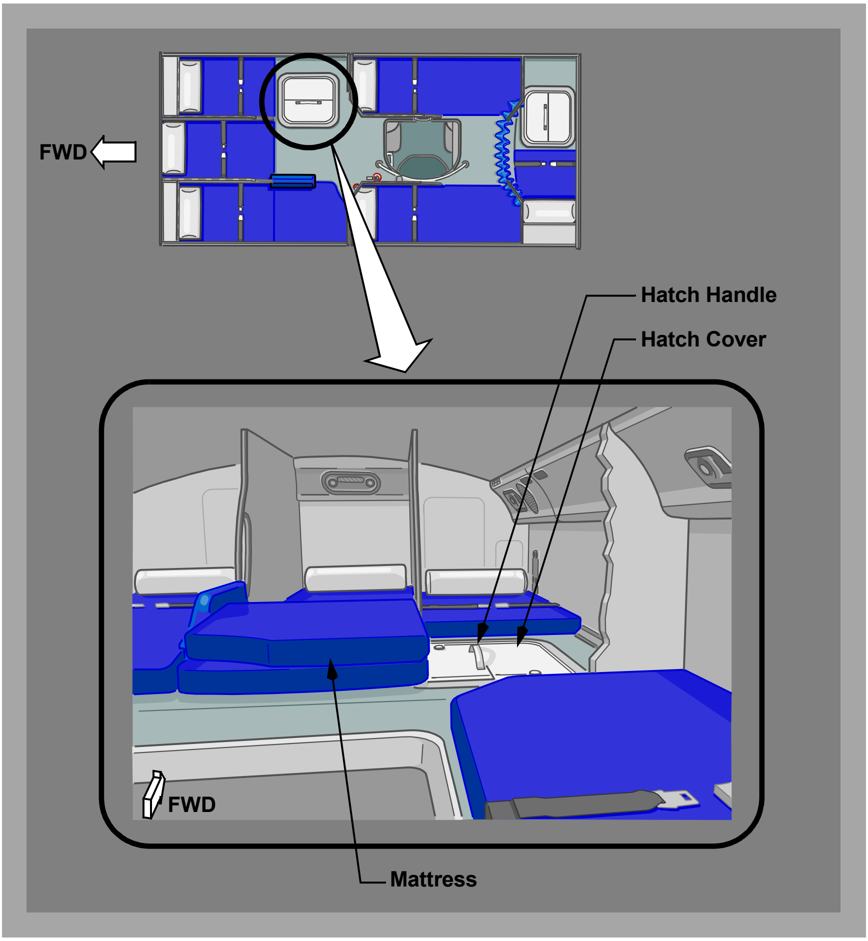
Emergency Equipment Location

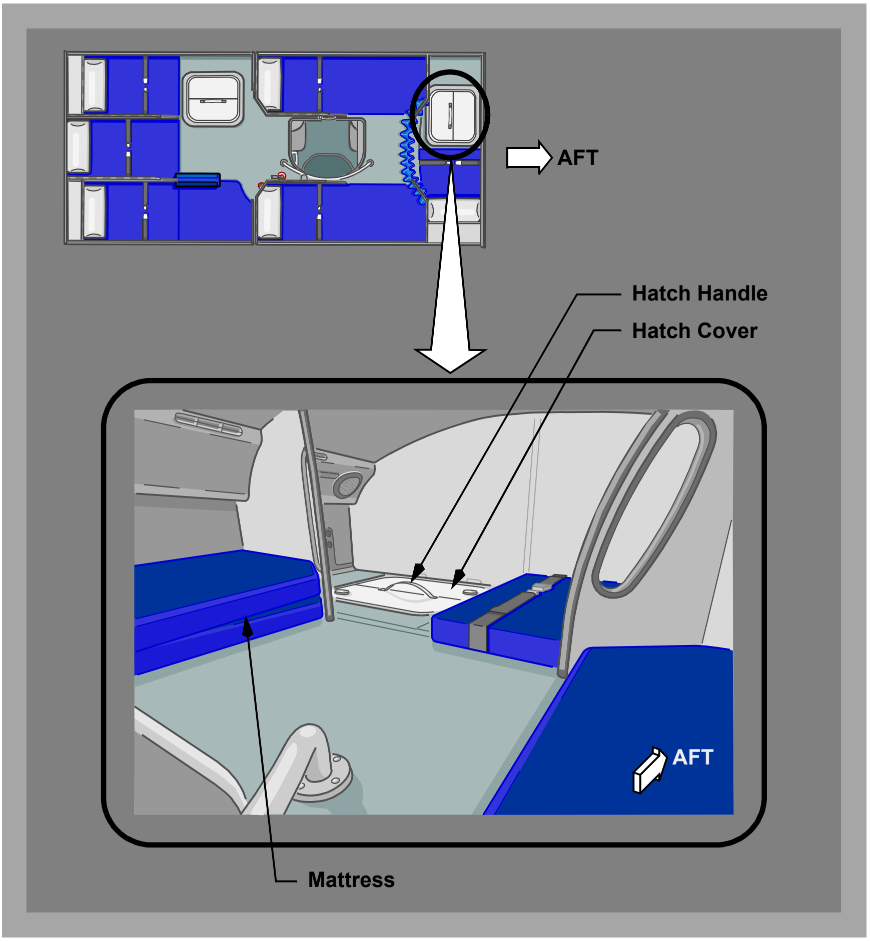


Evacuation

The primary evacuation route is down the entrance stairway through the entrance enclosure.

If the main entrance is unusable, evacuation is possible through the emergency hatches located at bunks 3 and 5.

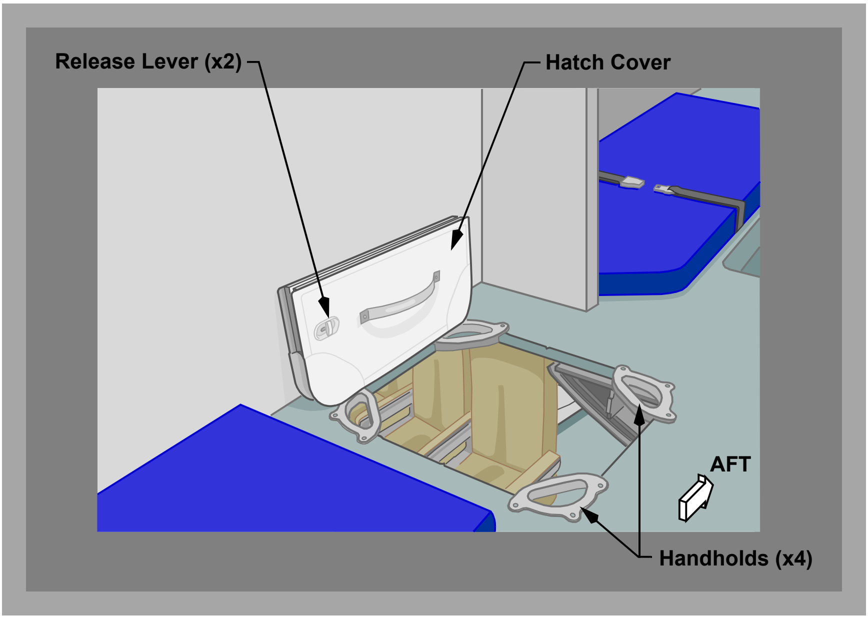




For egress from either emergency escape hatch:

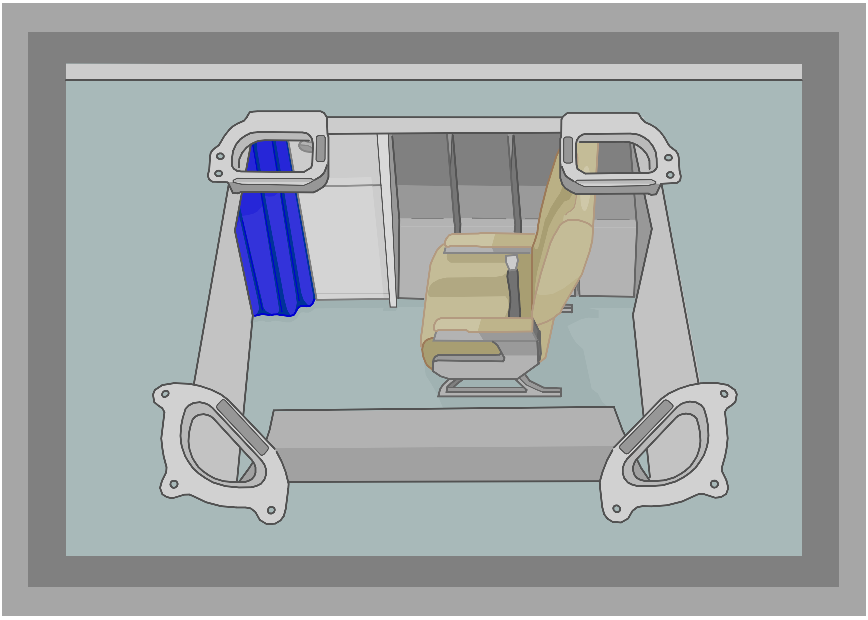
- lift and remove the mattress pad

  Note: Stow the mattress pad where it does not obstruct the emergency hatch.

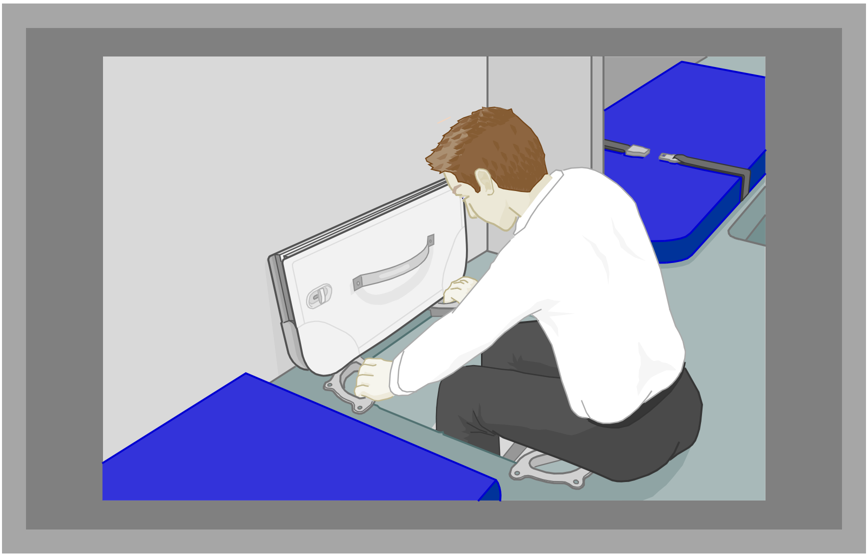


- unlatch the cover using the two release levers
- pull up on hatch handle to open the cover
- make sure to open the hatch fully to lock the cover in place

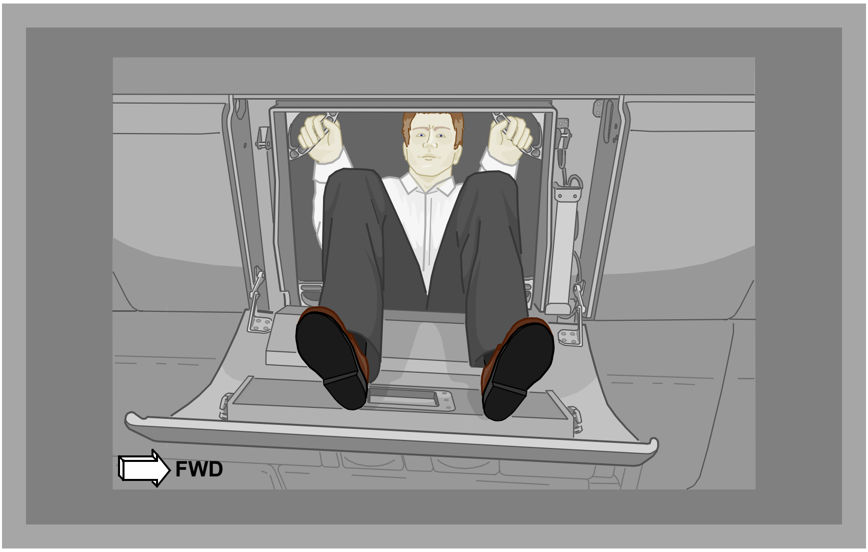
WARNING: Failure to ensure the hatch cover is locked in position may allow the hatch to unexpectedly close causing injury.



- unlatch lower hatch
  - push the lower hatch release lever
- command passengers in immediate area to move clear of evacuation area



- sit on bench facing the right side of the aircraft
- lower legs into hatch opening



- grasp the handholds keeping elbows tucked inward

- use the lower hatch to slide/swing down and drop to main deck
  - use the seat armrest to assist in maintaining balance as necessary

CAUTION: During exit to the main deck, stepping on the seat back may cause the seat back to fold. If this occurs, the crew member may lose balance and hand grip resulting in personal injury.

- close the lower hatch when evacuation is complete

WARNING: The lower evacuation hatch must be closed to help prevent the spread of smoke or fire.

Airplane General, Emergency Equipment, Doors, Windows EICAS Messages

The following EICAS messages can be displayed.

Doors and Windows

Message	Level	Aural	Condition
DOOR AFT, FWD CARGO	Caution	Beeper	The cargo door is not closed and secure.
DOOR BULK CARGO	Advisory		The bulk cargo door is not closed and secure.
DOOR AFT, FWD E/E ACCESS	Caution	Beeper	The electrical and electronic access door is not closed and secure.
DOOR ENTRY 1–4L, R	Advisory		An entry door is not closed and secure.
DOOR FD OVHD	Advisory		The overhead door is not closed and secure.
DOOR FWD ACCESS	Advisory		The forward access door is not closed and secure.
DOORS AUTO	Memo		All passenger doors are in the automatic mode.
DOORS AUTO/MANUAL	Memo		Some passenger entry doors are in the automatic mode and some are in the manual mode.
DOORS MANUAL	Memo		All passenger doors are in the manual mode.
FD DOOR AUTO UNLOCK	Warning		The correct emergency access code is entered.
FD DOOR LOCK FAIL	Advisory		One or more of these occur: • The flight deck door power is off • The lock is failed • The lock bolt is not engaged
FD DOOR OPEN	Advisory		The flight deck door is open.

Message	Level	Aural	Condition
DOORS	Advisory		Two or more doors are not closed and secure.

Emergency Lights and Passenger Signs

Message	Level	Aural	Condition
EMER LIGHTS	Advisory		One of these occurs: • The emergency lights are on • The emergency lights switch is not ARMED
SEATBELTS ON	Memo		The SEAT BELTS switch is in the ON position.

Oxygen System

Message	Level	Aural	Condition
CREW OXYGEN LOW	Advisory		Crew oxygen pressure is low.
PASS OXYGEN ON	Advisory		The passenger oxygen system is on.

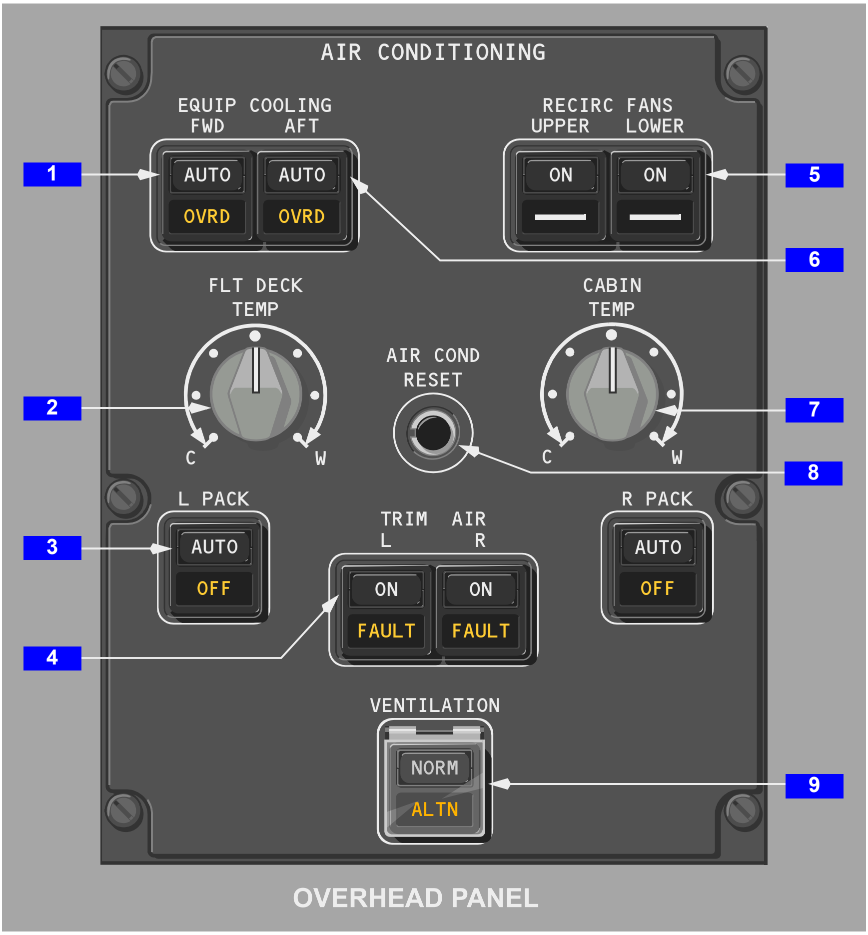
Miscellaneous Emergency Equipment

Message	Level	Aural	Condition
EVAC COMMAND	Warning		The evacuation command signal is on.

Air Systems — Chapter 2
Table of Contents — Section 0

Air Conditioning System

Air Conditioning Panel



1 Forward Equipment Cooling (EQUIP COOLING FWD) Switch

AUTO – forward equipment cooling mode is controlled automatically.

Off (AUTO not visible) –

- both forward equipment cooling supply fans, flight deck supply fan and vent fan are commanded off
- both the smoke/override valve and the flight deck isolation valve are commanded open
- forward cargo heat (or forward cargo air conditioning if installed) becomes inoperative
- OVRD illuminates

OVRD (illuminated amber) – SMOKE/OVRD mode is operating because:

- off is selected manually
- both forward equipment cooling supply fans fail, or
- the smoke/override mode is automatically selected by the smoke detection system

2 Flight Deck Temperature (FLT DECK TEMP) Control

- selects the target flight deck temperature

[Option – English & Metric units]

- turning the control toward C or W sets the desired temperature between 65 degrees F (18 C) and 85 degrees F (29 C). Mid position (12 o'clock) sets approximately 75 degrees F (24 C).

3 PACK Switches

AUTO – the pack is automatically controlled.

Off (AUTO not visible) – cabin air compressors are commanded off.

OFF illuminated (amber) – both associated cabin air compressors are not running:

- automatically during engine start
- automatically due to a pack or compressor outlet high temperature, or
- OFF is manually selected

4 TRIM AIR Switches

ON – the trim air valve is commanded open.

Off (ON not visible) –

- the trim air valve is commanded closed, and
- FAULT illuminates

FAULT illuminated (amber) –

- the trim air valve is failed closed
- the trim air valve is commanded closed because of a zone supply duct overheat, or
- the TRIM AIR switch is selected off

5 Recirculation Fans (RECIRC FANS) Switches

ON – provides automatic operation of the associated recirculation fans.

Off (ON not visible) – the selected recirculation fans do not operate.

EICAS advisory message are displayed if either the upper or lower switches are placed in the off position.

6 Aft Equipment Cooling (EQUIP COOLING AFT) Switch

AUTO – aft equipment cooling mode is controlled automatically.

Off (AUTO not visible) –

- both aft equipment cooling supply fans and vent fan are commanded off
- override valve is commanded open
- aft cargo heat becomes inoperative
- OVRD illuminates

OVRD (illuminated amber) – SMOKE/OVRD mode is operating because:

- off is selected manually
- both equipment cooling supply fans fail, or
- smoke/override mode is automatically selected by the smoke detection system

7 Cabin Temperature (CABIN TEMP) Control

Provides automatic passenger cabin temperature control.
[Option – English & Metric units]
Turning the control toward C or W sets the passenger cabin master reference temperature between 65 degrees F (18 C) and 85 degrees F (29 C).

8 Air Conditioning Reset (AIR COND RESET) Switch

Push –

- resets any latched air conditioning faults and attempts to restart normal operation
- resets any trim air valves held closed due to overheat, control failure, or valve failure
- attempts to reset a failed recirculation fan
- resets fault protection

9 Alternate Ventilation (VENTILATION) Switch

NORM – environmental control system is configured for normal operation

ALTN (illuminated amber) - alternate ventilation valve is in the open position. When valve is open, no alternate ventilation flow occurs when airplane is pressurized normally.

Shoulder and Foot Heaters

1 **SHOULDER HEATER Control**

LOW – electric heater operates on low setting.

Turn – the electric heater adds heat to the conditioned air flowing in at shoulder level at variable temperature settings up to HIGH.

2 **FOOT HEATER Control**

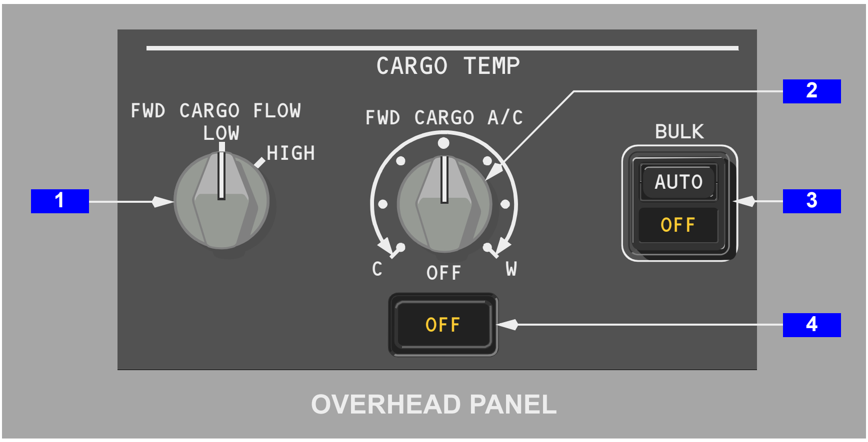
LOW – electric heater operates on low setting.

Turn – electric heater adds heat to the floor plate at variable temperature settings up to HIGH.

Cargo Temperature Control

Forward Cargo Air Conditioning Control

[Option – Forward cargo A/C]



1 FWD CARGO FLOW Selector

LOW – Normal ventilation flow for maintaining perishable cargo other than animal carriage.

HIGH – High ventilation flow demanded from air conditioning system for removing CO2 from live animal carriage.

2 Forward Cargo Air Conditioning (FWD CARGO A/C) Control

Provides automatic temperature control for the forward cargo compartment

[Option – English & Metric units]

Turning the control toward C or W sets the desired target temperature between 40 degrees F (4 C) and 85 degrees F (27 C). Mid position (12 o’clock) sets approximately 60 degrees F (16 C).

OFF – disables heater and cargo refrigeration unit. Normal cargo heating provided by the forward equipment ventilation system.

3 BULK CARGO TEMP Switch

[Option – English & Metric units]

AUTO – bulk cargo heat system targeting 70 degrees F (21 C).

Off (AUTO not visible) – bulk cargo heat is commanded off.

OFF (illuminated amber) –

- aft E & E exhaust fan inoperative
- supply ventilation valve closed
- aft cargo fire detected

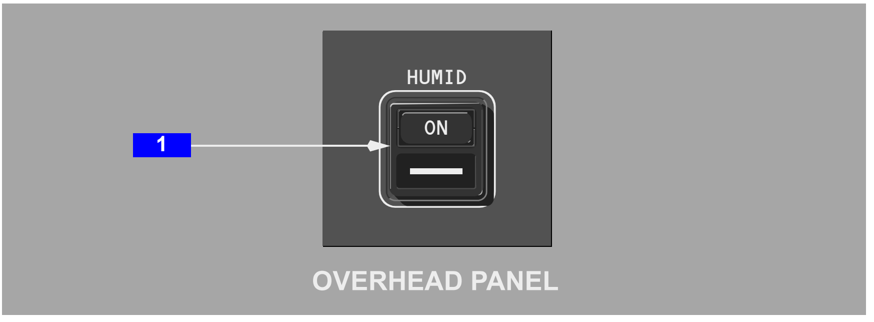
4 Forward Cargo Air Conditioning (FWD CARGO A/C) OFF Light

Illuminated amber –

- cargo refrigeration unit inoperative
- fwd E & E system in override
- supply ventilation fan (fwd E & E exhaust fan) inoperative
- fwd cargo fire detected

Flight Deck Humidification System

[Option – F/D humidity]



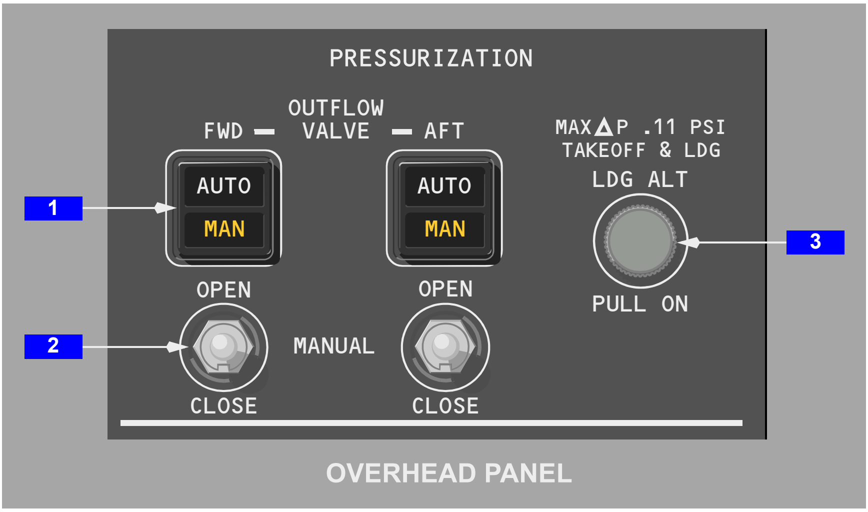
1 Humidification (HUMID)

ON – flight deck humidification system operates automatically.

Off (ON not visible) – humidification system does not operate.

Pressurization System

Pressurization Panel



1 OUTFLOW VALVE (FWD / AFT) Switches

AUTO – outflow valve controlled automatically.

MAN (manual) illuminated (amber) –

- outflow valve is controlled manually
- bypasses automatic outflow valve control and cabin altitude limiter
- AUTO extinguished

2 OUTFLOW VALVE MANUAL Switches

OPEN – moves the outflow valve toward open.

CLOSE – moves the outflow valve toward closed.

3 Landing Altitude (LDG ALT) Selector

Pull ON, then rotate –

- sets landing altitude manually
- landing altitude followed by MAN displayed on EICAS
- when turned slowly, landing altitude display changes in 100 foot increments. When turned quickly, display changes in 500 foot increments

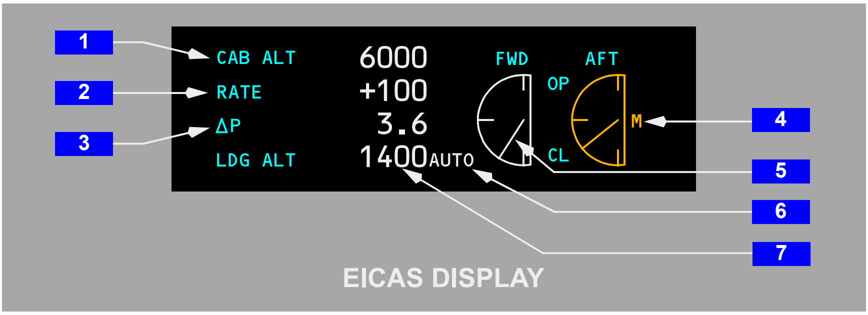
Push –

- landing altitude set automatically from FMS – Refer to Chapter 11, Flight Management Navigation – Approach
- landing altitude followed by AUTO displayed on primary EICAS

Pressurization System Indications

Pressurization system indications are displayed automatically when:

- landing altitude MAN
- either OUTFLOW VALVE switch in MAN
- cabin altitude is above normal range (amber)
- cabin differential pressure is above normal range (amber)
- cabin differential pressure is excessive (red)
- AIR synoptic selected on any MFD
- the following EICAS messages are displayed:
  - CABIN ALTITUDE
  - CABIN ALTITUDE AUTO
  - LANDING ALTITUDE
  - PACK L + R
  - OUTFLOW VALVE AFT
  - OUTFLOW VALVE FWD



1 Cabin Altitude

White – normal range.

Amber – above normal range.

Red – excessive cabin altitude.

2 Cabin Altitude Rate

+ (plus) – rate of climb.

– (minus) – rate of descent.

3 Cabin Differential Pressure

White – normal range.

Amber – above normal range.

Red – excessive cabin differential pressure.

4 **Outflow Valve Control Source**

M (manual) (amber) – manual control.

Blank – automatic control.

5 **Outflow Valves Position**

OP – open.

CL – closed.

6 **Landing Altitude Selection**

AUTO (white) – altitude set automatically from FMC.

MAN (amber) – altitude set by LANDING ALTITUDE selector.

7 **Landing Altitude**

Landing altitude supplied by the FMC or manually selected using the LANDING ALTITUDE selector.

Blank – display is blank without valid FMC landing altitude.

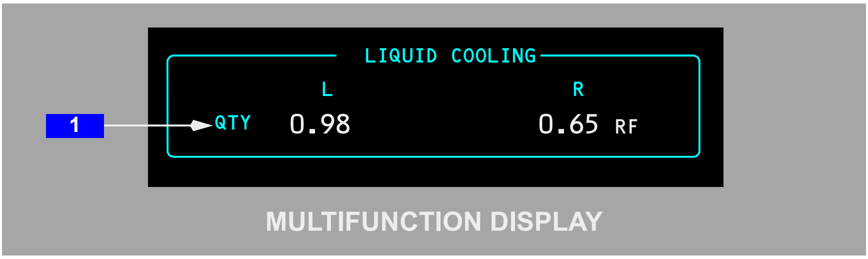
Equipment Cooling

Power Electronics Cooling System (PECS) Indications

PECS is the liquid cooling system for electronics. To view the status display, push the STAT display switch on the display select panel. Refer to Display Select Panel in Chapter 10, Section 10, for more information.

The liquid cooling status is displayed by pushing the systems (SYS) display switch on the display select panel, then selecting the status (STAT) synoptic key.

Status Display



1 **Liquid Quantity Display**

QTY –

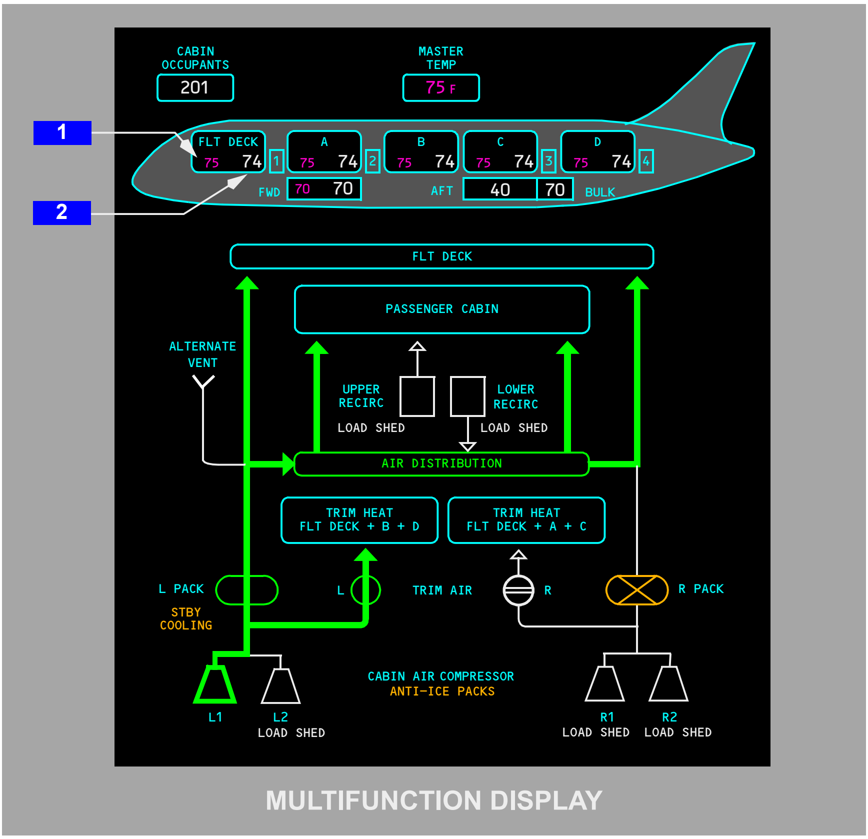
- displays the left and right system reservoir quantities as a percentage of the normal service level (1.00 is the normal service level)
- LO (amber) – displayed when the reservoir quantity is low

- OF (white) – displayed when the reservoir is over–full (inhibited in flight)
- RF (white) – displayed when the reservoir requires refilling (inhibited in flight)

Air Synoptic Display

The air systems synoptic is displayed by pushing the systems (SYS) display switch on the display select panel, then selecting the air systems (AIR) synoptic key. Refer to Display Select Panel in Chapter 10, Section 20 for additional information on display select panel operation.

[Option – Forward cargo A/C, English units]



1 **Selected Temperatures (magenta)**

[Option – Forward cargo A/C]

Selected by the FLT DECK TEMP, FWD CARGO A/C, and the CABIN TEMP controls.

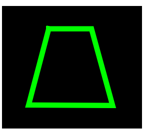
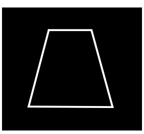
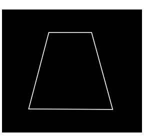
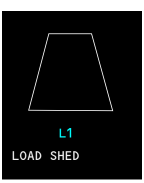
2 **Actual Temperatures (white)**

[Option – Forward cargo A/C]
Actual temperature sensed on the flight deck, forward cargo compartment, or the passenger zone.
[Option – Forward cargo A/C]

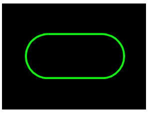
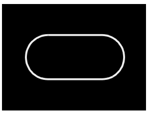
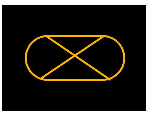
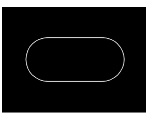
Note: When the forward cargo air conditioning system is off or inoperative, the forward cargo selected temperature display is blank.

Synoptic Indication Symbology

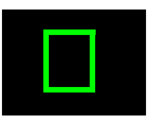
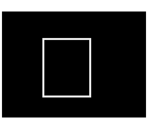
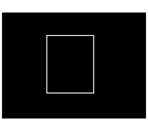
Cabin Air Compressor Synoptic Indications

Symbol	Condition	Remarks
	Compressor on (green)	Associated compressor is running and developing flow
	Compressor off (white)	Associated compressor is not developing flow
	Compressor invalid (white, low intensity)	Signal from associated compressor is invalid or missing
	Compressor load shed (white)	Associated compressor (L1,L2,R1,R2) has load shed

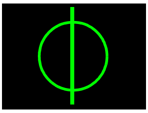
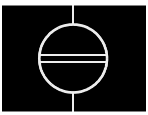
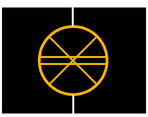
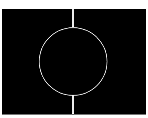
Pack Synoptic Indications

Symbol	Condition	Remarks
	Pack on (green)	Pack is running and developing conditioned airflow.
	Pack off (white)	Pack switch - OFF or both associated cabin air compressors are off and not PACK L(R) status message.
	Pack failed (amber)	Pack is not developing conditioned inflow when commanded to run. PACK switch - AUTO and PACK L(R) status message
	Pack signal invalid (white, low intensity)	

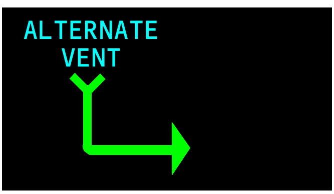
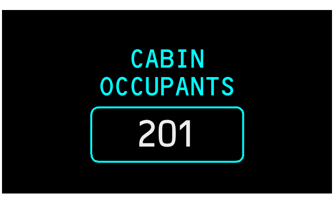
Recirculation Fan Synoptic Indications

Symbol	Condition	Remarks
	Fan on (green)	Upper fan or one of two lower fans is developing flow
	Fan off (white)	Upper fan or both lower fans are not running
	Fan invalid on (white, low intensity)	

Trim Air Valve Synoptic Indications

Symbol	Condition	Remarks
	Valve open (green)	
	Valve closed (white)	
	Valve failed open (amber)	
	Valve failed closed (amber)	
	Valve invalid (white, low intensity)	

Miscellaneous Synoptic Indications

Symbol	Condition	Remarks
	Associated pack in standby cooling mode	EICAS advisory message PACK MODE L (R) displayed.
	Compressor inlet anti-ice failure	EICAS advisory message ANTI-ICE PACKS displayed.
	Ventilation system is in the alternate mode	EICAS advisory message VENTILATION ALTN displayed. • Flight deck VENTILATION switch in ALTN position
	Number of cabin occupants as entered on the Cabin Attendant Panel	Blank if data missing or invalid.

Air Systems — Chapter 2
Air Conditioning System Description — Section 20

Introduction

The air conditioning system supplies conditioned outside air and recirculated cabin air at a controlled temperature throughout the airplane.

The system supplies conditioned air to the flight deck shoulder heaters.

The system supplies ventilation for the passenger cabin:

- lavatories
- galleys

[Option – Crew rest]

- overhead crew rest compartments

Pack control, zone temperature control, cabin air recirculation, fault detection, and overheat protection are all automatic. Backup system control modes operate automatically in the event of system failures.

The airplane is divided into seven temperature zones: the flight deck and six passenger cabin zones.

Note: Zones A and B contain sub-zones A1 and B1 that are not depicted on the air synoptic.

Air Conditioning Packs

Outside air is supplied to four electric cabin air compressors (CAC) through two dedicated ram scoops located in the wing to fuselage fairing. The air is pressurized and flow-regulated by the CACs and supplied to two identical air conditioning packs. Two CACs are dedicated to each pack. A single CAC provides sufficient air to operate its associated pack in all operating modes. Packs are controlled by two identical pack control systems. If one system fails, pack control automatically switches to the other system.

Air flow to the packs is controlled by regulating the cabin air compressors. CAC output is increased automatically during high demand periods (to compensate for a failed pack), or is limited during electrical load shed conditions to ensure sufficient electrical power is available to other critical systems. During normal operation, outside airflow is controlled to ensure that a minimum ventilation rate is maintained.

Pack Ground Operation

Both air conditioning packs are normally selected to AUTO for ground operations. To maximize system efficiency, one CAC on each side is off when the APU is the power source. For normal engine starts, the CACs are commanded off immediately. For an engine start in flight, power is also removed from the CACs immediately to maximize availability of power for an engine start.

A ground source of conditioned air may be used to supply conditioned air directly to the cabin distribution system, eliminating the need for pack operation.

Pack Non–Normal Operation

Pack control, fault detection, and overheat protection are all automatic. If an overheat or other significant pack fault is detected, the pack shuts down automatically and the EICAS advisory message PACK (L, R) is displayed. An attempt to restore pack operation may be made by pressing the AIR CONDITIONING RESET switch.

Standby Cooling Mode

For certain internal malfunctions, pack control automatically uses standby cooling mode as a backup to normal mode. In standby cooling mode, the EICAS advisory message PACK MODE (L, R) is displayed, and STBY COOLING is displayed in amber on the AIR synoptic.

If one pack is in standby cooling and the other pack is operating normally, the pack in standby cooling mode shuts down at lower altitudes and higher outside air temperatures when ambient conditions do not permit standby cooling. The pack restarts automatically when altitude and outside air temperatures are suitable for standby cooling.

In standby cooling mode, pack cooling capacity may be less than in normal mode and may result in warm flight deck or cabin temperatures at lower altitudes.

Air Distribution

Recirculation fans assist the packs to maintain a constant ventilation rate through the cabin. The fans draw cabin air through filters, then reintroduce the air into the conditioned air distribution system.

The flight deck receives 100% conditioned outside air and the passenger cabin receives a mix of outside air and recirculated air. Flight deck pressure is maintained slightly higher than the passenger cabin pressure to prevent smoke from entering the flight deck. Some recirculated air is supplied to the flight deck if one pack is off and its associated lower recirculation fan is on.

Outside air flow is reduced during failure conditions and electrical load shed conditions to protect the electrical power distribution system and to ensure that sufficient electrical power is available to other critical aircraft systems.

Cabin attendants can reduce outside airflow to the cabin based on the number of airplane occupants. This reduction is limited to ensure that a minimum air flow is always supplied to the cabin.

Air exhausted from the passenger cabin flows into the upper recirculation system or to the lower deck, where it is either exhausted overboard through outflow valves or drawn into the lower recirculation system. Air from the recirculation fans is mixed with pack air before entering the distribution ducts.

The lower recirculation ducts contain liquid-to-air heat exchangers capable of additional cabin cooling. Lower recirculation cooling reduces the power required from the CACs. Lower recirculation cooling is provided by the Integrated Cooling System (ICS) which is a common galley cooling system.

When upper and/or lower RECIRCULATION FAN switches are OFF, an EICAS advisory message RECIRC FAN UPR and/or LWR OFF is displayed. Recirculation fans should remain on to aid in cabin air filtration and cooling of the feeder wires over the center wing box area.

Alternate Ventilation System

The Alternate Ventilation System (AVS) provides an alternate means of ventilating the cabin and flight deck in the event both packs are inoperative. The system consists of a flight deck switch and a dedicated flush inlet valve and duct that delivers outside air flow downstream of the left pack outlet. When the airplane is unpressurized, placing the alternate ventilation system switch in the ALTN position opens a valve allowing fresh outside air to be drawn into the air distribution system.

Temperature Control

Hot trim air from each pack is added to the pack conditioned air to control the temperature in each zone. Each trim air system supplies two cabin zone ducts and one flight deck zone duct.

Cabin zone temperatures are regulated by controlling pack outlet temperature and adding hot trim air to the zone supply ducts through the trim air valves to meet the target temperature of each of the seven temperature zones.

[Option – English / Metric units]

The CABIN TEMP selector sets a master reference temperature between 65 and 85 degrees F / 18 and 29 degrees C. The master reference temperature is increased or decreased automatically or manually to set target temperatures for each temperature zone.

[Option – English / Metric units]
The target temperatures of each passenger cabin temperature zone may be further modified plus or minus 10 degrees F / 6 degrees C, within the range of 65 to 85 degrees F / 18 to 29 degrees C, using the cabin management system.
[Option – English / Metric units]
The flight deck temperature selector sets the flight deck temperature to between 65 and 85 degrees F / 18 and 29 degrees C.

The temperature zone requiring the coolest temperature controls the pack outlet temperature.
[Option – English / Metric units]
If the flight deck or cabin temperature selector setting is unavailable to the pack temperature controller, the pack outlet temperature is regulated to achieve either the last temperature set or an average cabin temperature of 75 degrees F / 24 degrees C.

Crew Rest Area Temperature Control

[Option – Crew rest]

Crew rest area temperature can be controlled manually by the heater controls in the compartments. Refer to Crew Rest Temperature Control, Chapter 1, Section 46, for additional information.

Temperature Control With Loss of Trim Air

[Option – English / Metric units]
If the left or right trim air system is off, the cabin temperature controllers attempt to maintain all zones at the average target temperature. Flight deck temperature is maintained between 65 and 85 degrees F / 18 and 29 degrees C.

The flight deck may become uncomfortably warm or cool. Setting the CABIN TEMP selector to a cooler or warmer master temperature may achieve a cooler or warmer flight deck temperature.

Shoulder and Foot Heaters

Flight crew shoulder heat is provided by electric elements in the side window air diffusers. The foot heaters have electric heating elements only, with no airflow. Both are available in flight only.

Cargo Temperature Control System

Cargo Heat System

The fwd and bulk cargo compartments have independent heating systems. An insulated curtain separates the aft and bulk compartments.

[Option – English / Metric units]
The forward cargo compartment is capable of carrying live animals. With the FWD CARGO TEMP selector set to AUTO, the fwd cargo heat shutoff valve opens and the temperature control valve opens/closes to maintain a target temperature of 70 degrees F / 21 degrees C. The EICAS advisory message CARGO HEAT FWD notifies the flight crew if a shutdown occurs or if a selector is off.

Selecting the AUTO setting on the BULK CARGO TEMP switch turns on the bulk ventilation fan to allow for live animal transport. The system has automatic overheat protection. When an automatic overheat shutdown occurs, cargo heat to the related compartment cannot be restored in flight. The EICAS advisory message CARGO HEAT BULK notifies the flight crew when the switch is off or a shutdown occurs.

The aft cargo compartment is heated by warm exhaust air from the aft equipment cooling system.

Forward Cargo Compartment Air Conditioning System

[Option – Forward cargo AC}

The forward cargo compartment air conditioning system provides temperature control and conditioned air for the transport of perishable, live, or other temperature sensitive cargo. Automatic ventilation ensures that odors do not go from the cargo compartment to the flight deck or passenger cabin.

Selecting the FWD CARGO A/C control to AUTO disables the forward cargo heating system and allows the selection of a target temperature for the forward cargo compartment. Target and actual temperatures are displayed on the AIR synoptic.
[Option – English / Metric units]
The flight crew can set the forward cargo compartment temperature control reference to between 40 and 85 degrees F / 4 and 27 degrees Cusing the FWD CARGO A/C control.

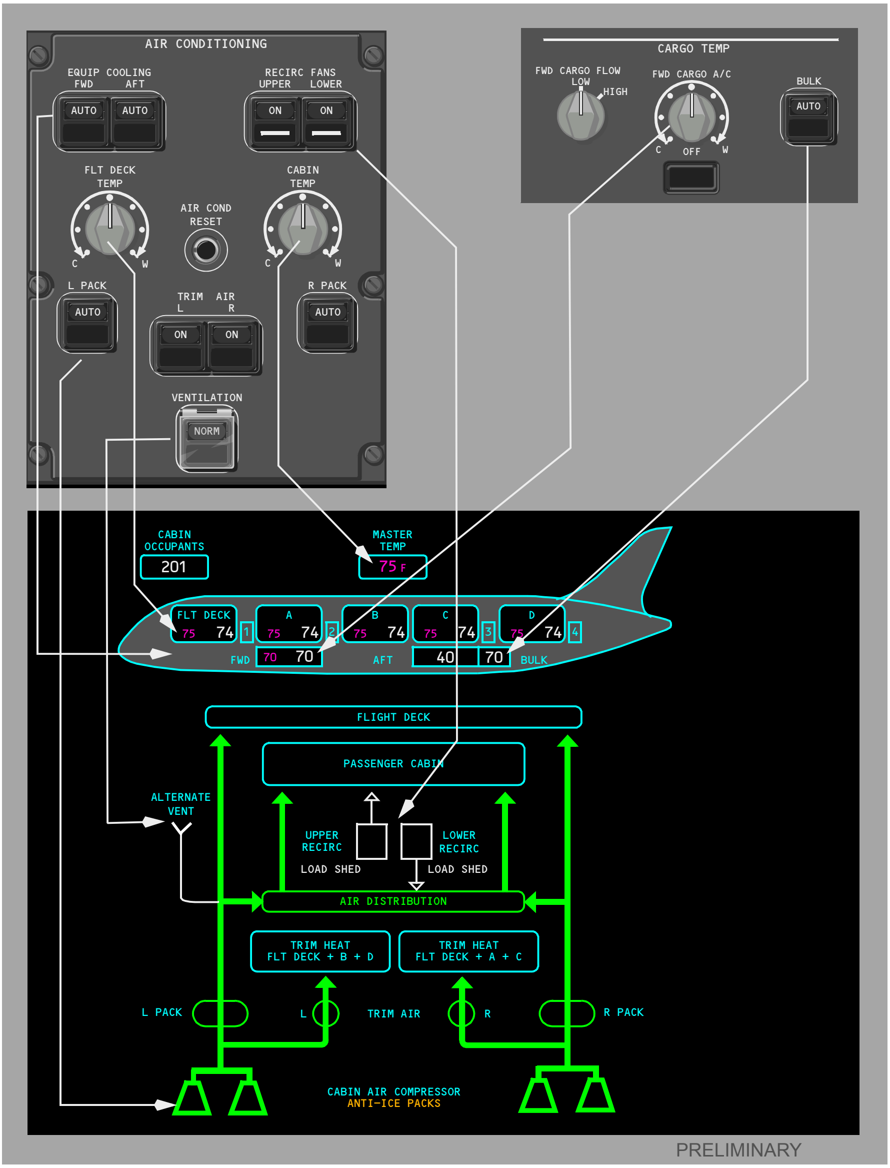
Note: If the flight deck control fails, the packs maintain the last selected target temperature.

Normal forward cargo heating is provided when the FWD CARGO A/C control is in the OFF position. The selected temperature display on the AIR synoptic is blanked.

The EICAS advisory message CARGO A/C FWD is displayed when a fault is detected in the forward cargo compartment air conditioning system.

Air Conditioning System Schematic

[Option – Forward cargo A/C, English units]



Equipment Cooling, Equipment Ventilation, Lavatory and Galley Ventilation

The forward equipment cooling and ventilation systems provide cooling and ventilation for the electrical and electronic equipment on the flight deck and in the forward electrical and electronic (E & E) compartment equipment racks.

The forward systems use internal fans and valves to direct air drawn from the cabin to the equipment and ventilates the warm exhaust air into the forward outflow valve or the forward cargo compartment, if the compartment requires additional heat. There are two cooling system supply fans, a primary and a backup. If the primary supply fan fails, the backup supply fan operates automatically.

The forward system reconfigures automatically to an override mode when:

- the FWD EQUIP COOLING switch is off, or
- in flight, both supply fans fail, or
- in flight, low airflow is detected, or
- smoke is detected in the forward equipment cooling system or the forward equipment ventilation system, or
- the FWD CARGO FIRE ARM switch is ARMED

In the override mode when the FWD CARGO FIRE ARM switch is not ARMED, the vent valve opens, both supply fans are inoperative, and the forward cargo heat valve is closed.

In the override mode when the FWD CARGO FIRE ARM switch is ARMED, the vent valve remains closed, both supply fans are inoperative, and the forward cargo heat valve is closed.

Cabin differential pressure draws air through the flight deck panels and into the forward E & E equipment compartment to create a reverse flow of air across the equipment, then through the override valve to an overboard vent.

The override mode supplies adequate cooling while the airplane is in cruise, but the airflow decreases as the airplane descends as the cabin pressure differential decreases.

In flight, the FWD EQUIP COOLING switch in OVRD aids smoke evacuation from the flight deck.

On the ground, the EICAS advisory message EQUIP COOLING FWD is displayed and the ground crew call horn in the wheel well sounds if the forward equipment cooling system is inoperative.

The aft equipment cooling system provides cooling and ventilating air for the aft E & E equipment compartment and heating/ventilating air for aft cargo compartment.

The aft system uses internal fans and valves to direct air drawn from the cabin to the aft equipment bay and ventilates the warm exhaust air into the aft overboard valve or aft cargo compartment. There are two cooling system supply fans, a primary and a backup. If the primary supply fan fails, the backup supply fan operates automatically.

The aft system reconfigures automatically to an override mode when:

- the AFT EQUIP COOLING switch is off, or
- in flight, both supply fans fail, or
- in flight, low airflow is detected, or
- smoke is detected in the aft equipment cooling system or aft equipment ventilation system, or
- the AFT CARGO FIRE ARM switch is ARMED

In the override mode when the AFT CARGO FIRE ARM switch is not ARMED, the vent valve opens, both supply fans are inoperative, and the aft cargo heat valve is closed.

In the override mode when the AFT CARGO FIRE ARM switch is ARMED, the vent valve remains closed, both supply fans are inoperative, and the aft cargo heat valve is closed.

In flight, the AFT EQUIP COOLING switch in OVRD aids smoke evacuation from the passenger cabin.

On the ground, the EICAS advisory message EQUIP COOLING AFT is displayed and the ground crew call horn in the wheel well sounds if the aft equipment cooling system is inoperative.

The lavatory/galley ventilation system provides ventilating air for the lavatories and galleys and smoke control for lavatories and optional crew rests. The system is also a secondary heat sink for the Power Electronics Cooling System (PECS).

Power Electronics Cooling System

The Power Electronics Cooling System (PECS), or liquid cooling system, provides liquid cooling to the high voltage direct current equipment in the aft E & E equipment compartment. It also provides liquid cooling to the supplemental cooling units and associated motor controllers of the Integrated Cooling System. The system consists of two independent liquid cooling loops. Each loop has a single pump package which contains two fully redundant pumps.

[Option – English / Metric units]

Liquid quantities and status for each liquid cooling loop are displayed on the STATUS page. The liquid cooling system controls the liquid coolant supply temperature of each loop to 85 degrees F / 29 degrees C during normal operation.

There is no flight deck control for the liquid cooling system. The system operation is completely automated and no crew action is required for either normal or non-normal modes of operation.

Integrated Cooling System

The Integrated Cooling System (ICS) is a centralized refrigeration system that provides cooling to galley carts and assists with cooling recirculated cabin air. ICS is integrated with the air conditioning system and the liquid cooling system to manage airplane heat loads. There is no flight deck control for the ICS.

Miscellaneous Equipment Cooling System

The miscellaneous equipment cooling system provides cooling to equipment located in various areas of the airplane. This includes IFE equipment as well as other non-essential equipment located in the crown and areas of the lower lobe not cooled by other equipment cooling systems. Operation is fully automatic and powered on whenever the airplane is powered. Miscellaneous cooling system power can be removed using the IFE switch on flight deck overhead panel.

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Introduction

Cabin pressurization is controlled by regulating the discharge of conditioned cabin air through the outflow valves.

Two outflow valves are installed: one forward and one aft. Normally, most of the outflow is through the aft outflow valve. This improves ventilation and smoke removal. Cabin altitude and full ventilation rates can be maintained by either valve.

Positive and negative pressure relief valves protect the fuselage against excessive pressure differential.

The pressurization system has automatic and manual operating modes. Other than accomplishing normal procedures for entering FMC data, no specific flight crew action is required for fully automatic operation.

Pressurization System Automatic Operation

In flight, the Cabin Pressure Control System (CPCS) operates in a climb mode, a cruise mode, or a descent mode.

The pressurization system uses ambient pressure and flight plan data from the FMC to calculate a cabin pressurization schedule. The schedule provides a comfortable cabin climb to cruise altitude.

For takeoff, the system supplies a small positive pressurization prior to rotation to cause a smooth cabin altitude transition to the cabin altitude climb schedule.

In climb mode, cabin altitude increases on a schedule related to the airplane climb rate and flight plan cruise altitude. When the FMC climb path has a planned level segment, it is included in the total time required for the airplane to reach the top of climb. Cabin altitude continues to increase during the planned level segment. For unplanned level segments or when VNAV disengaged, cabin altitude remains constant as long as aircraft altitude is not changing. When the airplane climb flight path is above the FMC climb path and maximum cabin pressure differential is reached during the climb, cabin rate then becomes a function of airplane climb rate so maximum cabin differential pressure is not exceeded.

If cruise altitude is unavailable from the FMC in AUTO, the default cruise altitude is 43,000 feet.

In the cruise mode, maximum cabin altitude is no more than 6,000 feet. The pressurization system enters descent mode after airplane descent has been initiated.

During descent, cabin altitude decreases to slightly below the FMC planned landing altitude. This ensures that the airplane lands pressurized. Landing altitude barometric pressure correction comes from the captain's altimeter setting.

At touchdown, both outflow valves open to depressurize the cabin.

For high altitude takeoffs, if the takeoff field elevation is higher than 8,000 feet, the cabin descends to the target altitude while the airplane is climbing.

For high altitude landings, if the destination airport elevation is greater than 8,000 feet, the cabin altitude climbs to 6,000 feet after takeoff and remains there during cruise. The cabin altitude then starts climbing to the destination airport elevation when appropriate.

Pressurization System Manual Operation

The pressurization system is in the manual mode when the OUTFLOW VALVE switches are set to MAN.

The system is manually operated by:

- setting the OUTFLOW VALVE switches to MAN
- holding the related OUTFLOW VALVE MANUAL switch to OPEN or CLOSE

Outflow valve position is displayed on the EICAS display. If the outflow valve position is not available on EICAS, holding the respective OUTFLOW VALVE MANUAL switch in the desired position for 30 seconds moves the valve from full open or close to the selected position.

Landing altitude (normally provided by the FMC) can be manually set using the LANDING ALTITUDE selector. Landing field selection limits are 2,000 feet below sea level to 14,000 feet above sea level. Pulling the selector out to the detent removes the FMC landing altitude and displays pressurization system indications on the EICAS display. The knob is rotated clockwise to increase or counterclockwise to decrease the landing altitude setting. Two rates of increase or decrease, low and high, are available in each direction from the spring–loaded center position.

Operation With Loss of Cabin Pressurization

With a sudden loss of cabin pressurization, the outflow valves close immediately in an attempt to control the cabin pressure. After descent, when the airplane and cabin altitudes are approximately equal, the outflow valves open to protect the airplane against negative pressure differentials.

It is important that the flight crew not attempt to manually close the outflow valves during the descent.

Air Systems — Chapter 2
Bleed Air System Description — Section 40

Introduction

Bleed air is supplied by the engines and is only used for engine anti–ice operations.

Engine Bleed Air Supply

Engine bleed air is supplied from a dedicated bleed port. The engine bleed air valves open when the ice detection system detects icing conditions. Hot bleed air flows to the inlet cowl to keep ice from forming.

The engine bleed air valves are armed when the ENGINE bleed switches are selected ON. The engine bleed valves close automatically:

- during start
- for bleed air overtemperature
- for bleed air overpressure
- when an engine fire switch is pulled

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Air Systems EICAS Messages

The following EICAS messages can be displayed.

Message	Level	Aural	Condition
CABIN ALTITUDE	Warning	Siren	Cabin altitude is excessive.
CABIN ALTITUDE AUTO	Caution	Beeper	One of these occurs: • Automatic pressurization control is failed • Both outflow valve switches are in manual
CABIN TEMPERATURE	Caution	Beeper	Flight deck or cabin temperature zone(s) are or may become excessively hot or cold.
CARGO A/C FWD	Advisory		Forward cargo air conditioning is inoperative.
CARGO HEAT BULK, FWD	Advisory		Cargo heat is inoperative.
EQUIP CLG OVRD AFT, FWD	Advisory		Equipment cooling system is in override mode.
EQUIP COOLING AFT, FWD	Advisory		The equipment cooling system is failed.
EQUIP OVBD VLV AFT	Advisory		Aft equipment cooling system overboard exhaust valve is failed in the open position on the ground.
EQUIP OVRD VLV AFT, FWD	Advisory		Equipment cooling system override valve is failed in the open position on the ground.
HIGH CABIN ALT MODE	Memo		The Cabin Altitude Warning limit is set higher than 10,000 feet due to a high takeoff or landing altitude.
LANDING ALTITUDE	Advisory		One of these occurs: • The FMC has failed to supply a landing altitude • The landing altitude selector is pulled

Message	Level	Aural	Condition
LIQUID CLG QTY L, R	Advisory		Liquid cooling system quantity is low.
LIQUID COOLING L, R	Caution	Beeper	A liquid cooling system fault occurs.
OUTFLOW VALVE AFT, FWD	Advisory		One of these occurs: • Automatic outflow valve control is inoperative • The outflow valve switch is in manual
PACK L, R	Advisory		A pack shutdown occurs.
PACK L+R	Caution	Beeper	Both packs are shut down.
PACK MODE L, R	Advisory		The pack is in the standby mode.
RECIRC FAN LWR, UPR OFF	Advisory		Recirculation fan switch is OFF.
TRIM AIR L, R	Advisory		The trim air valve is closed.
VENTILATION ALTN	Advisory		The ventilation system is in the alternate mode.

Anti-Ice, Rain — Chapter 3

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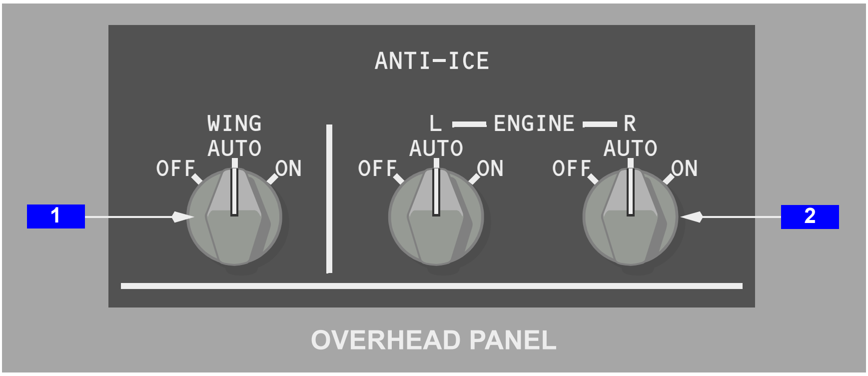
Anti-Ice, Rain — Chapter 3
Controls and Indicators — Section 10

Anti-Ice Panel



1 WING ANTI–ICE Selector

OFF – wing ice protection system is not powered.

Note: To enter the OFF position, switch must be pulled during rotation from AUTO to OFF.

AUTO – in flight, wing ice protection system is powered on or off automatically by the ice protection system.

ON – in flight, wing ice protection system is powered on and operates without input from automatic ice detection system (with TAT less than 10 degrees C).

2 ENGINE ANTI–ICE Selectors

OFF – the engine anti–ice valve is commanded closed.

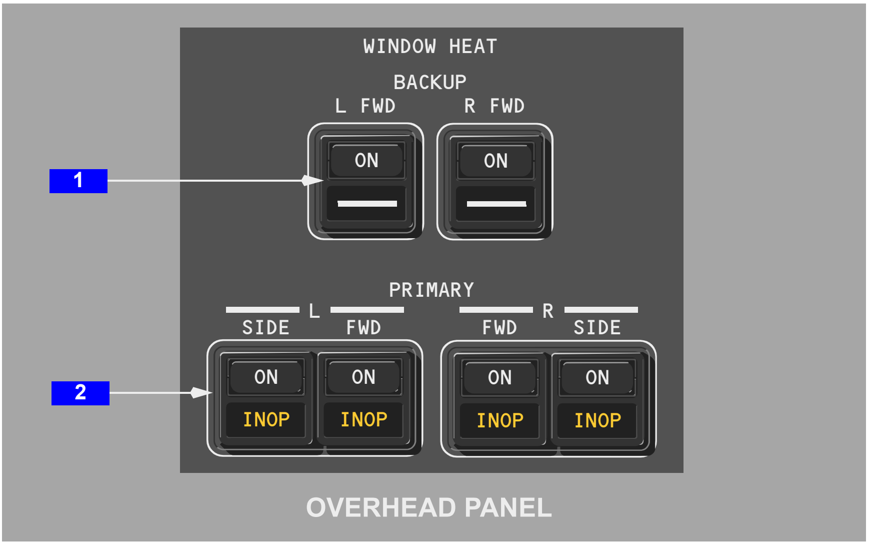
AUTO – in flight, the engine anti–ice valve is opened or closed automatically by the ice detection system.

ON – the engine anti-ice valve is commanded open.

Note: If the ENGINE ANTI-ICE selector is in AUTO and the anti-ice valve is commanded open, or if the selector is in ON, then approach idle is selected by the EEC.

Window Heat and Wiper/Washer Panels

Window Heat Panel



1 BACKUP WINDOW HEAT Switches

OFF (ON not visible) – backup window heat system is off.

ON – backup window heat is commanded on for the forward left and forward right windows.

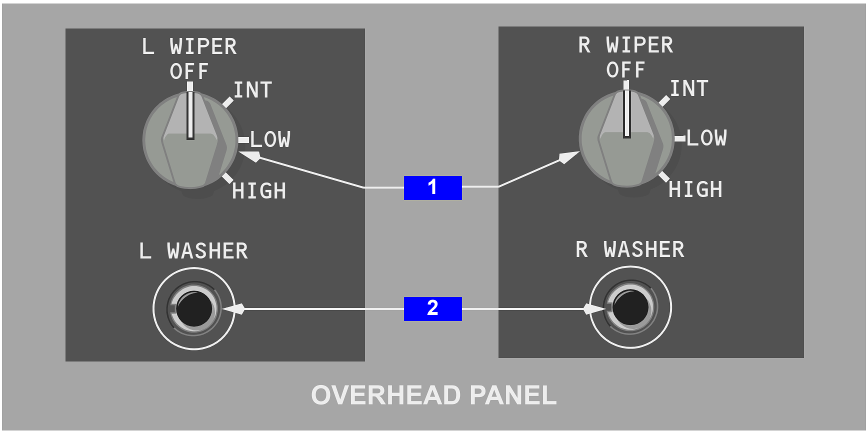
2 WINDOW HEAT Switches

ON – window heat is applied to the selected windows.

INOP (inoperative) illuminated (amber) –

- the switch is OFF
- an overheat is detected, or
- a system fault has occurred

Wiper/Washer Panels



1 WIPER Selectors

OFF – the wiper is stowed vertically.

INT (intermittent) – the wiper operates intermittently.

LOW – the wiper operates at low speed.

HIGH – the wiper operates at high speed.

2 WASHER Switches

Push (momentary action) – fluid is sprayed on windshield until switch is released.

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Anti-Ice, Rain — Chapter 3
System Description — Section 20

Introduction

The anti–ice and rain systems include:

- automatic ice detection
- engine anti–ice
- wing anti–ice
- pack inlet anti–ice
- flight deck window heat
- windshield wipers and washers
- probe heat

Automatic Ice Detection System

The automatic ice detection system senses the existence of icing conditions. The system consists of two icing condition detectors that measure liquid water content and use TAT and other air data information to determine if icing conditions exist. Both detectors are heated electrically after engine start. The system provides signals to control the engine, wing, and pack inlet anti–ice systems.

Automatic ice detection is inhibited on the ground below 60 knots.

Engine Anti–Ice System

The engine anti–ice system uses engine bleed air to provide engine cowl inlet ice protection. Engine anti–ice can be operated in flight or on the ground. The engine anti–ice indication EAI is displayed above the EICAS N1 indication when an engine anti–ice valve is open. The left and right engines have identical, independent anti–ice systems. This allows the remaining system to operate if one engine is shutdown.

Engine Anti–Ice System Automatic Operation

In flight, when the ENGINE ANTI–ICE selector is in AUTO, engine anti–ice system operation is automatic. When icing conditions are detected, the engine anti–ice valves open and engine bleed air is supplied to the engine inlet cowl.

When ice is no longer detected, the engine anti–ice valves close and bleed air is no longer supplied to the engine inlet cowl.

When icing conditions are no longer detected, the engine anti–ice valves close and bleed air is no longer supplied to the engine inlet cowl.

Automatic operation of the engine anti-ice system is inhibited on the ground.

Engine Anti–Ice System Manual Operation

On the ground or in flight, when the ENGINE ANTI–ICE selector is ON, engine bleed air opens the engine anti-ice valve and bleed air is supplied to the engine inlet cowl.

The engine anti-ice valves close automatically:

- during start
- for engine bleed air overtemperature
- for engine bleed air overpressure
- when an engine fire switch is pulled

Engine Anti–Ice Leak Detection System

Each engine has an anti–ice system duct leak detection system. If an anti–ice duct leak is detected, the respective engine anti–ice valve closes.

Wing Anti–Ice System

The electric wing anti–ice system powers thermal anti-icing mats on four midwing leading edge slats on each wing. There are three separate mats on each slat. Wing anti–ice is inhibited on the ground below 80 knots. Wing anti-ice may be momentarily shed (30 seconds maximum) during high electrical loads, such as during flap retraction. To maintain aerodynamic stability, system logic controls symmetrical operation of left and right wing anti-ice.

The wing anti–ice annunciation WAI is displayed below the EICAS N1 indication when wing anti–ice is powered.

Wing Anti–Ice System Automatic Operation

In flight, when the WING ANTI–ICE selector is in AUTO, wing anti–ice system operation is automatic. When icing conditions are detected, power is supplied to the thermal mats on the leading edge slats. When ice is no longer detected, power is removed. If one wing anti–ice thermal mat fails, the wing anti–ice system automatically de-powers the opposite thermal mat to prevent asymmetrical wing icing.

Automatic wing anti–ice operation is available in flight and on the ground above 80 knots airspeed.

Wing Anti–Ice System Manual Operation

In flight, when the WING ANTI–ICE selector is ON the wing anti–ice system on each wing is powered anytime TAT is below 10 degrees C.

Pack Inlet Anti-Ice System

The pack inlet anti-ice system provides ice protection for both ram air inlets for the cabin air compressors. An electric heater on the leading edge of each inlet prevents ice formation and reduces ice formation in the duct during icing conditions.

Pack inlet anti-ice functions automatically with signals from the automatic ice detection system. Operation is inhibited on the ground and when TAT is above 10 degrees C.

Flight Deck Window Heat

All flight deck windows are electrically heated. The forward windows have exterior surface anti–icing, and interior surface antifogging protection. The side windows have interior surface antifogging protection only.

The WINDOW HEAT switches control heating for all flight deck windows.

A backup antifogging system for the forward windows operates automatically if the primary window heat system fails.

Windshield Wipers/Washers

The forward windows are equipped with independently controlled, three–speed wipers. When the WIPER selector in OFF, the respective wiper is off and stowed.

The Captains and First Officers windshields are equipped with a windshield washer system. Windshield washer switches command a continuous application of washer fluid while held ON.

Windshield scratching may occur if wipers are used on a dry windshield surface.

Probe Heat

Three pitot probes and two angle of attack probes are electrically heated for anti-ice protection when either engine is operating.

The total air temperature probe is electrically heated for anti-ice protection in flight.

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Anti-Ice, Rain System EICAS Messages

The following EICAS messages can be displayed.

Message	Level	Aural	Condition
ANTI-ICE DET WING	Advisory		Wing ice detection is failed.
ANTI–ICE ENG L, R	Advisory		An engine anti–ice valve is closed when commanded open.
ANTI–ICE LEAK ENG L, R	Caution	Beeper	A bleed air leak occurs in an engine anti-ice or starter duct.
ANTI–ICE LOSS ENG L, R	Advisory		Anti–ice bleed air for the engine is not available.
ANTI–ICE ON	Advisory		All of these occur: • An ANTI-ICE system is on • TAT is more than 10 degrees C • Ice is not detected
ANTI–ICE PACKS	Advisory		Both pack inlet anti-ice systems are failed.
ANTI–ICE WING	Caution		Two or more zone pairs on the wing are failed. Wing anti-ice is degraded.
HEAT PITOT C	Advisory		The center pitot probe heat is failed.
HEAT PITOT L	Advisory		The left pitot probe heat is failed.
HEAT PITOT L+C+R	Advisory		Left, center and right pitot probe heat are failed.
HEAT PITOT R	Advisory		The right pitot probe heat is failed.
ICE DETECTORS	Advisory		The ice detectors are failed.
ICING ENG	Caution	Beeper	Ice is detected and an engine anti–ice selector is off.
OVERHEAT WING	Caution		A wing anti-ice overheat occurs.
WINDOW HEAT	Advisory		Two or more window heats are off.
WINDOW HEAT L, R FWD	Advisory		A primary window heat is off.

Message	Level	Aural	Condition
WINDOW HEAT L, R SIDE	Advisory		A side window heat is inoperative.
WING ANTI–ICE OFF	Advisory		The wing anti-ice selector is OFF.

Automatic Flight Chapter 4
Table of Contents Section 0

Automatic Flight — Chapter 4
Controls and Indicators — Section 10

Mode Control Panel (MCP)

Autopilot Flight Director System Controls

1 Autopilot (A/P) Engage Switches

Push (either switch can engage the autopilot) –

- if either flight director switch is ON, the autopilot engages in the selected flight director mode(s)
- if both flight director switches are OFF, the autopilot engages in:

[Option – Bank Angle Hold at Engage]

- heading hold (HDG HOLD) or track hold (TRK HOLD) as the roll mode, or if bank angle is greater than five degrees, attitude hold (ATT)

[Option – Heading Hold at Engage]

- heading hold (HDG HOLD) or track hold (TRK HOLD) as the roll mode, and
- vertical speed (V/S) or flight path angle (FPA) as the pitch mode

2 Autopilot Engaged Light

Illuminated (white) – all operating autopilots are engaged.

3 Flight Director (F/D) Switches

The left flight director switch activates the flight director steering indications on the left PFD and HUD. The right flight director switch activates the flight director steering indications on the right PFD and HUD.

ON –

- on the ground with both flight director switches OFF, the first flight director switch positioned ON arms the flight director in the takeoff go–around (TO/GA) roll and pitch modes. The flight mode annunciation appears on both PFDs and HUDs. Positioning the second switch ON displays the flight direction steering indications on the second PFD and HUD
- in flight, with the autopilot disengaged and both flight director switches OFF, the first flight director switch positioned to ON engages the flight director in:

[Option – Bank Angle Hold at Engage]

  - heading hold (HDG HOLD) or track hold (TRK HOLD) as the roll mode, or if bank angle is greater than five degrees, attitude hold (ATT)

[Option – Heading Hold at Engage]

  - heading hold (HDG HOLD) or track hold (TRK HOLD) as the roll mode, and
  - vertical speed (V/S) or flight path angle (FPA) as the pitch mode

- in flight, with the autopilot engaged and both flight director switches OFF, the first flight director switch positioned to ON engages the flight director in the currently selected autopilot mode(s)

OFF –

- the flight director steering indications are not displayed
- the flight director steering indications are displayed on the PFDs and HUDs if a TO/GA switch is pushed when airspeed is greater than 80 knots on takeoff, or on a go–around with the flaps not retracted

4 Autopilot (A/P) DISENGAGE Bar

Pull down –

- prevents autopilot engagement
- generates EICAS advisory message NO AUTOLAND (TBV)
- disables bank angle protection
- exposes the amber and black stripes
- if an autopilot is engaged:
  - it disconnects
  - displays the EICAS warning message AUTOPILOT DISC

- sounds an aural warning
- illuminates the master warning lights

Lift up –

- permits autopilot engagement
- hides the amber and black stripes

Autothrottle System Controls

MODE CONTROL PANEL (MCP)

1 Autothrottle (A/T) ARM Switches

The left autothrottle arm switch controls the left engine autothrottle. The right autothrottle arm switch controls the right engine autothrottle.

L and/or R – arms the selected autothrottle for mode activation. The selected autothrottle activates automatically when an AFDS mode (VNAV, FLCH, or TO/GA) is selected.

OFF –

- disconnects the selected autothrottle
- prevents selected autothrottle activation

2 Climb/Continuous (CLB/CON) Thrust Switch

On the ground and below 400 feet during takeoff, the switch is inoperative.

Push –

- with two engines operating, changes the engine thrust limit to the FMC selected climb thrust
- with only one engine operating, changes the thrust limit to maximum continuous (CON)

3 Autothrottle (A/T) Switch

Push – above 400 feet, with the autothrottle armed, activates the appropriate autothrottle mode for the selected AFDS pitch mode, or if no pitch mode, in the speed (SPD) mode.

4 **Autothrottle Light**

Illuminated (white) – an autothrottle mode is activated.

Autopilot Flight Director IAS/Mach Controls

1 **IAS/MACH Reference Switch**

Push –

- alternately changes the IAS/MACH window between IAS and Mach displays (Mach must be 0.4 or greater to switch from IAS to Mach)
- inoperative when the IAS/MACH window is blank

2 **IAS/MACH Window**

Upper line displays speed selected by the IAS/MACH selector and lower line displays uplinked ATC speed clearance.

Upper line is blank when the FMC controls the speed. When changing from TO/GA to V/S, FPA, or ALT, the window automatically displays:

- the flap placard speed minus 5 knots (flaps extended)
- 250 knots (flaps up), or
- a speed value entered in the IAS/MACH window after TO/GA was pushed

The display range is:

- 100 – 399 KIAS
- .400 – .950 Mach

The selected speed is displayed as the PFD selected speed.

The selected speed is displayed as the range to target speed dot (green) on the VSD.

Upper line displays 200 knots and lower line is blank when power is first applied.

During climb, automatically changes from IAS to MACH at .850 Mach.

During descent, automatically changes from Mach to IAS at 330 KIAS(TBV).

3 IAS/MACH Selector

Rotate –

- sets the speed on the upper line of the IAS/MACH window and as the selected speed on both the PFD and HUD
- inoperative when the IAS/MACH window is blank

Push –

- with VNAV engaged, alternately opens or closes the IAS/MACH window:
  - when the window is closed, the FMC computed target speed is active and is displayed on both the PFD and HUD
  - when the window is open, FMC speed–intervention is active and the IAS/MACH selector may be used to set the desired speed
- blanks when not in SPD, FLCH, or TO/GA

4 Uplink Transfer (XFR) Switch

Push – Transfers the IAS or Mach value from the lower line to the upper line. If upper line was blank/closed, it now opens to the uplinked ATC value. Lower line blanks after the transfer.

5 ATC Uplinked Speed Clearance

The ATC uplink function is always enabled. For immediate clearances, pushing the datalink ACCEPT switch displays the clearance IAS or Mach value in the lower line of the window. If the upper line was blank/closed, it remains unchanged. Pushing the datalink CNCL switch removes the clearance from the lower line.

For conditional clearances, pushing the ACCEPT switch automatically displays clearance IAS or Mach value in the lower line only after condition contained in the clearance is met.

Uplinked clearances are preceeded by the letters "UL".

Autopilot Flight Director Roll and Pitch Controls

1 Lateral Navigation (LNAV) Switch

Push –

- arms, engages, or disarms LNAV as the roll mode
- displays LNAV as armed mode on PFD (in white) and HUD roll flight mode annunciator. The previous engaged roll mode remains active
- LNAV engages if the airplane is above 50 feet radio altitude and:
  - within 2.5 NM of the active leg
  - if not within 2.5 NM of the active leg and on an intercept heading to the active leg, remains armed then engages when approaching the active leg
  - when engaged, displays LNAV in green on the PFD and HUD roll flight mode annunciator
- selection of LNAV with the airplane not on a heading to intercept the active leg, displays FMC INTERCEPT HDG EICAS advisory message
- selection of LNAV when an active FMC route is not available displays NO ACTIVE ROUTE in the CDU help window
- LNAV maintains current heading when:
  - passing the last active route waypoint
  - passing the last waypoint prior to a route discontinuity
  - passing the last route offset waypoint
  - activating the inactive route or activating an airway intercept and not within LNAV engagement criteria
- on go-around when valid missed approach path exists, LNAV mode engages automatically at 50 feet radio altitude with flight director only or 200 feet radio altitude with the autopilot engaged. LNAV is disengaged by engaging any other roll mode or by disengaging the autopilot and turning both flight directors off

LNAV is disengaged:

- by selecting heading hold (HDG HOLD) or track hold (TRK HOLD)
- by selecting heading select (HDG SEL) or track select (TRK SEL)
- when the localizer captures
- if there is a dual or triple FMC failure (LNAV may be re–engaged if one FMC remains functional)

LNAV is disarmed by pushing the LNAV switch a second time, or by arming LOC or APP.

2 LNAV Light

Illuminated (white) – the LNAV mode is armed or engaged.

3 Vertical Navigation (VNAV) Switch

Push –

- arms, engages, or disarms VNAV as the pitch mode
- displays VNAV as armed mode on PFD (in white) and HUD pitch flight mode annunciator below 400 feet
- VNAV engages at 400 feet AGL
- if VNAV is selected and the FMC has insufficient data to provide VNAV guidance (such as the gross weight is invalid or there is no end–of–descent point in descent) displays PERF/VNAV UNAVAILABLE in the CDU help window
- NAV SPD, VNAV PTH or VNAV ALT pitch mode is displayed in green (engaged) on the PFD pitch flight mode annunciator.
- VNAV SPD, VNAV PTH or VNAV ALT pitch mode is displayed in green (engaged) on the PFD and HUD pitch flight mode annunciator
- in the VNAV SPD pitch mode, the AFDS commands pitch to hold target airspeed. The autothrottle operates in the THR REF, THR, IDLE or HOLD mode, as required by the phase of flight
- in the VNAV PTH pitch mode, the AFDS commands pitch to maintain FMC target altitude or the VNAV path. The autothrottle maintains speed
- in the VNAV ALT pitch mode, the AFDS commands pitch to maintain the MCP selected altitude when that altitude is lower than the VNAV commanded altitude in climb or higher than the VNAV commanded altitude in descent
- if VNAV is selected and VNAV commands a descent with the MCP altitude window above the current airplane altitude, the autopilot maintains the altitude at which VNAV was selected. When on an instrument approach using VNAV, selecting the missed approach altitude does not interfere with the VNAV descent
- if VNAV is selected and VNAV commands a climb with the MCP altitude window below the current airplane altitude, the autopilot maintains the altitude at which VNAV is selected

- with the VNAV ALT pitch mode engaged, the autothrottle operates in the speed (SPD) mode
- with the VNAV PTH pitch mode engaged, the autothrottle operates in the following modes:
  - for climb or cruise – operates in the speed (SPD) mode
  - for descent – operates in the IDLE, HOLD, or speed (SPD) mode
- VNAV pitch guidance is available with one engine inoperative

VNAV is disengaged:

- by engaging TO/GA, FLCH SPD, V/S, FPA, ALT or G/S pitch mode
- if there is a dual FMC failure

  Note: VNAV functionality still available. Refer to Chapter 11, Flight Management, Navigation - Flight Management Computer.

- if all three FMCs fail

VNAV is disarmed by:

- pushing the VNAV switch a second time, or
- arming APP

4 **VNAV Light**

Illuminated (white) – the VNAV mode is armed or engaged.

5 **Flight Level Change (FLCH) Switch**

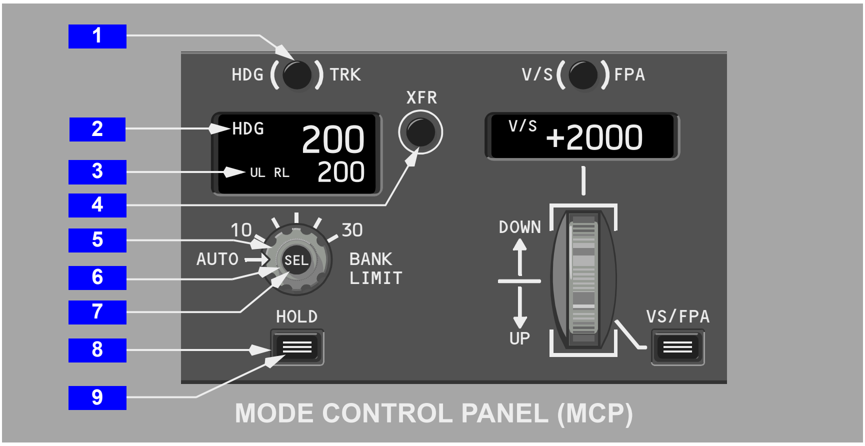
Push –

- FLCH SPD is displayed on the PFD and HUD pitch flight mode annunciator as the pitch mode
- if the IAS/MACH window is blank, the IAS/MACH window opens to the FMC target speed, if valid. If not valid, the IAS/MACH window opens to the current speed
- when changing from TO/GA to FLCH:
  - if the current speed is greater than the IAS/MACH window speed, the IAS/MACH window speed changes to the current speed
  - if the current speed is less than the IAS/MACH window speed, the IAS/MACH window speed does not change
- the autothrottle activates:
  - for climb – activates in THR mode with thrust targeting to reach selected altitude in two minutes; the thrust limit is CLB thrust
  - for descent – activates in THR mode with thrust targeting to reach selected altitude in two minutes, followed by HOLD if the thrust levers reach idle

6 **Flight Level Change Light**

Illuminated (white) – the flight level change mode is engaged.

Autopilot Flight Director Heading, Track, and Bank Angle Controls



1 Heading/Track (HDG/TRK) Reference Switch

Push – alternately changes the upper line of the heading/track window, PFD, HUD, and ND selected heading/track references between heading and track. Also changes the PFD and HUD roll flight mode annunciators, if the HDG or TRK mode is engaged.

2 Heading/Track Window

Upper line displays the selected heading or track and lower line displays uplinked ATC heading or track target.

The selected heading or track is displayed on the PFD, HUD and ND.

If approach is armed, the heading/track in the MCP window automatically changes to the selected ILS front course heading at LOC capture.

Upper line displays 360 degrees and lower line is blank when power is first applied.

3 ATC Uplinked Heading or Track

The ATC uplink function is enabled when the upper window and uplinked clearances are both heading values or both track values. If not both heading or track, pushing the heading/track reference switch will display the uplinked value. For immediate clearances, pushing the datalink ACCEPT switch displays the clearance heading or track value in the lower line of the window. Pushing the transfer (XFR) switch transfers the value from the lower line to the upper line. Pushing the datalink CNCL switch removes the clearance from the lower line.

For conditional clearances, pushing the ACCEPT switch displays the new heading or track value automatically in the lower line only after the clearance condition is met.

Uplinked clearances are preceeded by the letters "UL". Clearances containing a turn direction are also displayed preceeded by "L" or "R".

4 **Uplink Transfer (XFR) Switch**

Push – transfer the value from the lower line to the upper line. If upper line was blank/closed, it now opens to the uplinked ATC value. Lower line blanks after the transfer.

5 **BANK LIMIT Selector (outer)**

Rotate – sets the AFDS commanded bank limit when in the heading select (HDG SEL) or track select (TRK SEL) roll mode as follows:

- AUTO – varies between 15 – 25 degrees, depending on TAS
- 10, 15, 20, 25 or 30 – the selected value is the maximum, regardless of airspeed

6 **Heading/Track Selector (middle)**

Rotate – sets heading or track in the heading/track window and on the PFDs HUDs, and NDs.

7 **Heading/Track Select (SEL) Switch (inner)**

Push –

- selects heading select (HDG SEL) or track select (TRK SEL) as the roll mode
- displays HDG SEL or TRK SEL on the PFD and HUD roll flight mode annunciator
- the AFDS controls roll to fly the selected heading or track
- bank is limited by the bank limit selector

8 **Heading/Track Hold (HOLD) Switch**

Push –

- selects heading hold (HDG HOLD) or track hold (TRK HOLD) as the roll mode
- displays HDG HOLD or TRK HOLD on the PFD and HUD roll flight mode annunciator
- the AFDS commands wings level and holds the heading or track established when wings level is established

9 **Heading/Track Hold Light**

Illuminated (white) – the heading/track HOLD mode is engaged.

Autopilot Flight Director Vertical Speed (V/S) and Flight Path Angle (FPA) Controls

1 **V/S – FPA Reference Switch**

Push – alternately changes the vertical speed/flight path angle window and PFD references between vertical speed and flight path angle. Also changes the PFD / HUD pitch flight mode annunciator, if the V/S or FPA mode is engaged.

2 **Vertical Speed/Flight Path Angle (V/S – FPA) Window**

Displays the selected vertical speed in 100 fpm increments or the selected flight path angle in 0.1 degree increments.

The display range is:

- V/S: -8000 to +6000 fpm
- FPA: -9.9 to +9.9 degrees

Blank when the vertical speed (V/S) or flight path angle (FPA) pitch mode is not engaged.

The selected vertical speed is displayed on the PFD vertical speed indication.

The selected flight path angle is displayed on the PFD attitude indicator.

3 **V/S – FPA Switch**

Push –

- engages vertical speed (V/S) or flight path angle (FPA) as the pitch mode
- displays V/S or FPA on the PFD and HUD pitch flight mode annunciator
- displays dashed line on the VSD indicating selected vertical speed as a target angle when V/S mode is selected
- displays the current vertical speed or flight path angle in the vertical speed/flight path angle window
- when the selected altitude is reached, the pitch mode changes to altitude (ALT)

- AFDS commands pitch to maintain the vertical speed or flight path angle displayed in the vertical speed/flight path angle window
- if vertical speed or flight path angle is selected while in FLCH or VNAV, the autothrottle activates in speed (SPD) mode, if armed

4 **V/S – FPA Light**

Illuminated (white) – the vertical speed/flight path angle mode is engaged.

5 **V/S – FPA Selector**

UP or DOWN – sets the vertical speed or flight path angle in the vertical speed/flight path angle window and on the PFDs.

Autopilot Flight Director Altitude Controls

1 **Altitude Window**

Upper line displays the selected altitude and lower line displays an uplinked ATC altitude target.

The displayed altitude is the reference altitude for altitude alerting and level off.

The selected altitude displays on the PFD and HUD altitude tapes and the vertical situation display (VSD).

The altitude range is 0 to 50,000 feet.

Upper line displays 10,000 feet and lower line is blank when power is first applied.

Displayed altitude transmitted to ATC when Eurocontrol-compliant transponder installed.

2 Altitude Increment Selector (outer)

AUTO –

- the altitude selector changes in 100 foot increments
- displays the selected BARO minimum as the selector passes through that altitude. If the BARO minimum is not a 10 foot increment, displays the next highest 10 foot increment
- When rotated rapidly, the displayed altitude changes at two to four times the normal rate

1000 – the altitude selector changes in 1,000 foot increments.

3 Altitude Selector (inner)

Rotate – sets the altitude in the altitude window and on the PFD, HUD and VSD altitude indication displays.

Push –

- during climb or descent with altitude constraints, each push deletes the next waypoint constraint between the airplane altitude and the altitude window
- during climb with no altitude constraints, and the altitude window set above the FMC cruise altitude, the cruise altitude is changed to the altitude window value
- during cruise:
  - with the altitude window set above or below FMC cruise altitude, the FMC cruise altitude resets to the altitude window altitude
  - if in VNAV PTH or VNAV ALT pitch mode, the airplane begins a climb or descent toward the altitude window altitude
  - within 50 NM of the top–of–descent (T/D) point, with the altitude window set below cruise altitude, the airplane initiates the descend now (DES NOW) feature

4 Altitude HOLD Switch

Push –

- engages altitude (ALT) as the pitch mode
- ALT is displayed on the PFD and HUD pitch flight mode annunciator
- the AFDS commands pitch to maintain the altitude when the switch was pushed

5 Altitude Hold Light

Illuminated (white) – the altitude hold mode is engaged.

6 Uplink Transfer (XFR) Switch

Push – transfer the value from the lower line to the upper line. If upper line was blank/closed, it now opens to the uplinked ATC value. Lower line blanks after the transfer.

7 **ATC Uplinked Altitude**

The ATC uplink function for altitude is always enabled. For immediate clearances, pushing the datalink ACCEPT switch displays the clearance altitude value in the lower line of the window. Pushing the transfer (XFR) switch transfers the value from the lower line to the upper line. Pushing the datalink CNCL switch removes the clearance from the lower line.

For conditional clearances, pushing the ACCEPT switch displays the new altitude value automatically in the lower line only after the clearance condition is met.

Uplinked clearances are preceded by the letters "UL".

Autopilot Flight Director Approach Mode Controls

1 **Localizer / Final Approach Course (LOC/FAC) Switch**

Push –

- arms, disarms, engages, or disengages localizer (LOC) or final approach course (FAC) as the roll mode
- displays LOC or FAC in white (armed) on the PFD and in green on the HUD roll flight mode annunciator before localizer or course capture
- displays LOC in green (engaged) on the PFD and in green on the HUD roll flight mode annunciator after localizer or course capture
- arms the AFDS to capture and track inbound on the front course or IAN final approach course
- the capture point varies based on range and intercept angle
- capture can occur when an intercept track angle is within 120 degrees of the localizer or final approach course

The localizer / final approach course mode can be disarmed before capture by:

- pushing the LOC/FAC switch a second time, or
- selecting LNAV

The localizer / final approach course mode can be disengaged after capture by:

- selecting a roll mode other than LNAV
- pushing a TO/GA switch
- pushing the APP switch
- disengaging the autopilot and turning both flight director switches off, or
- engaging an autopilot when in flight director only

2 Localizer / Final Approach Course Light

Illuminated (white) – the localizer or final approach course mode is armed or engaged.

3 Approach (APP) Switch

Push –

- arms, disarms, engages, or disengages roll mode (LOC, FAC, B/CRS) pitch mode (G/S, G/P) for the approach selected in the FMC
- displays selected roll and pitch modes as armed on the PFD and HUD roll and pitch flight mode annunciators prior to localizer / lateral path and glideslope / glidepath capture
- displays selected roll and pitch modes in green (engaged) on the PFD and HUD roll and pitch flight mode annunciators after each one is captured
- the AFDS captures and tracks the localizer / lateral path roll mode and captures the glideslope / glidepath in the pitch mode upon interception
- localizer / lateral path captures when the intercept track angle is within 120 degrees of the localizer course
- glideslope glidepath captures when the intercept track angle is within 80 degrees of the localizer course

The approach mode can be disarmed with both pitch and roll modes armed by selecting APP, LOC, LNAV, or VNAV.

The approach mode disengages:

- with roll mode engaged and pitch mode armed, by selecting heading select (HDG/TRK SEL) or heading hold (HDG/TRK HOLD)
- independent of mode status, by engaging TO/GA mode, or by disengaging the autopilot and turning both flight director switches off
- after roll and/or pitch modes are captured, by pushing the approach switch a second time above 1,500 feet radio altitude (AFDS reverts to default roll and pitch modes)

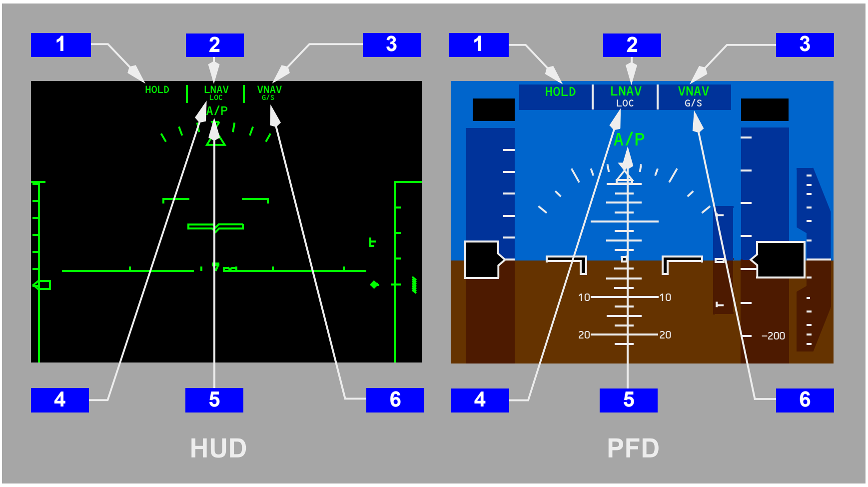
4 Approach Light

Illuminated (white) – the approach modes are armed or engaged.

PFD and HUD Flight Mode Annunciations (FMAs)

Note: When first engaged/activated, AFDS/autothrottle mode changes are emphasized for 10 seconds by a green box drawn around the mode. A change to the AFDS mode NO AUTOLAND is also emphasized by box (amber on the PFD and green on the HUD).

Note: A horizontal line is drawn through the appropriate ENGAGED pitch or roll mode when a flight mode fault is detected (amber on the PFD and green on the HUD).



1 Autothrottle Modes (Active)

Displayed (green) –

- THR
- THR REF
- HOLD
- IDLE
- SPD

2 AFDS Roll Modes (Engaged)

Displayed (green) –

- HDG HOLD
- HDG SEL
- LNAV
- LOC
- ROLLOUT
- TO/GA
- TRK SEL
- TRK HOLD
- ATT (optional)
- B/CRS
- HUD TO/GA (optional)

3 AFDS Pitch Modes (Engaged)

Displayed (green) –

- TO/GA
- ALT
- V/S
- VNAV PTH
- VNAV SPD
- VNAV ALT
- G/S
- FLARE
- FLCH SPD
- FPA
- G/P

4 AFDS Roll Modes (Armed)

Displayed (green on HUD, white on PFD) –

- LOC
- ROLLOUT
- LNAV

5 AFDS (Engaged)

Displayed (green) –

- FLT DIR
- A/P
- LAND 3

Displayed (green with white triangles) –
▷
LAND2
◁

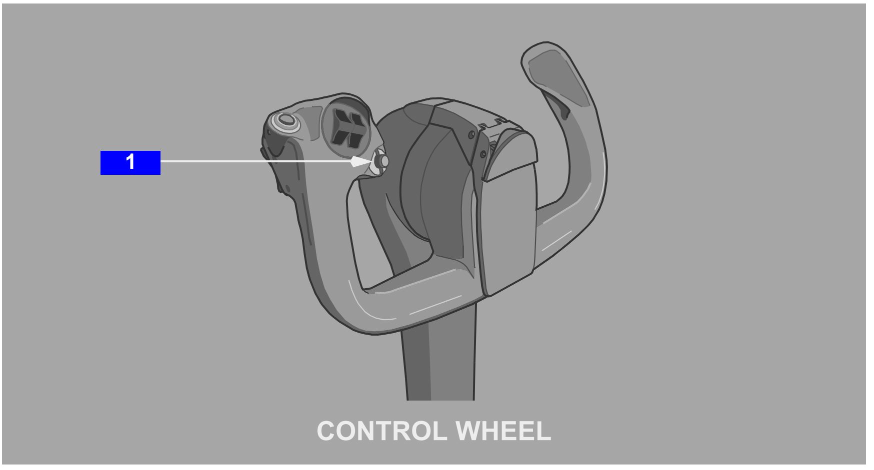
Displayed (green on HUD, amber on PFD) – NO AUTOLAND.

6 AFDS Pitch Modes (Armed)

Displayed (green on HUD, white on PFD) –

- G/S
- FLARE
- VNAV

Autopilot Disconnect Switch



1 Autopilot Disconnect Switches

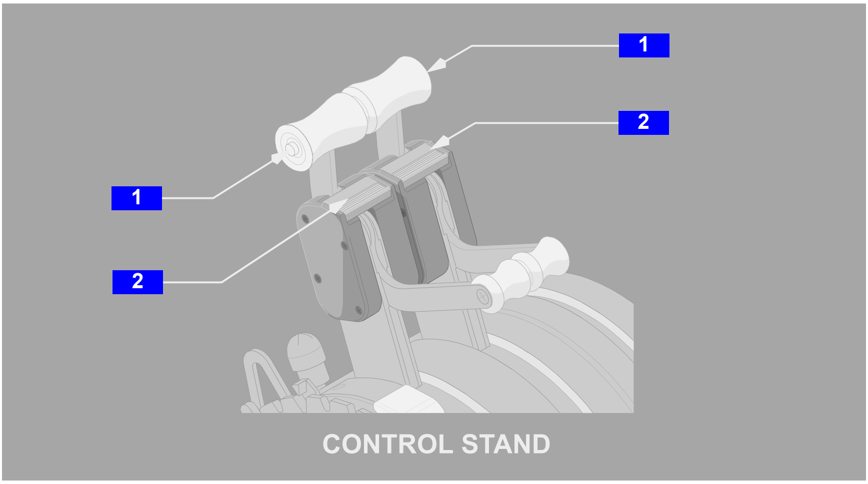
First push (either switch) –

- disconnects the autopilot
- the master warning lights illuminate
- displays the EICAS warning message AUTOPILOT DISC
- sounds an aural warning
- if the autopilot automatically disconnects, resets the master warning lights, EICAS warning message, and the aural warning

Second push – resets:

- the master warning lights
- EICAS warning message
- the aural warning

TO/GA and Autothrottle Disconnect Switches



1 Autothrottle Disconnect Switches

Push (either switch) –

- disconnects the autothrottle (both left and right)
- illuminates the master caution lights
- displays the EICAS message AUTOTHROTTLE DISC
- if the autothrottle automatically disconnects, resets the master caution lights and EICAS message

Second push –

- resets the master caution lights and EICAS message
- the autothrottle remains armed

2 Takeoff/Go-around (TO/GA) Switches

On the ground:

Push –

- below 50 knots and flaps out of up, activates autothrottle in THR REF mode at thrust limit selected on THRUST LIMIT page. If not pushed below 50 knots, autothrottle operation is inhibited until reaching 400 feet altitude
- pushing either switch above 80 knots disarms LNAV and VNAV

In flight:

Push (after lift-off with takeoff thrust limit displayed) –

- removes takeoff derates
- activates autothrottle in THR REF mode

- disarms AFDS modes
- between 50 feet and 400 feet, selects TO/GA roll mode
- above 400 feet, selects TO/GA roll and pitch modes

Push (on approach with flaps out of up or glideslope captured) –

- activates autothrottle in THR mode with GA thrust limit displayed
- disarms AFDS modes
- selects TO/GA roll and pitch modes
- arms or engages LNAV if an LNAV path is available
- second push – activates autothrottle in THR REF mode

Introduction

The automatic flight control system consists of the autopilot flight director system (AFDS) and the autothrottle system. Both the AFDS and the autothrottle are controlled using the mode control panel (MCP) and the FMC.

Normally, the AFDS and autothrottle are controlled automatically by the FMC to perform climb, cruise, descent, and approach flight path guidance.

Autopilot Flight Director System

The AFDS consists of three autoflight computing systems and the MCP.

The MCP provides control of the autopilot, flight director, altitude alert, and autothrottle systems. The MCP is used to select and activate AFDS modes, and establish altitudes, speeds, and climb/descent profiles.

The autoflight systems provide control of the flight directors and autopilot. Flight director information is displayed on the primary flight displays (PFDs) and head-up displays (HUDs). The AFDS does not have direct control of the flight control surfaces. The autopilot controls the elevators, ailerons, flaperons, and spoilers through the fly–by–wire flight control system. Autopilot rudder commands are added only during an autopilot approach and landing. The autopilot controls nose wheel steering during rollout after an automatic landing.

Flight director information is displayed on the primary flight displays (PFDs) and head-up displays (HUDs). Pilot MCP selections are sent to the autopilots. Autopilot commands are sent to the Primary Flight Computers (PFCs) to generate flight control surface commands. While autopilot(s) is engaged the pilot controls are back driven to provide visual and tactile indications of automatic commands. The PFCs sends backdrive commands which control the backdrive actuators to move the column, wheel, and pedals. Autopilot rudder commands are added only during an autopilot approach and landing.

MCP Mode Selection

MCP mode switches are used to select automatic flight control and flight director modes. A light on the switch illuminates to indicate that the mode is armed or engaged. Mode engagement is indicated by the PFD and HUD roll and pitch flight mode annunciations. Autothrottle modes are discussed later in this section.

Most modes engage with a single push. These modes include:

- flight level change (FLCH SPD)
- heading hold (HDG HOLD)
- track hold (TRK HOLD)
- heading select (HDG SEL)
- track select (TRK SEL)
- vertical speed (V/S)
- flight path angle (FPA)
- altitude hold (ALT)

Other modes arm or engage with a single push. These modes are:

- lateral navigation (LNAV)
- vertical navigation (VNAV)
- localizer / final approach course (LOC/FAC)
- approach (APP)

All modes except APP can be disengaged by selecting another mode. All modes can be disengaged by disconnecting the autopilot and turning both flight directors off. After localizer and glideslope capture, the localizer and glideslope modes can only be disengaged by disconnecting the autopilot and turning both flight directors off, engaging the go–around mode, or if above 1,500 feet radio altitude, by reselecting APP (roll and pitch will revert to default modes). The VNAV, LNAV, LOC and APP modes can be disarmed by pushing the mode switch a second time. (except when LNAV is automatically armed on go-around)

Desired target values can be selected on the MCP for:

- airspeed
- Mach
- heading
- track
- vertical speed
- flight path angle
- altitude

All of these parameters except vertical speed and flight path angle can be preselected prior to autopilot and/or flight director engagement.

Autopilot Engagement

The autopilot is engaged by pushing either of the two MCP autopilot engage switches.

Autopilot Disengagement

Normal autopilot disengagement is through either control wheel autopilot disconnect switch. The autopilots can also be disengaged by:

- the MCP autopilot disengage bar, or
- overriding with the control column, control wheel, or rudder pedals (pedals will only disengage the autopilots with LAND 2 or LAND 3 annunciated)

An automatic autopilot disconnect occurs for some failures detected by the autopilot. The EICAS warning message AUTOPILOT DISC is displayed if the autopilot is manually or automatically disconnected. Depending upon the system failure, it may be possible to re–engage an autopilot by pushing the autopilot engage switch.

Autopilot and Flight Director Mode Degradations

Autopilot

The autopilot system can detect the degradation of a specific autopilot mode. When an engaged mode degrades, the autopilot remains engaged in an attitude stabilizing mode based on inertial data. If the degradation persists, the condition is annunciated on the PFD and HUD line drawn through the affected flight mode annunciation (amber line on the PFD). If the degradation continues, the EICAS caution message AUTOPILOT is displayed to indicate the autopilot is operating in a degraded mode. When the degradation is no longer present the annunciations clear, the autopilot resumes using the mode, and a green box is drawn around the affected flight mode annunciation on the PFD and HUD for 10 seconds.

Flight Director

[Option – Flight Director Bars]

When a specific flight director mode degrades, the flight director provides an attitude stabilizing command based on inertial data. If the degradation persists, the condition is annunciated by removal of the affected (pitch or roll) flight director bar. When the degradation is no longer present the flight director commands immediately return to view.

ILS Signal Interference Monitor

The autopilot flight director system (AFDS) can detect significant ILS signal interference due to service vehicles or aircraft. If localizer or glideslope signal interference is detected, the autopilot disregards the ILS signal and remains engaged in an attitude stabilizing mode based on inertial data. Most ILS signal interferences last only a short period of time, so there is no annunciation other than erratic movement of the ILS raw data during the time the interference is present. If the condition persists, the annunciations described above for Autopilot and Flight Director Mode Degradation are provided.

Flight Director Display

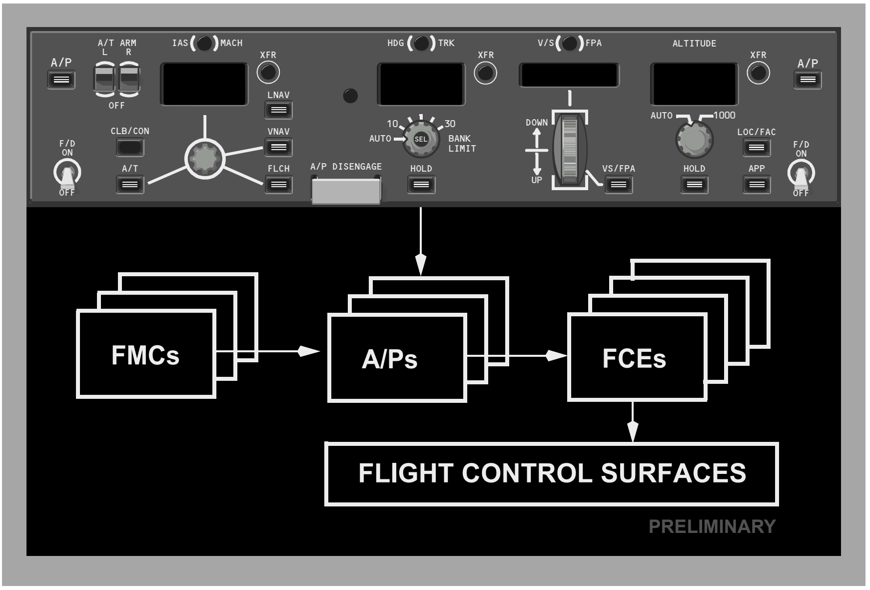
The flight director steering indications are normally displayed any time the related flight director switch is ON.

The steering indications are also displayed when the related flight director switch is OFF and a TO/GA switch is pushed, if airspeed is greater than 80 knots and the flaps are not retracted. In this case, the flight director display can be removed by cycling the respective flight director switch on and then off.

[Option – Flight Director Bars]

A flight director mode failure, in either pitch or roll, causes the respective steering bars to disappear. The stall and overspeed protection functions will also cause the pitch flight director bar to disappear.

Autopilot Flight Director System Schematic



AFDS Status Annunciation

The following AFDS status annunciations are displayed just above the PFD and HUD attitude display:

- FLT DIR (the flight director is ON and the autopilots are not engaged)
- A/P (the autopilots are engaged)
- LAND 3 (three autopilots are engaged and operating normally for an automatic landing)
- LAND 2 (AFDS redundancy is reduced; in some cases, only two autopilots are available)
- NO AUTOLAND (the AFDS is unable to make an automatic landing)

With a LAND 3 indication, the autopilot system level of redundancy is such that a single fault cannot prevent the autopilot system from making an automatic landing (fail operational).

With a LAND 2 indication, the level of redundancy is such that a single fault cannot cause a significant deviation from the flight path (fail passive).

An EICAS message is displayed for any fault which limits the capability of the automatic landing system. Aural alerts for EICAS messages not affecting safety of flight are inhibited until after touchdown. Changes in autoland status below 200 feet, other than a transition to NO AUTOLAND status, are inhibited.

AFDS Flight Mode Annunciations

The flight mode annunciations are displayed just above the PFD and HUD AFDS status annunciations. The mode annunciations, from left to right, are:

- autothrottle
- roll
- pitch

Engaged or captured modes are shown at the top of the flight mode annunciator boxes in large green letters. Armed modes (except for TO/GA in the air) are shown in smaller letters (white on the PFD) at the bottom of the flight mode annunciator boxes. Degradations of a specific mode while the autopilot is engaged are annunciated by an line (amber on the PFD) drawn through the mode annunciations. A green box is drawn around the mode annunciation for 10 seconds when a mode first becomes active, and when the line through a degraded mode is removed.

Autothrottle Modes

The autothrottle modes are:

- THR – The autothrottle applies thrust to maintain the vertical speed required by the pitch mode
- THR REF – Thrust is set to the selected thrust limit displayed on EICAS
- IDLE – Displayed while the autothrottle moves the thrust levers to idle; IDLE mode is followed by HOLD mode
- HOLD – The thrust lever autothrottle servos are inhibited. The pilot can set the thrust levers manually
- SPD – The autothrottle maintains the selected speed displayed on the PFD and HUD. Speed can be set by the MCP IAS/MACH selector or by the FMC, as shown on the CDU CLIMB, CRUISE, or DESCENT page. The autothrottle will not exceed the operating speed limits or the thrust limits displayed on the EICAS

Roll Modes

The roll modes are:

LNAV –

- LNAV (armed) – LNAV is armed to engage when parameters are met.
- LNAV (engaged) – LNAV engages if above 50 feet, and within 2 1/2 NM of the active route leg. The AFDS follows the active leg displayed on the ND
- On go-around, LNAV engages at 50 feet radio altitude with flight director only or 200 feet radio altitude with the autopilot engaged. LNAV is disengaged by engaging any other roll mode or by disengaging the autopilot and turning both flight directors off

HDG –

- HDG SEL (engaged) – The airplane is turning to, or is on the heading selected in the MCP heading/track window
- HDG HOLD (engaged) – The AFDS holds the present heading. If turning, the AFDS holds the heading reached after rolling wings level

TRK –

- TRK SEL (engaged) – The airplane is turning to, or is on the track selected in the MCP heading/track window
- TRK HOLD (engaged) – The AFDS holds the present track. If turning, the AFDS holds the track reached after rolling wings level

[Option – Bank Angle Hold at Autopilot Engage]

ATT – (engaged) – When the autopilot is first engaged or the flight director is first turned on in flight, the AFDS holds a bank angle between 5 and 30 degrees and will not roll to wings level. If the bank angle is less than 5 degrees, the AFDS returns to wings level (HDG HOLD or TRK HOLD). If the bank angle is greater than 30 degrees, the AFDS returns to 30 degrees of bank

LOC –

- LOC (armed) – The AFDS captures the localizer when within range and within 120 degrees of the localizer track
- LOC (engaged) – The AFDS follows the selected localizer course

FAC –

- FAC (armed) – The AFDS captures the IAN final approach course
- FAC (engaged) – The AFDS tracks the IAN final approach course along the inbound bearing

B/CRS –

- B/CRS (armed) – The AFDS captures the localizer final approach back course
- B/CRS (engaged) – The AFDS tracks the localizer final approach course along the inbound back course bearing

TO/GA –

- On the ground, TO/GA annunciates by positioning either flight director switch ON when both flight directors are OFF, or by pushing either TO/GA switch with airspeed greater than 80 KTS. TO/GA roll guidance becomes active at lift–off
- In flight, TO/GA is armed when flaps are out of up or glideslope is captured. There is no flight mode annunciation for TO/GA armed. TO/GA is activated in flight by pushing a TO/GA switch. The TO/GA roll mode maintains the existing ground track.

[Option – HUD Low Visibility Takeoff Guidance]

HUD TO/GA (Low Visibility Takeoff)

- On takeoff, HUD provides lateral guidance for takeoff roll and rejected takeoff using ILS or GLS signals. Selecting a HUD TAKEOFF departure in the FMC and turning either flight director on sets HUD TO/GA as the engaged roll mode on the PFD and HUD
- HUD guidance becomes active and cue appears when the airplane approaches the runway center line and airplane heading is within 45 deg of runway heading

  Note: The lateral flight director bar on the PFD also moves with the guidance commands but is not certified for use during a low visibility takeoff.

- During takeoff, the HUD symbology automatically changes to full mode symbology and the HUD symbology control switch is inhibited

ROLLOUT –

- ROLLOUT (armed) – Displayed below 1500 feet radio altitude and engages below 2 feet
- ROLLOUT (engaged) – After touchdown, the AFDS uses rudder and nosewheel steering to keep the airplane on the localizer centerline

Pitch Modes

The pitch modes are:

TO/GA –

On the ground, TO/GA annunciates by positioning either flight director switch ON when both flight directors are OFF, or by pushing either TO/GA switch with airspeed greater than 80 knots. The flight director PFD pitch bar and HUD guidance cue indicates an initial pitch of eight degrees up.

After takeoff, the AFDS commands a pitch attitude to maintain:

- a target speed of V2 plus 15 knots
- if current airspeed remains above the target speed for 5 seconds, the target airspeed is reset to current airspeed, to a maximum of V2 plus 25 knots
- the IAS/MACH window speed if the IAS/MACH window speed is changed to a speed greater than the target speed

Note: The AFDS uses the speed set in the IAS/MACH window prior to takeoff for V2.

In flight, TO/GA is armed when flaps are out of up or glideslope is captured .

When a go–around is initiated, the commanded speed is the MCP IAS/MACH window or current airspeed, whichever is higher, to a maximum of the IAS/MACH window speed plus 25 knots. GA displays as the thrust limit on the primary EICAS engine display.

VNAV –

VNAV is armed by pushing the VNAV switch (the switch bar is displayed and VNAV is annunciated in small characters on the PFD (in white) and HUD pitch mode annunciator below the current pitch mode).

VNAV engages above 400 feet after takeoff, if armed. VNAV engages in the appropriate VNAV mode as required to maintain the current flight path:

- VNAV SPD (engaged) – The AFDS maintains the FMC speed displayed on the PFD and HUD airspeed indicator and/or the CDU CLIMB or DESCENT pages. If speed intervention is selected, the MCP IAS/MACH selector is used to manually select the speed
- VNAV PTH (engaged) – The AFDS maintains FMC altitude or descent path with pitch commands. If the MCP altitude window is set to the current cruise altitude as the airplane approaches the top of descent, the CDU scratchpad message RESET MCP ALT displays
- VNAV ALT (engaged) – When a conflict occurs between the VNAV profile and the MCP altitude, the airplane levels and the pitch flight mode annunciation becomes VNAV ALT. VNAV ALT maintains altitude. To continue the climb or descent, change the MCP altitude and push the altitude selector or change the pitch mode
- if an early descent is desired, FLCH, V/S, or FPA may be selected to descend below the VNAV descent path. If, during the decent, VNAV is armed and the airplane descent path subsequently intercepts the VNAV descent path, VNAV engages in VNAV PTH

V/S (engaged) – Pushing the MCP VS/FPA switch, opens the vertical speed window to display the current vertical speed. Pitch commands maintain the rate of climb or descent selected in the VS/FPA window.

FPA (engaged) – Pushing the MCP VS/FPA switch opens the flight path angle window to display the current flight path angle. Pitch commands maintain the flight path angle selected in the VS/FPA window.

FLCH SPD (engaged) – Pushing the MCP FLCH switch opens IAS/MACH window (if blanked). Pitch commands maintain IAS/MACH window airspeed or Mach.

ALT (engaged) – Altitude hold mode is engaged by:

- pushing the MCP altitude HOLD switch, or
- capturing the selected altitude from a V/S, FPA, or FLCH climb or descent

G/S (engaged) – The AFDS follows the ILS glideslope.

G/P (engaged) – the AFDS follows the IAN glidepath.

FLARE (armed) – During an autoland, FLARE is displayed below 1500 feet RA.

FLARE (engaged) – During an autoland, flare engages between 60 and 40 feet radio altitude. FLARE accomplishes the autoland flare maneuver so the AFDS can transition to the ROLLOUT mode.

Autothrottle System

The autothrottle system provides automatic thrust control from takeoff through landing.

Autothrottle operation is controlled from the MCP and the CDUs. The MCP provides mode and speed selection. The CDU provides FMC thrust reference mode selection. When the VNAV mode is selected, the FMC selects the autothrottle modes and target thrust values. Refer to Chapter 11, Flight Management, Navigation, for FMS and CDU operation.

The autothrottle can be operated without using the flight director or the autopilot. In this condition, the autothrottle operates in either the THR REF, SPD, HOLD or IDLE modes.

When the autothrottle is used during a manual landing, thrust reduces to IDLE at 25 feet radio altitude when the flight director is off or the pitch mode is V/S, FPA, G/S, or any VNAV mode (VNAV SPD, VNAV PTH, or VNAV ALT). The autothrottle does not automatically retard if the pitch mode is TO/GA or FLCH.

With the autothrottle armed, the autothrottle automatically activates if:

- no autopilot or flight director active, or
- an autopilot or flight director is in VNAV XXX, FPA, ALT, V/S, or G/S

and:

- speed less than an FMC calculated value for one second
- thrust below reference thrust
- airplane altitude above 100 feet RA on approach, or airplane barometric altitude 400 feet above airport on takeoff

Note: During a descent in VNAV SPD, the autothrottle may activate in HOLD mode and will not support stall protection.

The EICAS advisory message AUTOTHROTTLE L or R is displayed when the respective autothrottle servo fails. If the autothrottle is active and only one autothrottle is armed, the PFD autothrottle flight mode annunciation displays L or R preceding the mode. For example, L SPD indicates only the left autothrottle is active in speed mode.

Autothrottle Thrust Lever Operation

The autothrottle system moves either or both thrust levers to provide speed or thrust control, depending on the active mode.

The thrust levers can be manually positioned without disconnecting the autothrottle. After manual positioning, the autothrottle system repositions the thrust levers to comply with the active mode. The autothrottle system does not reposition the thrust levers while in HOLD mode.

Autothrottle Disconnect

The autothrottle system can be disconnected manually by pushing either thrust lever autothrottle disconnect switch, except during conditions that cause the autothrottle to automatically activate. The autothrottle can also be disconnected manually by positioning both A/T ARM switches to OFF, or individually by positioning the left or right A/T ARM switch to OFF. Positioning one or both A/T ARM switches to OFF prevents activation of all autothrottle modes for the affected autothrottle.

Autothrottle disconnect occurs automatically:

- if a fault in the active autothrottle mode is detected
- when either reverse thrust lever is raised to reverse idle
- if the thrust levers are overridden during a manual landing, after the autothrottle has begun to retard the thrust levers to idle
- when both engines are shut down

The EICAS caution message AUTOTHROTTLE DISC is displayed and an aural alert sounds when the autothrottle is manually or automatically disconnected. The EICAS caution message and aural alert are inhibited if the disconnect occurs because of reverse thrust.

Automatic Flight Operations

Automatic Flight Takeoff and Climb

Takeoff is a flight director only function of the takeoff/go–around (TO/GA) mode. The autopilot may be engaged after takeoff.

During preflight:

- With the autopilot disengaged and both flight director switches OFF, engagement of TO/GA roll and pitch mode occurs when the first flight director switch is positioned ON
- the PFD and HUD displays FLT DIR as the AFDS status and TO/GA as the pitch and roll flight mode annunciations
- the pitch command is a fixed attitude (about eight degrees up)
- the roll command is wings level

During takeoff prior to lift–off:

- with speed less than 50 KIAS, pushing a TO/GA switch activates the autothrottle in the thrust reference (THR REF) mode. The thrust levers advance to the selected thrust limit. If the autothrottle is not active by 50 knots, it cannot be activated until above 400 feet
- at 80 knots, the autothrottle mode annunciation changes to HOLD
- with speed greater than 80 knots, pushing a TO/GA switch disarms LNAV and VNAV

At lift–off:

- the pitch command target speed is V2 + 15. If current airspeed remains above the target speed for 5 seconds, the target airspeed is reset to current airspeed (limited to a maximum of V2 + 25)
- if an engine failure occurs on the ground, the pitch command target speed at lift–off is V2 or airspeed at lift–off, whichever is greater
- the roll command maintains ground track

After lift–off:

- if an engine failure occurs, the pitch command target speed is:
  - V2, if airspeed is below V2
  - existing speed, if airspeed is between V2 and V2 + 15
  - V2 + 15, if airspeed is above V2 + 15
- if a TO/GA switch is pushed:
  - takeoff derates are removed
  - the autothrottle activates in THR REF
- at 50 feet radio altitude, LNAV engages, if armed. Roll commands bank to track the active route

- at 400 feet AGL, VNAV engages, if armed. Pitch commands the current airspeed. The autothrottle sets the selected reference thrust and annunciates THR REF
- at acceleration height, pitch commands speed to 5 knots below takeoff flap placard speed. As flaps are retracted, pitch commands an acceleration to 5 knots below the placard speed of the commanded flap position
- when flaps are up, pitch commands an acceleration to VNAV climb speed. VNAV climb speed is the greater of:
  - VREF + 80 knots, or
  - speed transition associated with origin airport
- at thrust reduction point (either an altitude or a flap position), the FMC changes the thrust limit to the armed climb limit (CLB, CLB 1, or CLB 2)

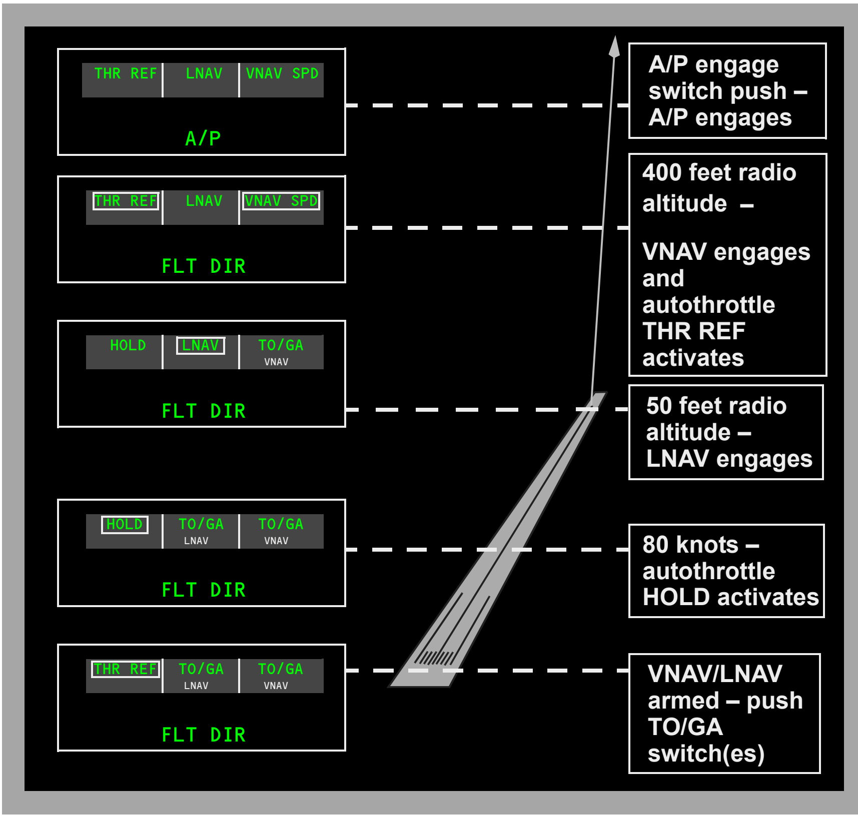
The TO/GA mode is terminated by selecting any other pitch and roll mode; automatic LNAV/VNAV engage terminates TO/GA mode.

HUD Takeoff

[Option – HUD Low Visibility Takeoff Guidance]

The low visibility takeoff guidance system provides lateral guidance on the HUD for takeoff roll and rejected takeoff using ILS or GLS signals. Selecting a HUD TAKEOFF departure in the FMC and turning either flight director on sets HUD TO/GA as the engaged roll mode on the PFD and HUD and enables the guidance. Guidance becomes active and guidance cue appears on the HUD when the airplane approaches the runway center line and airplane heading is within 45 degrees of runway heading. The lateral flight director bar on the PFD also moves with the guidance commands, but is not certified for use during a low visibility takeoff. For additional information, refer to Chapter 10 - Flight Instruments, Displays.

Automatic Flight Takeoff Profile



Automatic Flight En Route

The autopilot and/or the flight director can be used after takeoff to fly a lateral navigation track (LNAV) and a vertical navigation track (VNAV) provided by the FMS. Using LNAV and VNAV ensures the most economical operation.

Other roll modes available are:

- heading hold (HDG HOLD)
- heading select (HDG SEL)
- track hold (TRK HOLD)
- track select (TRK SEL)

Other pitch modes available are:

- altitude hold (ALT)
- flight level change (FLCH SPD)
- vertical speed (V/S)
- flight path angle (FPA)

Profile illustrations show the use of LNAV and VNAV.

Automatic Flight Approach and Landing

The AFDS provides autopilot guidance for Instrument Landing System (ILS), GPS Landing System (GLS) and Integrated Approach Navigation (IAN) approaches.

ILS approaches are flown in the G/S and LOC modes with the approach path deviation data from the localizer and glideslope transmitters.

GLS approaches are also flown in the G/S and LOC modes, but the approach path deviation data is from the Ground Based Augmentation System (GBAS).

IAN approaches can be flown in the G/P and FAC, LOC or B/CRS modes. For the G/P and FAC modes, the FMC computes a three-dimensional path and sends ILS look-alike deviations to the autopilots. For the LOC and B/CRS modes, the localizer provides the deviation information. The IAN function is available for the following instrument approach types:

- Fly G/P and FAC, for RNV
- Fly G/P and FAC, for GPS
- Fly G/P and FAC, for VOR
- Fly G/P and FAC, for NDB
- Fly G/P and LOC, for ILS if G/S is selected OFF
- Fly G/P and LOC, for IGS if G/S is selected OFF
- Fly G/P and LOC, for LOC
- Fly G/P and LOC, for LDA if G/S is selected OFF
- Fly G/P and LOC, for SDF if G/S is selected OFF
- Fly G/P and B/CRS, for BAC

[Option – GS capture inhibited before LOC capture]

For any of the three approach types, pushing the APP switch arms the pitch and roll modes after an approach procedure selection is made in the FMC. Glideslope capture is inhibited until the localizer is captured.

Pushing the LOC/FAC switch arms the AFDS to capture and maintain an approach lateral flight path to a runway using an ILS localizer beam or a lateral path provided by the FMC. Descent on the localizer or final approach course can be accomplished using VNAV, V/S, FLCH, or FPA pitch modes. The LOC or FAC mode cannot capture if the intercept angle exceeds 120 degrees.

With a command speed of VREF+5 knots and landing flaps, there is sufficient wind and gust protection available with the autothrottle active. The autothrottle adjusts thrust quickly when the airspeed decreases below the command speed. The autothrottle decreases thrust slowly when the airspeed is more than the command speed. In turbulence, the result is that the thrust average is higher than necessary to keep the command speed. This causes the speed average to be more than the command speed.

Runway Alignment

Runway alignment is a submode of the approach mode. With crosswinds, the crab angle is reduced at touchdown. Runway alignment also compensates for a single engine approach.

For crosswinds requiring more than 10 degrees of crab angle, initial runway alignment occurs at 500 feet AGL. A sideslip of 5 degrees is established to reduce the crab angle. This configuration is maintained to 200 feet AGL, where a second sideslip alignment increases the sideslip, up to 5 degrees total, to further reduce the crab angle. This configuration is maintained until touchdown. The airplane lands with a minimum of a 5 degree crab angle.

For crosswinds requiring a crab angle of between 5 and 10 degrees, an initial alignment occurs at 500 feet AGL, followed by a second alignment at 200 feet AGL. The initial alignment initiates a sideslip to reduce the crab angle to 5 degrees. This configuration is maintained to 200 feet AGL, where a second sideslip alignment increases the sideslip to further reduce the touchdown crab angle.

For crosswinds requiring a crab angle of less than 5 degrees, no runway alignment occurs until 200 feet AGL, where a sideslip is introduced to align the airplane with the runway.

If an engine fails prior to the approach, the AFDS introduces an after rudder engagement sideslip at 500 feet AGL. This establishes a wings level configuration. If an engine fails during the approach, the wings level configuration is established when the engine failure is detected.

In the event of moderate or strong crosswinds from the side opposite the failed engine, no wings level sideslip is commanded, since the airplane is already banked into the wind.

Flare

The flare mode brings the airplane to a smooth automatic landing touchdown. The flare mode is not intended for single autopilot or flight director only operation.

Flare is armed when LAND 3 or LAND 2 is annunciated on the PFDs and HUDs. At approximately 50 feet radio altitude, the autopilots start the flare maneuver. FLARE replaces the pitch flight mode annunciation.

During flare:

- between 25 and 50 feet radio altitude, the autothrottle begins retarding the thrust levers to idle
- the PFD and HUD autothrottle annunciation changes from SPD to IDLE
- at touchdown, the FLARE annunciation is no longer displayed, and the nose is lowered to the runway

Rollout

Rollout provides localizer centerline rollout guidance. Rollout is armed when LAND 3 or LAND 2 is annunciated on the PFD and HUDs.

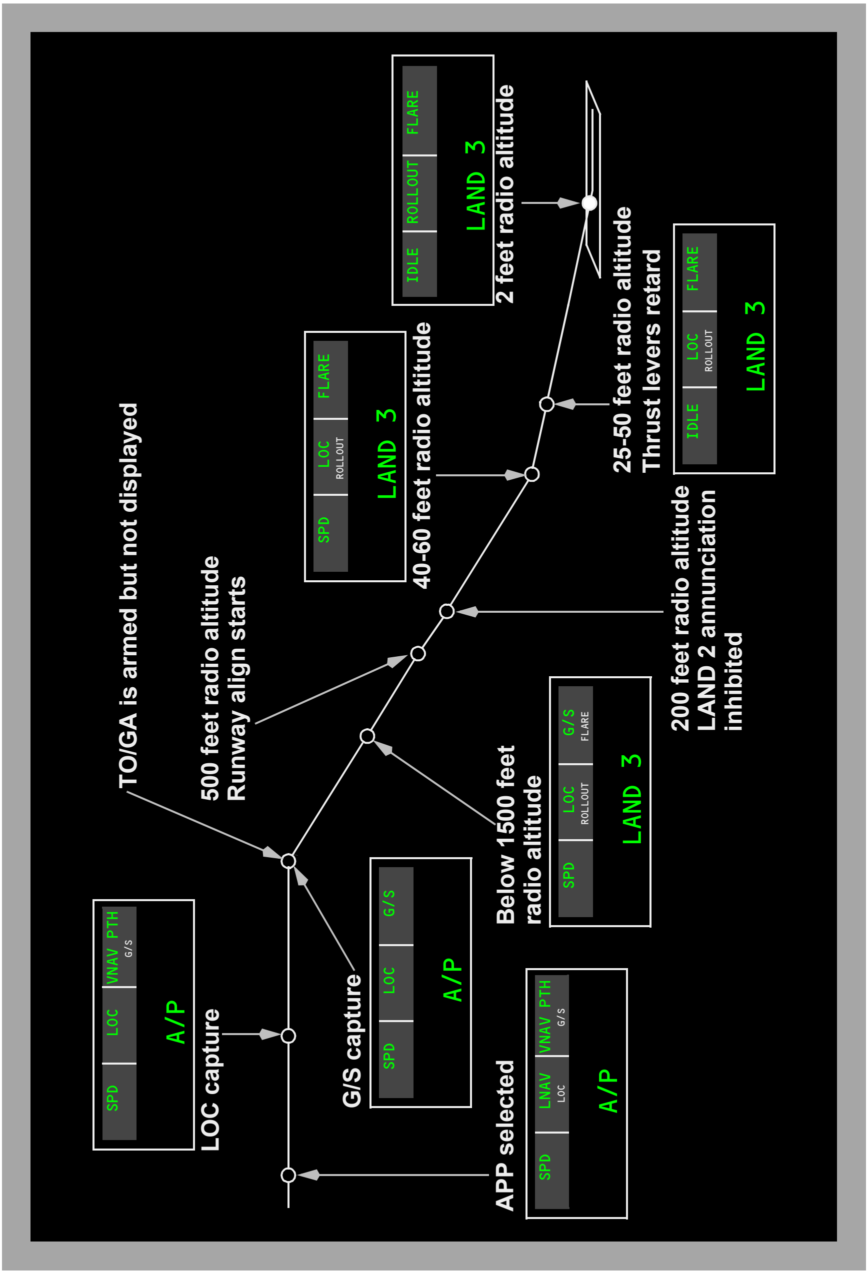
At less than two feet radio altitude, rollout engages. ROLLOUT replaces the roll mode annunciation.

The autopilot controls the rudder and nose wheel steering to keep the airplane on the localizer centerline.

During rollout, the autothrottle IDLE mode remains active until the autothrottle is disconnected.

Rollout guidance continues until the autopilots are disengaged.

Automatic Flight Approach Profile (ILS)



Go–Around

TO/GA is armed when flaps are out of UP or glideslope is captured. The thrust limit changes to GA when flaps are extended out of UP, flaps are extended to landing position, or glideslope is captured. The thrust limit is locked in GA when flaps are in landing position or glideslope is captured.

Pushing either TO/GA switch activates a go-around. The mode remains active even if the airplane touches down while executing the go–around.

When the flight director switches are not on, pushing either TO/GA switch displays the flight director bars.

The TO/GA switches are inhibited when on the ground and enabled again when in the air for a go–around or touch and go.

With the first push of either TO/GA switch:

- the PFDs and HUDs display roll and pitch guidance to fly the go–around
- the autothrottle activates in thrust (THR) mode for a 2,000 FPM climb
- the AFDS increases pitch to hold the selected speed as thrust increases
- if current airspeed remains above the target speed for 5 seconds, the target airspeed is reset to current airspeed, (to a maximum of the IAS/MACH window speed plus 25 knots)
- if an LNAV path is available, LNAV automatically arms and engages:
  - above 50 feet radio altitude when autopilot is not engaged, or
  - above 200 feet radio altitude when autopilot is engaged

Note: During go-around from a LAND 2 or LAND 3 approach, automatic LNAV engagement causes disconnect of autopilot rudder control.

With the second push of either TO/GA switch:

- the autothrottle activates in the thrust reference (THR REF) mode for full go–around thrust

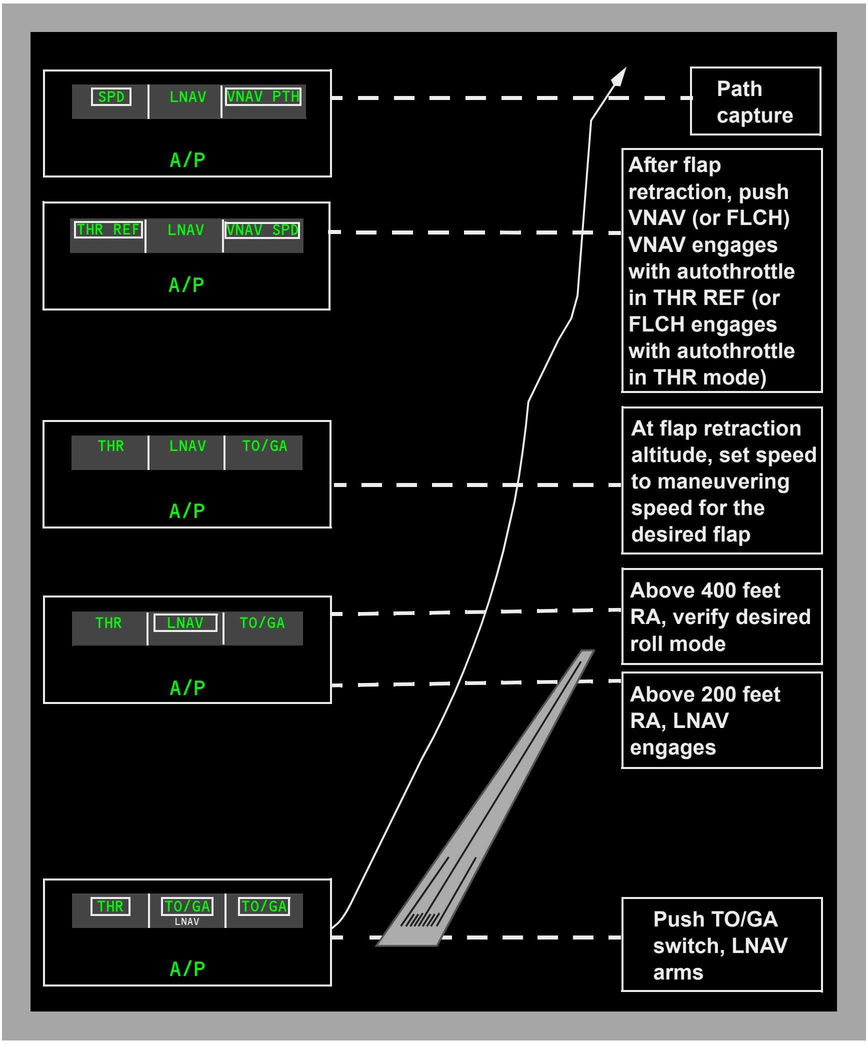
TO/GA level–off:

- at the selected altitude, the AFDS pitch mode changes to altitude hold (ALT)
- if altitude is captured, or if V/S or FPA is engaged, MCP speed is automatically set to:
  - the flap placard speed minus 5 knots
  - 250 knots if flaps are up, or
  - a speed value entered in the IAS/Mach window after TO/GA was pushed
- go–around remains the engaged roll mode until LNAV automatically engages or another mode is selected

TO/GA mode termination:

- below 400 feet radio altitude, the AFDS remains in the go–around pitch and roll mode unless:
  - the autopilot is disconnected and both flight directors are turned off, or
  - LNAV automatically engages (after automatic LNAV engagement, a different roll mode can be selected)
- above 400 feet radio altitude, select a different MCP pitch or roll mode.

Automatic Flight Go–Around Profile



Automatic Flight Windshear Recovery

The AFDS provides windshear recovery guidance by means of the normal go–around pitch and roll modes. Go–around is engaged by pushing a TO/GA switch. The AFDS commands a pitch–up of 15 degrees or slightly below the pitch limit, whichever is lower.

As rate of climb increases, the AFDS transitions from pitch to airspeed control. The target airspeed is IAS/MACH window airspeed or current airspeed, whichever is greater when TO/GA is engaged. If current airspeed remains above the selected speed for 5 seconds, the selected airspeed is reset to current airspeed, (to a maximum of the IAS/MACH window speed plus 25 knots).

Flight Envelope Protection

There are three forms of flight envelope protection in the autopilot:

- stall protection
- overspeed protection
- roll envelope bank angle protection

An AUTOPILOT caution message and roll or pitch mode failures alert the pilot if the envelope is exceeded, and the autopilot prevents further envelope violations.

Refer to Chapter 9, Flight Controls, for a description of flight envelope protection.

Automatic Flight EICAS Messages

The following EICAS messages can be displayed.

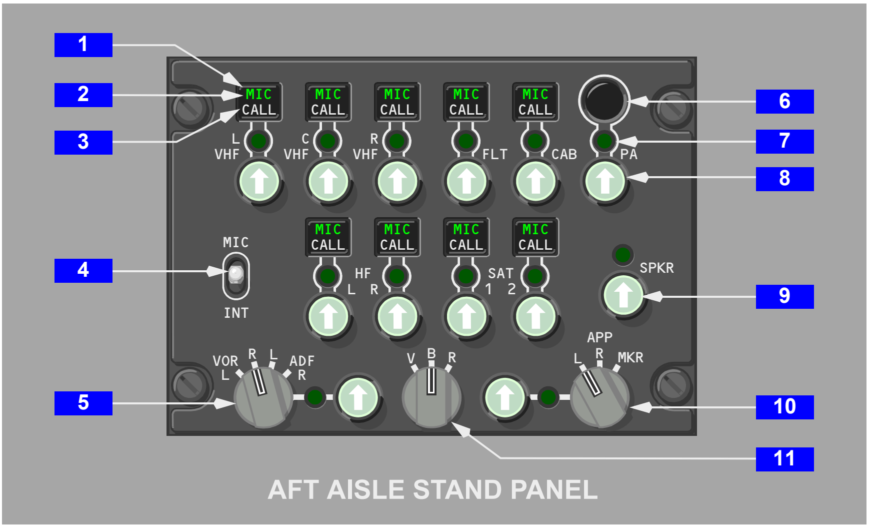
Message	Level	Aural	Condition
AUTOPILOT	Caution	Beeper	One or more of these occur: • The autopilot runs in a degraded mode other than the selected mode • The engaged roll mode fails • The engaged pitch mode fails • The autopilot is in flight envelope protection
AUTOPILOT DISC	Warning	Siren	All autopilots are disconnected.
AUTOTHROTTLE DISC	Caution	Beeper	Both autothrottles are disconnected.
AUTOTHROTTLE L, R	Advisory		One autothrottle is inoperative.
NO AUTOLAND	Caution Advisory	Beeper	The autoland system is not available. Message is a caution if fault occurs after LAND 3 or LAND 2 is annunciated, or approach has been selected but does not engage by 600 AGL. Message is an advisory if fault occurs before LAND 3 or LAND 2 is annunciated.
NO AUTOLAND GLS	Advisory		The autoland system is not available for a GLS approach.
NO AUTOLAND ILS	Advisory		The autoland system is not available for an ILS approach.
NO LAND 3	Caution Advisory	Beeper	The autoland system does not have redundancy for a triple channel autoland. Message is a caution if fault occurs after LAND 3 is annunciated. Message is an advisory if fault occurs before LAND 3 is annunciated.

Message	Level	Aural	Condition
T/O THRUST DISAGREE	Caution	Beeper	The thrust management takeoff thrust calculation disagrees with the ECC takeoff thrust calculation.

Communications — Chapter 5

Table of Contents — Section 0

Audio Control Panel (ACP)



1 Transmitter Select Switches

Push –

- the MIC light illuminates
- normally, the MIC light for any other transmitter extinguishes
- selects the respective transmitter (radio or intercommunications) for transmission from this crew station
  - normally, only one can be selected at a time for each crew station
  - CAB and SAT may be selected at the same time for cabin to SATCOM conferencing
- selects the receiver audio on, if not already manually selected on

Second push –

- deselects the transmitter
- deselects receiver audio

Note: Second push of the CAB select switch deselects the transmitter and receiver audio only after one second has elapsed from the first push.

2 MIC Lights

Illuminated (green) – indicates the transmitter is selected.

3 CALL Lights

Illuminated (white) –

- indicates a call on SELCAL, the flight interphone (FLT), the cabin interphone (CAB), or SATCOM (SAT)
- resets when the respective transmitter select switch is pushed or, if already pushed, by pressing a MIC/INTERPHONE switch (the SATCOM CALL light remains illuminated until the call ends)
- PA does not have a CALL light

4 MIC/Interphone Switch

MIC – keys the boom microphone or oxygen mask on the selected radio transmitter or other system.

Center – off position (spring-loaded to center).

INT – keys the boom microphone or oxygen mask on the flight interphone.

5 VOR/ADF Receiver Selector

Selects the VOR or ADF receiver to be monitored:

- VOR L – left VOR and DME
- VOR R – right VOR and DME
- ADF L – left ADF
- ADF R – right ADF

6 PA Mic Switch

Push and hold –

- the MIC light for any other transmitter extinguishes
- keys passenger address announcement from this station to all PA areas

7 Receiver Lights

Illuminated (green) – indicates the respective receiver volume control is manually selected on.

8 Receiver Volume Controls

Push – turns the respective receiver audio on or off.

Rotate – controls receiver volume.

9 Speaker (SPKR) Volume Control

Push – turns the respective flight deck speaker on or off.

Rotate – controls flight deck speaker volume.

Note: Inoperative on first observer audio control panels.

10 **Approach (APP) Receiver Selector**

Selects the approach receiver to be monitored:

- APP L – left ILS/GLS and DME
- APP R – right ILS/GLS and DME
- MKR – marker beacon

11 **Navigation Filter Selector**

Filters VOR, ADF, ILS, or DME audio:

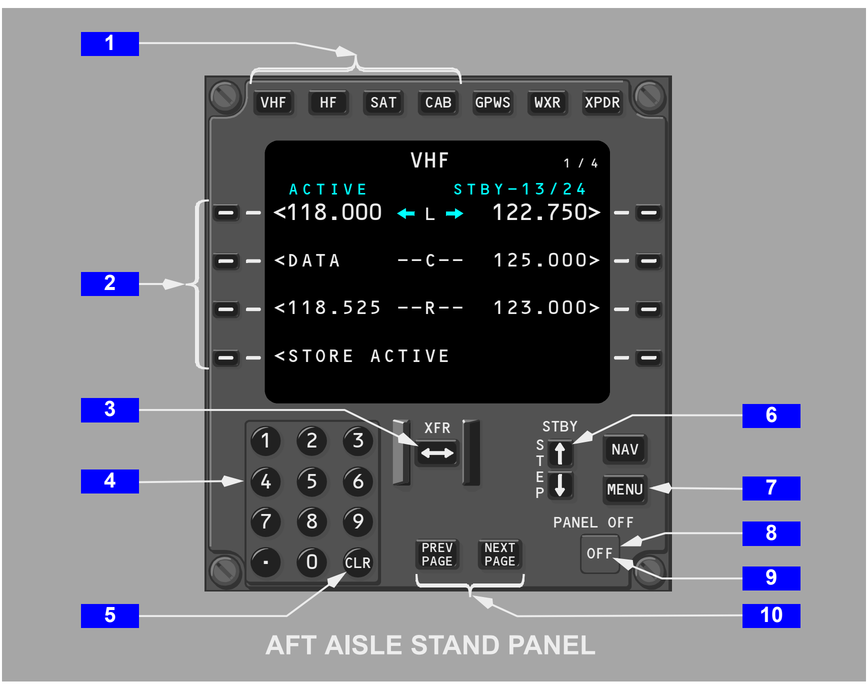
- V (voice) – only the voice audio is heard
- B (both) – both the voice and range audio are heard
- R (range) – range audio (navigation aid Morse code identifier) is heard

Note: Marker beacon audio is available in all positions.

Radio System

Tuning and Control Panel

[Option – Active entry, Store active]



1 Mode Select Keys

Push – Selects desired communication tuning mode page for display

- VHF – VHF Radio Key

[Option – HF radios]

- HF – HF Radio Key

[Option – SATCOM]

- SAT – SATCOM Key
- CAB – Cabin Interphone Key

2 Line Select Keys

Push –

- selects function line to be updated
- moves data from scratchpad to selected line

3 Frequency Transfer Switch

Push –

- transfers the STBY frequency to the ACTIVE frequency and tunes the selected radio to the new active frequency
- transfers the ACTIVE frequency to the STBY frequency

4 Numeric Keypad

Push – puts selected character in scratchpad.

5 Clear (CLR) Key

Push – clears last scratchpad character or scratchpad message.

Push and hold – clears all scratchpad data

- displays CLEAR if on VHF, HF, CABIN INTERPHONE (main page) or ALTN NAV page
- displays CLEAR PAGE if CLEAR is already displayed on STORED VHF or HF frequency pages
- displays CLEAR ALL if CLEAR is already displayed on CABIN INTERPHONE (main page)

6 Standby (STBY) Frequency STEP Control

Active when a list (- N/X) number is displayed next to the STBY radio title.

Push (Up) – moves up in the stored frequency list for VHF and HF radios.

Push (Down) – moves down in the stored frequency list for VHF and HF radios.

7 MENU Key

Push – selects the MENU page for display of

- SYS POWER (surveillance system power)
- ALERT / XPDR (transponder) CTRL (control)

- SATCOM SYStem selection
- MISC RADIO

8 **Tuning & Control Panel OFF Switch**

Push – removes associated TCP display and processor power.

9 **Tuning & Control Panel OFF Light**

Illuminated – associated TCP is off.

10 **Previous (PREV) / NEXT PAGE Keys**

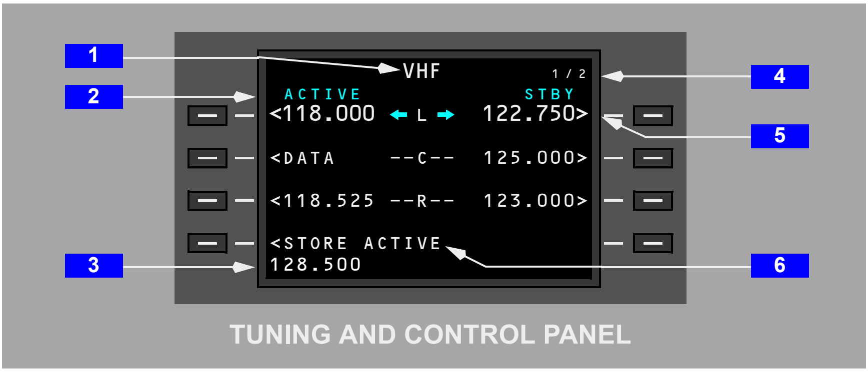
PREV PAGE – displays previous page of multiple page displays.

NEXT PAGE – displays next page of multiple page displays.

TCP Page Components

VHF Operation

[Option – Active entry, Store active]



1 **Page Title**

Displays selected mode for data displayed on page.

2 **Line Title**

Displays title of data on line below.

3 **Scratchpad**

Displays –

- numeric entries from keypad
- line selected data
- system messages
- frequencies preceded by UL indicate uplink

Data (except CLEAR messages) is retained when switching between TCP modes for VHF and HF.

4 **Page Number**

Left number is page number. Right number is total number of related pages. Page number is blank when only one page exists.

5 **Line**

Displays –

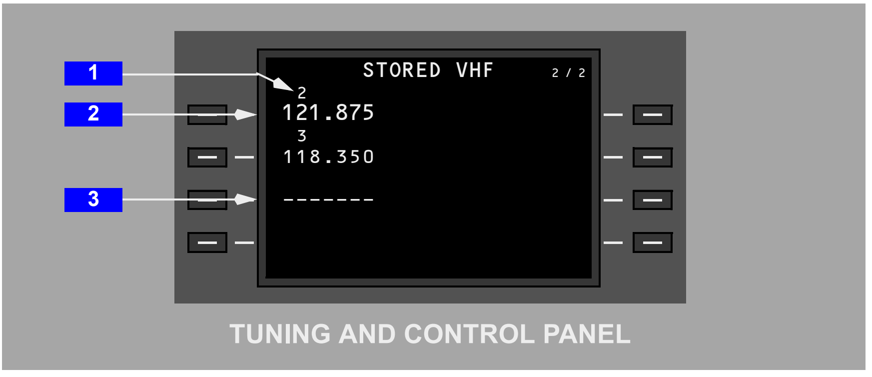
- availability prompts
- data associated with line title
- line function

[Option – Store active]

6 **Store Active**

Push – Stores active frequency on alternate frequency page.

VHF Page 2 Operation



1 **List Number**

Displays the number assigned to stored frequency below. The STBY frequency on page 1 is considered stored frequency number 1.

2 **Frequency**

Displays the stored frequency. A total of 24 frequencies may be stored on 3 STORED VHF pages.

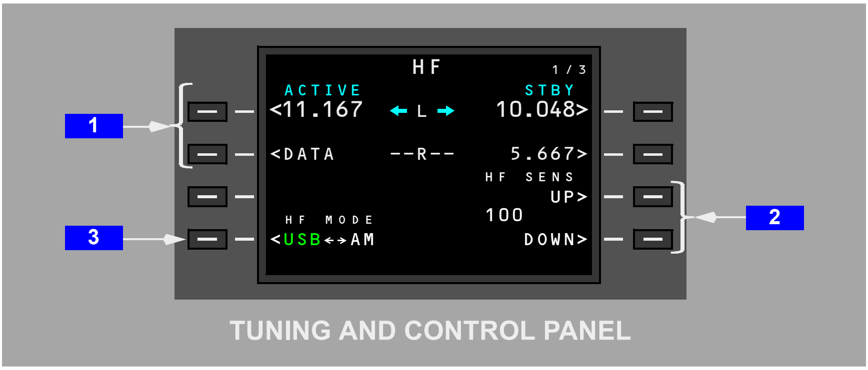
3 **Dash Prompts**

Indicates that a new frequency can be added to the stored list. Up to 8 frequencies are stored on each page.

[Option – HF radios]

HF Operation

[Option – Active entry, USB/AM]



1 **Dual HF Radios**

Operation of HF radio selection and usage is identical to VHF radio operation.

2 **HF Sensitivity Keys**

Push – UP

- increases HF sensitivity in increments up to 100 or full volume
- holding key down slews sensitivity up to desired volume

Push – DOWN

- decreases HF sensitivity in increments down to 0 or minimum volume
- holding key down slews sensitivity down to desired volume

[Option – USB/AM]

3 **HF USB/AM Key**

Push – Toggles between upper side band (USB) and amplitude modulation (AM) modes.

SATCOM Operation

SATCOM Main Menu
[Option – SATCOM]

1 SATCOM Channel Status

Displays associated SATCOM channel (-1 or -2) status:

- READY – system ready to make call
- CABIN USE – system in use by cabin attendants
- DIALING – system is dialing or placing the call
- RINGING – call is ringing and waiting for ground station to answer
- ANSWERED – call has been picked up by ground station
- CALL FAIL – call failed to be received
- NOT READY – system is not ready to make a call
- GND CALL – there is an incoming call
- IN QUEUE – an incoming call has been placed in SATCOM queue

2 SATCOM CALL Key

Push – MAKE CALL

- initiates a SATCOM call to the identifier / number listed below call key
- once call is in progress, prompt returns to END CALL

Push – END CALL

- cancels the current call
- prompt returns to MAKE CALL

Push – MANUAL ENTRY

- (displayed when any entry is made into the scratchpad)
- initiates a SATCOM call to the number entered in scratchpad
- once call is in progress, prompt returns to END CALL

Push – PREEMPT

- (displayed when another call is in progress)
- overrides call in progress and initiates selected call
- once call is in progress, prompt returns to END CALL

Push – CLR STATUS

- clears the CALL FAIL channel status message
- prompt returns to MAKE CALL

Push – ANSWER

- answers incoming call
- once call is in progress, prompt returns to END CALL

3 SATCOM Phone Number Identifier

Displays

- identifier station name to be called from directory
- in manual dial mode, displays phone number of station entered from scratchpad
- when last use was an incoming call, line is blank

4 SATCOM Response Key

Push – REJECT

- rejects incoming call
- prompt returns to blank

Push – QUEUE CALL

- (displayed when another call is in progress)
- places incoming call into SATCOM call queue
- channel status shows IN QUEUE
- prompt returns to END QUEUE

Push – END QUEUE

- cancels call in SATCOM queue
- prompt returns to blank

5 SATCOM Channel 2

Second SATCOM voice channel operates identical to channel 1.

6 SATCOM Call Priority Key

Push – toggles through call priorities

- EMG – emergency call
- HGH – high priority call
- LOW – low priority call

7 **SATCOM DIRECTORY Key**

Push – Displays directory of available SATCOM phone numbers by geographic region.

SATCOM Page 2/2

1 **SATCOM LOG Key**

Push – displays the SATCOM LOG page (controls connection to satellite).

2 **SATCOM DIRectory Details Key**

Push – displays the directory details page (a list of phone number identifiers).

3 **SATCOM RETURN Key**

Push – returns display to main SATCOM page.

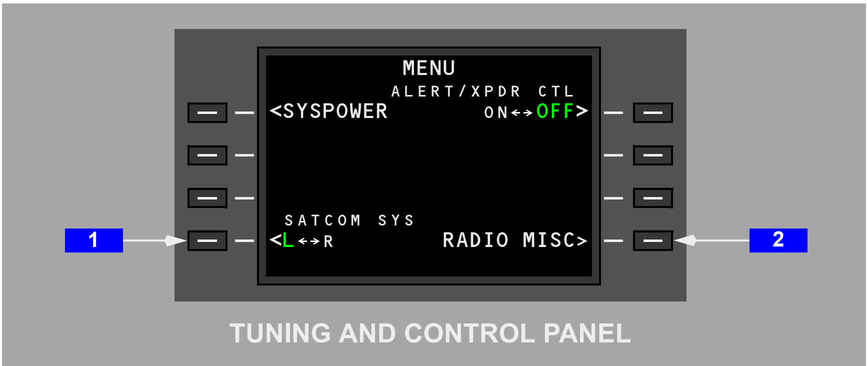
4 **SATCOM BITE OK Key**

Push – displays BITE page (maintenance use only).

5 **SATCOM CONFIG Key**

Push – displays controls for SATCOM configuration (maintenance use only).

Menu Page
[Option – Dual SATCOM]



[Option – Dual SATCOM]

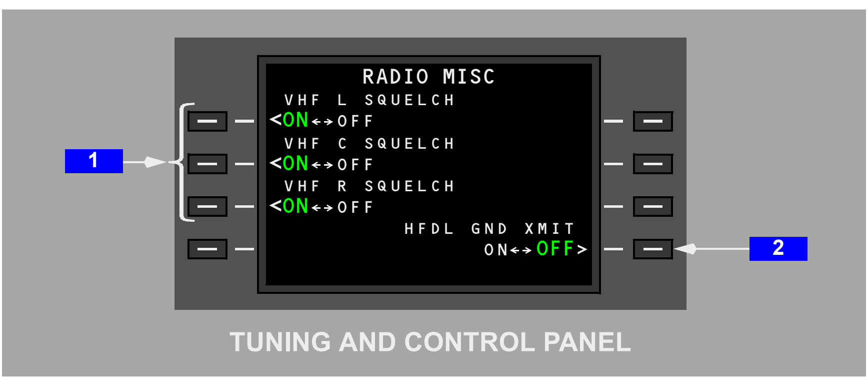
1 **SATCOM SYS Key**

Push – selects either Left or Right SATCOM system.

2 **RADIO MISC Key**

Push – displays RADIO MISC page.

RADIO MISC Page
[Option – HF radios]



1 **VHF SQUELCH Key**

Push –

- toggles VHF squelch between ON and OFF
- when squelch is OFF, displays memo message VHF SQUELCH OFF

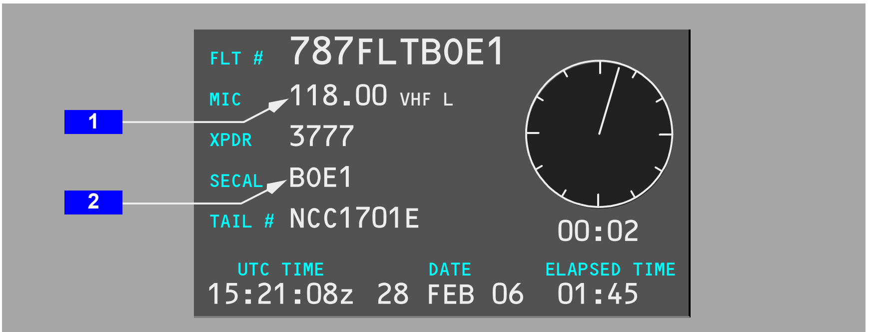
[Option – HF radios]

2 **HF Datalink Ground Transmit (HFDL GND XMIT) Key**

Push –

- toggles HF datalink between ON and OFF for ground transmit
- when selected ON, displays memo message HFDL GND XMIT

Communication Indications



FLIGHT DATA BLOCK
(Typical)

1 **MIC (microphone) Indicator Display**

Displays (white) –

- onside ACP selected mic source

[Option – HF radios]

- associated onside mic source frequency if VHF or HF
- DATA if onside radio is being used for datalink

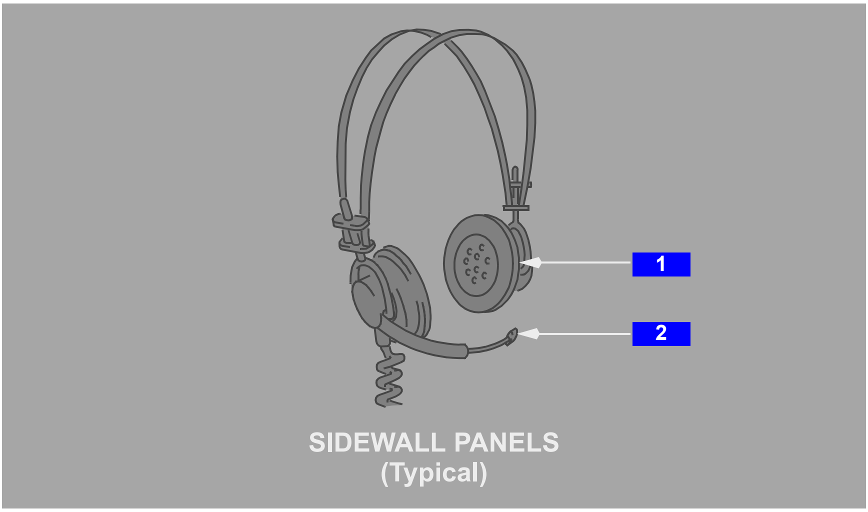
Displays (green) – onside mic source selection is being keyed.

2 **SELCAL Indicator Display**

Displays assigned airplane SELCAL number.

Miscellaneous Communication Controls

Headphone/Boom Microphone



1 Headphone

Used to monitor audio from the respective audio control panel.

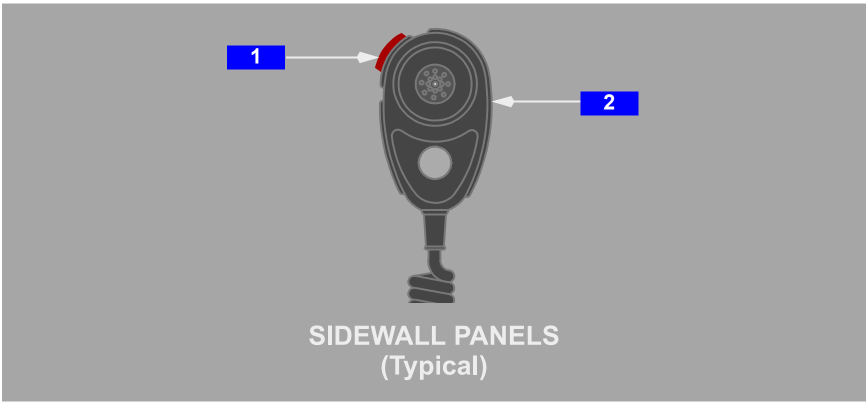
Audio volume is adjusted using audio control panel controls for the associated station.

Available at all flight deck stations.

2 Boom Mic

Activation of a control wheel, glareshield, audio control panel mic/interphone switch or PA mic switch transmits on the system selected for use at that station.

Hand Microphone



1 Hand Microphone Push-To-Talk Switch

Push – activates the hand microphone.

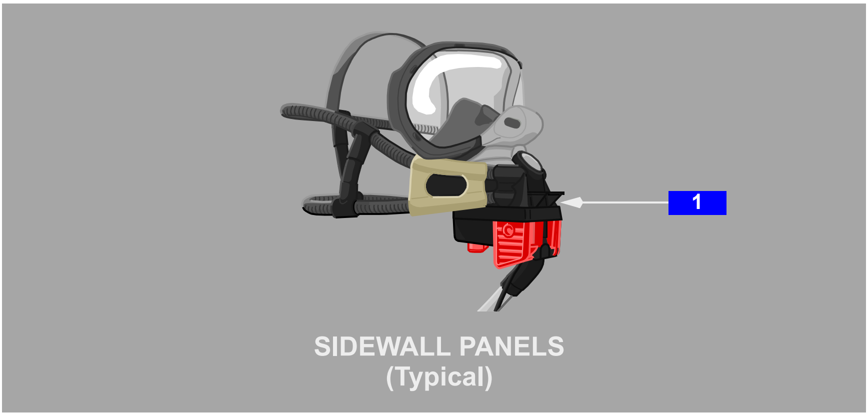
2 Hand Microphone

Transmits on the system selected by the audio control panel.

Available at the captain, first officer and first observer stations.

Optional for the second observer station.

Oxygen Mask Microphone

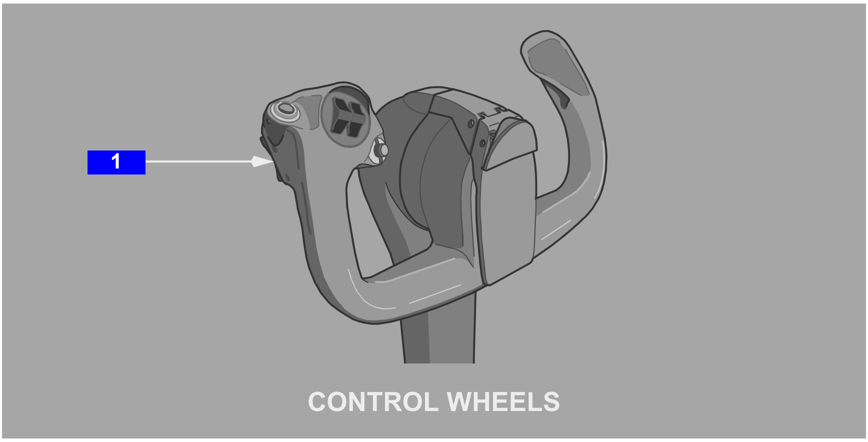


1 Oxygen Mask Microphone

Enabled when the oxygen mask doors are open. The boom microphone is disabled.

Activation of a control wheel, glareshield or audio control panel mic/interphone switch transmits on the system selected for use at that station.

Control Wheel Microphone/Interphone Switch



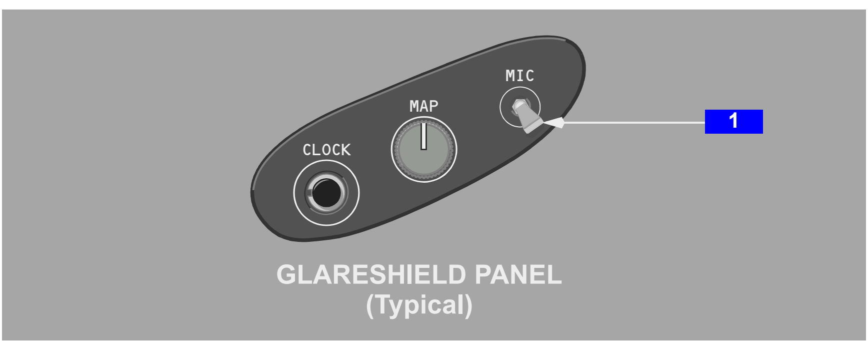
1 Control Wheel Mic/Interphone Switch

MIC – allows oxygen mask or boom microphone transmission on selected transmitter. Spring-loaded to center.

CENTER – off position.

INT – allows oxygen mask or boom microphone transmission on the flight interphone system. Latched in position.

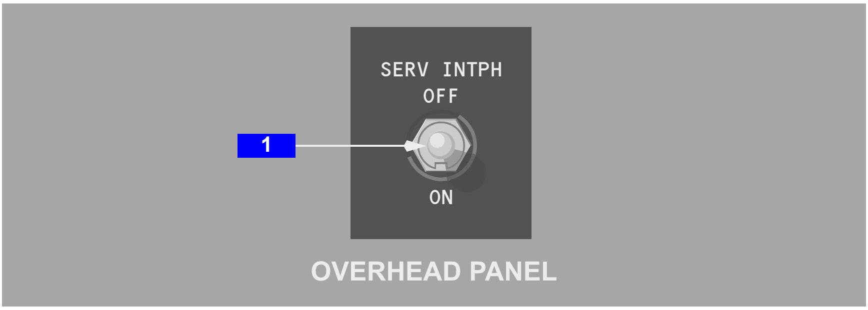
Glareshield Microphone Switch



1 Glareshield Mic Switch

Push – allows oxygen mask or boom microphone transmission on the selected transmitter.

Service Interphone Switch

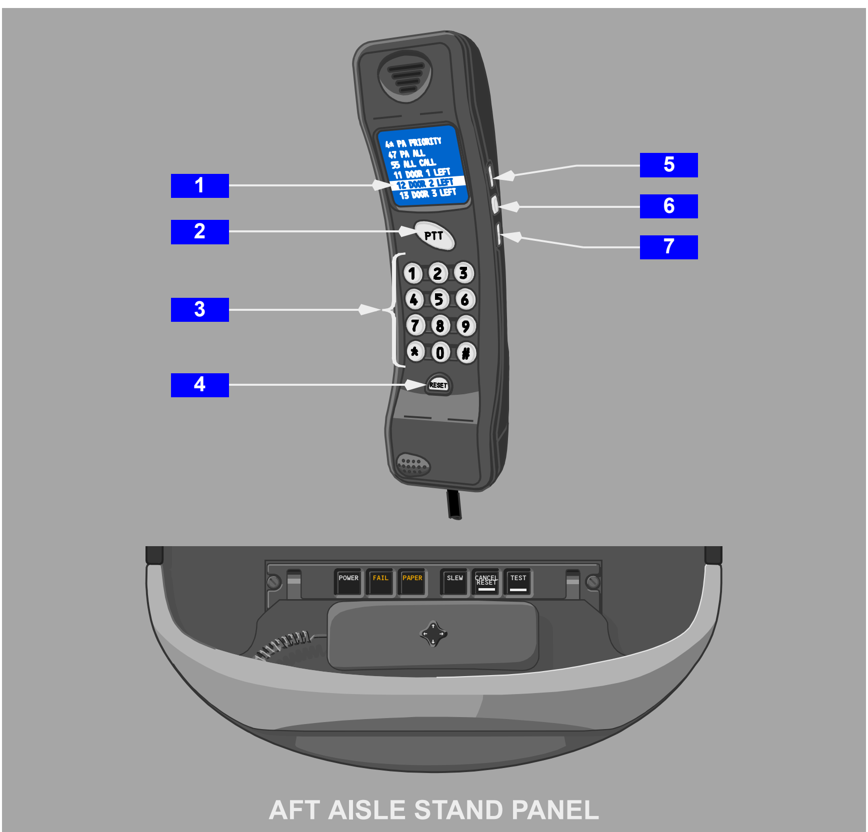


1 Service Interphone Switch

OFF – allows independent operation of the service and flight interphone systems.

ON – connects the service and flight interphone systems.

Handset



1 Handset Display

Displays –

- a directory of dial codes
- a dial code and label of predefined station or station groups for incoming or outgoing call
- INVALID ENTRY message when incorrect dial code is entered
- PUSH RESET when handset is off hook and not being used for more than 30 seconds

2 Handset PA Push-To-Talk Switch

Push –

- connects the handset microphone to the selected PA area
- only used in the PA mode

3 Handset Numeric Keys

Push – selecting a code calls the respective station or PA area.

Note: Dial codes entered using the handset are not displayed on the TCP cabin interphone pages.

4 Handset Reset Switch

Push – cancels a call or incorrectly selected code.

5 Handset Dial Code Step Up Switch

Push – moves up and highlights dial code from a list of predetermined crew station(s) and PA areas.

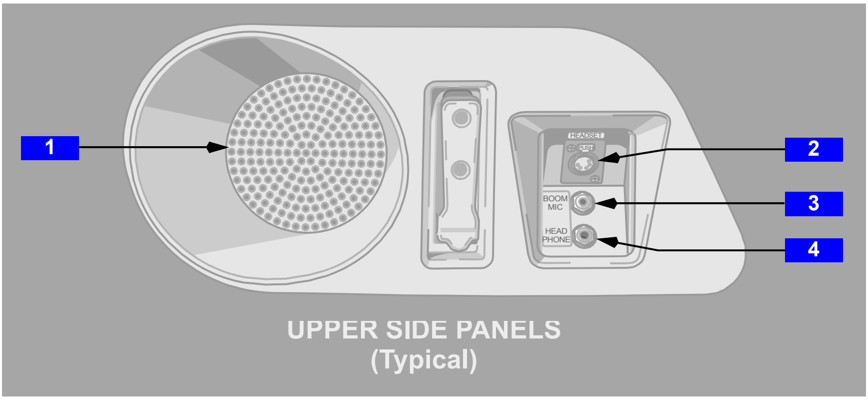
6 Handset Dial Code Select Switch

Push – initiates a call to the selected crew station(s) or PA area dial code.

7 Handset Dial Code Step Down Switch

Push – moves down and highlights dial code from a list of predetermined crew station(s) and PA areas.

Flight Deck Speaker/Boom Mic/Headphone Panel



1 Flight Deck Speaker

Controlled by the speaker volume control on the respective audio control panel.

2 Headset Jack

Accepts a flight crew headset plug.

3 Boom Mic Jack

Accepts a flight crew boom mic plug.

4 Headphone Jack

Accepts a flight crew headphone plug.

Observer Audio Selector

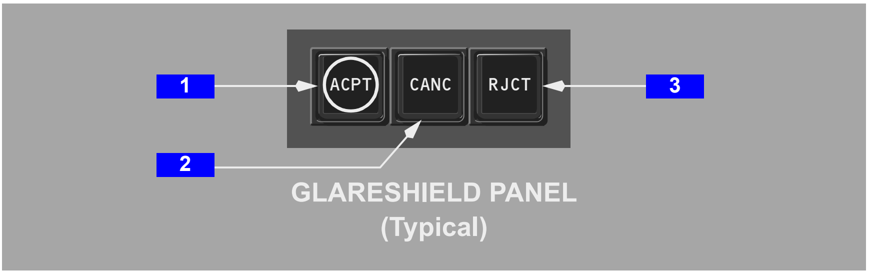
1 Observer (OBS) AUDIO Selector

Captain (CAPT) – connects the captain's hand microphone, headphone, boom microphone/headset, oxygen mask microphone, speaker, and mic/interphone switches to the first observer audio control panel.

Normal (NORM) – the first observer audio control panel is connected to the first observer's hand microphone, headphone, boom microphone/headset and oxygen mask microphone.

First Officer (F/O) – connects the first officer's hand microphone, headphone, boom microphone/headset, oxygen mask microphone, speaker, and mic/interphone switches to the first observer audio control panel.

Datalink Accept/Cancel/Reject Switches



1 Accept (ACPT) Switch

Push –

- a positive response to a displayed message is downlinked to the origin of the displayed message
- functions the same as selecting an MFD communications display ACCEPT command key

2 Cancel (CANC) Switch

Push –

- the message is removed from the display
- functions the same as selecting an MFD communications display CANCEL command key

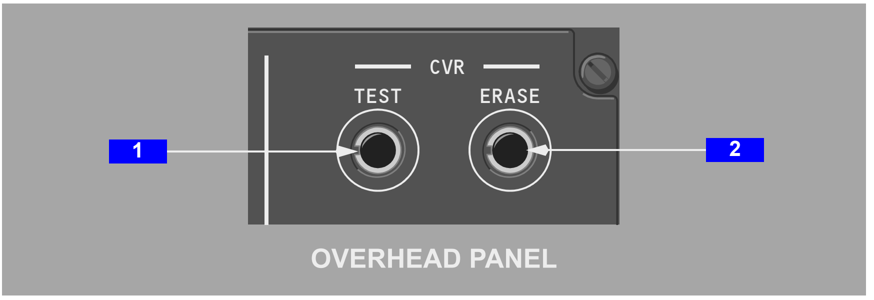
3 Reject (RJCT) Switch

Push –

- a negative response to the displayed message is downlinked to the origin of the displayed message
- functions the same as selecting an MFD communications display REJECT command key

Cockpit Voice Recorder System

Cockpit Voice Recorder Panel



1 Cockpit Voice Recorder TEST Switch

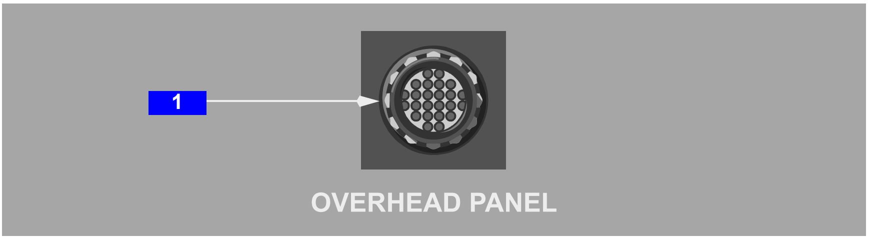
Push and hold for two seconds (on the ground and engines off) –

- tests area microphone CVR channel
- initiates 10 minute voice recording

2 Cockpit Voice Recorder ERASE Switch

Push and hold for two seconds (on the ground and engines off) – erases voice recorder.

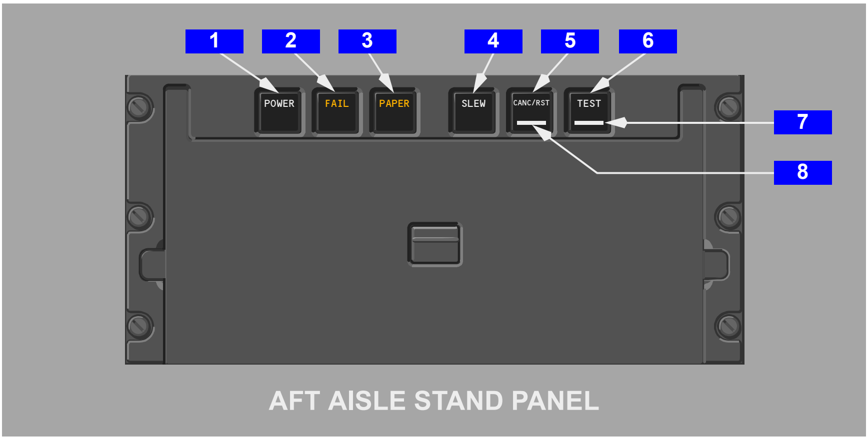
Cockpit Voice Recorder Microphone



1 Cockpit Voice Recorder Microphone

Area microphone for the voice recorder.

Printer Controls



1 Printer POWER Switch

Push – applies power to printer.

White band around switch – power is not applied to printer.

2 Printer FAIL Light

Illuminated (white) – the printer is failed.

3 Printer PAPER Light

Illuminated (white) –

- printer is out of paper, or
- paper loading door is open

Note: With both FAIL and PAPER lights illuminated, printer is overheated.

4 Printer SLEW Switch

Push and hold – advances the printer paper.

5 Printer CANC/RST Switch

Push – cancels current printing cycle

Push and hold – resets the printer if it stops operating

6 Printer TEST Switch

Push –

- tests the printer and printer lights
- prints a test pattern

7 Printer TEST Light

Illuminated (white) –

- a printer test is in progress, or
- a printer reset is in progress

8 Printer RESET Light

Illuminated (white) – a printer reset is in progress

Introduction

The communication systems include:

- cockpit voice recorder system
- radio communication system
- SELCAL system
- SATCOM system
- communication crew alerting system
- interphone communication system (Refer to Interphone Communication System, Ch 5, Sec 30, for additional information.)
- data communication system (Refer to MFD Communications Functions, Ch 5, Sec 40, for additional information.)

The communication systems are controlled using the:

- audio control panels
- tuning and control panels (TCP) (Refer to Interphone Communication System, Ch 5, Sec 30, for additional information.)
- control display unit (CDU) communications pages (Refer to Company Datalink, Ch 11, Sec 34, for additional information.)
- multifunction display (MFD) communications pages (Refer to MFD Communications Functions, Ch 5, Sec 40, for additional information.)

Audio Control Panels

The audio control panels are used to manage the radio and interphone communication systems. Navigation receiver audio can also be monitored. The captain, first officer, and first observer audio control panels are installed on the aft aisle stand.

Microphones are keyed by pushing the desired audio control panel transmitter select switch and using the MIC (microphone) position of a control wheel or audio control panel microphone/interphone switch, a glareshield MIC switch, or a hand microphone push-to-talk switch. Systems are monitored using headphones or speakers. An oxygen mask microphone is enabled and the boom microphone is disabled when the oxygen mask stowage doors are open. The oxygen mask microphone is disabled and the boom microphone is enabled when the left oxygen mask stowage box door is closed and the RESET/TEST lever is pushed.

Cockpit Voice Recorder System

The cockpit voice recorder records any transmitted or received flight deck audio as selected on the audio control panels. It also records flight deck area conversations using an area microphone. All inputs are recorded continuously.

Tuning and Control Panels

[Option - HF, SATCOM]

The tuning and control panels (TCP) are used to tune and control the VHF, HF, SATCOM, cabin interphone, and other airplane systems. The panels are designated left, center, and right, and are normally associated with the respective VHF and HF radios.

Radio Communication Systems

[Option - HF, SATCOM]

The radio communication systems consist of the very high frequency (VHF) communication system, the high frequency (HF) communication system, the satellite communication (SATCOM) system, and the selective calling (SELCAL) system.

VHF Communication System

Three independent VHF voice/data radios, designated VHF L (left), VHF C (center), and VHF R (right) are installed. Any VHF radio can be controlled by any TCP. The audio control panels are used to control voice transmission and receiver monitoring.

When a VHF radio is tuned to frequency 121.5, all flight crew automatically monitor the radio. The receiver lights on all audio control panels illuminate.

VHF L is configured for voice communication only and VHF C is normally used for data communication. VHF C and VHF R can be used for both voice or data communication. However, only one VHF radio can operate in the data mode at a time. ------- - X - ------- is displayed on the TCP when the affected radio (X) is inoperative.

VHF Page Displays

Four VHF page displays are used to tune the left, center and right VHF radios. The main VHF page (1/X) is always displayed when the VHF mode select key is pushed. The main display controls the active and standby frequency selection for all three radios. The selected radio for each TCP is indicated by ACTIVE and STBY titles above large white text of the radio name (L, C, R) and the current frequencies assigned. Pushing another active or standby line select key changes the radio to be tuned.

For the selected radio, the frequency transfer switch moves the pretuned, standby frequency to become the active, tuned frequency. The previously active frequency then becomes the standby frequency.

[Option - Active entry]

New frequencies are entered into the scratchpad. Entering the decimal and/or following zeros for this new frequency are optional. The decimal is inserted automatically when the line select key is pushed. Scratchpad frequencies can be enter into either the active or standby windows. If an invalid frequency is entered, an INVALID ENTRY scratchpad message is displayed. Pushing the clear key erases the INVALID ENTRY message and displays the previous scratchpad entry.

Alternate frequencies

VHF pages 2, 3, and 4 can contain up to eight alternate frequencies for all three radios (24 total). These frequencies can be entered manually into the TCP by the flight crew.

Alternate frequencies are accessed from the main VHF page by using the standby frequency step control. Selecting UP or DN scrolls through the stored frequencies for the active radio in the standby window. Once the desired frequency is displayed in STBY, pushing the frequency transfer switch makes it active.

[Option - No auto clear of alternate frequencies]

Alternate frequencies stored during flight (VHF pages 2, 3, and 4) may be manually deleted using the CLR key. Frequencies not manually deleted remain stored in the TCP after flight is completed.

ATC Uplink

[Option - Active entry]

If an ATC uplink containing a VHF frequency is accepted, the uplink frequency is displayed in the scratchpad preceded by a UL indicator. Line selecting this frequency into the active, standby or a stored position clears the scratchpad. It also turns the uplink frequency green in the uplink data block.

Data Mode

The data mode can be selected and deselected by pushing the frequency transfer switch when the word DATA is displayed on the active radio line. If the selected VHF radio is the default data radio (VHF C), then DATA is displayed in the TCP active frequency window.

When a standby frequency is transferred to the active DATA window, DATA is now displayed in the standby window. If a new frequency is selected in the standby window when DATA is displayed, DATA is replaced by the new frequency. Data can be returned to the standby window by stepping through the list of standby frequencies until DATA appears.

When a VHF radio is in the data mode, it is not available for voice communications. A VHF radio can be returned to the voice communication mode by transferring a voice frequency into the ACTIVE frequency window.

[Option - Dual HF]

HF Communication System

There are two independent HF communication radios, designated HF L (left) and HF R (right). Each HF radio can be tuned by any TCP from the main HF page. Managing HF frequencies on the TCP is identical to VHF mode operation. Up to three pages of alternate HF frequencies (24 total) can be stored in the TCP.

[Option - No auto clear of alternate frequencies]

Alternate frequencies stored during flight (HF pages 2, and 3) may be manually deleted using the CLR key. Frequencies not manually deleted remain stored in the TCP after flight is completed.

[Option - USB/AM]

The HF radios operate in one of two modes, upper side band (USB) or amplitude modulation (AM). The USB/AM key on the main HF page is used to toggle between these two modes. In addition, the HF sensitivity is controlled by the HF sensitivity keys. Pushing the sensitivity UP or DOWN keys increment HF sensitivity between maximum (100) and minimum (0) volume.

The audio control panels are used to control voice transmission and receiver monitoring.

When an HF transmitter is keyed after a frequency change, the antenna tunes while a continuous or intermittent tone may be heard through the audio system. A tone lasting longer than 7 seconds indicates failure of the system to tune. Data is stored in memory for the last 100 tuned frequencies. Stored frequencies may tune quickly and a tone may not be noticeable.

Both HF radios use a common antenna. When either HF radio is transmitting, the antenna is disconnected from the other HF radio, and it cannot be used to transmit or receive. However, both HF radios can receive simultaneously if neither is being used for transmitting.

Stuck Mic Protection

In the event a VHF or HF radio transmits for more than 30 seconds, the EICAS advisory message RADIO TRANSMIT CAPT, F/O or OBS is displayed. The message is removed when the transmission stops.

On the ground with both engines shut down, any radio that transmits for more than 35 seconds is automatically disabled and dashes (-------) appears in the TCP frequency line for that radio. That radio is enabled when the microphone switch for that radio is released.

Selective Calling (SELCAL) System

[Option - Dual HF]

The SELCAL system monitors the three VHF radios and the two HF radios. When the system receives a call from a ground station, the crew is alerted through the communication crew alerting system.

Communication Crew Alerting System

The communication crew alerting system provides aural and visual alerts for normal operations requiring crew awareness that may require crew action. Visual alerts are presented as EICAS messages preceded by a bullet symbol (•). The aural alert is a high–low chime. The following table shows communication crew alert categories and the respective aural and visual alerts for each category. (Refer to Communications EICAS Alert Messages, Ch 5, Sec 50, for additional information)

Crew Alert Categories

Communication Crew Alert Category	Aural Alert	Visual Alert	Comments
High	High–low chime	Communication EICAS alert	None currently implemented. Reserved for future use.
Medium	High–low chime	Communication EICAS alert	Message awareness required. Crew action may be required.
Low	None	Communication EICAS alert	Crew action may be required.

Intentionally
Blank

Interphone Communication System

The interphone communication system includes the:

- flight interphone system
- cabin interphone system
- service interphone system
- passenger address (PA) system

The flight interphone, service interphone, and passenger address systems are normally operated through the audio select panel. The cabin interphone is operated through the TCP or the flight deck handset.

Flight Interphone System

The flight interphone system provides communications on the flight deck and between the flight deck and the ground crew through the flight interphone jack on the APU ground control fire protection panel in the nose landing gear wheel well.

The system is used by selecting the INT (interphone) position of a control wheel or audio control panel mic/interphone switch. The interphone can also be used by selecting the FLT transmitter selector on an audio control panel and then selecting one of the following microphone switches:

- MIC position of a control wheel switch
- MIC position of an audio control panel mic/interphone switch
- a hand microphone push-to-talk switch
- a glareshield MIC switch

Crew alerting of a ground crew initiated call is provided by an aural alert chime, the GROUND CALL EICAS communications alert message, and a CALL light illuminated on the audio control panel transmitter select switch.

Service Interphone System

The service interphone system provides voice communications between ground crew stations at various locations around the airplane. The system can be connected to the flight interphone system through the service interphone switch on the overhead panel.

Passenger Address System

The passenger address (PA) system is used by the flight crew to make cabin announcements. Pushing a PA mic switch on an audio control panel provides direct access to all PA areas.

The system is monitored by pushing the PA receiver volume control on an audio control panel. The PA system can also be selected through the cabin interphone system or the flight deck handset.

Cabin PA announcement priorities are:

- flight deck announcements from an audio control panel
- cabin handset direct access announcements
- priority (all area) announcements
- normal announcements from flight attendant or flight deck handsets

Cabin Interphone System

The cabin interphone system provides voice communications between the flight deck and the flight attendant stations. Boom microphones, oxygen mask microphones, and hand microphones are used by selecting the CAB (cabin) transmitter select switch on an audio control panel and pushing the mic/interphone switch to the MIC position. A cabin interphone station(s) must be selected and a call initiated from the TCP CABIN INTRERPHONE page to alert the desired station to pick up the call.

EICAS communications alert messages and chimes alert the pilots to incoming cabin calls. Normal priority calls from the cabin display the CABIN CALL EICAS message. Normal priority calls made to the flight deck while another call is in progress results in a busy signal at the handset, the calling station being displayed in the call queue, and the CABIN CALL memo message being set in EICAS. The call queue and memo messages are cleared when communication is established between that calling station and the flight deck. Priority calls from the cabin display the CABIN ALERT EICAS message. Priority calls automatically disconnect lower priority cabin interphone calls. Priority calls placed while a priority call is in progress are automatically connected as a conference call.

The cabin interphone call queue, speed dial numbers, and directories are accessed from the TCP CABIN INTERPHONE page menu.

Calls are initiated by:

- line selecting a one of three predefined SPEED DIAL locations on the CABIN INTERPHONE page, or
- accessing the DIRECTORY menu, selecting the appropriate subdirectory and then selecting the desired call location(s), or
- manually entering a valid two digit dial code in the scratchpad and selecting MAKE CALL

Pushing the audio control panel CAB (cabin) transmitter select switch twice within one second places a priority call to an airline–designated call location. If the cabin station is already in use, it is disconnected from the call in progress and connected directly to the flight deck.

Note: Flight deck initiated calls do not interrupt a current PA announcement from the dialed station.

Calls can be answered by selecting an audio control panel CAB transmitter select switch or, if a CAB transmitter select switch is already pushed in, by pressing a mic/interphone switch to the MIC position.

Calls can be ended by selecting the CABIN INTERPHONE page prompt END CALL or de–selecting the CAB transmitter selector on the audio control panel. The call also ends if the other party terminates the call.

Calls can also be answered or placed using the flight deck handset. The desired call location is entered using the dial code step switches or numeric keys. The call is then made by pushing the dial code select switch. Pressing the handset reset switch or placing the handset back on the cradle terminates the call.

Note: The handset PA push-to-talk switch is not required to operate the handset except for PA announcements.

Note: The cabin interphone system provides access to voice gate link (if installed at the gate). Gate link allows phone calls to and from the flight deck while the airplane is at the gate.

Cabin Interphone Main Menu

The cabin interphone menu allows the pilots to make or end calls. Calls are made by selecting a station from the speed dial page or the directory. Two digit station codes can be manually entered into the scratchpad and the call sent using the MAKE CALL prompt. A list of the two digit station codes is located on the handset.

The directory of stations is created by the customer airline and is not shown here. The following depict typical main menu pages and selected options.

Speed Dial

The speed dial menu provides a quick means to call up to three predefined stations or groups of stations. A single push initiates the selected call.

Call Queue

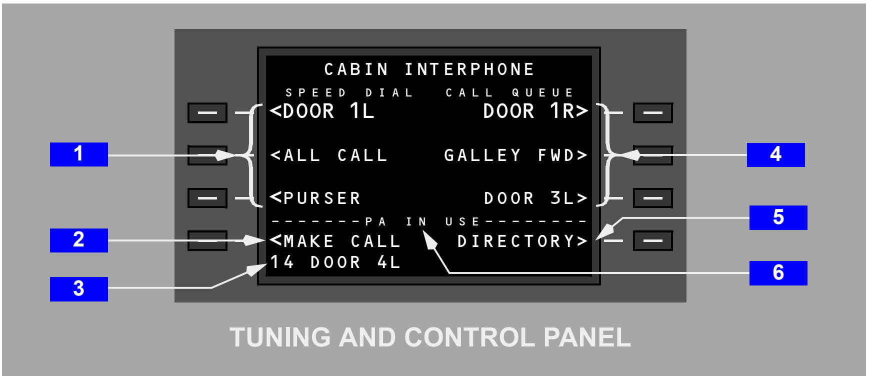
When the flight deck is involved in a call, additional incoming calls are displayed in the queue. Up to three calls can be displayed in order of the priority assigned as follows:

- PILOT ALERT
- conference calls
- cabin calls
- other calls

The PILOT ALERT queue entry is displayed only when the flight deck is using the PA and an incoming call is received.

When there are three calls in the queue and a new, higher priority call is received, the lowest priority call is removed from the queue and the new call is displayed in the proper priority.

Cabin Interphone Main Menu Page [Typical]



1 SPEED DIAL Labels

Lists the dial code labels of predefined stations, station groups, or functions:

- PA CALL – selects the passenger address system
- ALL CALL – selects all cabin interphone stations
- PURSER – selects the purser station
- GALLEY FWD – selects the forward galley station
- GND CREW – activates an alert horn in the nose wheel well. When selected, the horn sounds briefly to alert the ground crew for communications with the flight crew

Push – directly dials the selected station, station group or enables the selected call function.

2 MAKE CALL

A two–digit dial code may be manually entered with the TCP keyboard. If the dial code is valid, the dial code, dial code label, and MAKE CALL are displayed. If the dial code is invalid, INVALID CODE is displayed in the scratchpad.

Push – initiates a call to the selected station.

2 END CALL

Displayed during a connect call.

Push – disconnects all existing call connections.

3 CURRENT CALL

Displays the most recently selected dial code and label when a call is being connected. Dial code is removed when call is established.

4 CALL QUEUE Labels

Lists the dial code labels of unanswered calls to the flight deck.

Push –

- initiates a call back to the displayed station(s)
- adds station(s) to the existing call (if the flight deck is currently connected in a call)

5 DIRECTORY

Push – displays the cabin interphone DIRECTORY page.

6 IN USE Status

PA IN USE –

- a portion of the airplane PA system is in use, or
- both the PA and video entertainment systems are in use

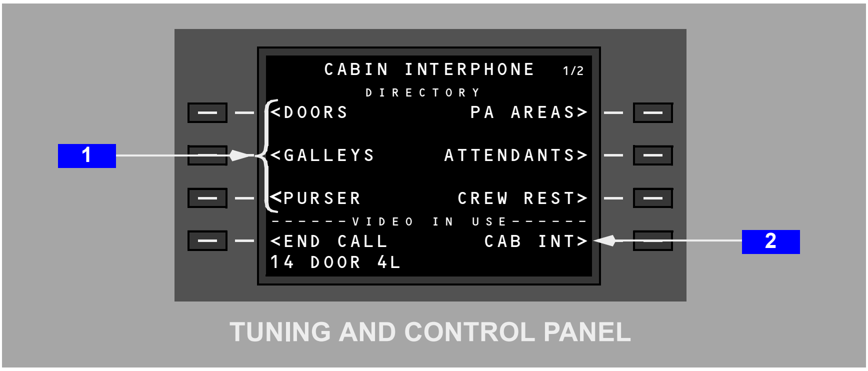
VIDEO IN USE – a portion of the video entertainment system is in use.

Blank (dashes) – neither the PA or video system is in use.

Cabin Interphone Directory Page [Typical]

The cabin interphone directory pages are used to access subdirectory pages. TCP cabin interphone directory pages and individual directory entries are predefined by the airline. Each directory label is the name of a subdirectory where the dial code labels of the individual stations or functions are listed.

Selection of the specific location(s) is accomplished on the subdirectory page.



1 Directories

Up to 12 subdirectories can be predefined.

Push – displays the appropriate subdirectory page

2 CAB INT

Push – returns the display to the cabin interphone main menu page.

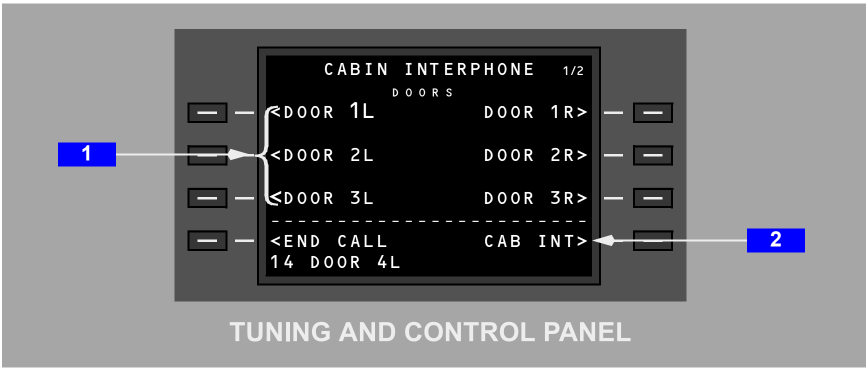
Cabin Interphone Subdirectory Page [Typical]

Selecting a dial code label on the subdirectory page initiates a call to that station or station group.

The cabin interphone subdirectory pages are used to view and select individual locations through their dial code labels.

Typical stations or station groups are:

- individual cabin station
- two or more cabin stations for conference calls
- PA call to all cabin areas
- PA call to individual cabin areas
- PA priority call to all cabin areas
- ground crew alert
- gate station (on the ground)



1 **Dial Code Labels**

Push – initiates a call to the appropriate station(s).

2 **CAB INT**

Push – returns the display to the cabin interphone main menu page.

Intentionally
Blank

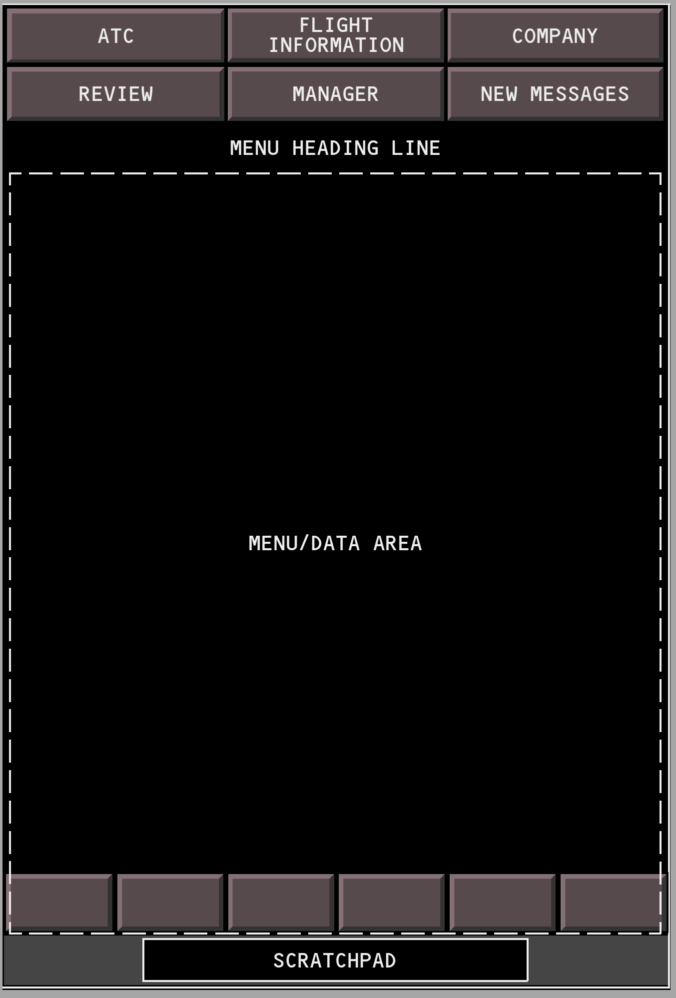
MFD Communications Functions

The MFD communications functions are used to control datalink features. Datalink messages not processed by the FMC are received, accepted, rejected, reviewed, composed, sent, and printed using communications functions on the MFD. Datalink communications can be established with participating ATC and company locations. ACARS and datalink radio management functions are provided through communications management menus.

The display select panel communication (COMM) display switch displays the communications main menu on the selected multifunction display (MFD). Communications functions are selected using the cursor control device. Message text entry is accomplished by entering data into the COMM scratchpad and transferring it to the appropriate area. Messages can be printed on the flight deck printer. Incoming message traffic is annunciated by an EICAS message and displayed in the ATC message block on both auxiliary displays.

Illustrations shown in this section depict the COMM menu with all features enabled. ATC datalink requires appropriate airplane and ATC capability.

Communications Menus



MFD

Note: Shown with no menu functions active.

Company communications functions can be customized by airlines. Descriptions and illustrations provided in this section are examples of a typical installation with all communications functions active (depending on airline configuration or function availability, some functions may be inhibited).

Selectable menu items (active functions) have white text on a gray background. Inhibited items have cyan text on a black background with a cyan border. Inhibited items cannot be selected. The background color for a selected top level function is green.

Selecting ATC, FLIGHT INFORMATION, COMPANY, REVIEW, MANAGER, or NEW MESSAGES selection:

- places the appropriate title in the menu heading line
- displays the subordinate menu selections for that function in the menu/data area

Subordinate menu items which lead to subsequent subordinate menu(s) are followed by three dots (…). Making a selection from the subordinate menu places the title of that function in the menu heading and displays a new subordinate menu or data below. Making a selection from the subordinate menu displays the appropriate title, the menu heading, and the data below.

ATC provides downlink messages to ATC, where available.

FLIGHT INFORMATION provides uplink and downlink messages that allow requests of Departure Clearance, Oceanic Clearance, Automatic Terminal Information Service (ATIS) information, Pushback, Terminal Weather Information for Pilots (TWIP) and Expected Taxi.

COMPANY provides for downlink messages to airline facilities.

REVIEW displays a list of all transmitted messages, received messages not requiring a response, or received messages with the response already sent. REVIEW is inhibited if there are no listed messages.

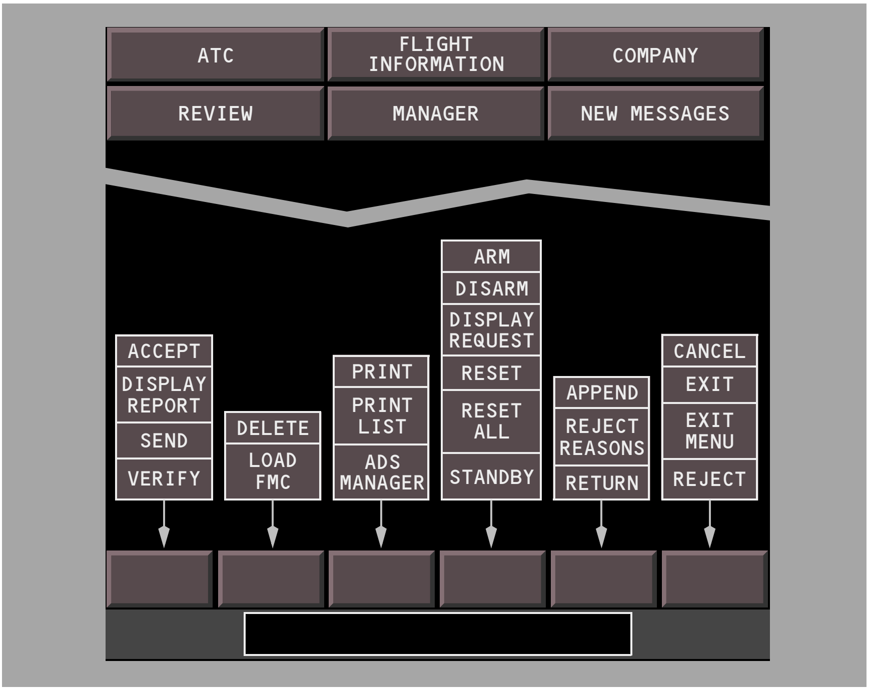
MANAGER provides the controls for datalink and communications systems in general.

NEW MESSAGES displays a list of uplinked messages that have not been displayed or responded to. NEW MESSAGES is inhibited when there are no new messages.

Communications Control and Input Functions

Communications menus, controls, and data input methods are similar for ATC, FLIGHT INFORMATION, and COMPANY functions. Basic functions are explained here.

Command Key Locations



Communications command keys are displayed at the bottom of communications pages. Command keys change as appropriate for pages displayed. Each key has a label which changes based on the page displayed and the possible action. Only one label is displayed in a single location for a specific condition on the page.

Command Key Functions

The following table describes the key functions and labels for all ATC, FLIGHT INFORMATION, and COMPANY functions.

Command key label	Displayed/Inhibited	Key function
ADS MANAGER	Displayed when ATC LOGON/STATUS page is displayed.	Displays ADS MANAGER page.

Command key label	Displayed/Inhibited	Key function
ACCEPT (uplink messages)	Displayed when: • message requires an accept/reject response, and • all message pages have been displayed Inhibited for first 2 seconds of message display.	Select: • message acceptance downlinked to message sender • ACCEPT & REJECT keys removed • message status displayed in info box • CANCEL command key displayed
ADS MANAGER	Displayed when ATC LOGON/STATUS page is displayed.	Displays ADS MANAGER page.
APPEND (company downlink accept/ reject response)	Displayed when: • all pages of the uplinked message have been displayed, and • company datalink capability is operational Inhibited when: • for first 2 seconds of uplink display, or • when company datalink capability is not operational	Select: • uplink message is removed, and • downlinked message page is displayed

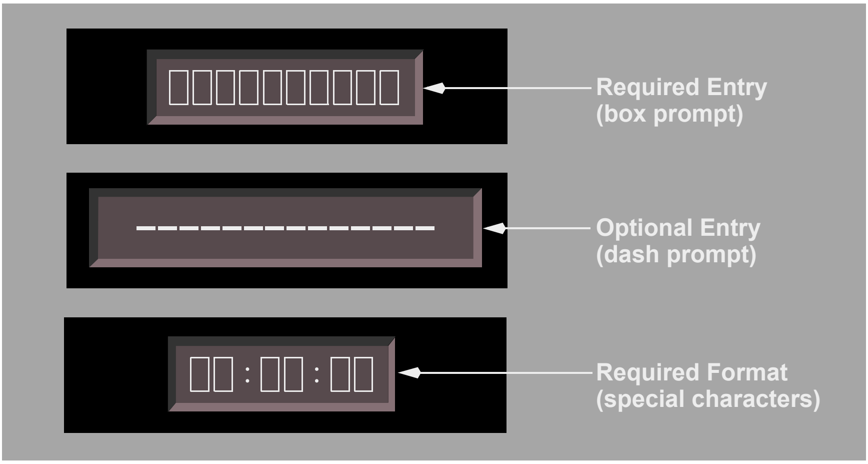
Command key label	Displayed/Inhibited	Key function
ARM (ATC downlink reports)	Displayed when an armable report is open: • REPORT LEAVING • REPORT LEVEL • REPORT PASSING • REPORT REACHING	Select: • arms the report for automatic downlink to ATC when report conditions are met • key function changes to DISARM • report status changes from OPEN to ARMED
CANCEL	Displayed when: • uplink message is displayed which does not require an accept or reject response, or • an uplink message is displayed which has been accepted, rejected, or • review message is displayed Inhibited for first 2 seconds of message display.	Message is removed.
DELETE (ATC reports)	Displayed when a downlink report page is open for entry.	Select: • deletes the report without sending. • displays the COMM menu
DISARM (ATC reports)	Displayed when an armable report is ARMED: • REPORT LEAVING • REPORT LEVEL • REPORT PASSING • REPORT REACHING	Select: • disarms automatic report downlink to ATC • key function changes to ARM • Report status changes from ARMED to OPEN
DISPLAY REPORT	Displayed after accepting an uplink message which contains a report.	Displays the downlink report attached to an uplinked message.

Command key label	Displayed/Inhibited	Key function
DISPLAY REQUEST	Displayed after accepting an ATC uplink message which contains a request.	Downlink request which required an ATC response is displayed,
EXIT	Displayed when: • a downlink message is displayed, or • a manager page is displayed	COMM main menu is displayed.
EXIT MENU	Displayed when menu is displayed.	COMM main menu is displayed.
LOAD FMC (ATC uplink)	Displayed when uplinked ATC message contains data which can be loaded into the FMC. Inhibited when active route is in a MOD condition.	Select: • FMC data is transferred into the active route, and • FMC modification is started
PRINT	Displayed when: • displayed message can be printed, and • printer is available Inhibited when printer is not available.	Message is sequenced for printing.
PRINT LIST	Displayed when: • new message list page is displayed, or • review list page is displayed Inhibited when printer is not available.	All messages in the list are sequenced for printing.

Command key label	Displayed/Inhibited	Key function
REJECT (uplink messages)	Displayed when: • message requires an accept/reject response, and • all message pages have been displayed Inhibited for first 2 seconds of message display.	Select: • message rejection downlinked to message sender • ACCEPT and REJECT command keys removed • CANCEL command key displayed • message status displayed in info box, and • message cleared from the display 5 seconds after status changes to REJECTED
REJECT REASONS (ATC reject downlink)	Displayed when an uplink message requires an accept or reject response.	Displays REJECT REASON page.
RESET (downlink pages)	Displayed when downlink page is displayed.	Message parameters are reset to their default values.
RESET ALL (ATC downlink pages)	Displayed when ATC VERIFY REQUEST page is displayed.	Select: • all request parameters on the VERIFY REQUEST are set to reset/default values • ATC combined request pages are reset, or • COMM main menu is displayed

Command key label	Displayed/Inhibited	Key function
RETURN	Displayed when: • a review message is displayed, or • a downlink message is displayed, or • a VERIFY REQUEST page is displayed, or • a manager page is displayed	Previous list page, request page, or menu is displayed.
SEND (downlink messages)	Displayed when: • required data complete, and • all company message pages have been displayed Inhibited when transmission queue is full.	Select: • message transmission initiated • message status displayed in info box, and • message cleared from the display 5 seconds after status changes to SENT
STANDBY (ATC uplink messages)	Displayed when: • uplinked message is received which requires an accept/reject response, and • STANDBY has not been previously selected for this message	Standby response is sent.
VERIFY	Displayed when data is entered on more than one of the following ATC pages: • ALTITUDE REQUEST • ROUTE REQUEST • SPEED REQUEST	Displays VERIFY REQUEST page.

Text Entry



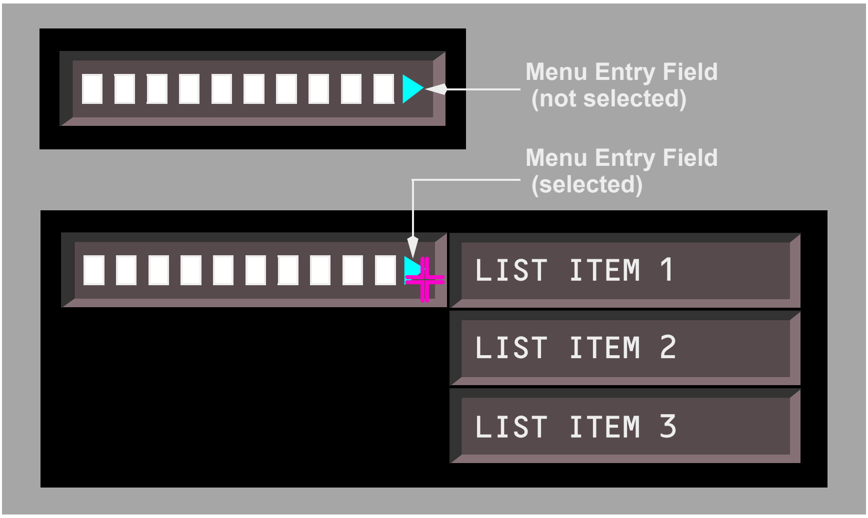
Downlink message pages provide text entry fields. Scratchpad entries transfer to selected entry fields when a cursor select switch is pushed. Scratchpad entries blank when successfully transferred. Scratchpad entries remain and an INVALID ENTRY message is displayed in the help window when the entry is not valid.

An entry field resets to a default value when a blank scratchpad is transferred. An entry field blanks when a space is transferred. An entry field resets to the default entry prompt when DELETE is transferred.

Box and dash prompts indicate the maximum number of characters allowed.

Some entry fields have format requirements. Entry prompts display the required entry format, with special characters separating entry boxes. The required data is entered without the special characters or spaces. Scratchpad data is transferred to entry boxes after being checked for proper format. Invalid data or format prevents transfer and displays INVALID ENTRY in the help window.

Menu Entry Fields



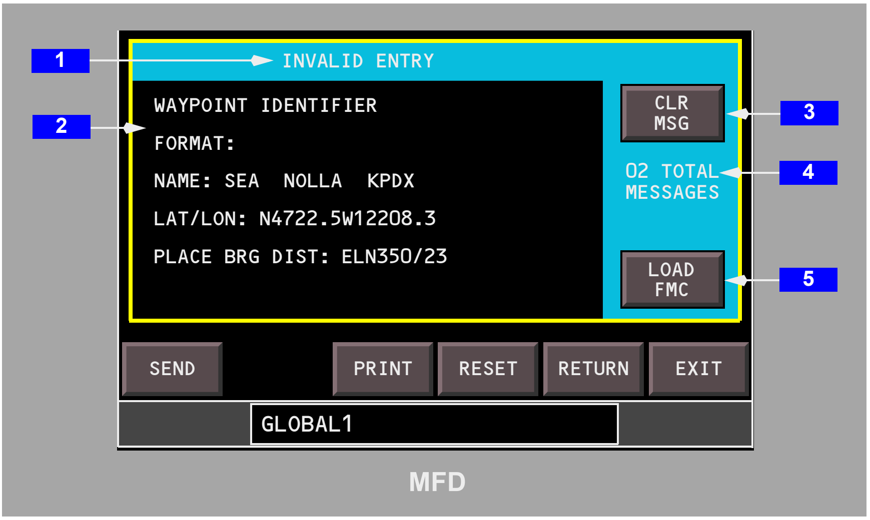
Menu entry fields are used to make text entry selections from a list. Menu entry fields distinguish mandatory versus optional entry in the same manner as CDU entry field.

The menu entry field is distinguished from other entry fields by the pointer to the right of the field.

When initially selected, a list of menu items is displayed to the side of the pointer. If an item from the list is then selected using the cursor and cursor select switch, that item is transferred to the entry field. If the menu prompt is selected again and the scratchpad contains a valid value, that scratchpad value is transferred to the entry field. Actions for invalid values, an empty scratchpad, space characters, and the delete key are the same as for CDU entry fields. When the entry field is selected with text already inserted, the menu list is removed from the display.

Help Window

A help window is provided in both COMM and CDU displays at the bottom of the MFD to assist in resolving data entry errors and to display FMC information messages. Some help window messages clear automatically when the condition is removed. Others, such as INVALID ENTRY, INVALID DELETE and NOT IN DATABASE must be manually cleared using the CLR MSG key.



1 Help Window Title

Displays help window message title.

2 Help Window Text

Displays text message information to:

- help correct data entry errors
- provide FMC alerting messages
- provide FMC communications messages

3 Clear Message (CLR MSG) Key

Push –

- removes help window for current message from display
- displays next help message (if one exists)

4 TOTAL MESSAGES

Displays total number of messages in help window queue.

5 LOAD FMC Key

Displays when loadable ATC RTE CLEARANCE UPLINK message is received.

Push –

- clears ATC message
- enters modified route into FMC for execution
- displays next help message (if one exists)

COMM Help Messages

COMM help messages are described in the following table.

Help Window Title	Condition	Help Window Text
ABORTED	ATC connection not established, lost or loss of handoff to a new active center, while a message is transmitting or before acceptance.	UPLINK ABORTED BEFORE FLIGHT CREW RESPONSE CONTACT ATC BY VOICE IF RESPONSE REQUIRED
COMM MASTER SWITCH	Comm master switch - messages lost.	COMPANY MESSAGE LOG LOST
INVALID ENTRY	An entry box is selected and the scratchpad value is not valid.	(Specific to type of entry error)
MESSAGE LIMIT EXCEEDED	Message exceeded the maximum allowable length.	DOWNLINK MESSAGE STORAGE IS FULL CONFIRM DATALINK STATUS BEFORE SENDING MESSAGES
MESSAGE LIMIT EXCEEDED	Selection of a message element when the number already selected equals the maximum.	CANNOT SELECT ADDITIONAL MESSAGE ELEMENTS
NO ACCEPT (company)	ACCEPT response is not successfully transmitted or an ACCEPT response is not required.	UNSUCCESSFUL WILCO, ROGER OR AFFIRM RESPONSE RESPOND TO ATC BY VOICE
NO PRINT	An attempt to send a message(s) to the printer is unsuccessful.	UNSUCCESSFUL PRINT CHECK PRINTER
NO REJECT (company)	REJECT response is not successfully transmitted or a REJECT response is not required by the message.	UNSUCCESSFUL UNABLE OR NEGATIVE RESPONSE RESPOND TO ATC BY VOICE
NO SEND	An attempt to send a downlink message is unsuccessful.	UNSUCCESSFUL MESSAGE TRANSMISSION RETRY OR CONTACT ATC ON VOICE
NOT ALLOWED	An attempt was made to enter data into a menu entry field.	NO DATA ENTRY IN THIS BOX ITEM MUST BE SELECTED FROM LIST

Help Window Title	Condition	Help Window Text
NOT IN DATABASE	Scratchpad entry cannot be found in TCP database.	(Specific to identifier entered)
NOT ON ROUTE	Position report ETA waypoint must be on active route.	(Specific to identifier entered)
UNABLE TO LOAD	ATC uplink route modification is in progress.	FLIGHT PLAN MODIFICATION IN PROGRESS ON EXECUTION OF MOD RTE, ATC UPLINK WILL LOAD
UNABLE TO LOAD	No active route.	NO ACTIVE ROUTE EXISTS ATC ROUTE MODIFICATION MUST BE APPLIED TO ACTIVE ROUTE
UNABLE TO LOAD	ATC clearance contains unloadable elements.	ATC CLEARANCE INCLUDES INVALID DATA ITEMS REJECT AND REQUEST NEW CLEARANCE
UNDEFINED CLEARANCE	Conditional clearance cannot be located.	CONDITIONAL CLEARANCE CONTAINS POSITION NOT IN ACTIVE ROUTE

CDU Help Messages

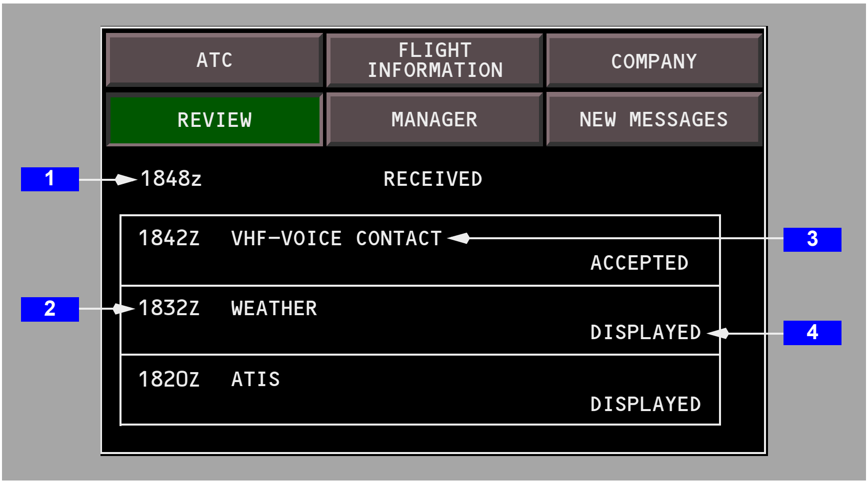
(Refer to FMC Communications Messages, Ch 11, Sec 60, for CDU help window messages.)

Message List

Message titles and related information can be displayed in a list. The illustration shows the REVIEW message list. A similar list is available for NEW MESSAGES.

The NEW MESSAGE list is sorted by the time of receipt, the most current message at the top. ATC uplink messages have an ATC label to the right of the message block. The message remains in the list until it is accepted, rejected, or displayed. Messages requiring an accept/reject remain in the list until the accept/reject response is accomplished.

Selecting an item from the list with the cursor and pushing the cursor select switch displays the message page. Lists are also used to view new messages.



1 **Current Time**

Displays current time.

2 **Message Time**

For new messages – time the message is received.

For review messages – time the message is received or sent.

3 **Message Title**

Displays message title information.

4 **Message Status**

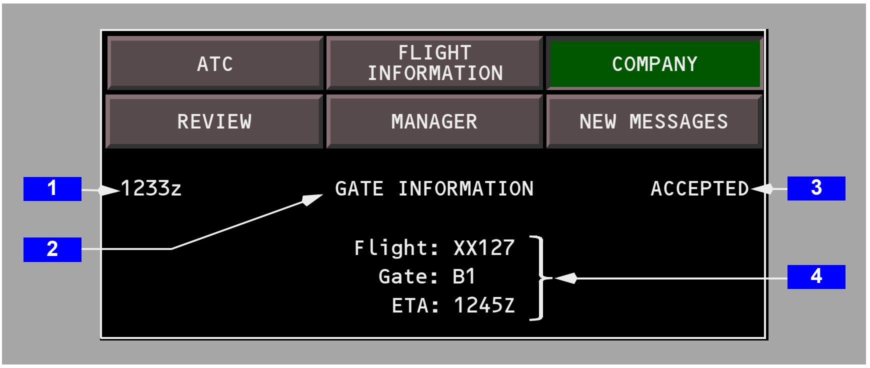
Only displayed for review list boxes.

The appropriate status indicator is displayed.

Message Display Format

A typical message display format is shown. Messages selected from a list are displayed in this format.

Note: Selection of a main menu item exits the message page.



1 Message Time

For downlink messages – current time.

For new messages – time the message is received.

For review messages – time the message is received or sent.

2 Message Title

Displays message title information.

3 Review State

Only displayed for review messages.

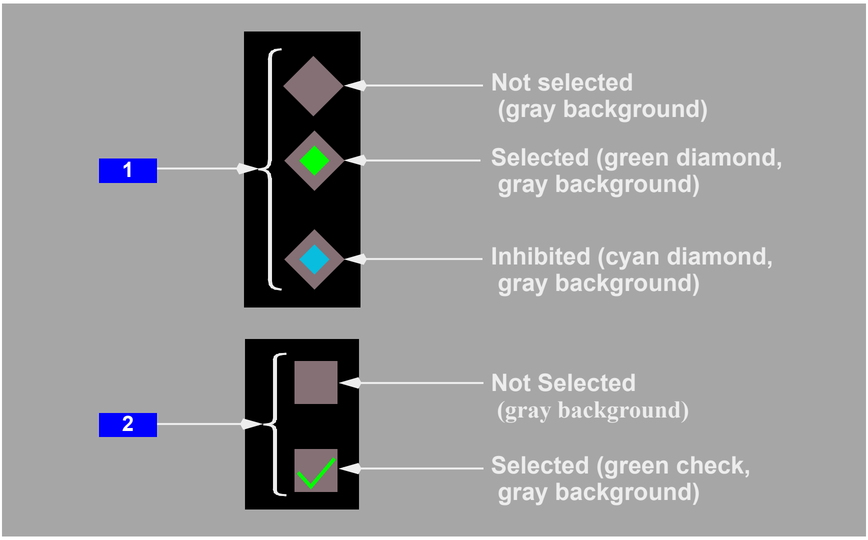
The appropriate state indicator is displayed.

4 Message Content

Located between the title and the keys.

Exclusive and Nonexclusive Select Keys

Manager and new message pages can contain select keys to activate features. Pushing the cursor select switch when the key is highlighted makes the selection. A second selection of a nonexclusive key toggles to the deselected state.



1 Exclusive Select Key

The diamond–shaped exclusive select keys are used to select a single feature from a group. Selecting a key activates the feature and all other exclusive select keys in that group are deselected. The keys are displayed in their selected or default condition. If selection is required, the SEND key is not displayed until a selection is made.

2 Nonexclusive Select Key

The square–shaped nonexclusive select keys are used to select multiple features. Selecting a key activates the feature. The keys are displayed in their previously selected or default condition. If selection is required, the SEND key is not displayed until a selection is made.

Information Messages

Messages are displayed in an information box at the bottom of the MFD and relate to message status. The information box covers the command keys. Information messages, such as SENT, are cleared by selecting EXIT INFO. Some information messages automatically disappear.

1 Information Message Text

The text starts at the left of the box.

2 EXIT INFO Key

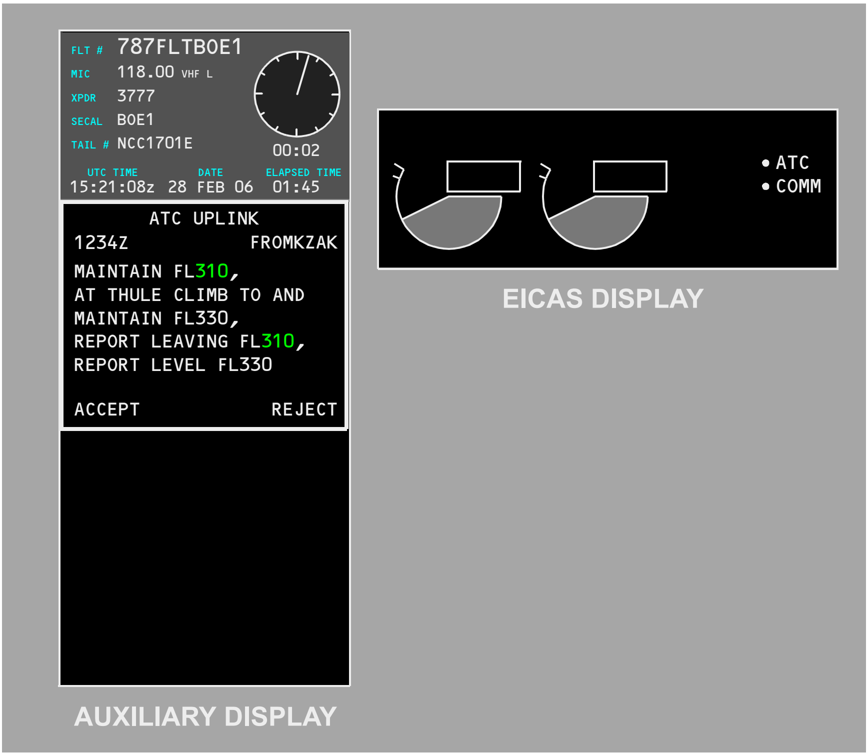
Select – removes the information box for the displayed message from the display.

Communications Information Messages

Communications information messages are described in the following table.

Information Message Status	Condition
ABORTED	ATC connection not established, lost or loss of handoff to a new active center, while a message is transmitting, or before acceptance.
ACCEPTED	ACCEPT response successfully received.
ACCEPTING	ACCEPT response is sent.
DISPLAYED	All pages of a message not requiring an ACCEPT or REJECT response have been displayed.
RESPONSE RECEIVED	Downlink status (changed from SENT) when an uplink is received in response to the downlink request.
REJECTED	REJECT response successfully received.
REJECTING	REJECT response is transmitting.
SENDING	The downlink message is sent.
SENT	The downlink message is successfully received.

Uplink Message



ATC Uplinks

Arriving ATC uplink messages are annunciated by an •ATC communications message, an aural chime, and an auxiliary display ATC message block. The message text is displayed in the ATC message block. The message text can also be displayed using the NEW MESSAGE menu selection.

Flight Information Uplinks

Arriving flight information uplink messages are annunciated by a •COMM communications message. The message text is displayed using the NEW MESSAGE menu selection.

Company Uplinks

Arriving company uplink messages are annunciated by a •COMM communications message and an optional aural chime.

Accept/Reject Uplinks

ATC messages requiring an accept or reject response display those options on the EICAS display. The MFD message page displays ACCEPT, STANDBY, REJECT REASONS, and REJECT keys at the bottom. Select ACCEPT or REJECT to respond to the uplink message. The REJECT REASONS key can be selected to inform ATC why the message is being rejected.

Company messages can also be accepted or rejected on the message page.

After making a selection, the status changes to ACCEPTING/REJECTING while the response is transmitting. When the communications network sends a response indicating that the message was received, the message status changes to ACCEPTED/REJECTED. After a message has been accepted or rejected, a CANCEL key is displayed at the bottom of the page. Selecting CANCEL clears the message from the display. Rejected messages are automatically removed 5 seconds after the message status changes to REJECTED.

The ACCEPT, CANCEL, and REJECT buttons on the glareshield perform the same function as the same keys on the MFD.

ATC Datalink

ATC datalink communicates with participating air traffic control centers, reducing the need for VHF voice communications. Airplane situation reports, route changes, speed and vertical clearances, and voice contact requests can be sent or received as appropriate. The COMM display ATC menu selection allows display of downlink message pages.

Uplink and downlink messages are stored. All messages are assigned the time of receipt/transmission and are printable.

ATC datalink requires manual logon to a participating ATC facility. Once logged on, transfer to adjacent ATC facilities is normally automatic.

[Option – FANS-2]

The airplane automatically manages datalink functions depending on its current global position. When in ATN airspace, some optional selections on downlink pages are unavailable (displayed in cyan).

Crew Feedback

ATC uplinks containing clearance data that the crew can set on the MCP or EFIS control panel have a crew feedback display function. When the message is displayed on EICAS or the message page, the data values change from white to green when properly set by the crew. Data which provides feedback is:

- MCP speed
- MCP heading
- MCP altitude
- barometer setting
- transponder code
- VHF frequency
- HF frequency

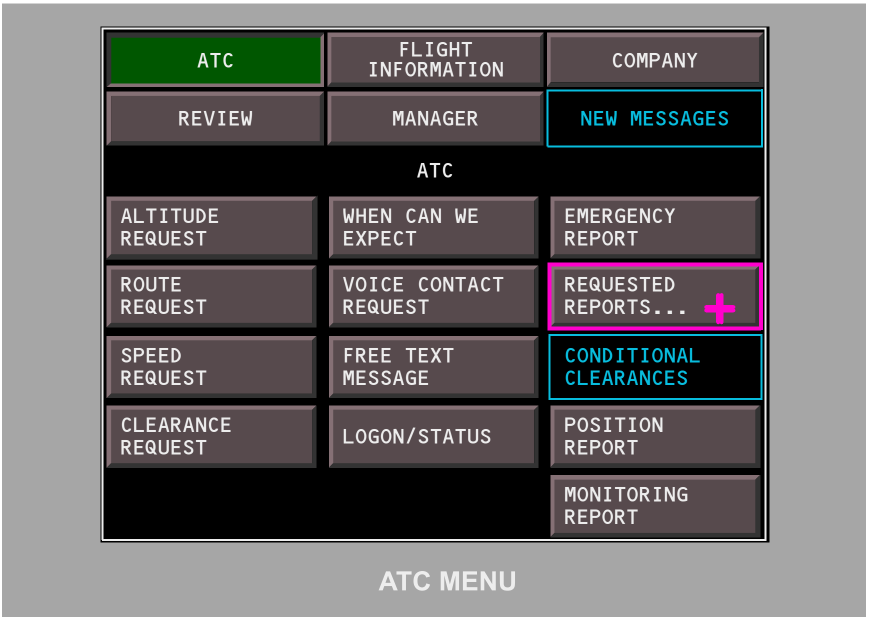
FMC Data Loading

Some ATC uplinks contain data for loading into the FMC. Display of the LOAD FMC command key indicates that FMC data is available for loading. Selecting LOAD FMC transfers data to the FMC and creates an FMC modification.

Both MFD information messages and help window messages provide indications of loading progress.

Downlink Pages

ATC Menu



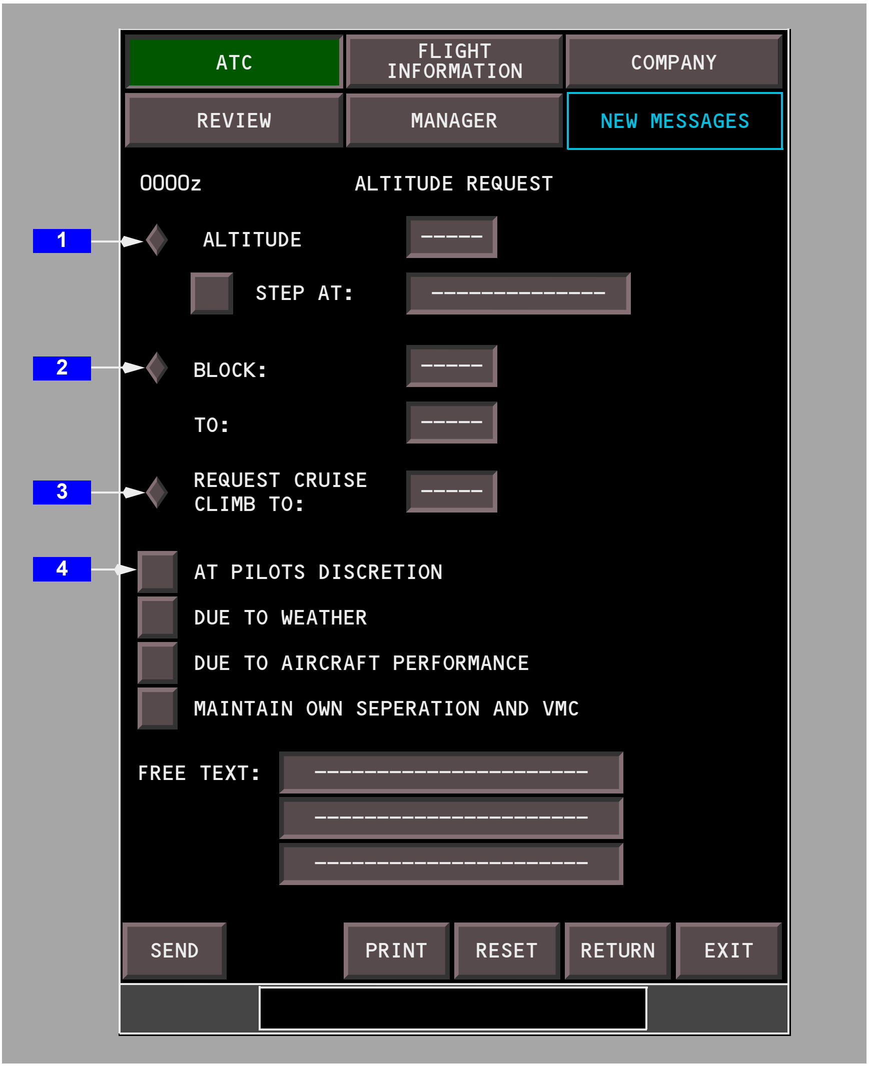
The ATC menu provides access to ATC downlink pages.

The ATC REQUESTED REPORTS menu selection is inhibited (cyan) when no reports are requested by ATC.

Note: This menu is not repeated when describing individual pages.

Altitude Request

The ALTITUDE REQUEST page allows selection of an altitude, an altitude block, or a VMC descent. A second request page allows selection of a reason for the request.



1 ALTITUDE

The requested altitude is entered into the dash prompt and the SEND key becomes active.

Pushing the SEND key requests a normal climb at climb power unless otherwise requested, or a normal descent.

Additional climb or descent options are:

- STEP AT – allows entering a time or position for the start of the climb or descent

STEP AT is inhibited when the ALTITUDE value is less than 150 feet from current airplane altitude. Altitude entries are any valid FMC altitude. Time entries are in four digit, hours and minutes, optionally followed by a Z. Position entries are any valid FMC position.

2 BLOCK

BLOCK is the beginning of a block altitude. TO is the end of the altitude block. Altitude entries are any valid FMC altitude.

The SEND key becomes active with an entry.

3 REQUEST CRUISE CLIMB TO

Begin a cruise climb from present position.

Assumes a minimum rate climb based on fuel burnoff.

Note: ALTITUDE should be used for a normal VNAV cruise climb.

The SEND key becomes active with this selection.

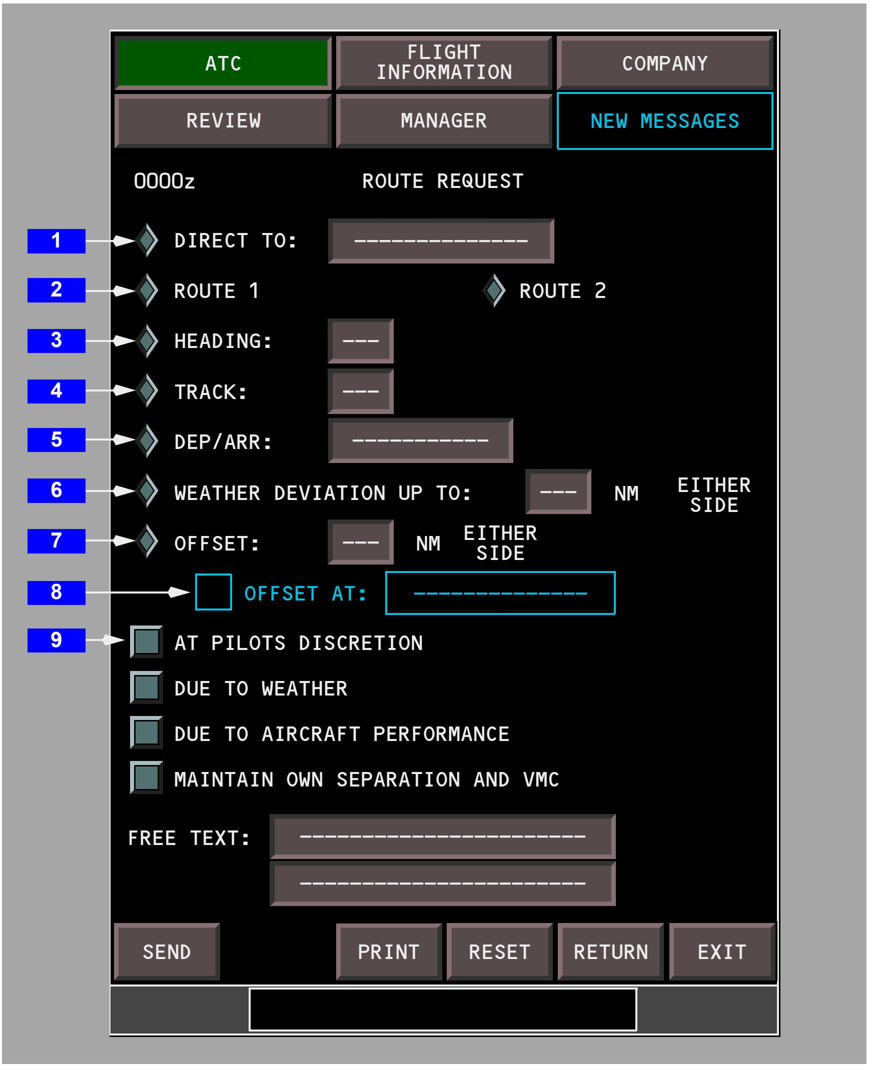
4 ADDITIONAL REQUEST INFORMATION

One or more reasons for a request are optionally selected.

Up to three lines of free text can be included.

Route Request

The ROUTE REQUEST page allows selection of a direct to waypoint, new route, heading or track, departure and transition, arrival and transition, weather deviation, or a route offset. A second request page allows selection of a reason for the request.



1 DIRECT TO

Enter any valid FMC waypoint. The SEND key becomes active with this selection.

2 ROUTE

Selects FMC route 1 or 2. Sends the selected route, including any modifications. The SEND key becomes active with this selection.

3 **HEADING**

Enter desired heading. When displays are referenced to true north, a TRU label is displayed right of the heading. The SEND key becomes active with this selection.

4 **TRACK**

Enter desired ground track. When displays are referenced to true north, a TRU label is displayed right of the ground track. The SEND key becomes active with this selection.

5 **DEP/ARR**

Enter one of the following:

- departure
- arrival
- departure and transition
- arrival and transition

Default entries are:

- departure procedure/transition selected for the selected route
- the approach procedure/transition selected for the active route when the airplane is in the air and an arrival procedure/transition is not selected

The SEND key becomes active when one of the check boxes is selected.

6 **WEATHER DEVIATION UP TO**

Enter desired offset in nautical miles. Valid entries are L (left) or R (right) NNN (NNN is any number from 1 to 128). The SEND key becomes active with this selection.

7 **OFFSET**

Enter desired FMC route offset in nautical miles. Valid entries are L (left) or R (right) XX (XX is any number from 1 to 99). The SEND key becomes active with this selection.

8 **OFFSET AT**

Enter a time or position to begin the offset. Time entries are in four digit, hours and minutes, optionally followed by a Z. Position entries are any valid FMC position.

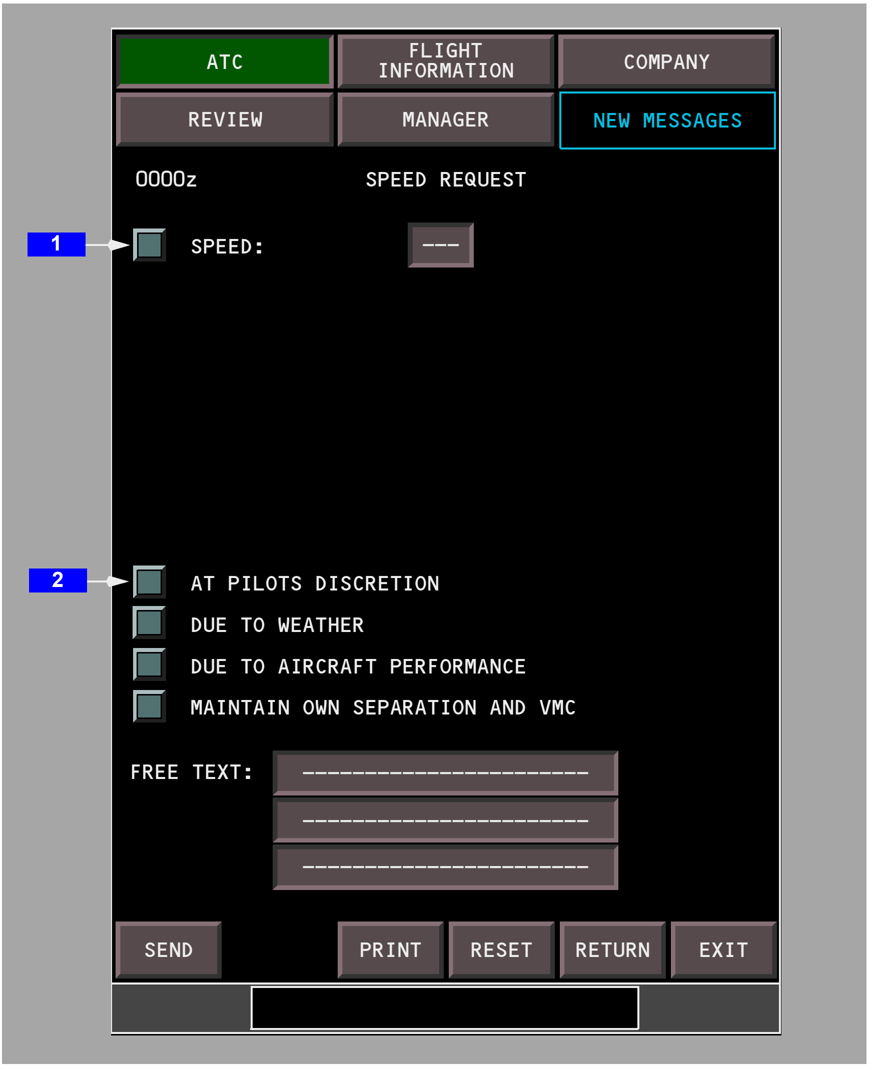
9 **ROUTE REQUEST REASON**

One or more reasons for a request are optionally selected.

Up to three lines of free text can be included.

Speed Request

The SPEED REQUEST page allows selection of speed. A second request page allows selection of a reason for the request.



1 SPEED

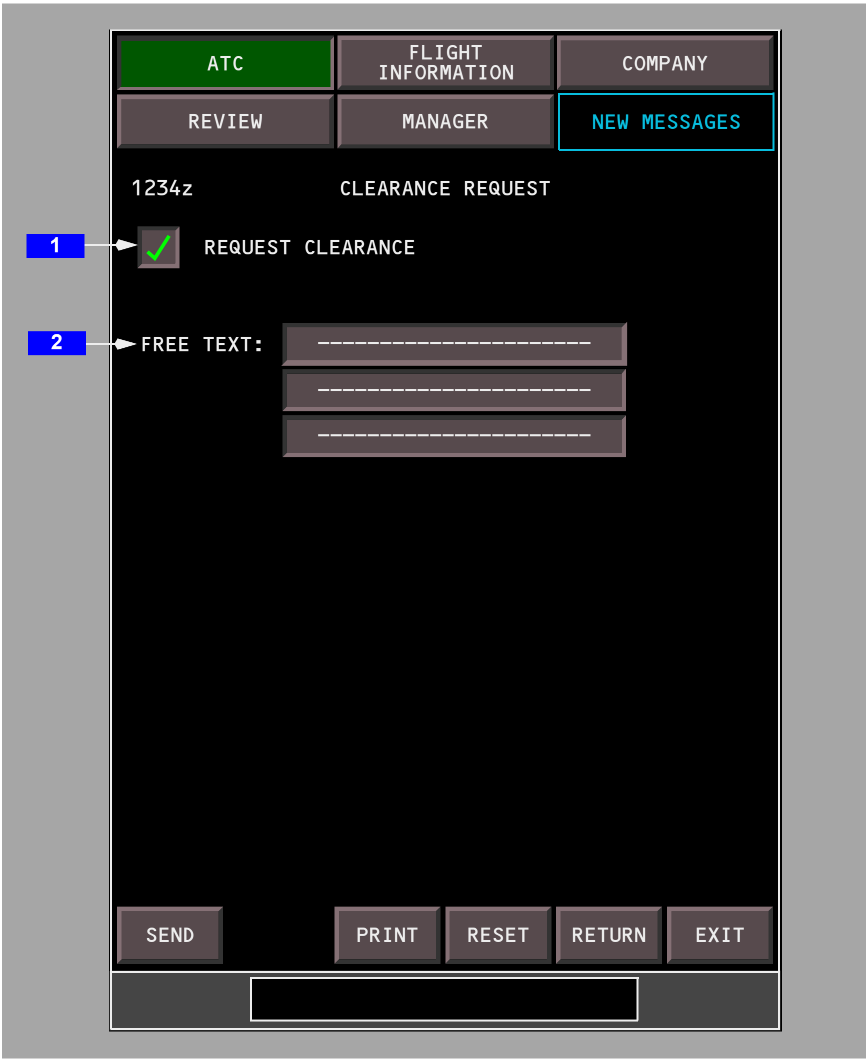
Enter any valid FMC speed or mach number. IAS entries are rounded to the nearest 10 knots. The SEND key becomes active with this entry.

2 SPEED REQUEST REASON

One or more reasons for a request are optionally selected.

Up to three lines of free text can be included.

Clearance Request



1 CLEARANCE REQUEST

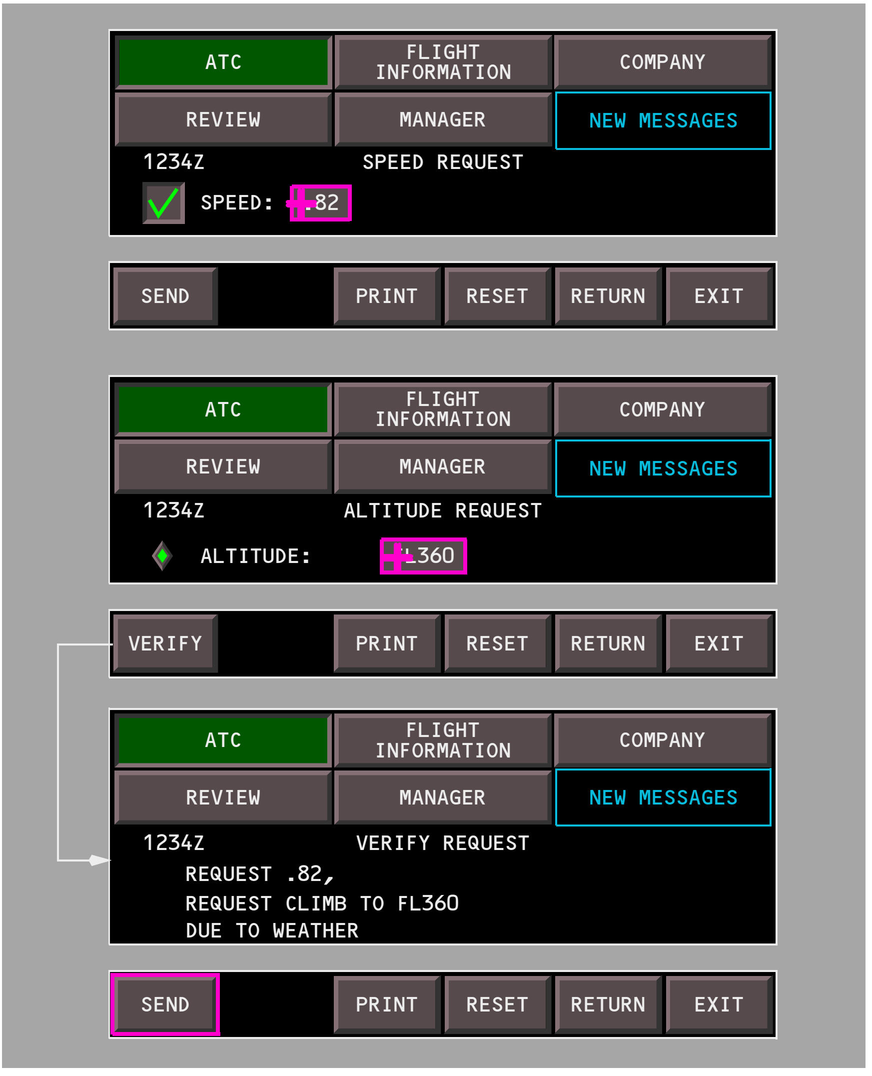
Informs ATC that the crew is ready for a clearance, such as predeparture or pushback.

The SEND key becomes active with this entry.

2 CLEARANCE REQUEST REASON

Up to three lines of free text can be included.

Combination Downlink Request



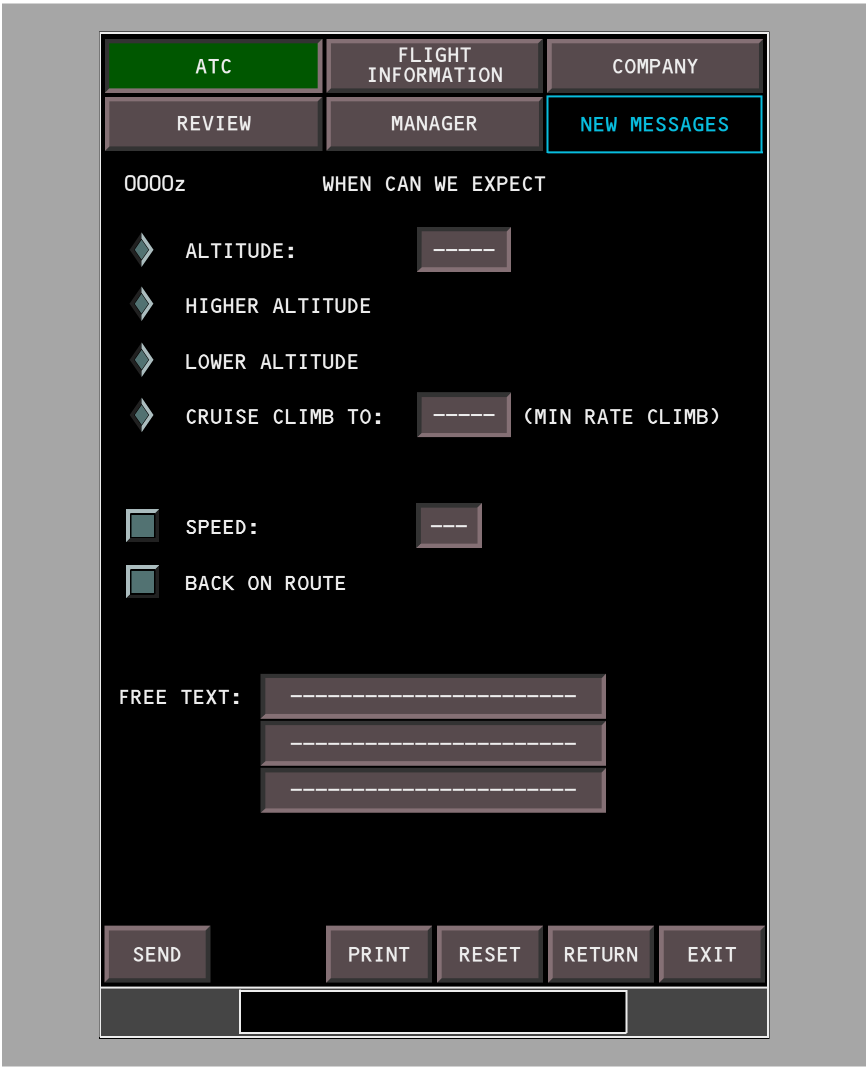
Requests from the altitude, speed, and route pages can be combined into one downlink request. Each request is individually selected and filled out. Select subsequent request pages by selecting RETURN, and selecting additional downlink pages from the ATC main menu. When data is entered into the second request page, the SEND key changes to VERIFY.

The SEND key is active on the VERIFY REQUEST page. A combined request is limited to five elements. Selecting a sixth request element displays the MESSAGE LIMIT EXCEEDED information message.

The verify page provides a display of the combined request elements. Each element is displayed on separate lines. Elements requiring revision before sending are revised on their respective request page. Selecting SEND transmits the combined downlink message to ATC.

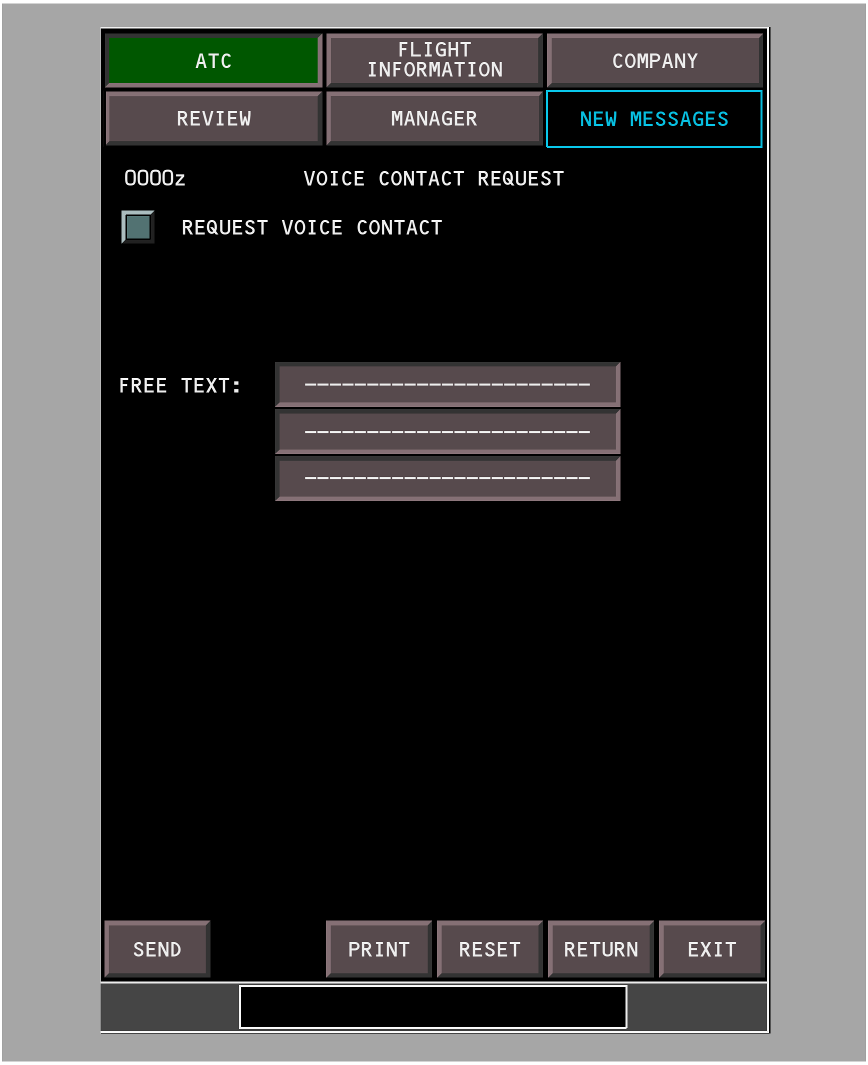
The example shows a combined altitude and speed request. The altitude request is created first.

When Can We Expect



Making selections asks ATC the time or location the crew can expect clearance for the requested items. Altitude, speed, and cruise climb entry rules are the same as on the ALTITUDE REQUEST and SPEED REQUEST pages. Up to three lines of free text can be included. The SEND key becomes active when a check box is selected.

Voice Contact Request

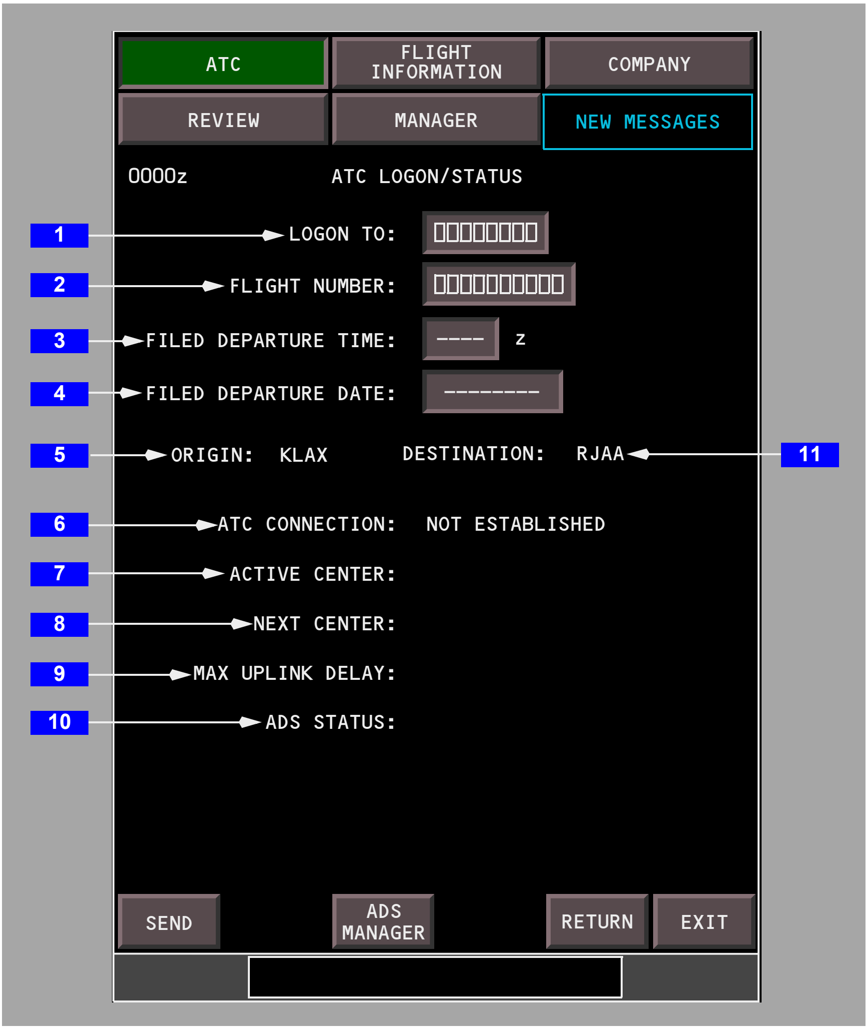


Making selection asks ATC for a voice contact. Up to three lines of free text can be included. The SEND key becomes active when the request for voice contact box is selected.

ATC Logon/Status

The ATC LOGON/STATUS page allows entry of the desired ATC facility for establishment of a datalink connection.

The SEND key is displayed after all logon entries are completed. Selecting the SEND key displays SENDING status during logon transmission. Five seconds after the logon status changes to SENT, the page is exited.



1 **LOGON TO**

Box prompts are initially displayed. Enter the ICAO four letter identifier for the desired ATC center. The display changes to dashed prompts after establishing an ATC connection.

2 **FLIGHT NUMBER**

Normally displays the flight number entered on the FMC route page. When the flight number is not available, box prompts are displayed. Flight number entry on this page is copied to the FMC route page. Changing this entry after establishing an ATC connection cancels the ATC connection.

3 **FILED DEPARTURE TIME**

Displays filed flight number UTC departure time.

4 **FILED DEPARTURE DATE**

Displays filed flight number departure date.

5 **ORIGIN**

Displays flight number airport of origin.

6 **ATC CONNECTION**

Displays the status of the ATC connection, ESTABLISHED or NOT ESTABLISHED.

7 **ACTIVE CENTER**

Displays the ATC facility identifier where a connection is established.

8 **NEXT CENTER**

Displays the ATC facility identifier to which an automatic handoff transfers the connection.

9 **MAX UPLINK DELAY**

Elapsed time from transmission to receipt of an ATC uplink message that triggers a late annunciation. The words "UPLINK DELAY EXCEEDED" precede any late ATC uplink message. Valid entries are from 1 to 999. Resets to off and displays dashes at:

- power-up
- datalink system reset
- ATC connection terminated
- "DELETE" entry

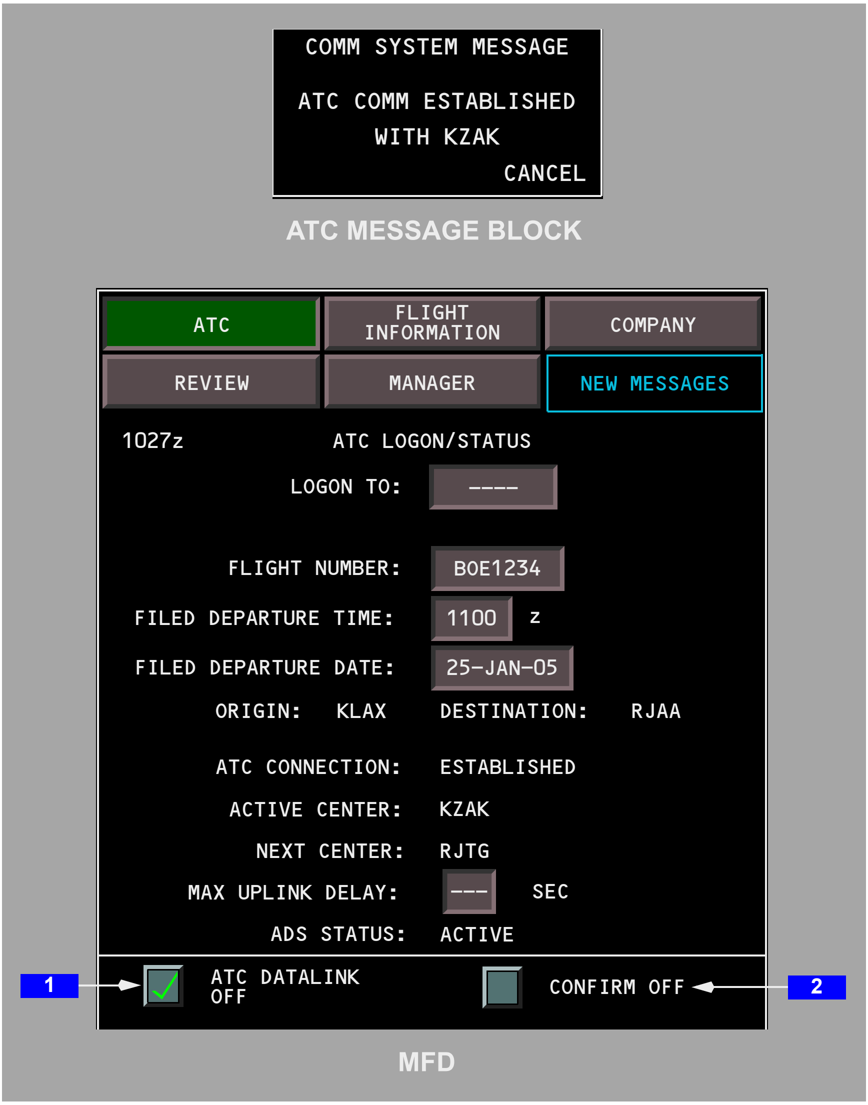
10 **ADS STATUS**

Displays status of ADS connection.

11 **DESTINATION**

Displays flight number destination airport.

ATC Connection Displays



1 **ATC DATALINK OFF**

Displayed when an ATC connection is established.

Selecting ATC DATALINK OFF displays the CONFIRM OFF selection.

2 **CONFIRM OFF**

Selecting CONFIRM OFF sends the termination request.

The EICAS ATC DATALINK LOST message is displayed when the connection is terminated.

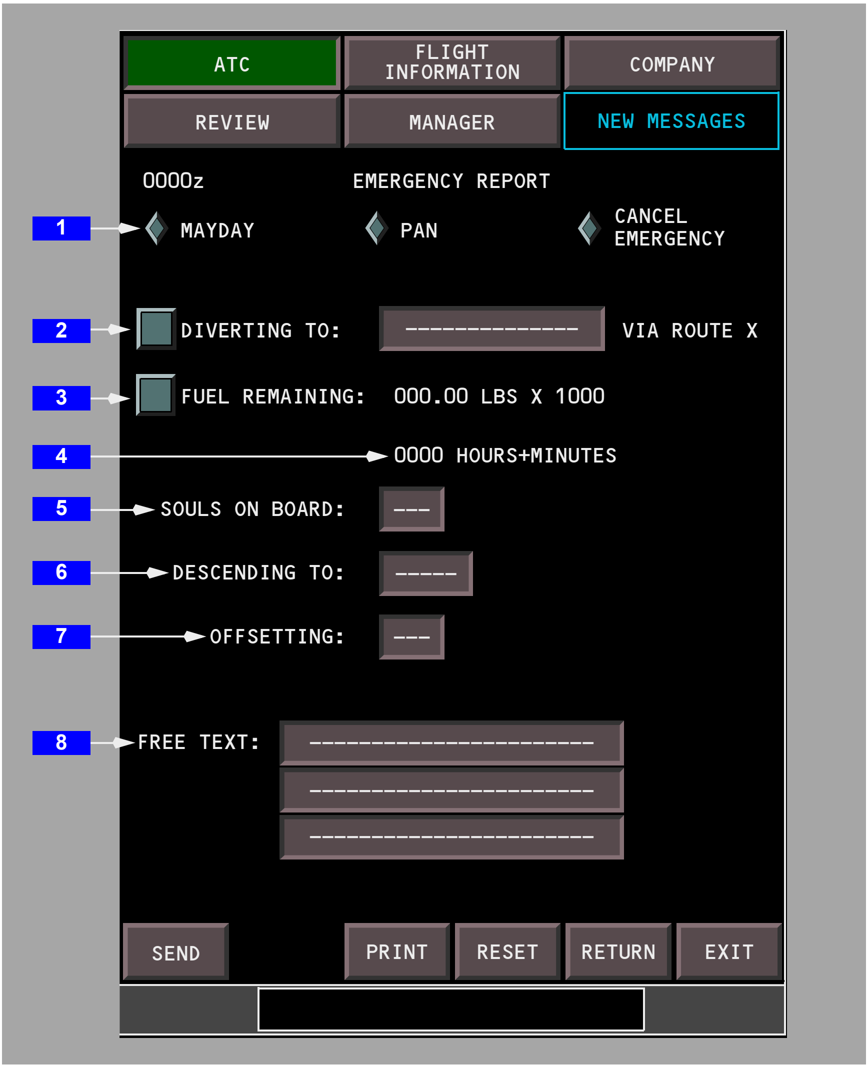
Loss of ATC Connection

If the EICAS advisory message DATALINK LOST is displayed for 16 minutes, the ATC connection is automatically lost and the EICAS advisory message ATC DATALINK LOST is displayed.

Once an ATC connection is terminated or lost, the logon entries revert to the default values.

Emergency Report

This page informs ATC of an emergency. Sending this report places automatic dependant surveillance (ADS) into the emergency mode.



1 **MAYDAY, PAN, CANCEL EMERGENCY**

Select MAYDAY or PAN emergency. The SEND key becomes active. CANCEL EMERGENCY informs ATC that a previous emergency is now canceled and returns ADS to the normal mode. CANCEL EMERGENCY is inhibited until MAYDAY or PAN downlink is sent.

2 **DIVERTING TO**

Defaults to the destination airport from the active route. The default route number is displayed. Enter any valid FMC position.

3 **FUEL REMAINING**

Displays the FMC fuel remaining from the PROGRESS page.

4 **FUEL REMAINING – HOURS + MINUTES**

Defaults to time provided from the FMC. Manually enter fuel remaining in hours and minutes. Use two numeric characters for hours followed by two numeric characters for minutes.

5 **SOULS ON BOARD**

Manual entry of number of souls on board is required. Enter up to three numeric characters.

6 **DESCENDING TO**

Enter the altitude for an immediate descent. The default value is the MCP altitude when it is more that 150 feet below current altitude.

7 **OFFSETTING**

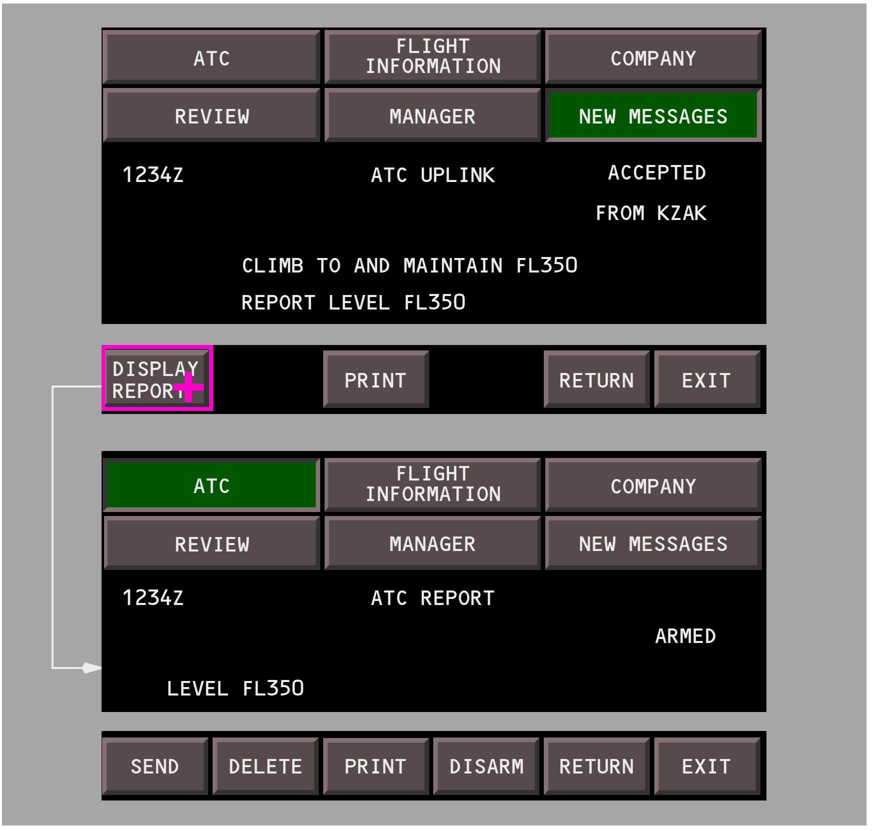
Enter any valid FMC route offset value.

8 **FREE TEXT**

Up to three lines of free text can be included.

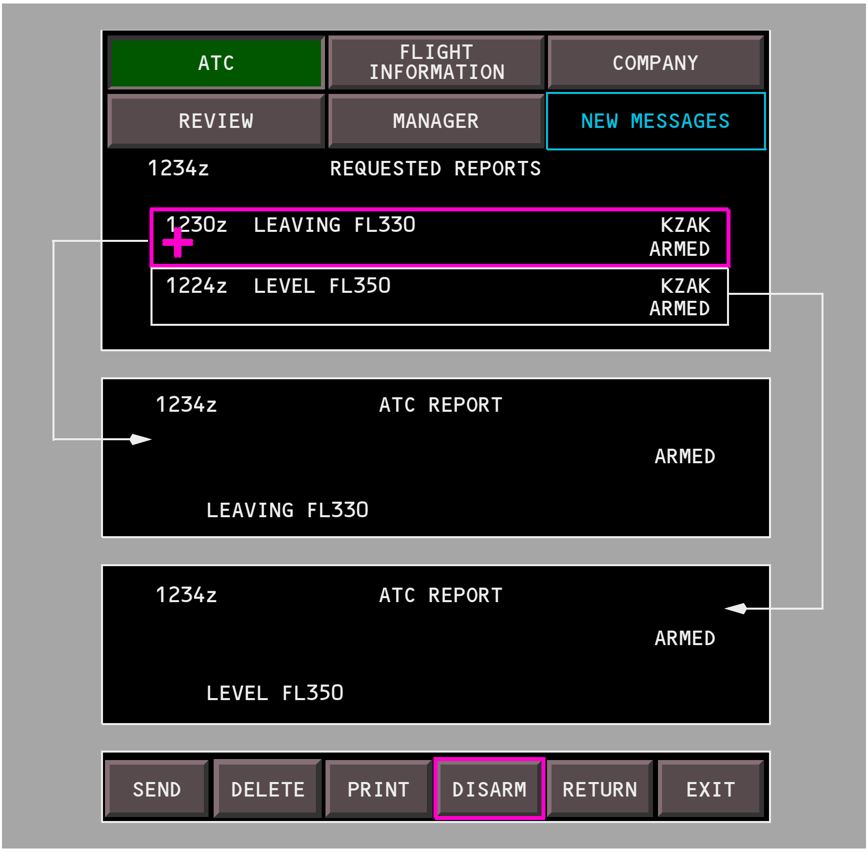
ATC Reports

ATC Requested Report



ATC uplink messages can contain a request for a report. When the uplink is accepted, the DISPLAY REPORT key is displayed. Selecting DISPLAY REPORT displays the ATC requested report. A displayed report can be sent. Some reports can be armed for automatic transmission when conditions are met.

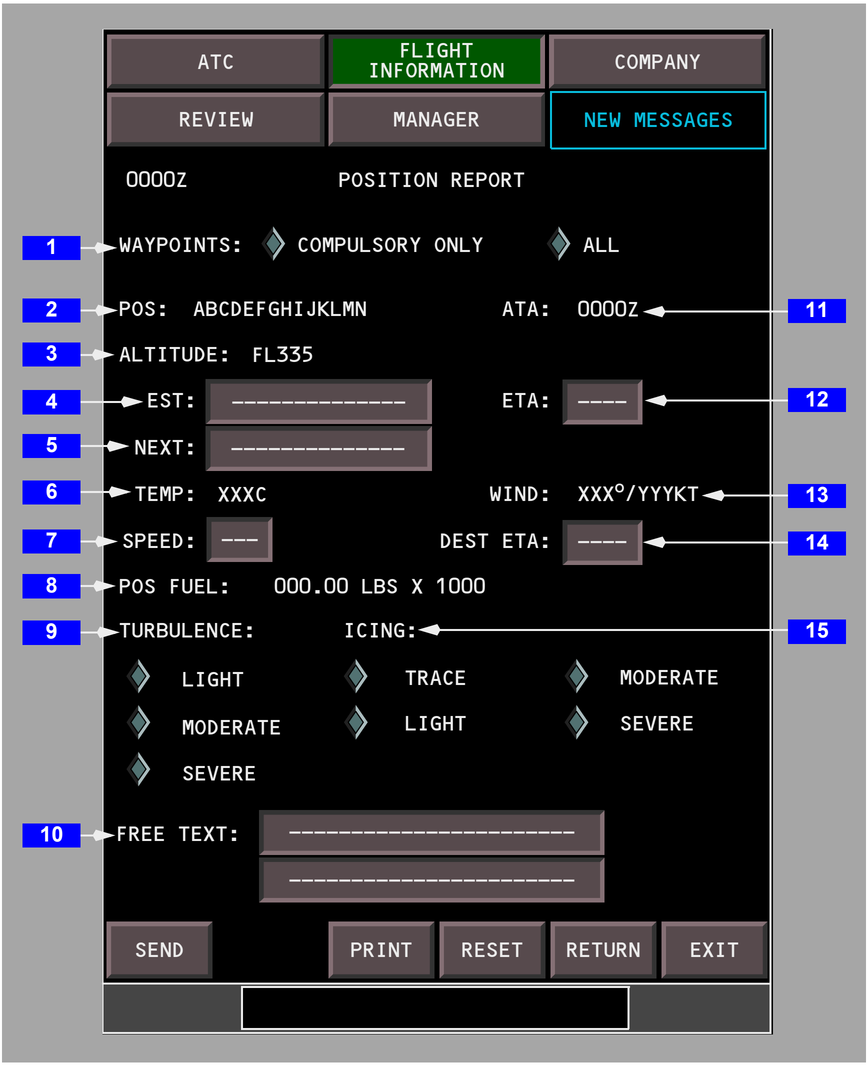
Armable Report



All reports requested by ATC can be displayed using the ATC REQUESTED REPORT menu selection. The LEAVING, LEVEL, PASSING, and REACHING reports can be armed for automatic transmission. Selecting the ARM key for a report displays ARMED for the report status. When a report is armed, the ARM key changes to DISARM. When a report is automatically transmitted, an ATC uplink message confirms the report was sent.

Position Report

Use the POSITION REPORT page to manually send a position report.



1 WAYPOINTS

COMPULSORY ONLY – reports only compulsory fixes as defined in the FMC NAV database for the active route.

ALL – reports all fixes for the active route as shown on the FMC LEGS page.

2 POS

Displays the last sequenced FMC waypoint. Displays all asterisks (*) when no FMC data is available.

Latitude and longitude are displayed in the same order as the FMC position report page. Degree and minute values precede the compass letter, just as the crew uses in a voice report.

3 ALTITUDE

Displays current altitude.

4 EST

Displays the next FMC waypoint. Accepts any valid FMC waypoint entry. Requires manual entry for ATC reporting position which is not a route waypoint.

5 NEXT

Displays the next FMC waypoint following EST waypoint. Accepts any valid FMC waypoint entry. Requires manual entry for ATC reporting position which is not a route waypoint.

6 TEMP

Displays current air temperature. Displays all asterisks (*) when no FMC data is available.

7 SPEED

Displays the current FMC speed. Accepts valid speed entry. Displays all asterisks (*) when no FMC data is available.

8 POS FUEL

Displays FMC calculated fuel remaining at the POS waypoint. Displays all asterisks (*) when no FMC data is available.

9 TURBULANCE

Select LIGHT, MODERATE or SEVERE to report current turbulence condition.

10 FREE TEXT

Up to two lines of free text can be included.

11 ATA

Displays actual time of arrival at the last sequenced FMC waypoint. Displays all asterisks (*) when no FMC data is available.

12 ETA

Displays estimated time of arrival for the next FMC waypoint. Accepts valid time entry.

13 WIND

Displays current wind bearing and speed. Displays all asterisks (*) when no FMC data is available.

14 **DEST ETA**

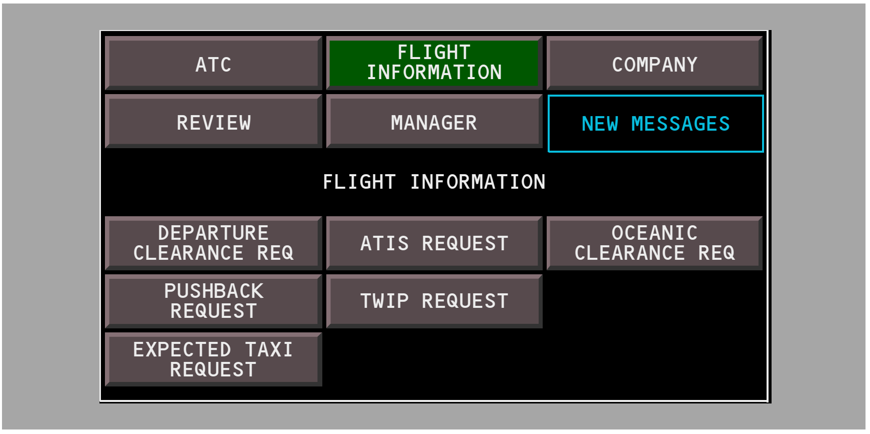
Displays estimated time of arrival for the last FMC waypoint. Accepts a valid time entry. Displays all asterisks (*) when no FMC data is available.

15 **ICING**

Select TRACE, LIGHT, MODERATE or SEVERE to report current icing condition.

Flight Information

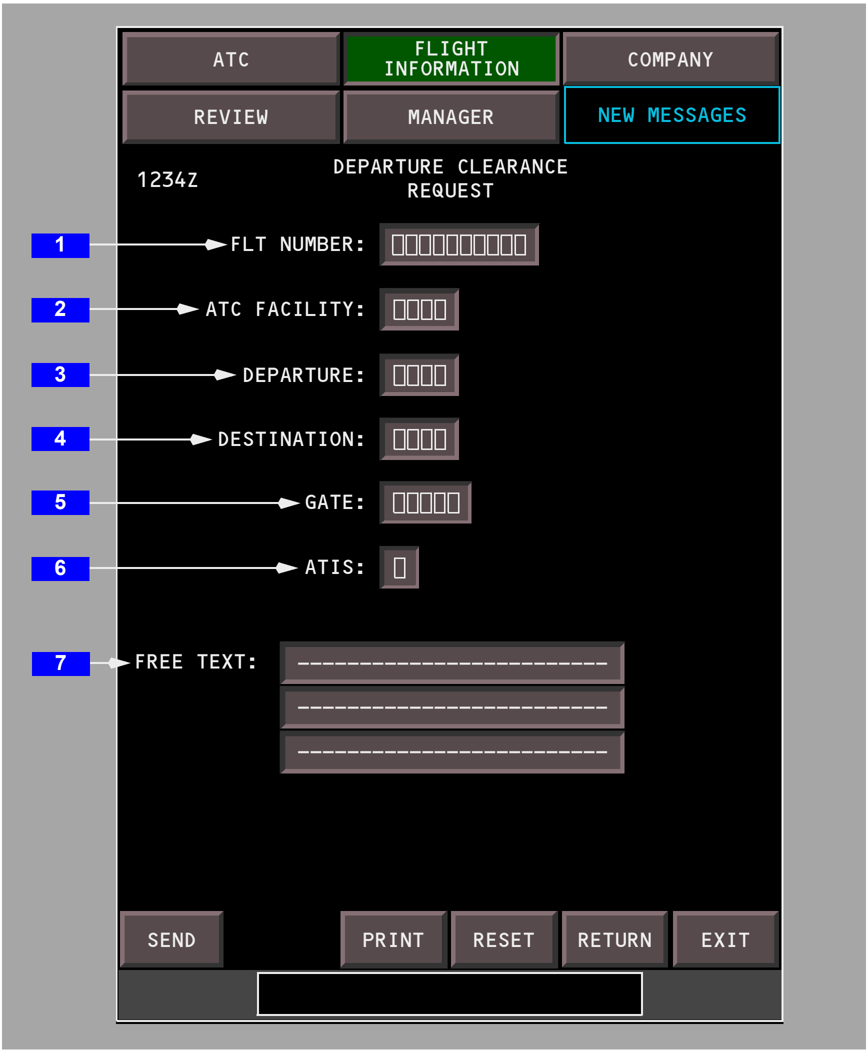
Flight Information Menu



The Flight Information menu provides access to FLIGHT INFORMATION downlink pages.

Departure Clearance Request

The DEPARTURE CLEARANCE REQUEST page allows request downlinks to obtain clearance via datalink in a more timely manner with reduced risk of incorrect voice transmission. The clearance may be viewed on the MFD or printed.



1 FLIGHT NUMBER

Flight number defaults to FMC flight number, if entered.

When boxes display, valid entry is flight number up to 10 characters.

Note: Entering a new flight number terminates the current ATC connection.

2 ATC FACILITY

Valid entry is a 4 character ATC facility identifier.

3 DEPARTURE

Departure airport defaults to FMC origin.

Valid entry is a valid ICAO identifier.

4 DESTINATION

Destination airport defaults to FMC destination.

Valid entry is a valid ICAO identifier.

5 GATE

Valid entry is a gate number at the reference airport, POS INIT page.

6 ATIS

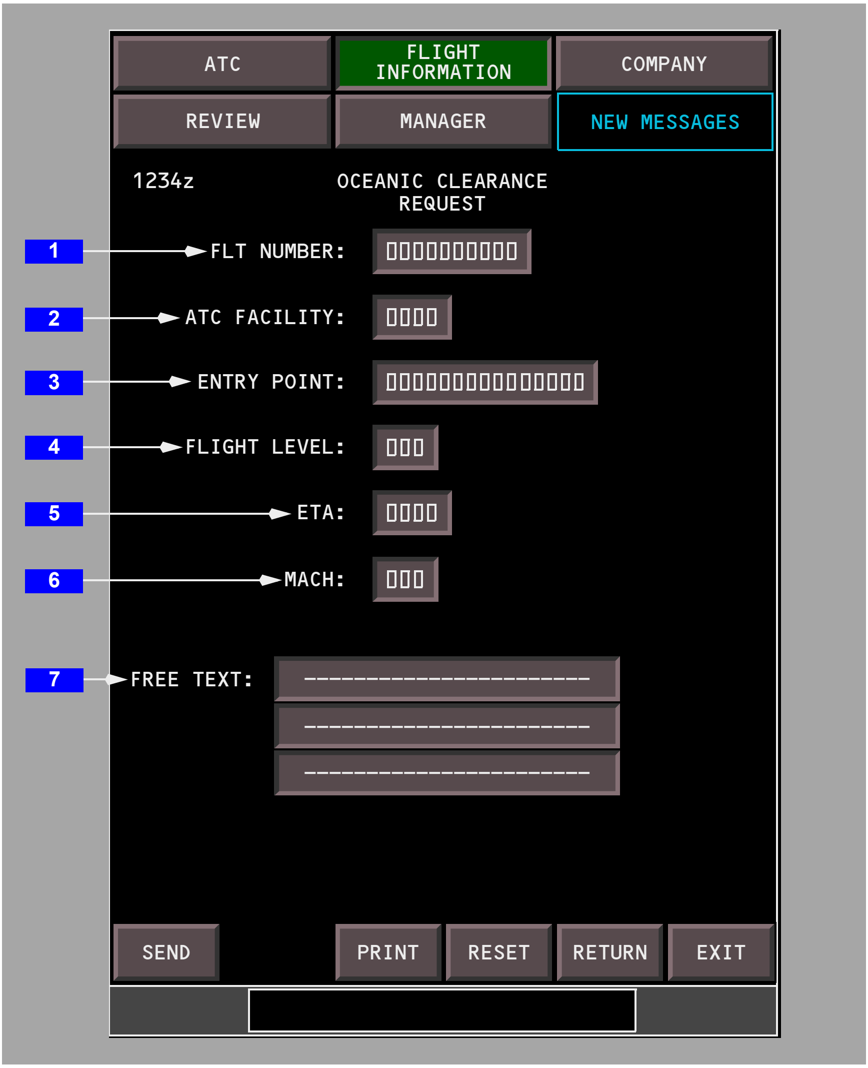
Valid entry is any character A through Z.

7 FREE TEXT

Up to three lines of free text can be included.

Oceanic Clearance Request

The OCEANIC CLEARANCE REQUEST page allows request downlinks to obtain clearance via datalink in a more timely manner with reduced risk of incorrect voice transmission. The clearance information may be viewed on the MFD or printed.



1 FLIGHT NUMBER

Flight number defaults to FMC flight number, if entered.

When boxes display, valid entry is flight number up to 10 characters.

Note: Entering a new flight number terminates the current ATC connection.

2 ATC FACILITY

Valid entry is a 4 character ATC facility identifier.

3 ENTRY POINT

Valid entry is up to 15 characters; tenths of a minute of latitude or longitude may not display. A valid entry must be at least 3 characters. Entries of 7 or more characters are decoded as a latitude/longitude.

4 FLIGHT LEVEL

Valid entry is a 3 character flight level; for example, 350.

5 ETA

If an ENTRY POINT has been entered, it is a waypoint in the active route, and an ETA has not been entered; the ETA box defaults to the predicted ETA at the waypoint.

Valid entry is any time in the range 0000 to 2359.

6 MACH

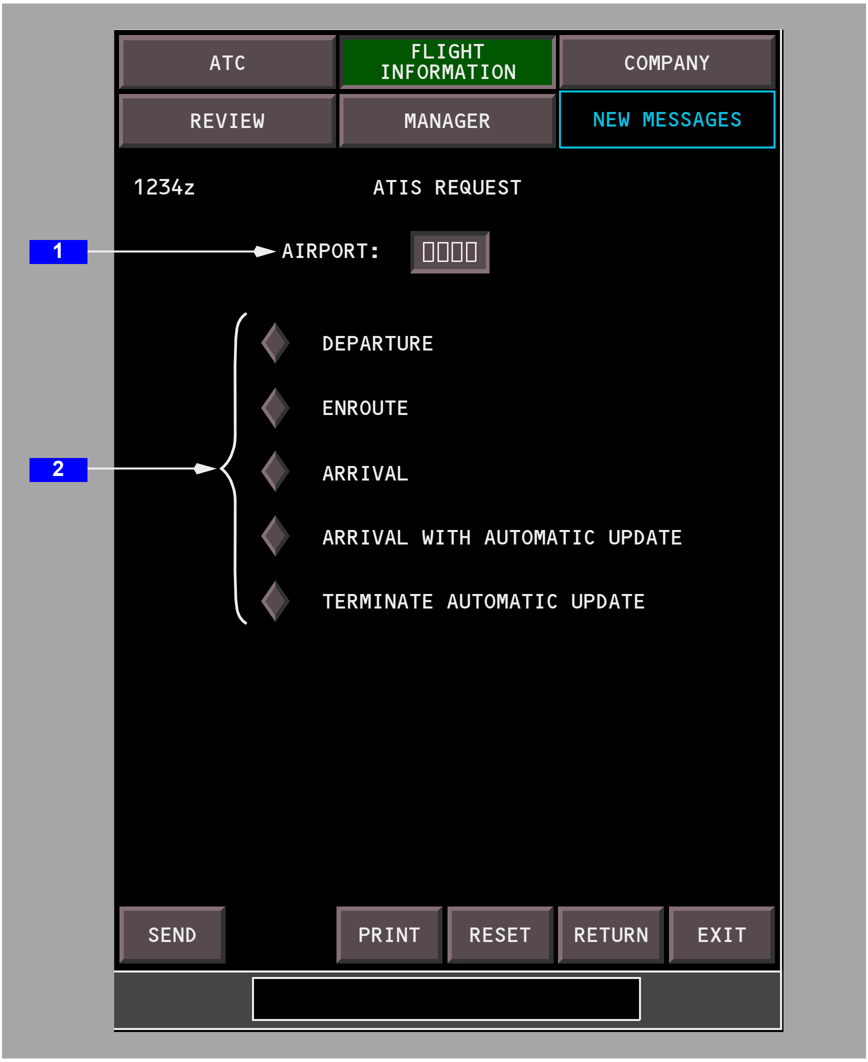
Valid entry is any Mach number between 0.4 and 0.92. Entry of leading zero and decimal point is not required.

7 FREE TEXT

Up to three lines of free text can be included.

ATIS Request

The ATIS REQUEST page allows request downlinks for digital ATIS information without using voice radio. ATIS information may be viewed on the MFD or printed.



1 AIRPORT

If a departure airport exists in the active route and the airplane is on the ground, the default entry is the departure airport. If the destination airport exists in the active route and the airplane is in flight, the default entry is the destination airport.

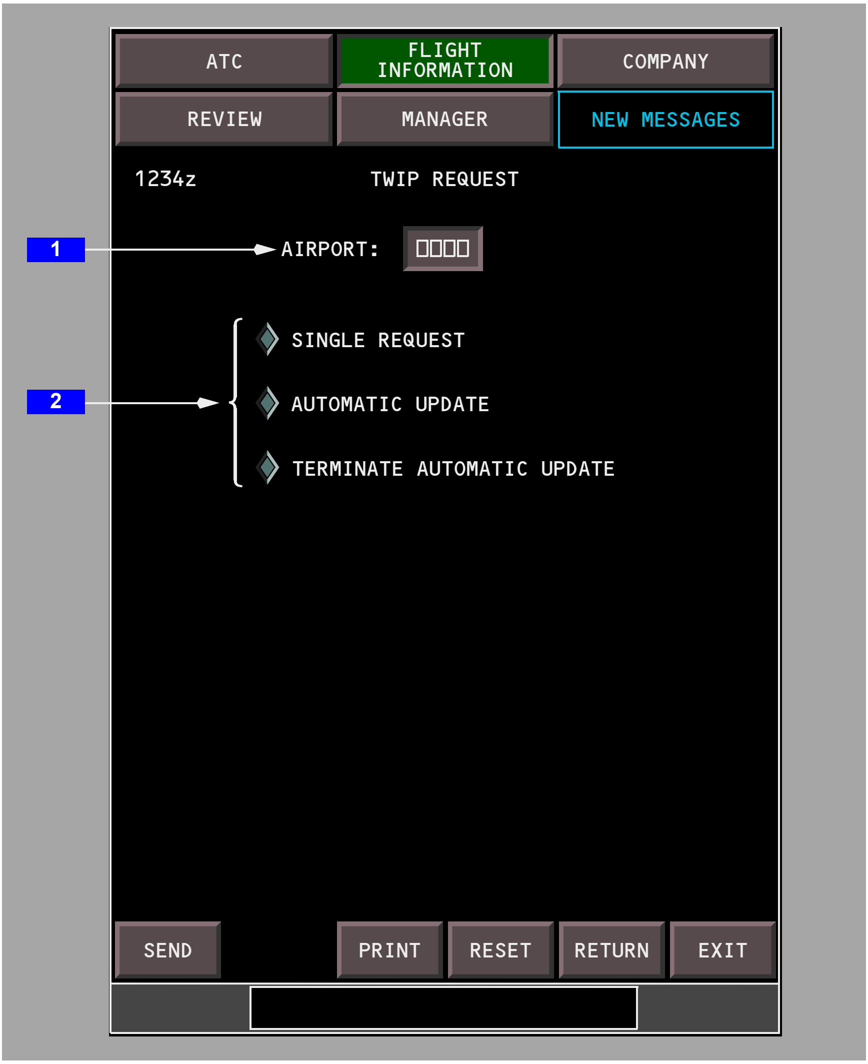
Valid entry is a four character ICAO identifier.

2 ATIS SELECTOR GROUP

The default is none selected. Only one selection can be made at a time. If ENROUTE selected, updating is automatic. TERMINATE AUTOMATIC UPDATE is inhibited unless an automatic update has been requested. The SEND key becomes active with selection. Pushing the SEND key requests the selected information.

TWIP Request

The Terminal Weather Information for Pilots (TWIP) REQUEST page allows request downlinks for digital weather information without using voice radio. TWIP information may be viewed on the MFD or printed.



1 AIRPORT

If a departure airport exists in the active route and the airplane is on the ground, the default entry is the departure airport. If the destination airport exists in the active route and the airplane is in flight, the default entry is the destination airport.

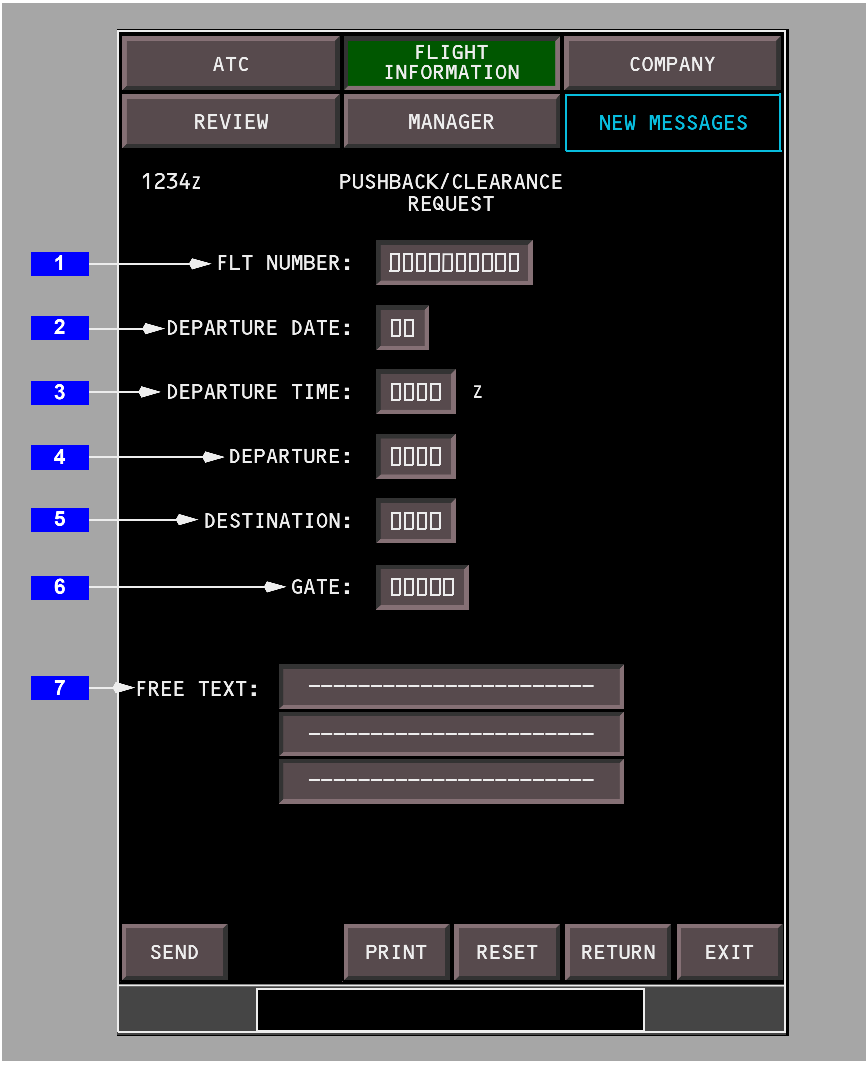
Valid entry is a four character ICAO identifier.

2 TWIP SELECTOR GROUP

The default is none selected. Only one selection can be made at a time. TERMINATE AUTOMATIC UPDATE is inhibited unless an automatic update has been requested. The SEND key becomes active with selection. Pushing the SEND key requests the selected information.

Pushback Clearance Request

The PUSHBACK CLEARANCE REQUEST page allows request downlinks for pushback information without using voice radio. Pushback information may be viewed on the MFD or printed.



1 FLIGHT NUMBER

Flight number defaults to FMC flight number, if entered.

When boxes display, valid entry is flight number up to 10 characters.

Note: Entering a new flight number terminates the current ATC connection.

2 DEPARTURE DATE

Departure date defaults to the current date.

Enter day of the month of scheduled departure, any number between 1 and 31.

3 DEPARTURE TIME

Departure time defaults to ETD entered on ATC LOGON/STATUS page unless a different time has been entered on the EXPECTED TAXI CLEARANCE REQUEST.

Any valid UTC departure time may be entered.

4 DEPARTURE

Defaults to the departure airport in the active FMS route.

Valid entry is a four character ICAO identifier.

5 DESTINATION

Defaults to the destination airport in the active FMS route.

Valid entry is a four character ICAO identifier.

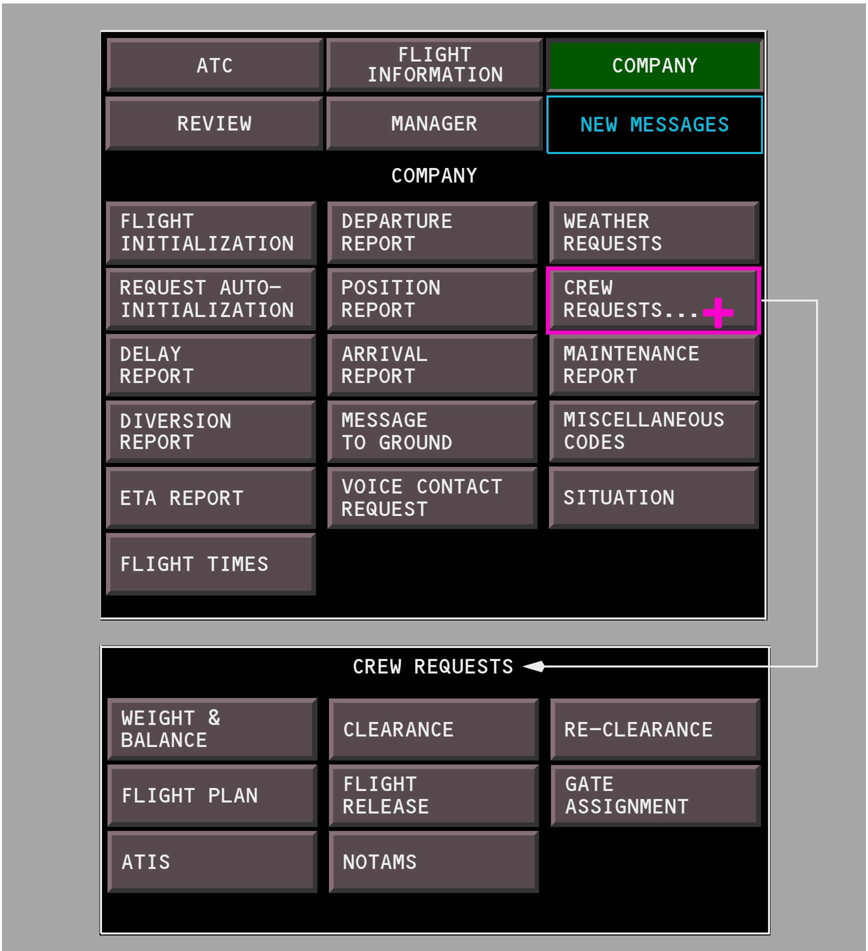
6 GATE

Allows entry of up to five alphanumeric characters.

7 FREE TEXT

Up to three lines of free text can be included.

Company Menu



(Typical)

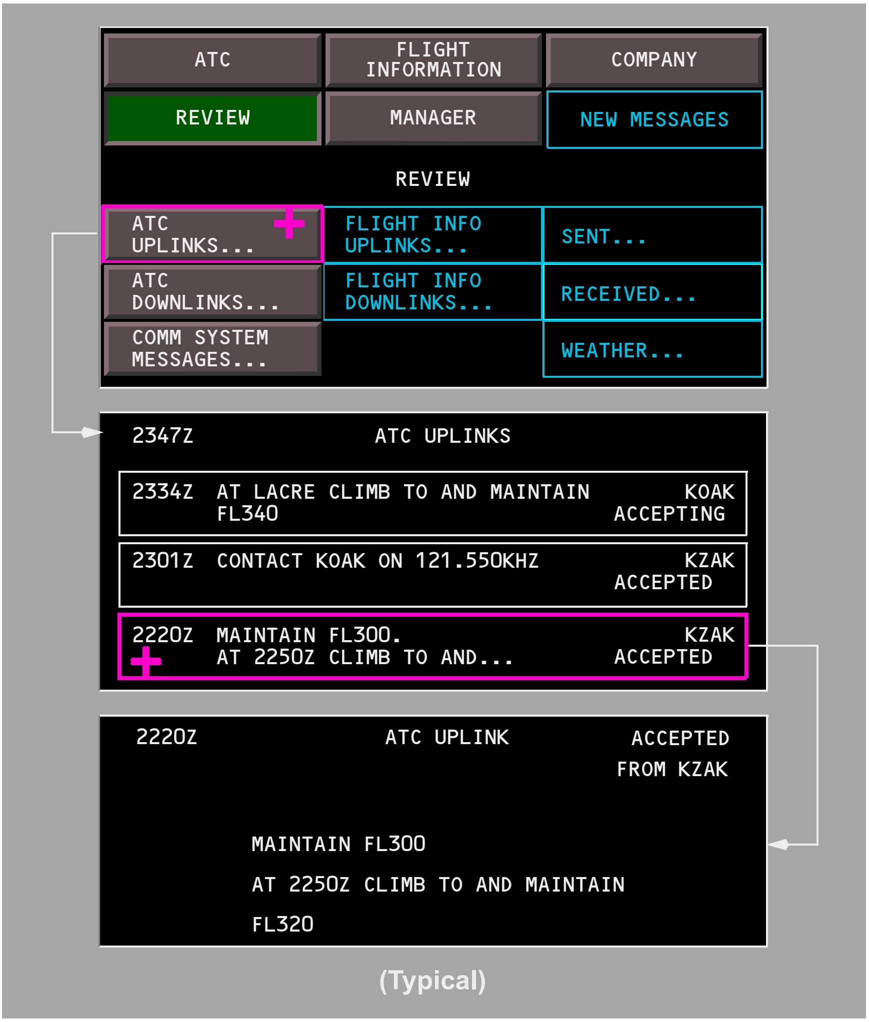
Company downlink menus are accessed by selecting the COMPANY function. Actual menu and page layout is determined by the airline. An example of a typical menu and report page are provided to show common features.

Company Downlink Message Page

(Typical)

This typical COMPANY report page shows exclusive selections, required entry, and optional menu selections.

Review Menu



(Typical)

Review messages are accessed by selecting the REVIEW menu. Both uplink and downlink messages are displayed in review lists. The review menu is inhibited (cyan) if there are no review messages in that category.

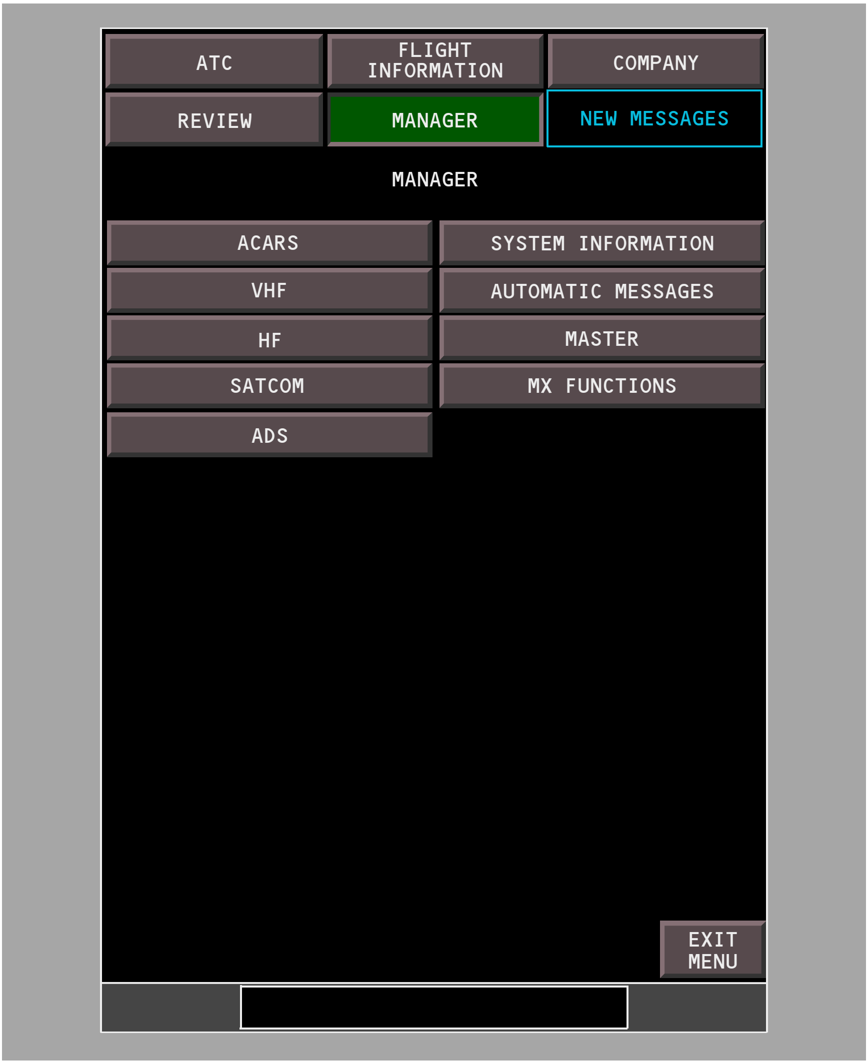
Review State Indicators

Each review message list field and each review message displays the last state of the referenced message. Only one state can apply to a message at a time.

State Indicator	Condition
ABORTED	ATC datalink connection lost before sending response to uplink message or completing a downlink message.
ACCEPTING	The received message was displayed and an ACCEPT response was initiated.
ACCEPTED	The received message was displayed, an ACCEPT response was initiated, and the service provider has acknowledged receipt of the response.
DISPLAYED	The received message was displayed (no accept/reject response was required).
NO ACCEPT	The received message was displayed, an ACCEPT response was initiated, but the service provider did not acknowledge receipt of the response.
NO REJECT	The received message was displayed, a REJECT response was initiated, but the message destination did not acknowledge receipt of the response.
NO SEND	The downlink message was initiated to be sent and the service provider did not acknowledge receipt of the message.
REJECTING	The received message was displayed and a REJECT response was initiated.
REJECTED	The received message was displayed, a REJECT response was initiated, and the message destination has acknowledged receipt of the response.
RESPONSE RCVD	ATC uplink message received in response to a downlink request.
SENDING	The downlink message was initiated to be sent.
SENT	The downlink message was initiated to be sent and the service provider has acknowledged receipt of the message.

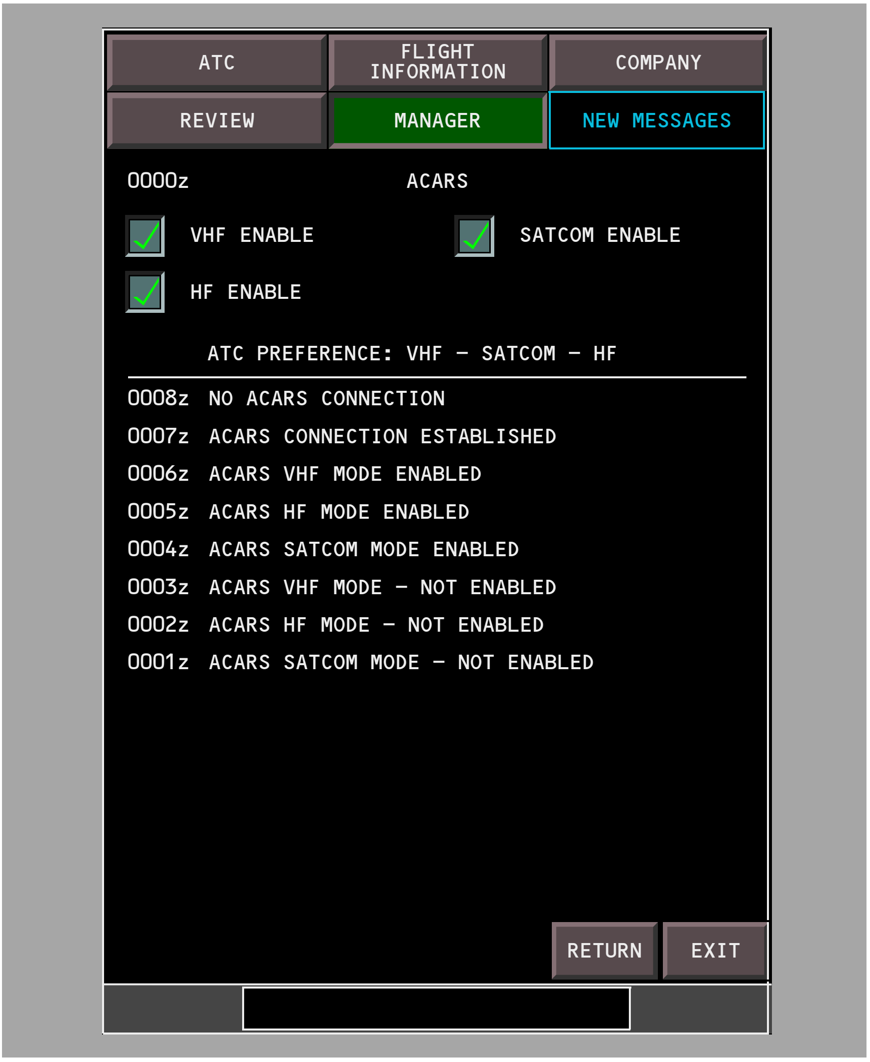
Manager Functions

Manager Menu



The MANAGER menu page provides access to the manager functions.

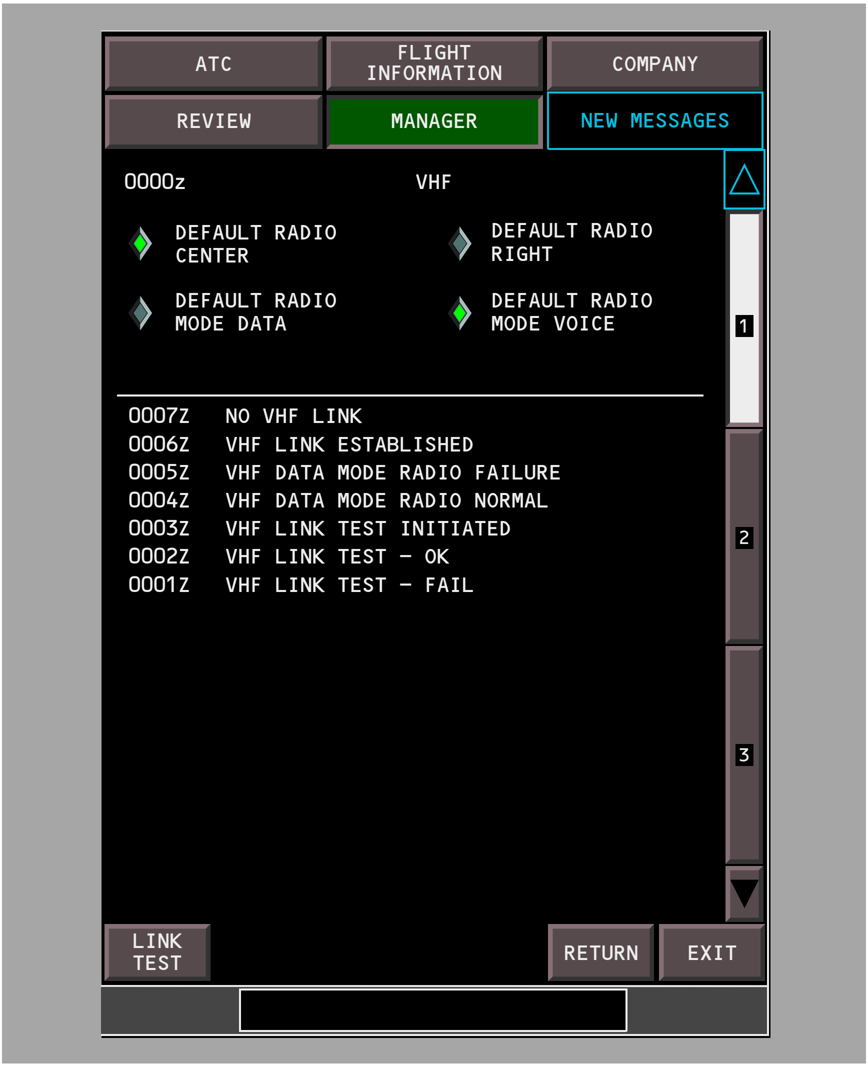
ACARS Manager



This page allows the operator to select/deselect VHF, SATCOM, or HF transmission of data. ACARS is set to auto mode (all boxes selected) at power-up or data communication system reset. Normally, this permits ACARS to automatically use VHF, SATCOM (if VHF is unavailable), or HF (if VHF and SATCOM are unavailable). If all boxes are deselected, ACARS loses the capability to send downlink messages, but can receive and display uplink messages.

The lower portion of the ACARS page displays system status messages.

VHF Manager



The VHF manager page provides the capability to select the default radio and to configure the default radio to the voice or data mode. Manager messages related to the VHF system are also presented on this page.

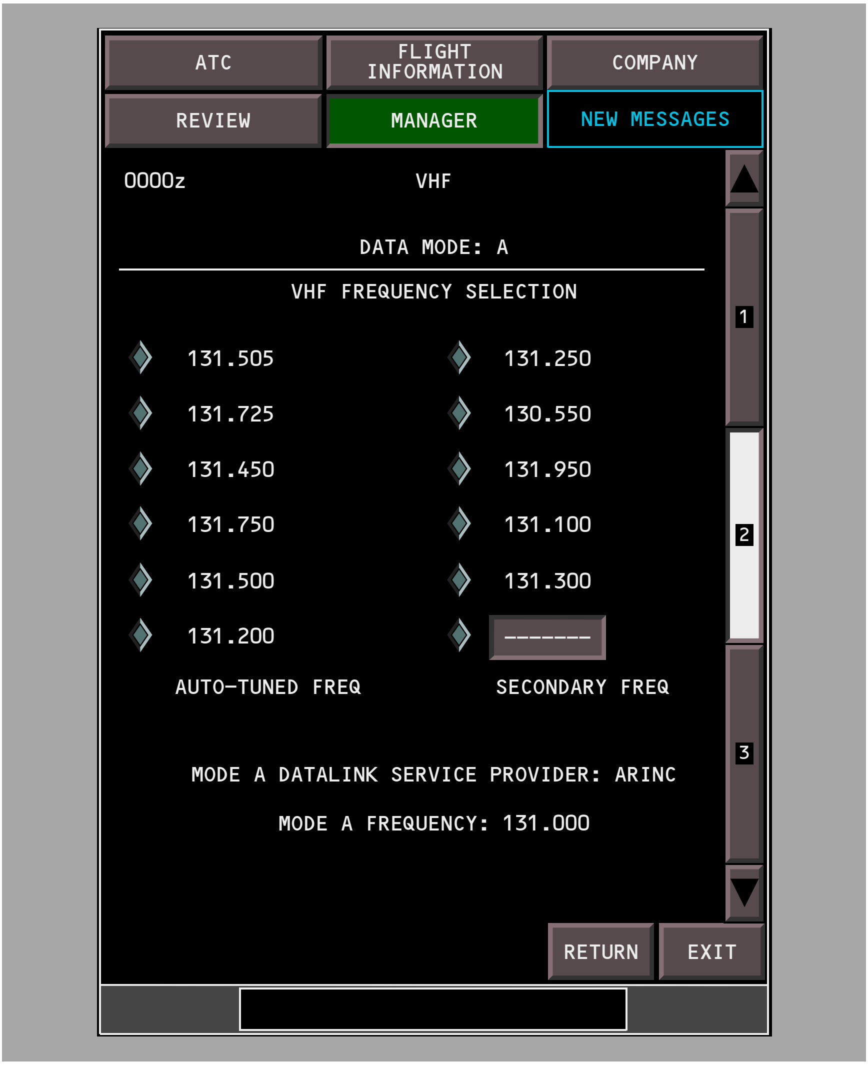
If the DEFAULT RADIO CENTER key is selected, the center VHF radio becomes the default radio. If the DEFAULT RADIO RIGHT key is selected, the right VHF radio becomes the default radio.

If the DEFAULT RADIO MODE DATA key is selected, the default radio is set to the data mode. If the DEFAULT RADIO MODE VOICE key is selected, the default radio is set to the voice mode

The lower portion of the VHF page displays system status messages.

Note: The default radio can also be set to the data or voice mode via the TCP.

VHF Manager Page 2/3

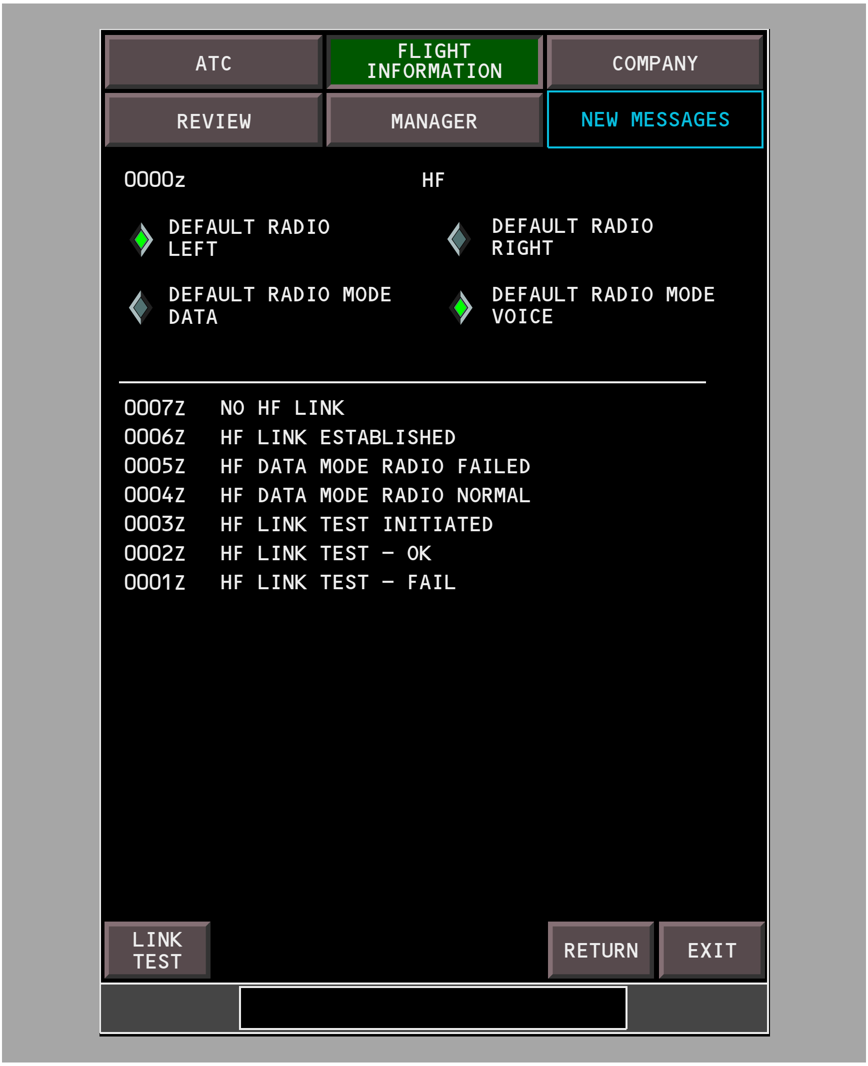


The VHF manager page 2/3 provides selection of ACARS frequencies and mode. If a FREQUENCY key is selected, the ACARS system tunes to the appropriate frequency. If a secondary frequency is entered, the SECONDARY FREQUENCY key becomes active and must be selected to tune to the secondary frequency. Frequency selections are normally changed automatically by ACARS.

VHF Manager Page 3/3

The VHF manager page 3/3 provides override capability of the automatically selected datalink region based on airplane position. When a manual selection is made, the RETURN TO AUTO selection becomes available. Selecting RETURN TO AUTO returns control of region selection back to CMF.

HF Manager



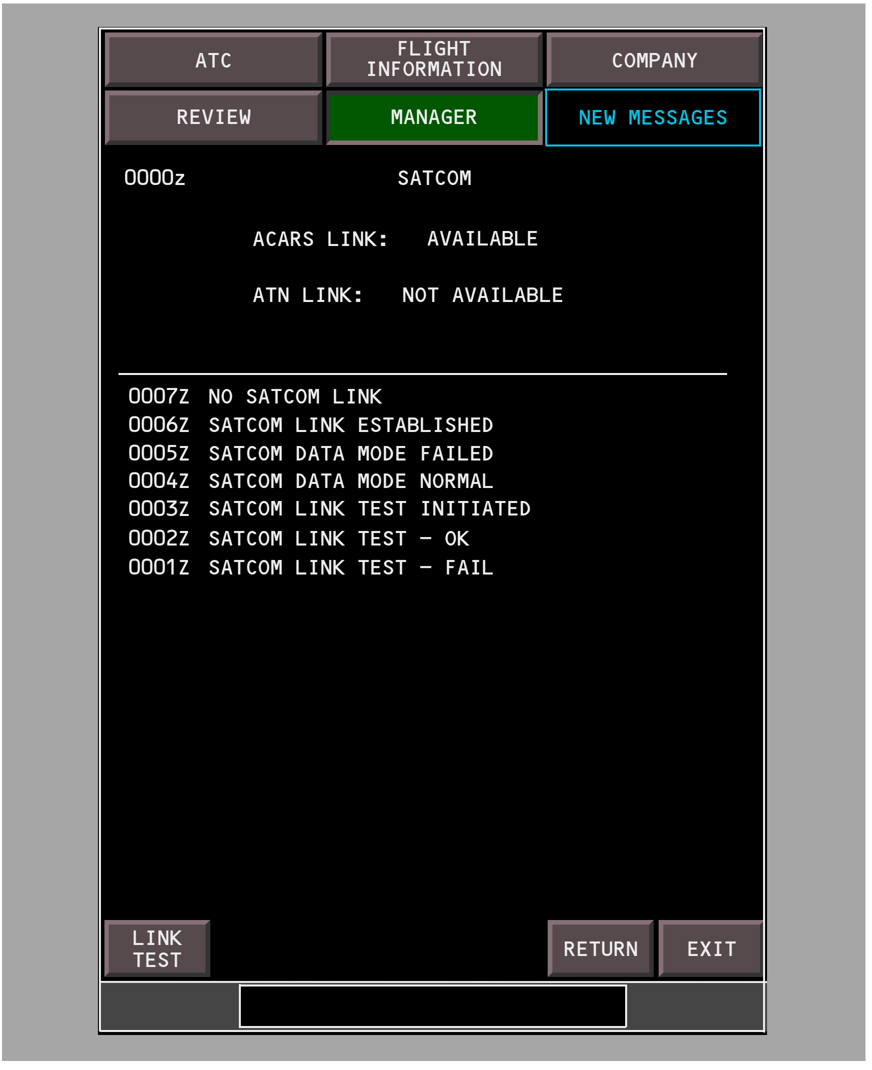
If the DEFAULT RADIO LEFT is selected, the left HF radio becomes the default radio. If the DEFAULT RADIO RIGHT is selected, the right HF radio becomes the default radio.

If the DEFAULT RADIO MODE: DATA is selected, the default HF radio is set to data mode. If the DEFAULT RADIO MODE: VOICE is selected, the default HF radio is set to voice mode.

The lower portion of the HF page displays system status messages.

Note: The default HF radio can also be set to the data or voice mode via the TCP.

SATCOM Manager



The SATCOM manager page displays manager messages related to the SATCOM system.

The lower portion of the SATCOM page displays system status messages.

Automatic Dependent Surveillance Manager

When automatic dependant surveillance (ADS) is armed, AUTOMATIC position report messages are sent to ATC and COMPANY.

The ADS page controls the following airplane ADS functions:

- ADS ARM – allows airplane ADS functions
- ADS OFF – inhibits airplane ADS functions

- ADS EMERGENCY – sends an alert to ATC indicating an emergency situation (resets to ADS EMERGENCY OFF at power-up)
- ADS EMERGENCY OFF – cancels emergency indication to ATC

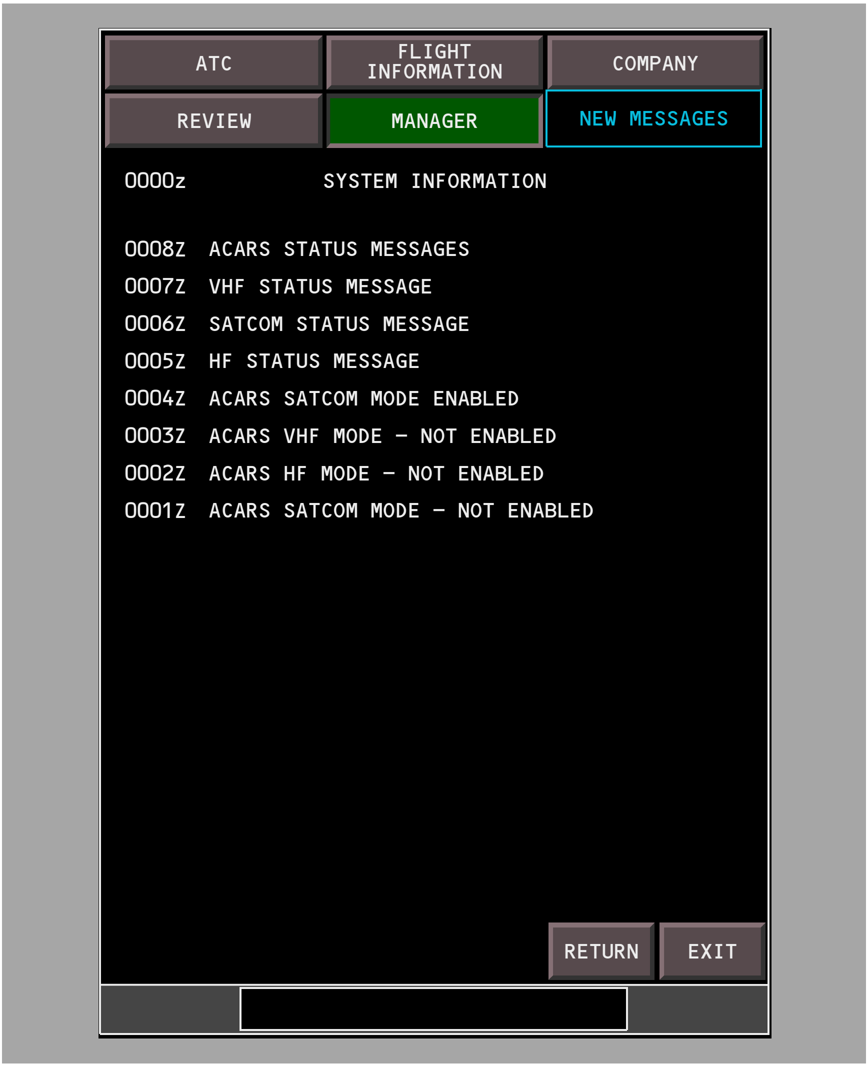
A list of ADS connection status is displayed on the ADS page.

A select key is available to terminate any active air traffic service provider (ATSP) facility ADS connection. Selecting the adjacent DISCONNECT key causes a disconnect message to be sent to the associated ground station.

A select key is also available to INHIBIT/ENABLE an ATSP from establishing an ADS contact with the airplane. Entering the ICAO identifier of the ATSP into the data box and selecting INHIBIT prohibits an ADS connection from that facility. Entering the identifier of an inhibited ATSP and selecting the ENABLE box allows a connection to be made with that facility. Only one ATSP can be inhibited at a time.

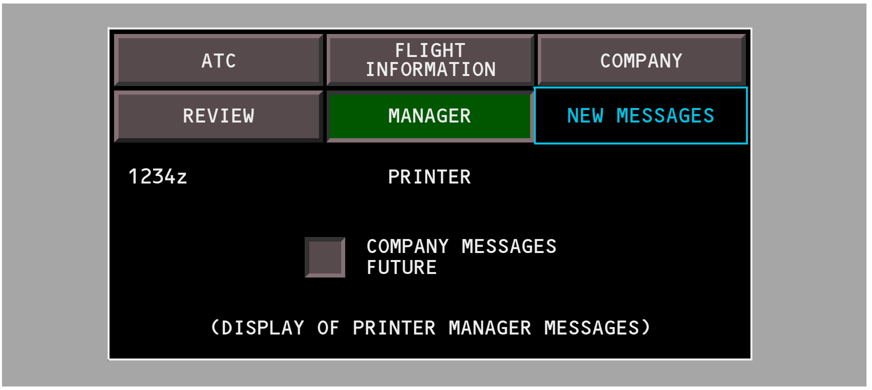
The lower portion of the ADS page displays system status messages.

System Information Manager



The system information manager page displays manager messages for all applicable systems.

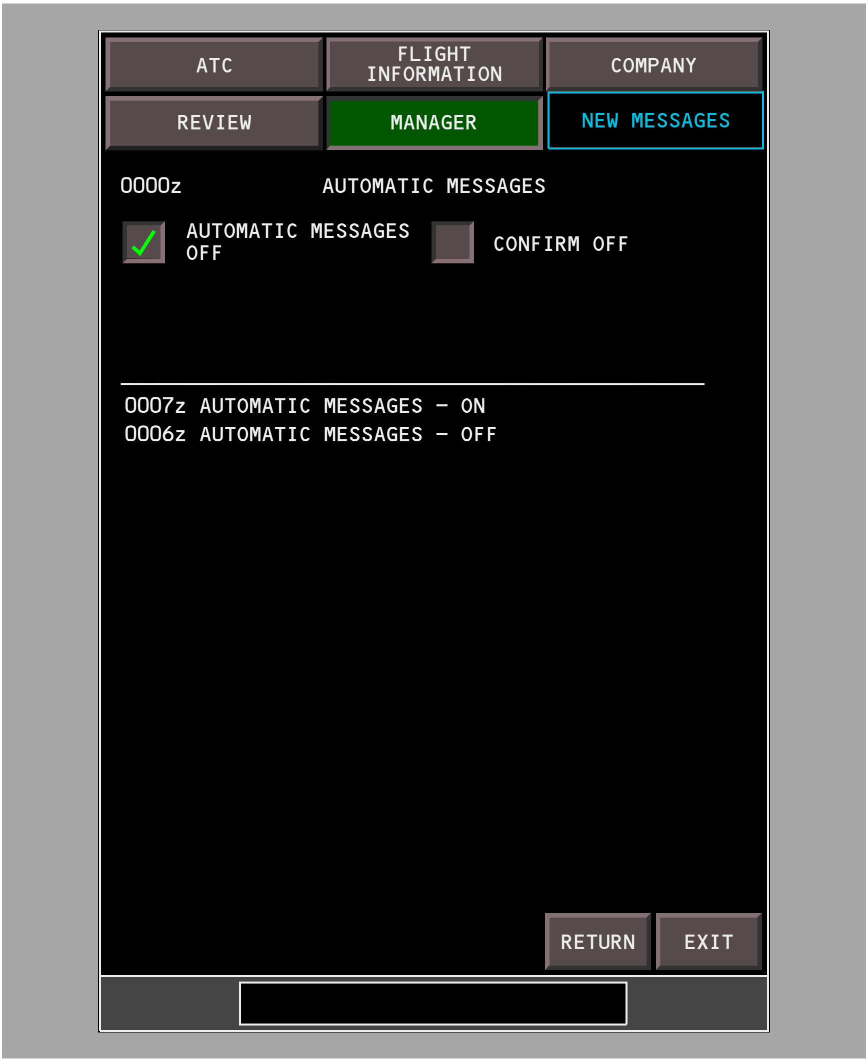
Printer Manager



The printer manager page can be set to send messages directly to the printer. Manager messages related to the printer system are also presented on this page.

If the COMPANY MESSAGES FUTURE key is selected, company messages are sent directly to the printer and the •PRINTER EICAS message is displayed. Future messages are not included in the new messages or review categories.

Automatic Messages Manager



The AUTO MESSAGES OFF selection inhibits automatic sending of flight operations related messages. Manager messages related to the automatic messages capability are also presented on this page.

When the AUTOMATIC MESSAGES OFF key is selected, the CONFIRM OFF key is displayed. Selecting the CONFIRM OFF key turns off the capability to automatically send flight operations related messages.

The lower portion of the AUTOMATIC MESSAGES page displays system status messages.

Master Manager

The master manager page provides the capability to reset the data communication system. Manager messages related to the master features are also presented on this page.

If the DATALINK SYSTEM RESET key is selected, the CONFIRM RESET key is displayed. If the CONFIRM RESET key is selected, the following occurs:

- ATC connection is reset to not established
- review messages are deleted
- the center VHF radio is selected as the default
- the VHF default radio is set to data mode on the ground or voice mode in the air
- the right HF radio is selected as the default and set to voice mode
- ACARS is set to the auto mode
- automatic messages are set to ON
- the future company messages to printer feature is deselected
- downlink message parameters are initialized
- ADS EMERGENCY is reset to ADS EMERGENCY OFF
- two seconds after selection, the CONFIRM RESET key is removed from the display and the DATALINK SYSTEM RESET key is displayed as not selected

This reset does not occur at power–up.

The data communication system is automatically reset after each flight. Reset occurs approximately 10 minutes after the last engine is shut down, and with any passenger entry door open.

Datalink capability for the flight management system, OMS, and EICAS related maintenance functions, and cabin functions are not reset with this feature.

The lower portion of the MASTER page displays system status messages.

Manager Messages

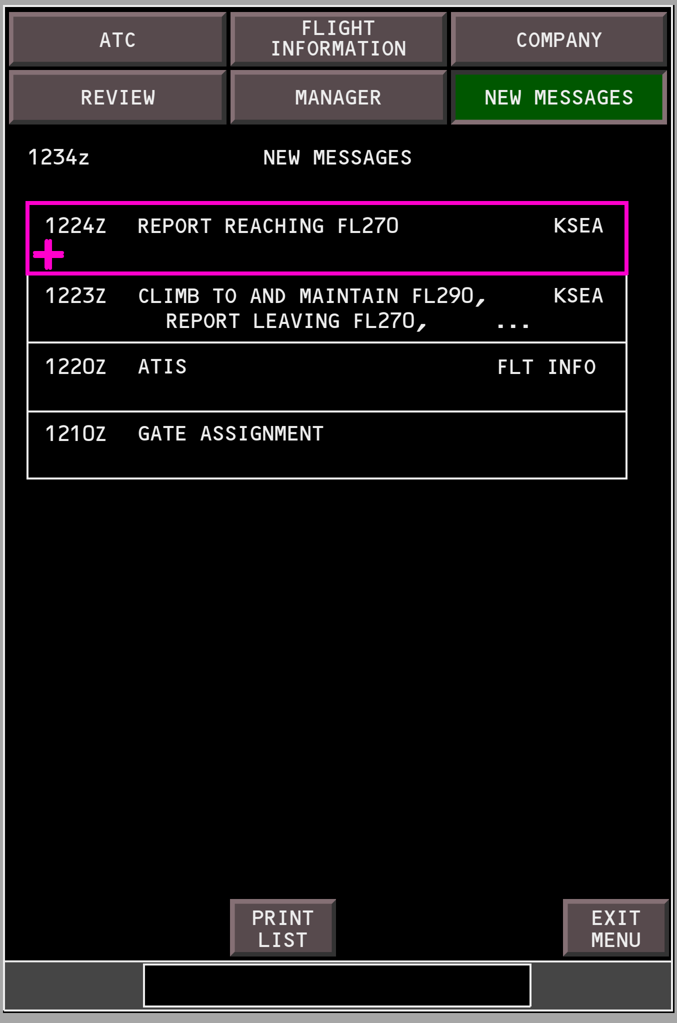
Manager messages are displayed in reverse chronological order (the newest message is nearest the top of the display). The time of occurrence is displayed with each message. The manager messages are listed in the following table.

Function	Manager Message
ACARS	ACARS CONNECTION ESTABLISHED
	NO ACARS CONNECTION
	ACARS MODE VHF - ENABLE
	ACARS MODE VHF - NOT ENABLE
	ACARS MODE SATCOM - ENABLE
	ACARS MODE SATCOM - NOT ENABLE
	ACARS MODE HF - ENABLE
	ACARS MODE HF - NOT ENABLE
ADS	ADS CONNECTION ESTABLISHED – ATC facility
	ADS CONNECTION LOST – ATC facility
	ADS CONNECTIONS LOST
VHF	VHF LINK ESTABLISHED
	NO VHF LINK
	VHF DATA MODE RADIO FAILURE
	VHF DATA MODE RADIO NORMAL
SATCOM	SATCOM LINK ESTABLISHED
	NO SATCOM LINK
	SATCOM DATA MODE FAILED
	SATCOM DATA MODE NORMAL
PRINTER	PRINTER OPERABLE
	PRINTER NOT OPERABLE
	PRINTER BUFFER FULL
	COMPANY FUTURE MESSAGES TO PRINTER – ON
	COMPANY FUTURE MESSAGES TO PRINTER – OFF
AUTOMATIC MESSAGES	AUTOMATIC MESSAGES – ON
	AUTOMATIC MESSAGES – OFF

Function	Manager Message
MASTER	DATALINK SYSTEM – RESET
HF	HF LINK ESTABLISHED
	NO HF LINK
	HF DATA MODE RADIO FAILURE
	HF DATA MODE RADIO NORMAL

New Messages

New Messages Menu



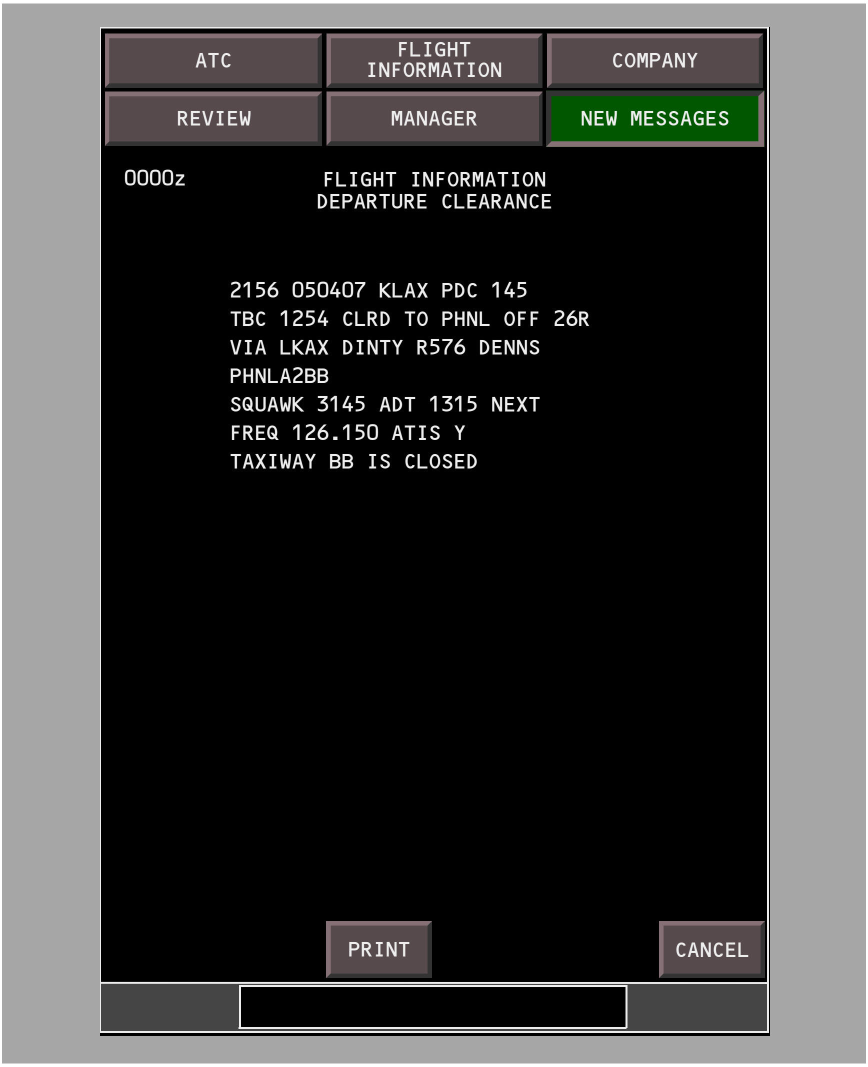
(Typical)

New uplink messages are displayed with ATC messages displayed above flight information messages which are displayed above company messages. Within ATC, flight information and company, messages are listed by the time they are received. The newest message is at the top of the group. Messages are removed from the list when displayed or an accept/reject response is sent.

New messages can also be accessed by selecting the NEW MESSAGES menu, which displays list boxes for all pending messages. A message is displayed by selecting the appropriate message line.

New ATC uplinks which respond to downlink requests display a key which displays the original downlink request.

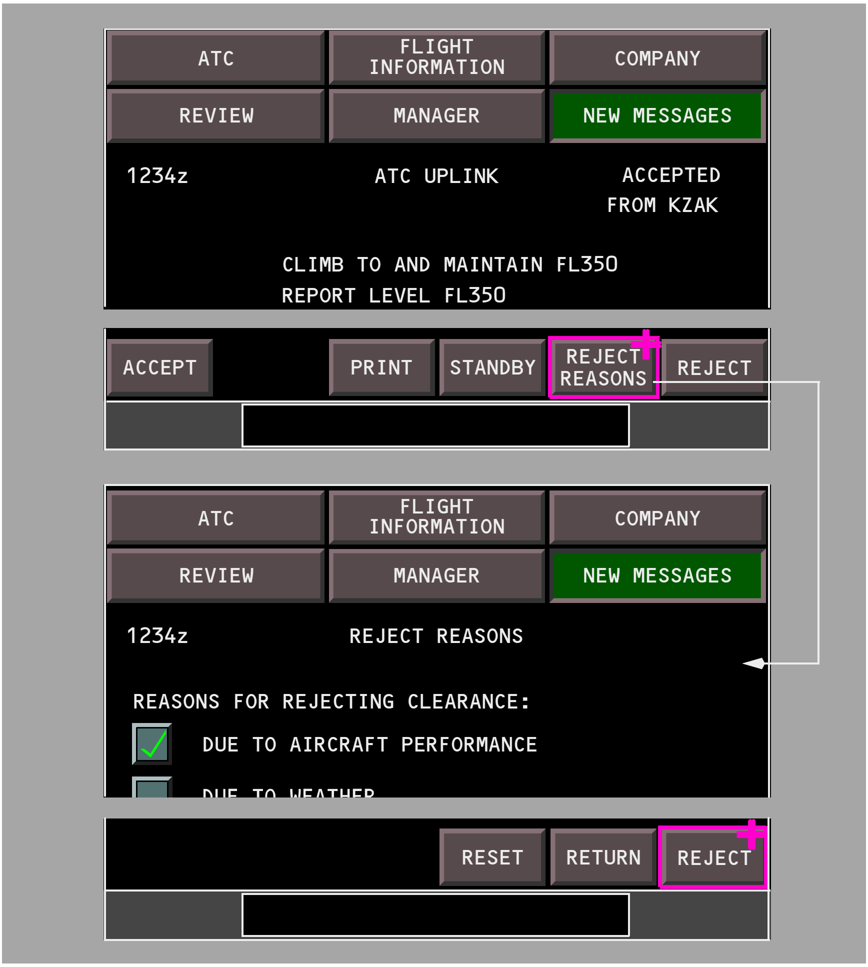
New Message – No Response Required



Received messages remain in the new messages list until after they are displayed. If an ACCEPT or REJECT response is required, the message remains in the list until accepted or rejected.

The display above shows a received message that does not require a response. The ACCEPT and REJECT keys are not displayed for this message. The message can be cleared by selecting the CANCEL key on the MFD or pushing the CANCEL switch on the glareshield.

New Message – Response Required



The display above shows a message that requires an ACCEPT or REJECT response. The ACCEPT and REJECT keys are displayed.

An APPEND capability is provided for certain received messages which require an accept or reject response. In this case, the APPEND key is displayed.

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Communications EICAS Alert Messages

The following EICAS alert messages can be displayed.

Datalink

Message	Level	Aural	Condition
DATALINK LOST	Advisory		The ACARS datalink is temporarily lost.
DATALINK SYS	Advisory		The datalink system is failed.
HF DATALINK	Advisory		The HF datalink is failed.
HF DATALINK OFF	Memo		The HF datalink is off.
HF GND OVRD XMIT	Memo		The HF datalink mode is on, on the ground.
SATCOM DATALINK OFF	Memo		The SATCOM datalink is off.
VHF DATALINK	Advisory		The VHF datalink is failed.
VHF DATALINK OFF	Memo		The VHF datalink is off.

Radios

Message	Level	Aural	Condition
RADIO TRANSMIT CAPT, F/O, OBS	Advisory		A VHF or HF radio transmits for more than 30 seconds.
VHF SQUELCH OFF	Memo		The VHF radio squelch is off.

SATCOM

Message	Level	Aural	Condition
SATCOM	Advisory		The SATCOM system is failed.
SATCOM DATALINK	Advisory		The SATCOM datalink is failed.
SATVOICE LOST	Advisory		SATCOM voice communication is temporarily lost.

EICAS Communication Messages

The following EICAS communication messages can be displayed.

Crew Communications

EICAS Communication Message	Level	Condition	Crew Action
•CABIN ALERT	Medium	Pilot alert received over cabin interphone.	Respond to the alert.
•CABIN CALL	Medium	Pilot call received over cabin interphone.	Respond to the call.
•CABIN READY	Medium	CABIN READY received over cabin interphone.	Crew awareness. Automatically removed after one minute.
•FD DOOR CALL	Medium	Doorbell command entered at FDAS keypad.	Respond to the call.
•GROUND CALL	Medium	Pilot call received over flight interphone from nose wheel well.	Respond to the call.

Datalink

EICAS Communication Message	Level	Condition	Crew Action
•COMM	Medium/ low	A datalink message has been received.	Push COMM switch on the display select panel. View the message title and text in the help window.
•COMM BUSY	Medium	Communications system pending datalink message queue is full.	Respond to current pending datalink messages.
•FMC	Medium	An FMC related datalink message has been received.	Push CDU switch on the display select panel. View the message title and text in the help window.

EICAS Communication Message	Level	Condition	Crew Action
•PRINTER (with datalink installed)	Medium/ low	A datalink message has been received and sent to the printer.	Review the printed message.
•ATC	Medium	An ATC datalink message has been received or an armed report has been sent.	Push COMM switch on the display select panel. View the message title and text in the help window.

SATCOM

EICAS Communication Message	Level	Condition	Crew Action
•SATCOM CALL	Medium/ low	Voice call received over SATCOM.	Respond to call.

SELCAL

EICAS Communication Message	Level	Condition	Crew Action
•SELCAL	Medium	SELCAL received or any SATCOM voice call received.	Respond to the call.

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Electrical — Chapter 6
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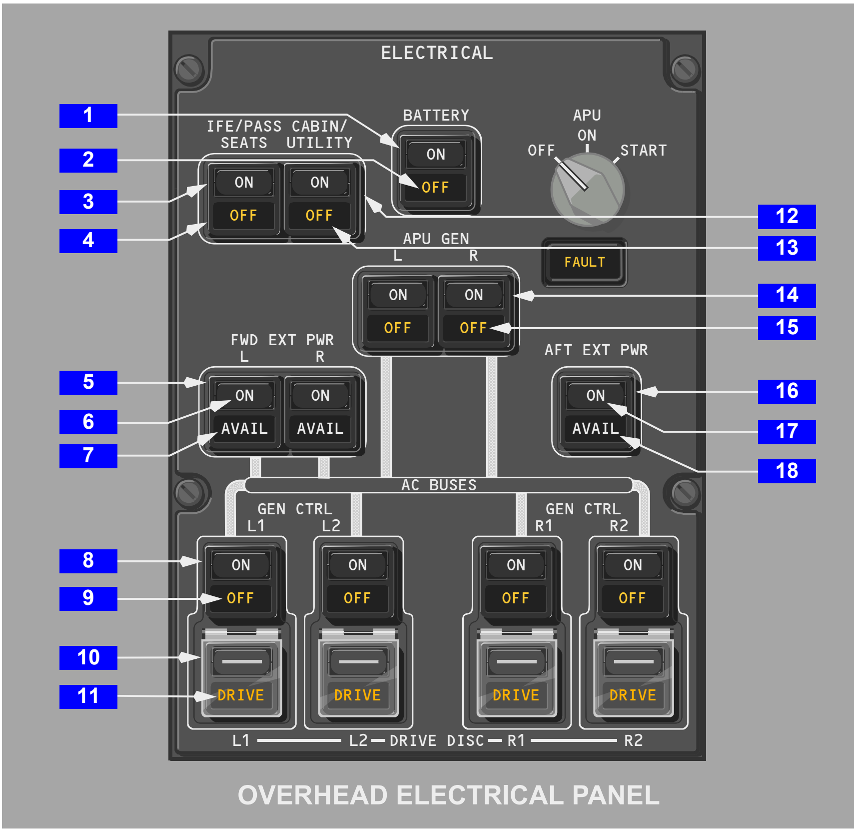
Electrical Panel



1 BATTERY Switch

ON –

- Unpowered airplane on the ground:
  - powers loads designated for use on battery power
  - allows the APU to be started
  - lower display unit powered
- Powered airplane (in flight or on the ground) when AC power is removed or lost:
  - the standby power loads are powered
  - all display units are powered except lower display unit

OFF – opens the main battery relay to turn battery power off after a 1-2 (TBD) minute time delay.

2 Battery OFF Light

Illuminated (amber) – the BATTERY switch is OFF.

3 IFE/PASS SEATS Power Switch

ON – powers in-flight entertainment and passenger seat systems when AC power is available.

OFF – removes power from in-flight entertainment and passenger seat systems.

4 IFE/PASS SEATS OFF Light

Illuminated (amber) – the IFE/PASS SEATS power switch is OFF.

5 Forward External Power (FWD EXT PWR) Switches

Push – (if AVAIL light illuminated) closes forward external power contactor

Push – (if ON light illuminated) opens forward external power contactor.

6 Forward External Power ON Lights

Illuminated (white) –

- illuminates if forward external power has been selected and is powering the buses
- extinguishes if forward external power is deselected and the AVAIL light illuminates

7 Forward External Power AVAIL Lights

Illuminated (white) –

- illuminates if forward external power is plugged in, power quality is acceptable. (Ground handling and service loads are then powered.)
- extinguishes if forward external power is selected and the ON light illuminates

8 Generator Control (GEN CTRL) Switches

ON –

- arms generator control breaker (allows it to close automatically when power is available)
- closes generator field

OFF –

- opens generator control breaker
- opens generator field
- resets fault protection systems

9 Generator OFF Lights

Illuminated (amber) – the generator control breaker is open.

10 Generator Drive Disconnect (DRIVE DISC) Switches

Push – disconnects generator drive from engine.

Requires maintenance action on the ground to reconnect generator drive.

11 Generator DRIVE Lights

Illuminated (with the engine running) (amber) – a generator drive malfunction has occurred.

12 CABIN/UTILITY Power Switch

ON – powers cabin and utility systems when AC power is available.

OFF – removes power from cabin and utility systems.

13 CABIN/UTILITY Power OFF Light

Illuminated (amber) – CABIN/UTILITY power switch is selected OFF.

14 APU Generator (APU GEN) Switches

ON –

- arms generator control breaker (allows it to close automatically when power is available)
- closes generator field

OFF –

- opens generator control breaker
- opens generator field
- resets fault protection systems

15 APU Generator OFF Lights

Illuminated (amber) – the APU generator breaker is open.

16 AFT External Power (AFT EXT PWR) Switch

Push – (if AVAIL light illuminated) closes aft external power contactor

Push – (with ON light illuminated) opens aft external power contactor

17 AFT External Power ON Light

Illuminated (white) –

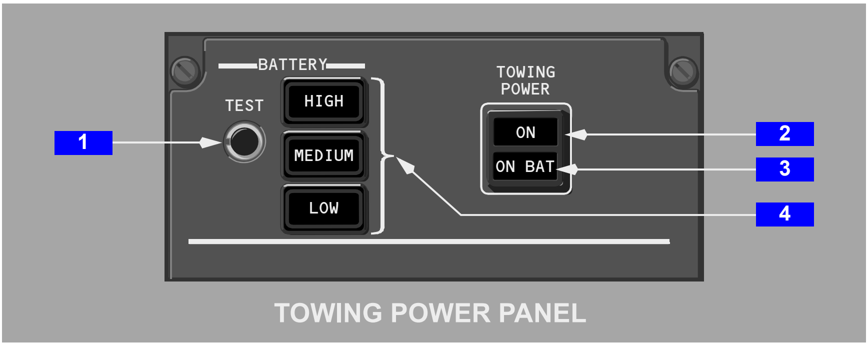
- illuminates if aft external power has been selected and is powering the motor controllers (for engine start)
- extinguishes if aft external power is deselected and the AVAIL light illuminates

18 AFT External Power AVAIL Light

Illuminated (white) –

- illuminates if aft external power is plugged in and power quality is acceptable
- extinguishes if aft external power is selected and the ON light illuminates

Towing Power Panel



1 Towing Battery Test Switch

Push (BATTERY switch OFF) – illuminates applicable towing battery charge light (HIGH, MEDIUM, or LOW) depending on current voltage

2 TOWING POWER Switch

Note: Radio communication systems are not powered by the towing power switch.

ON – (BATTERY switch off and no AC power)

- selects main and APU batteries for powering towing operation loads, including:
  - left audio control panel and flight interphone
  - flight deck dome lights
  - wing and tail position lights
  - brakes
- applicable towing battery charge light illuminates, depending on current battery voltage (HIGH, MEDIUM, LOW)

OFF – (BATTERY switch OFF and no AC power)

- removes power for towing operations

3 ON BAT Light

Illuminated (white) – the battery TOWING POWER switch is ON.

4 Towing Battery Charge Lights

Illuminated (white) –

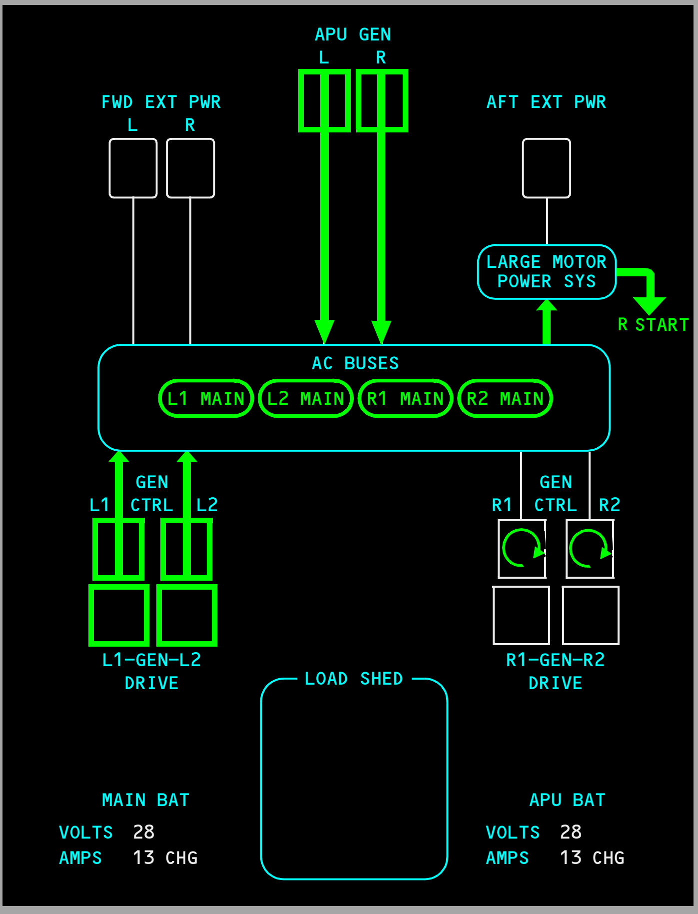
- towing battery TEST switch is pushed with TOWING POWER switch ON (BATTERY switch OFF and no AC power)
  - HIGH illuminated – a minimum of one hour (TBD) is available before battery is depleted
  - MEDIUM illuminated – a minimum of 30 minutes (TBD) is available before battery is depleted
  - LOW illuminated – a minimum of 15 minutes (TBD) is available before battery is depleted

Note: Minimum times assume steady state towing (no braking) before battery is depleted. If heavy braking occurs, the battery voltage may decrease and illuminate a different light and / or may decrease the time available on battery power below the minimum times listed.

Electrical Synoptic Display

The electrical synoptic is displayed by pushing the systems (SYS) display switch on the display select panel, then selecting the electrical (ELEC) synoptic key.

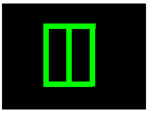
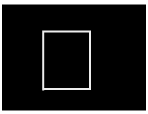
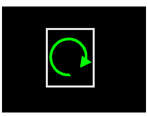
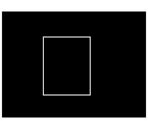
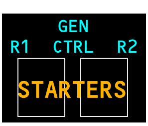
For more information on display select panel operation, see Chapter 10, Flight Instruments, Displays.



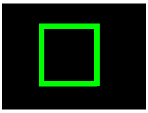
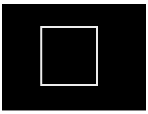
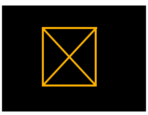
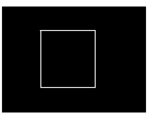
ELECTRICAL SYNOPTIC DISPLAY
(Typical engine start using APU power)

Synoptic Indication Symbology

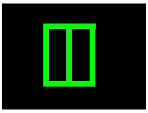
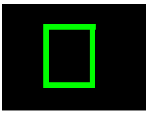
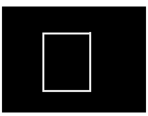
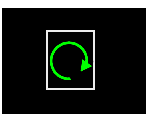
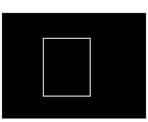
Engine Generator Synoptic Indications

Symbol	Condition	Remarks
	Engine generator on (green)	Engine is running, and • engine GEN CTRL switch is ON • engine generator is powering buses
	Engine generator off (white)	Engine is not running, or engine GEN CTRL switch is OFF with engine running. If GEN CTRL switch is OFF with engine running, EICAS advisory message ELEC GEN OFF L1, L2, R1, R2 also displays.
	Engine starter on (white box with green arrow)	An engine start is in progress. Start power indication (green arrow) from Large Motor Power System symbol would also be displayed at this time.
	Engine generator failed (amber)	Engine is running, and • GEN CTRL switch is ON • engine generator failure has occurred • engine generator is not powering buses • OFF light on GEN CTRL switch illuminates • EICAS advisory message ELEC GEN OFF L1, L2, R1, R2 displays
	Engine generator data invalid (white, low intensity)	Engine generator condition undetermined.
	Both (L1, L2 or R1,R2) Starters inoperative (amber)	If both starters on respective engine fail: • STARTERS message appears across both starter symbols • EICAS advisory message ENG STARTERS L, R displays See chapter 7 Engines, APU, for more information.

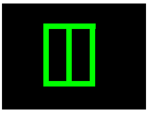
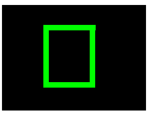
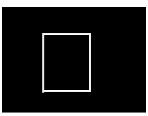
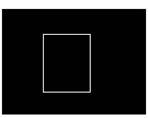
Engine Generator Drive Synoptic Indications

Symbol	Condition	Remarks
	Engine generator drive on (green)	Engine is running and drive is connected.
	Engine generator drive off (white)	Engine is not running.
	Engine generator drive disconnected (amber)	Engine is running and drive is disconnected.
	Engine generator drive data invalid (white, low intensity)	Engine generator drive condition undetermined.
	Engine generator drive fault (amber)	If an engine generator drive malfunction occurs: • DRIVE (amber) appears next to (L1,L2,R1, or R2) engine generator drive symbol • respective engine generator drive requires disconnect • DRIVE light on generator drive disconnect switch illuminates • EICAS advisory message ELEC GEN DRIVE L, R displays **Note:** DRIVE symbol and engine generator drive disconnected symbol appear together when drive is disconnected.

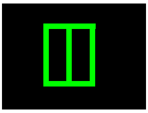
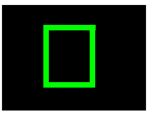
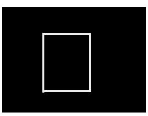
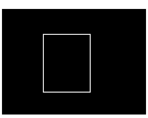
APU Generator Synoptic Indications

Symbol	Condition	Remarks
	APU generator on (green)	APU is running, and • APU GEN switch is ON • APU generator is powering buses
	APU generator available (green)	APU is running, and • APU GEN switch is ON • APU generator is available for power • APU is not powering buses
	APU generator off (white)	APU is not running, or APU GEN switch is OFF with APU running. If APU GEN switch is OFF with APU running, EICAS advisory message ELEC GEN OFF APU L,R also displays.
	APU starter on (white box with green arrow)	An APU start is in progress. Start Power Indication (green arrow) from Large Motor Power System symbol would also be displayed at this time.
	APU generator failed (amber)	APU is running, and • APU GEN switch is ON • APU generator failure has occurred • APU generator is not powering buses • OFF light on APU GEN switch illuminates • EICAS advisory message ELEC GEN OFF APU L,R displays
	APU generator data invalid (white, low intensity)	APU generator condition undetermined.

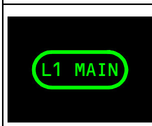
Forward External Power Synoptic Indications

Symbol	Condition	Remarks
	Forward external power on (green)	Forward external power: • switch has been selected • is powering the buses • ON light illuminates in power switch
	Forward external power available (green)	Forward external power: • is plugged in, power quality is acceptable, ground handling and service loads are powered • switch has not been selected • AVAIL light illuminates in power switch
	Forward external power off (white)	Forward external power is not available.
	Forward external power data invalid (white, low intensity)	Forward external power condition undetermined.

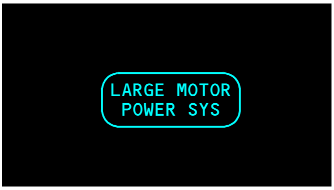
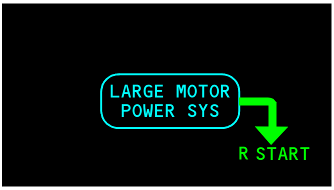
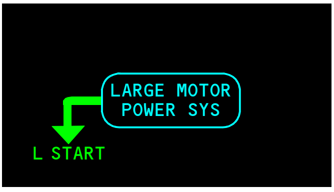
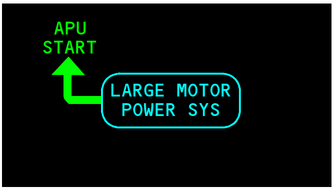
Aft External Power Synoptic Indications

Symbol	Condition	Remarks
	Aft external power on (green)	Aft external power: • switch has been selected • is powering the motor controllers (for engine start) • ON light illuminates in power switch
	Aft external power available (green)	Aft external power: • is plugged in, power quality is acceptable • switch has not been selected • AVAIL light illuminates in power switch
	Aft external power off (white)	Aft external power is not available.
	Aft external power data invalid (white, low intensity)	Aft external power condition undetermined.

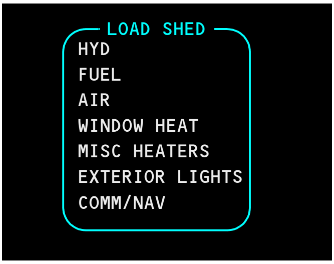
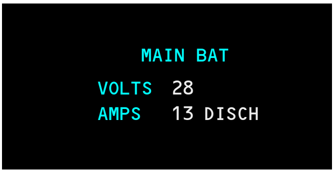
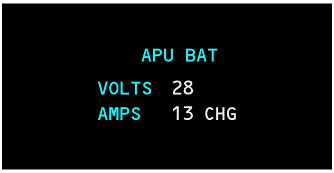
Main Bus Synoptic Indications

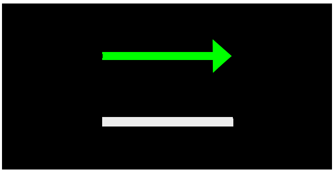
Symbol	Condition	Remarks
	Bus on (green)	L1,L2,R1,R2 bus is powered.
	Bus off (amber)	L1,L2,R1,R2 bus is not powered. **Note:** If the bus is unpowered because of a fault, EICAS caution message ELEC AC BUS L1,L2,R1,R2 displays.
	Bus data invalid (white, low intensity)	Bus condition undetermined.

Large Motor Power System and Start Power Synoptic Indications

Symbol	Condition	Remarks
	Large Motor Power System (no power flowing to or from symbol)	Symbol represents all of the high power electrical motors. Power flow lines from aft external and main AC buses depict power flow to motors when applicable. Power flow lines from these motors display during APU and engine start.
	Start Power Indication deploys right engine start in progress (green arrow)	Both right engine starter on symbols would also be displayed at this time.
	Start Power Indication deploys left engine start in progress (green arrow)	Both left engine starter on symbols would also be displayed at this time.
	Start Power Indication deploys APU start in progress (green arrow)	Either the left or right APU starter on symbol would also be displayed at this time.

Miscellaneous Synoptic Indications

Symbol	Condition	Remarks
	Load Shed Message List (white text)	Load shed alert messages are displayed here only if caused by a non-normal reduction in electrical system capacity. The most recent system impacted by load shed is listed at the top. (refer to each system description in applicable chapter for more information).
	Main Battery Indications	VOLTS (white value) – battery charge in volts. If voltage level is low, the MAIN BATTERY LOW EICAS advisory message displays. AMPS (white value) – battery rate of charge or discharge in amps. CHG (white) – battery is charging. DISCH (white) – battery is discharging. If DISCH is indicated, the MAIN BATTERY DISCH EICAS advisory message displays.
	APU battery indications	VOLTS (white value) – battery charge in volts. AMPS (white value) – battery rate of charge or discharge in amps. CHG (white) – battery is charging. DISCH (white) – battery is discharging.

Symbol	Condition	Remarks
	Flow lines (green with arrow end or white solid)	Green flow lines with directional arrow display if power is flowing. White solid flow lines display if power is not flowing.

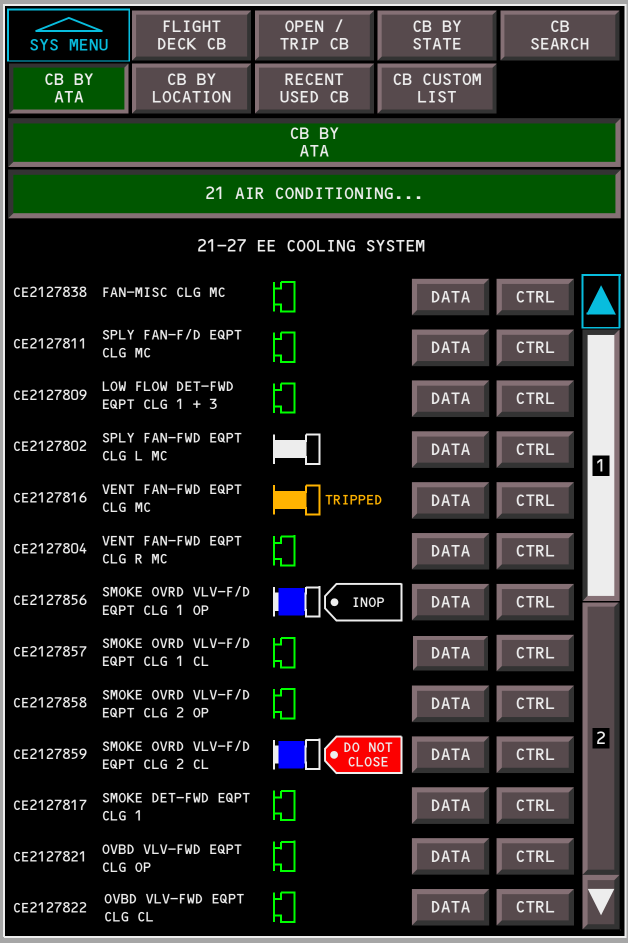
Circuit Breaker Indication and Control (CBIC)

The CBIC provides indication and control for Electronic Circuit Breakers (ECB), and indication only for Thermal Circuit Breakers (TCB). The CBIC is displayed by pushing the systems (SYS) display switch on the display select panel, then selecting the CB key. For more information on display select panel operation, see Chapter 10, Flight Instruments, Displays.

The circuit breaker (CB) list can be sorted by the following categories:

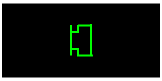
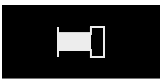
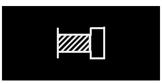
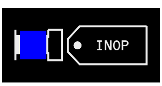
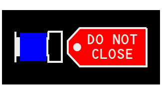
- Flight Deck CB
- Open/Trip CB
- CB by State
- CB Search
- CB by ATA
- CB by location
- Recent Used CB
- CB Custom List

Individual circuit breakers operational status is represented by a symbol, depicted in the following CBIC example and table:



MULTIFUNCTION DISPLAY
CBIC Display

CBIC Symbology

Symbol	Condition	Remarks
	ECB or TCB closed (green)	Circuit is powered. **Note:** The same symbol depicts a closed ECB or TCB.
	ECB open (white)	Circuit is not powered.
	TCB open (white)	Circuit is not powered.
	ECB tripped (amber)	ECB is tripped due to a fault. Circuit is open and not powered.
	ECB collared and tagged INOP (white tag, cyan lock collar)	ECB is open and collared for dispatch. Circuit is not powered.
	ECB collared and tagged DO NOT CLOSE (red tag, cyan lock collar)	ECB is open and collared for maintenance purposes. Circuit is not powered.
	ECB or TCB condition unknown (amber)	The circuit status can not be determined.

Introduction

The system generates, distributes, and manages high and low voltage AC and DC electrical power. System operation is automatic.

AC Electrical System

The AC electrical system is the main source for airplane electrical power.

AC Electrical System Power Sources

The main AC electrical power sources are:

- four engine starter/generators
- two APU starter/generators
- external power

Engine Starter/Generators

Each engine has two starter/generators. L1 and L2 are connected to the left engine. R1 and R2 are connected to the right engine. Both function as starters to electrically start the engine. After engine start, they function as electrical generators to provide power for their respective main AC buses, also designated L1, L2, R1, and R2. Start power can be provided by ground, APU, and the opposite engine's generated electrical power.

Engine generator control switches on the electrical panel provide a means to arm or disarm the starter/generators, and reset fault protection systems if necessary.

Engine DRIVE DISC (disconnect) switches on the electrical panel provide a means to disconnect the generator drive during fault conditions.

APU Starter/Generators

The APU has two starter/generators; L and R. Although both are able to function as electrical starters, only one is necessary to start the APU. The electrical system automatically selects which starter is used. APU start power can be provided by the APU battery, external power, or engine generated power.

After APU start, both function together as generators. They provide the necessary electrical power for ground operations and engine start.

Additionally, the APU generators can provide supplemental power in flight in the event of an engine generator failure. After APU start while in flight, the electrical system automatically selects one or both APU generators to supply power to the buses. At higher altitudes, only one generator is selected to be online.

APU generator control switches on the electrical panel provide a means to arm or disarm the starter/generators, or reset fault protection systems if necessary.

See chapter 7, Engines, APU, for more information on APU operation.

External Power

External power can be used to power ground handling and ground service loads. In addition, it can be used to power the engine starters.

There are two forward and one aft power connections, with associated control panel switches. Both forward connections are normally used for ground operations. The airplane is capable of powering ground handling and ground service loads with only a single forward connection, but power for additional airplane loads is limited (TBD).

When combined with the two forward connections, the aft connection provides additional power for large loads. If only two connections are available to support main engine start (APU not operating), the two forward connections should be used. In this configuration, other non-essential loads are temporarily shed.

Note: Aft external power is not utilized unless forward external power is also connected.

A white AVAIL light illuminates on the external power switches when power of acceptable quality is available from ground power sources. Selecting the switch ON connects power to the airplane electrical system, and extinguishes the AVAIL light.

AC Buses

Main AC Buses

There are four main AC buses; L1, L2, R1, and R2. These buses distribute power to various airplane systems and to all other buses.

Each bus is powered by a dedicated generator. Another generator can power a main bus if its normal generator fails.

During ground operations, the airplane buses can be powered from the APU generators, or by forward external power sources. Although the APU and ground power cannot power the main buses at the same time, forward external power may provide power to other buses to supplement the APU.

DC Electrical System

DC Powered Loads

High voltage DC powers large motor controlled loads, such as:

- hydraulic electric motor pumps
- cabin air compressors (CACs)
- ram fans
- engine and APU starters
- center fuel system override/jettison pumps
- nitrogen generation system (NGS)

Low voltage DC powers various airplane systems, including:

- flight instruments/avionics
- cabin loads
- ground operation loads
- standby power

Battery Power and Battery Buses

The airplane has two batteries; main and APU.

The main battery powers the (main) hot battery bus. The hot battery bus then provides power for:

- airplane power-up
- APU start (assists APU battery)
- refueling operations
- towing operations
- electric braking
- loss of all AC power in flight (powers instruments until RAT deployment)

The APU battery powers the APU hot battery bus. The APU hot battery bus then provides power for:

- APU start
- airplane power-up (assists main battery)
- refueling operations (assists main battery)
- towing operations (assists main battery)

The APU battery is designed to support two consecutive unsuccessful start attempts. After a 5 minute cooling period, a third start attempt can be made.

Standby Electrical System

If AC power fails in flight, the standby electrical power system automatically provides power to essential instruments/avionics for navigation and communication. The main battery provides power until the RAT is fully deployed.

Ram Air Turbine (RAT) Generator

A Ram Air Turbine (RAT) is installed in the right wing-to-body fairing as an emergency source of electrical and hydraulic power.

The is RAT deployed automatically in the air with loss of:

- electrical power, or
- hydraulic power, or
- both engines

The RAT can also be deployed manually if necessary by pushing the RAM AIR TURBINE switch on the hydraulic panel.

RAT deployment and hydraulic operation are described in Chapter 13, Hydraulics.

Main Battery

The main battery provides standby power until RAT deployment.

Electrical Load Management

Load Shedding

Load shedding can occur if:

- additional power is needed temporarily (example: engine start)
- a fault condition exists that reduces electrical system capacity

The airplane sheds non-essential electrical loads to maintain power for essential systems. The electrical synoptic displays a list of airplane systems affected by fault condition load shedding.

IFE/PASS SEATS and CABIN/UTILITY Systems

Electrical power to some non-essential cabin loads can be controlled from the flight deck. Two switches are provided for de-powering these loads in an emergency. One switch is for control of In-Flight Entertainment (IFE) and passenger seat power, and the other switch is for galleys, lights, and other non-essential (utility) loads. Pushing the IFE/PASS SEATS and CABIN/UTILITY switches de-power these systems.

Electrical EICAS Messages

The following EICAS messages can be displayed.

Electrical System

Message	Level	Aural	Condition
ELEC AC BUS L1, L2, R1, R2	Caution	Beeper	The AC bus is not energized.
ELEC BATTERY OFF	Advisory		The BATTERY switch is OFF.
ELEC GEN DRIVE L1, L2, R1, R2	Advisory		A generator drive malfunction occurs.
ELEC GEN OFF APU L, R	Advisory		The generator control breaker is open.
ELEC GEN OFF L1, L2, R1, R2	Advisory		The generator control breaker is open.
ELEC STANDBY SYS	Advisory		A standby power system failure occurs.
MAIN BATTERY DISCH	Advisory		One of these occurs: • A main battery discharge occurs • The hot battery bus is not energized
MAIN BATTERY LOW	Advisory		The main battery charge is low.

Cabin System

Message	Level	Aural	Condition
ELEC CABIN/UTIL OFF	Advisory		The CABIN/UTILITY power switch is OFF.
ELEC IFE/SEATS OFF	Advisory		The IFE/PASS SEATS power switch is OFF.

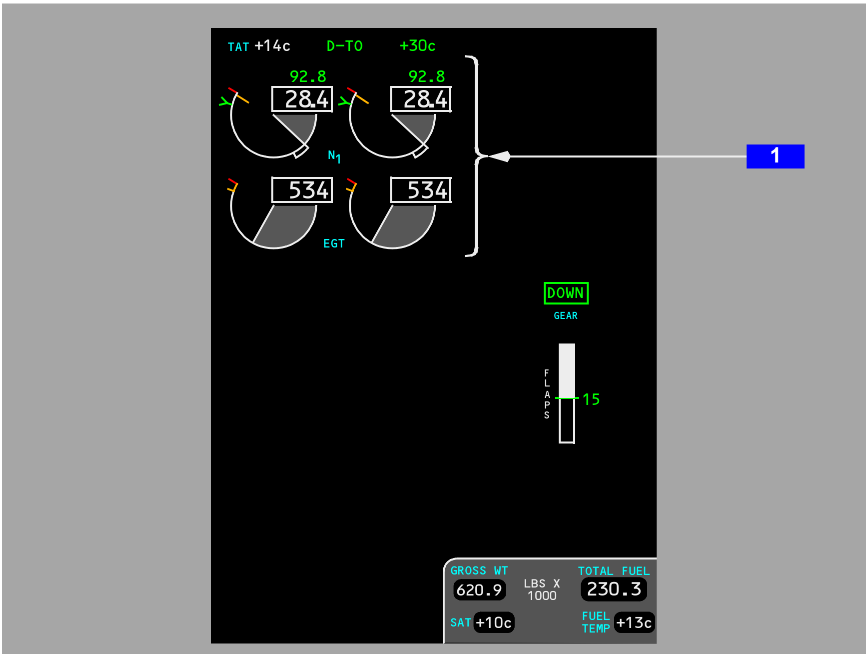
Intentionally
Blank

Engines, APU — Chapter 7
Table of Contents — Section 0

Intentionally
Blank

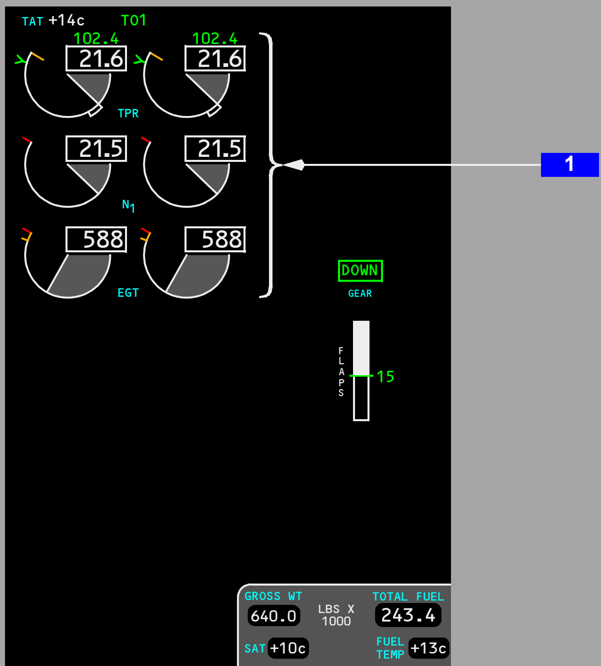
EICAS Display

[Option – GE engines, English units]



CAPTAIN / FIRST OFFICER INBOARD DISPLAY

[Option – RR engines, English units]



CAPTAIN / FIRST OFFICER INBOARD DISPLAY

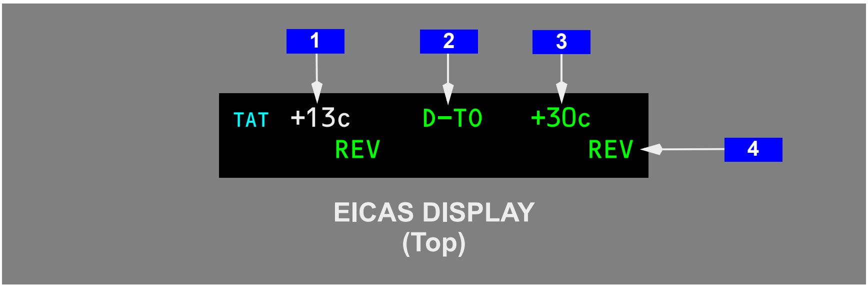
1 **Primary Engine Indications**

Displayed full time on the EICAS display:

[Option – RR engines]

- TPR
- N1
- EGT

Mode Indications



1 Total Air Temperature (TAT)

Displayed (white) – TAT (degrees C).

2 Thrust Reference Mode

Displayed (green) – selected FMS thrust reference mode:

- TO – maximum rated takeoff thrust

[Option]

- TO 1 – derate one takeoff thrust

[Option]

- TO 2 – derate two takeoff thrust
- D–TO – assumed temperature derated takeoff thrust

[Option]

- D–TO 1 – derate one assumed temperature derated takeoff thrust

[Option]

- D–TO 2 – derate two assumed temperature derated takeoff thrust
- CLB – maximum rated climb thrust

[Option]

- CLB 1 – derate one climb thrust

[Option]

- CLB 2 – derate two climb thrust
- CON – maximum rated continuous thrust
- CRZ – maximum rated cruise thrust
- G/A – maximum go-around thrust

3 Assumed Temperature

Displayed (green) – selected assumed temperature (degrees C) for reduced thrust takeoff.

4 Thrust Reverser Indication

Displayed REV (amber) – reverser in transit.

Displayed REV (green) – reverser fully deployed.

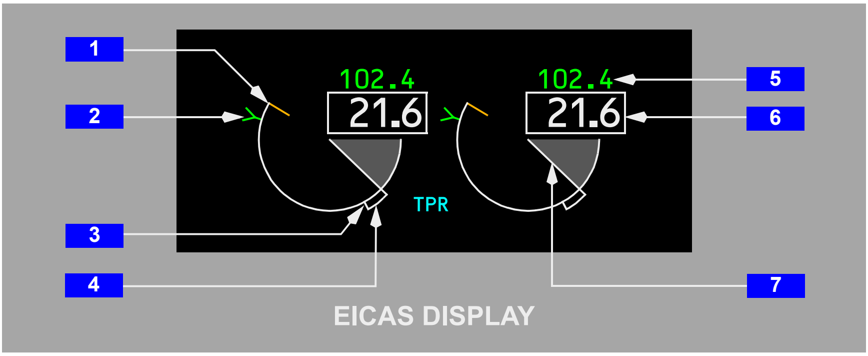
[Option – RR engines]

TPR Indications

Note: During tailwind conditions, slight TPR fluctuations may occur prior to 30 knots forward airspeed.

Note: When reverse thrust is activated, the following indications are not displayed:

- maximum TPR line
- commanded TPR
- reference/target TPR indication
- reference TPR



1 Maximum TPR Line

Displayed (amber).

2 Reference/Target TPR indication

Displayed (green) – reference TPR limit.

Displayed (magenta) – target FMC commanded TPR when VNAV is engaged and:

- the autothrottle is engaged in THR or THR REF mode, or
- the autothrottle is not engaged

3 Commanded TPR

Displayed (white).

4 Commanded TPR Sector

Displayed:

- (white) – a momentary difference between engine TPR and TPR commanded by thrust lever position
- (amber filled) – a difference between engine TPR and commanded TPR exists and engine TPR is not closing toward commanded TPR. EICAS alert message ENG THRUST (L or R) is displayed

5 **Reference TPR**

Displayed (green).

6 **Actual TPR**

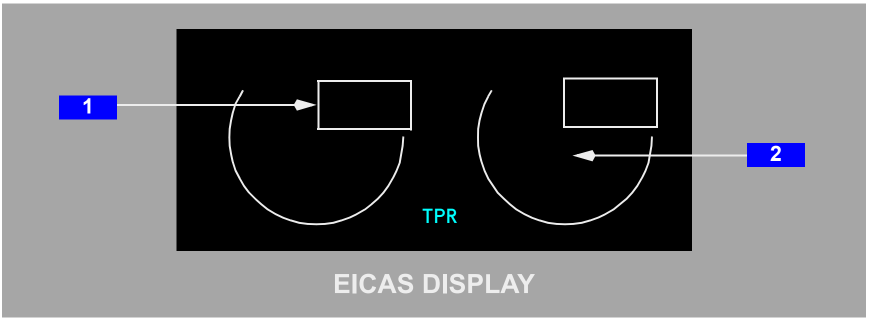
Displayed (white).

7 **Actual TPR indication**

Displayed (white).

[Option – RR engines]

TPR Indications (Alternate Mode)



1 **TPR Indication**

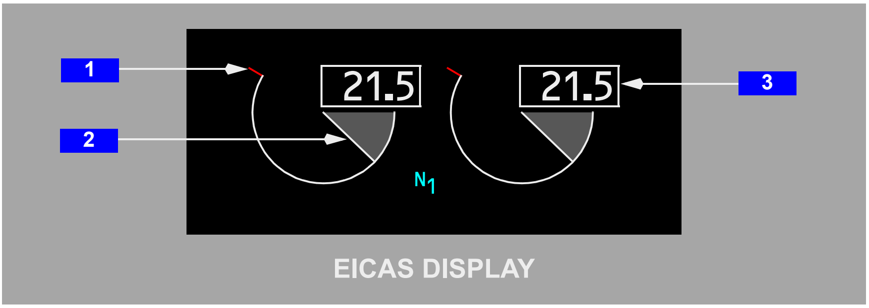
Displayed (blank).

2 **Actual TPR Indication**

Displayed (blank).

[Option – RR engines]

N1 Indications



1 **N1 Red Line**

Displayed (red) – N1 RPM operating limit.

2 **N1 Indication**

N1 RPM, displayed:

- (white) – normal operating range
- displayed (red) – operating limit reached

3 **N1**

Digital N1 RPM (%), displayed:

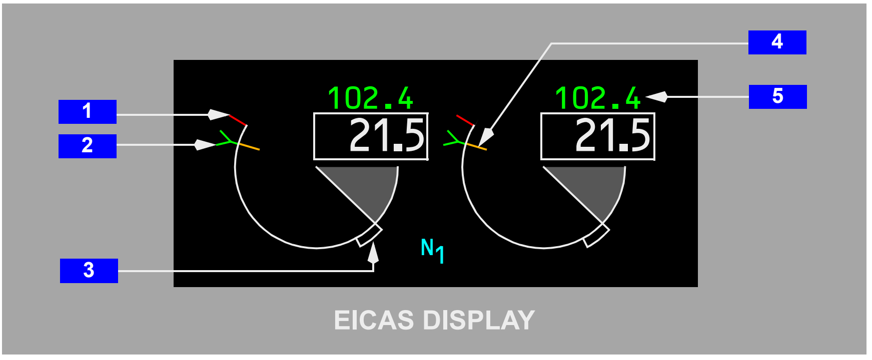
- (white) – normal operating range
- displayed (red) – operating limit reached

[Option – RR engines]

N1 Indications (Hard Alternate Mode)

Note: When reverse thrust is activated, the following indications are not displayed:

- maximum N1 line
- commanded N1
- reference/target N1 indication
- reference N1



1 **N1 Red Line**

Displayed (red).

2 **Reference/Target N1 Indication**

Displayed (green) – reference N1 limit.

Displayed (magenta) – target FMC commanded N1 when VNAV is engaged and:

- the autothrottle is engaged in THR or THR REF mode, or
- the autothrottle is not engaged

3 Commanded N1 Sector

Displays momentary difference between engine N1 and N1 commanded by thrust lever position.

Displayed:

- (white) – a momentary difference between engine N1 and N1 commanded by thrust lever position
- (amber filled) – a difference between engine N1 and commanded N1 exists and engine N1 is not closing toward commanded N1. EICAS alert message ENG THRUST (L or R) is displayed

4 Maximum N1 Line

Displayed (amber).

5 Reference N1

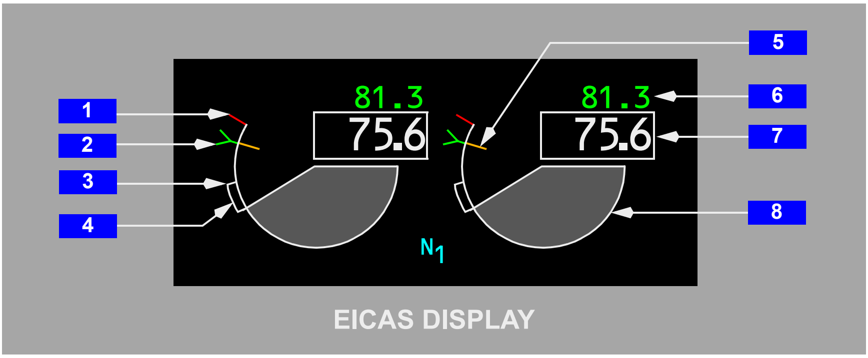
Displayed (green) – thrust reference calibrated for N1.

[Option – GE engines]

N1 Indications (All Modes)

Note: When reverse thrust is activated, the following indications are not displayed:

- maximum N1 line
- commanded N1
- reference/target N1 indication
- reference N1



1 N1 Red Line

Displayed (red) - N1 RPM operating limit.

2 Reference/Target N1

Displayed (green) – reference N1 limit.

Displayed (magenta) – target FMC commanded N1 when VNAV is engaged and:

- the autothrottle is engaged in THR or THR REF mode, or
- the autothrottle is not engaged

3 Commanded N1

Displayed (white).

4 Commanded N1 Sector

Displayed:

- (white) – momentary difference between engine N1 and N1 commanded by thrust lever position
- (amber filled) – a difference between engine N1 and commanded N1 exists and engine N1 is not closing toward commanded N1. EICAS alert message ENG THRUST (L or R) is displayed

5 Maximum N1 Line

Displayed (amber).

6 Reference N1

Displayed (digital, green).

7 N1

Digital N1 RPM (%), displayed:

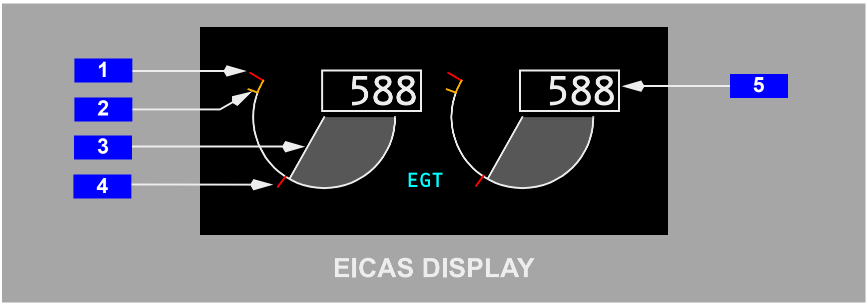
- (white) – normal operating range
- displayed (red) – operating limit reached

8 N1 Indication

N1 RPM, displayed:

- (white) – normal operating range
- displayed (red) – operating limit reached

EGT Indications



1 EGT Red Line

Displayed (red) – maximum takeoff EGT limit.

2 **EGT Amber Band**

Displayed (amber) – maximum continuous EGT limit.

3 **EGT Indication**

Displayed:

- (white) – normal operating range
- (amber) – maximum continuous limit reached
- (red) – maximum start or takeoff limit reached

4 **EGT Start Limit Line**

Displayed (red):

- with the FUEL CONTROL switch in CUTOFF, or

[Option – GE engines]

- with the N2 RPM below idle

[Option – RR engines]

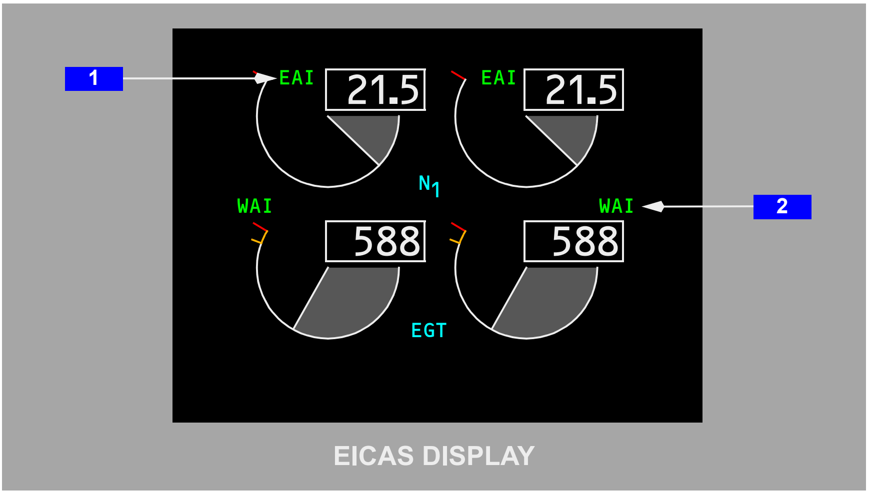
- with the N3 RPM below idle

5 **EGT**

EGT (degrees C), displayed:

- (white) – normal operating range
- (amber) – maximum continuous limit reached
- (red) – maximum start or takeoff limit reached

Anti–Ice Indications



1 **Engine Anti-ice Indication**

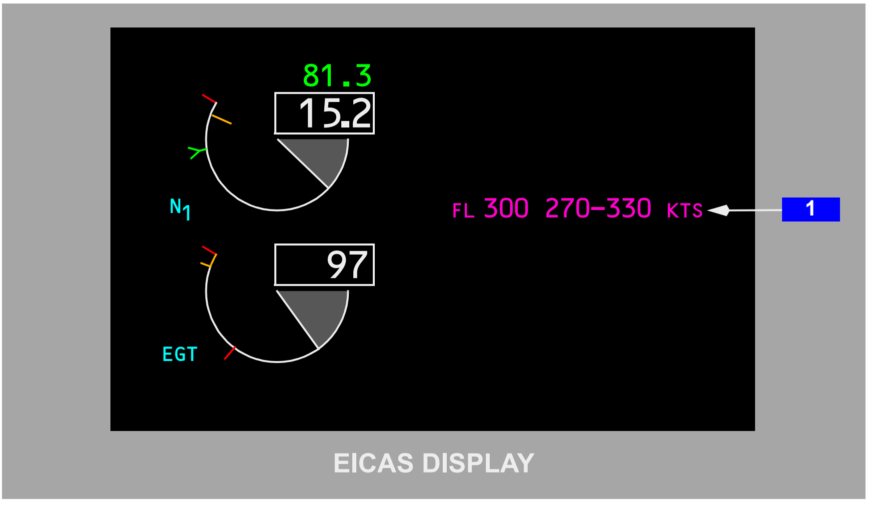
Displayed (green) – engine anti-ice is on.

2 **Wing Anti-Ice Indication**

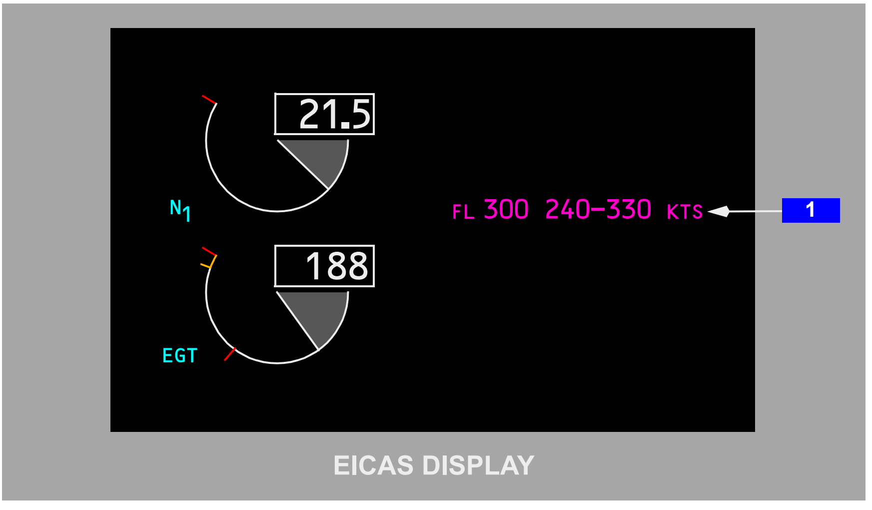
Displayed (green) – wing anti-ice is on.

In–Flight Start Envelope

[Option – GE engines]



[Option – RR engines]



1 In-Flight Start Envelope

Displayed (magenta) – airspeed range for a windmilling in-flight start at the current flight level or maximum flight level (whichever is less) when the respective engine fire switch is in and:

- a FUEL CONTROL switch is in CUTOFF, or

[Option – GE engines]

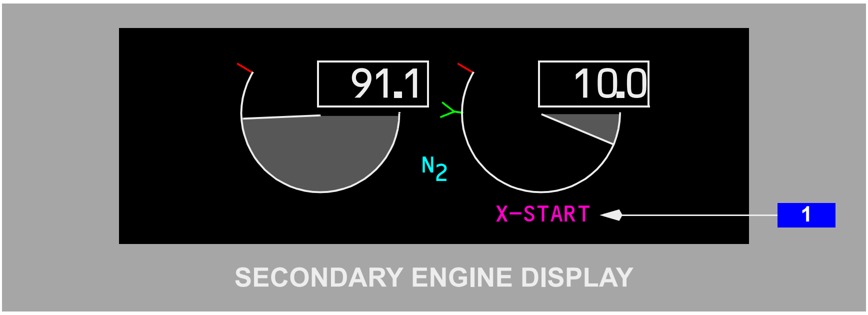
- engine N2 RPM is below idle

[Option – RR engines]

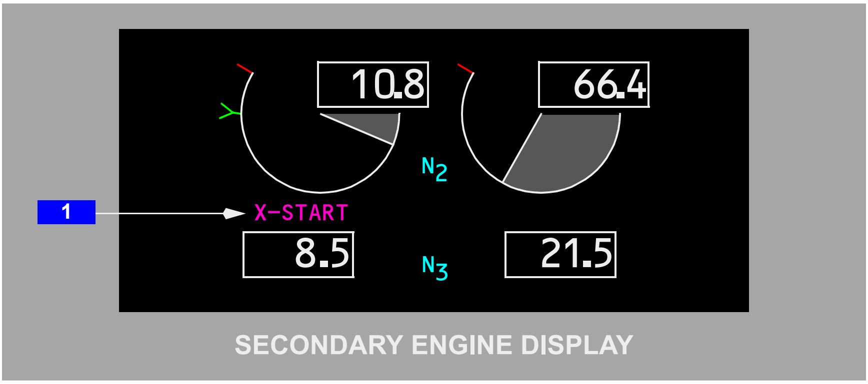
- engine N3 RPM is below idle

Cross Start Indications

[Option – GE engines]



[Option – RR engines]



1 CROSS START Indication

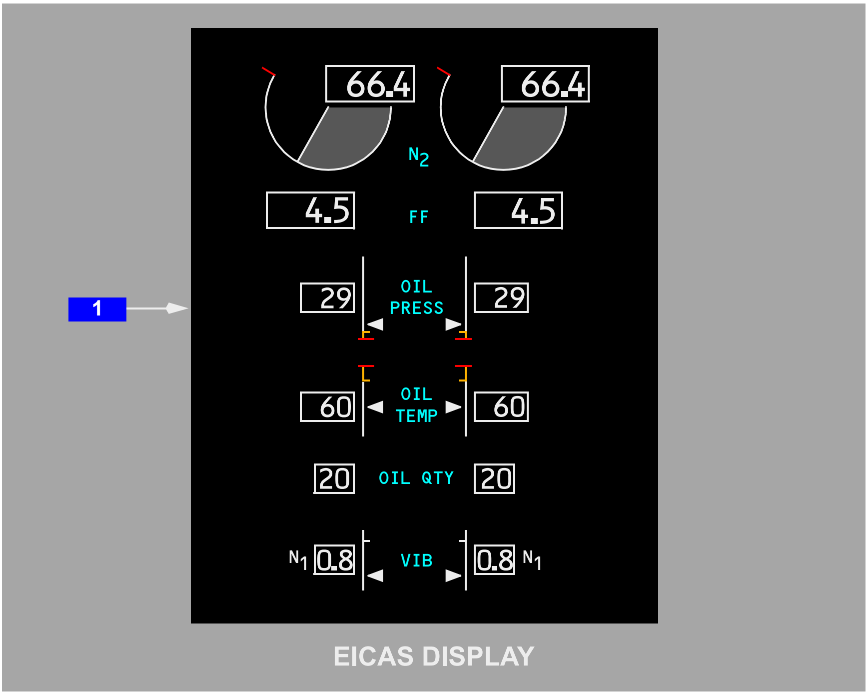
Displays X-START (magenta) when current altitude and/or airspeed are outside the windmilling start envelope. Starter assist is recommended for an in-flight start.

Secondary Engine Indications

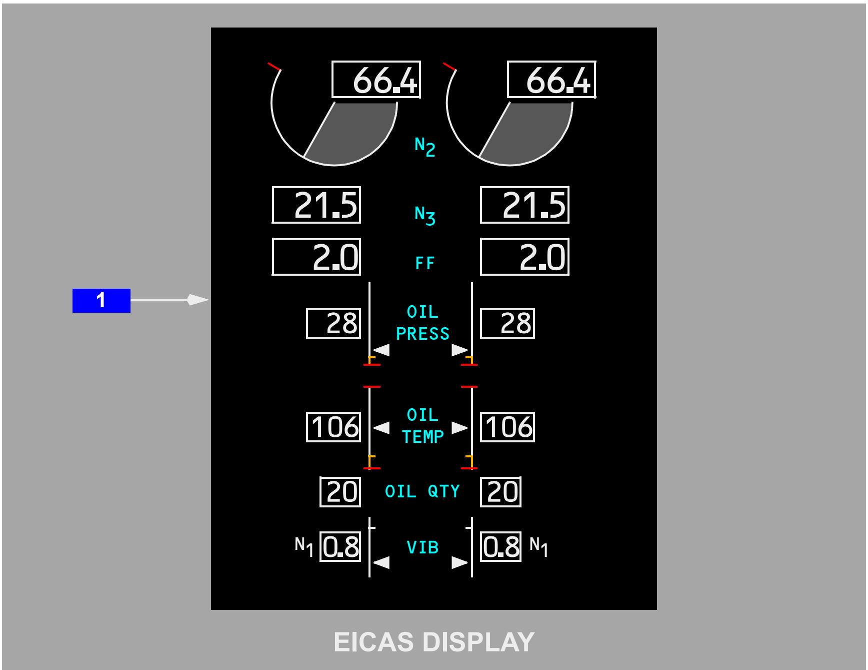
Refer to Display Select Panel, Chapter 10, Section 10, for display selection of the Secondary Engine indications.

Secondary Engine Display

[Option – GE engines]



[Option – RR engines]



[Option – GE engines]

1 Secondary Engine Display

Displays:

- N2 RPM
- fuel flow (FF)
- oil pressure
- oil temperature
- oil quantity
- vibration

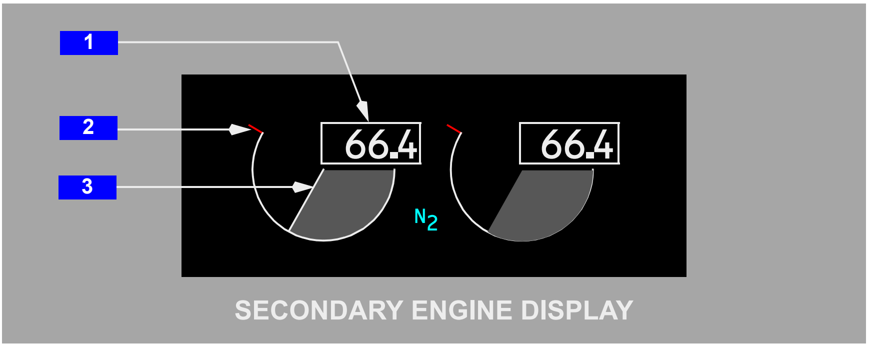
[Option – RR engines]

1 Secondary Engine Display

Displays:

- N2 RPM
- N3 RPM
- fuel flow (FF)
- oil pressure
- oil temperature
- oil quantity
- vibration

N2 Indications



1 N2

N2 RPM (%), displayed:

- (white) – normal operating range
- (red) – operating limit reached

2 N2 Red Line

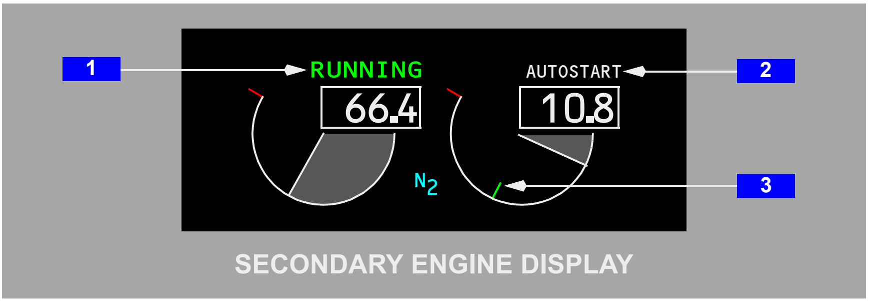
N2 RPM operating limit, displayed (red)

3 N2 Indication

N2 RPM, displayed:

- (white) – normal operating range
- (red) – operating limit reached

Starting Mode and Idle Target Indication



1 RUNNING Indication

Displayed (green) –

- fuel control switch is in the RUN position, and
- engine is at or above idle

The RUNNING indication blanks 30 seconds after engine reaches idle.

2 Starting Mode

Displayed AUTOSTART (white) –

- EEC is in autostart mode (ground or in-flight)
- indication blanks when autostart is no longer attempting an engine start

Displayed AUTORELIGHT (white) –

- EEC is in autorelight mode (in-flight)
- indication blanks when the system is no longer attempting an engine relight

3 Idle Target Indication

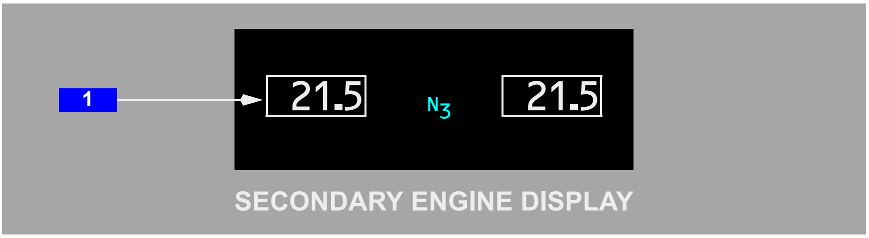
Indicates highest approximate RPM where the engine can maintain self-sustained running operation.

Displayed (green) –

- fuel control switch is in the RUN position, and
- engine is at or above idle

[Option – RR engines]

N3 Indications

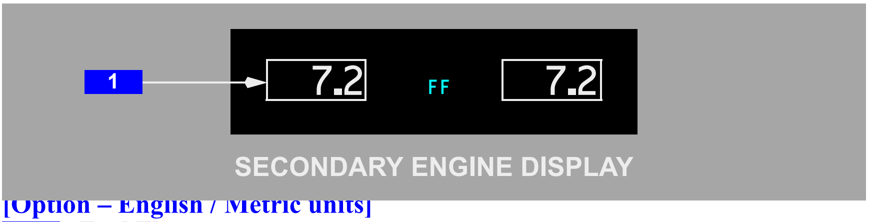


1 N3

N3 RPM (%), displayed:

- (white) – normal operating range
- (red) – operating limit reached

Fuel Flow Indications

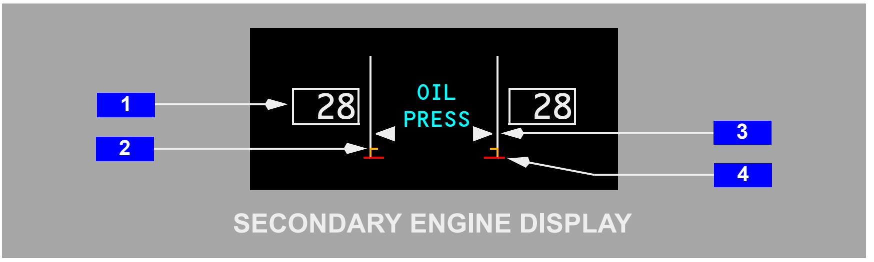


[Option – English / Metric units]

1 Fuel Flow

Displayed (white) – fuel flow to the engine (pounds / kilograms per hour x 1000).

Oil Pressure Indications



1 Oil Pressure

Engine oil pressure (psi), displayed:

- (white) – normal operating range
- (amber) – caution range reached
- (red) – operating limit reached

2 Oil Pressure Amber Band

Displayed (amber) – oil pressure caution range.

3 Oil Pressure Pointer

Engine oil pressure, displayed:

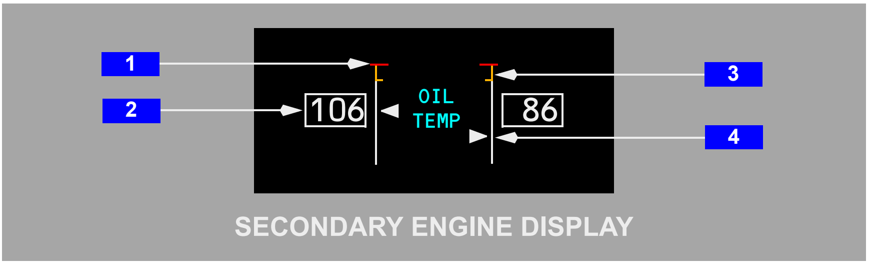
- (white) – normal operating range
- (amber) – caution range reached
- (red) – operating limit reached

4 Oil Pressure Red Line

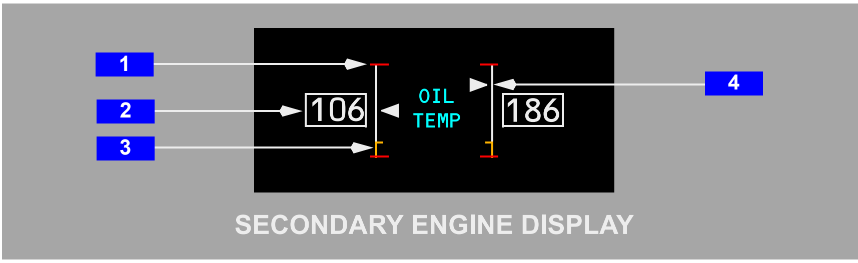
Displayed (red) – oil pressure operating limit.

Oil Temperature Indications

[Option – GE engines]



[Option – RR engines]



1 Oil Temperature Red Line

Displayed (red) – oil temperature operating limit.

2 Oil Temperature

Engine oil temperature (degrees C), displayed:

- (white) – normal operating range
- (amber) – caution range reached
- (red) – operating limit reached

3 Oil Temperature Amber Band

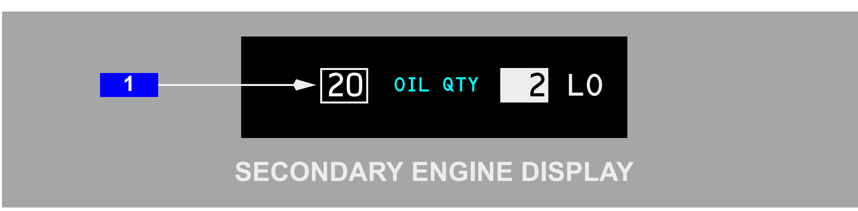
Displayed (amber) – oil temperature caution range.

4 Oil Temperature Pointer

Engine oil temperature, displayed:

- (white) – normal operating range
- (amber) – caution range reached
- (red) – operating limit reached

Oil Quantity Indications



1 Oil Quantity

[Option – English / Metric units]

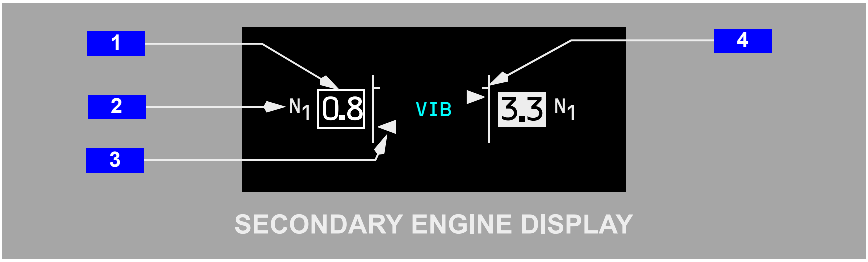
Usable oil quantity (quarts / liters).

Displayed:

- (white) – normal quantity
- (black numbers on white background) – low quantity

Note: LO – displayed (white) when quantity is low.

Engine Vibration Indications



1 Engine Vibration

Engine vibration, displayed:

- (white) – normal operating range
- (black numbers on a white background) – high vibration

2 Vibration Source

Identifies the vibration source being displayed.

Displayed (white) – vibration source with the highest vibration:

- N1 rotor vibration
- N2 rotor vibration

[Option – RR engines]

- N3 rotor vibration
- BB (broad band) vibration

If the vibration source BB is displayed, the source is unknown and average vibration is displayed.

3 Engine Vibration Pointer

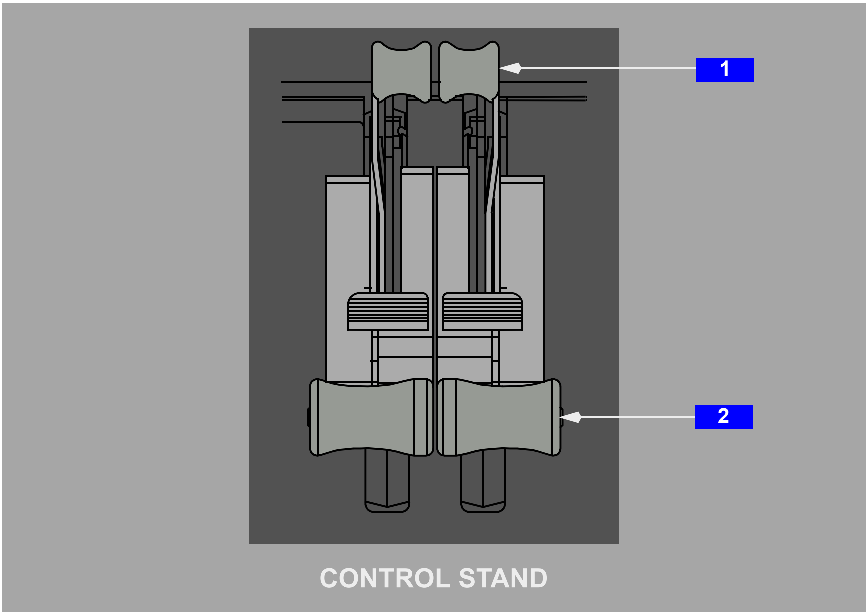
Displayed (white) – engine vibration.

4 Engine Vibration High Band

Displayed (white) – vibration level at which automatic display of secondary engine indications occurs.

Engine Controls

Thrust Levers



1 Reverse Thrust Levers

Controls engine reverse thrust.

Reverse thrust can only be selected when the forward thrust levers are closed.

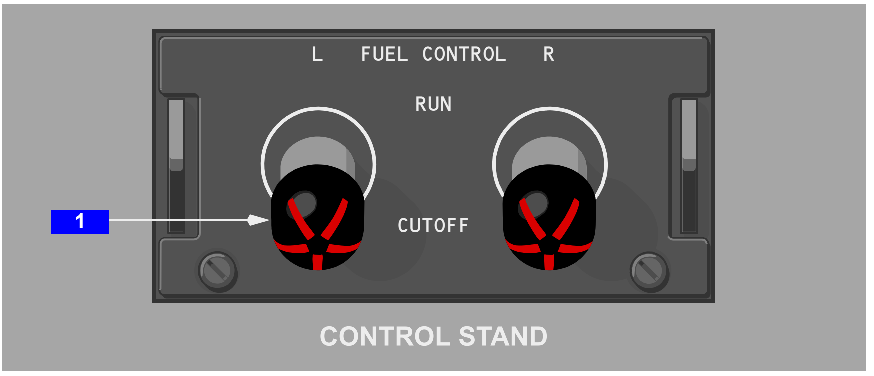
Actuates the automatic speedbrakes (refer to Spoiler Speedbrake Operation, Chapter 9, Section 20, for additional information).

2 Forward Thrust Levers

Controls engine forward thrust.

The thrust levers can only be advanced if the reverse thrust levers are down.

Fuel Control Switches



1 FUEL CONTROL Switch

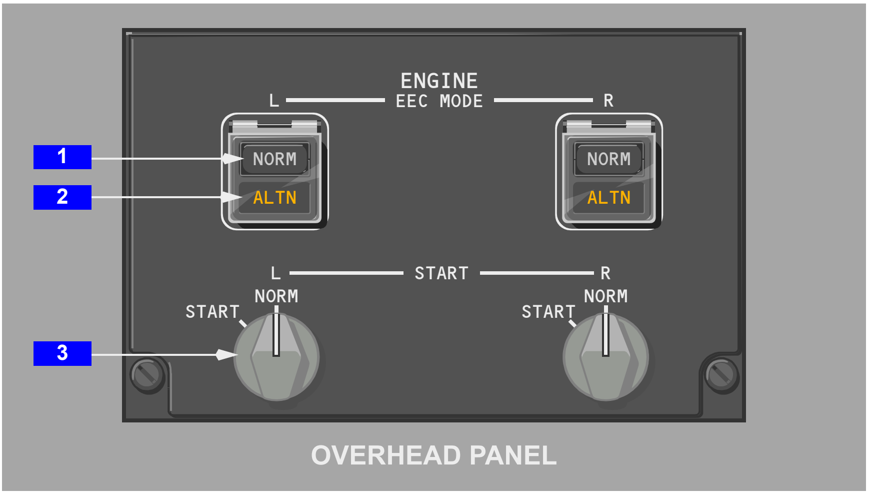
RUN –

- Opens the spar fuel valve
- arms the engine fuel valve (the EEC opens the valve when required)
- arms the selected ignitors(s) (the EEC turns the ignitors on when required)

CUTOFF –

- closes the fuel valves (and spar valve if start switch not in START)
- removes ignitor power
- unlocks the engine fire switch

Engine Control Panel



1 Electronic Engine Control (EEC) Mode Switch

NORM –

- selects the normal engine control mode for engine control

[Option – GE engines]

- the EEC sets thrust using N1 as the controlling parameter

[Option – RR engines]

- the EEC sets thrust using TPR as the controlling parameter

Off (ALTN visible) –

- selects the alternate engine control mode for engine control
- thrust is set using N1 RPM as the controlling parameter

2 Electronic Engine Control (EEC) Alternate (ALTN) Light

Illuminated (amber) – the alternate engine control mode is either automatically or manually selected.

3 START Selector

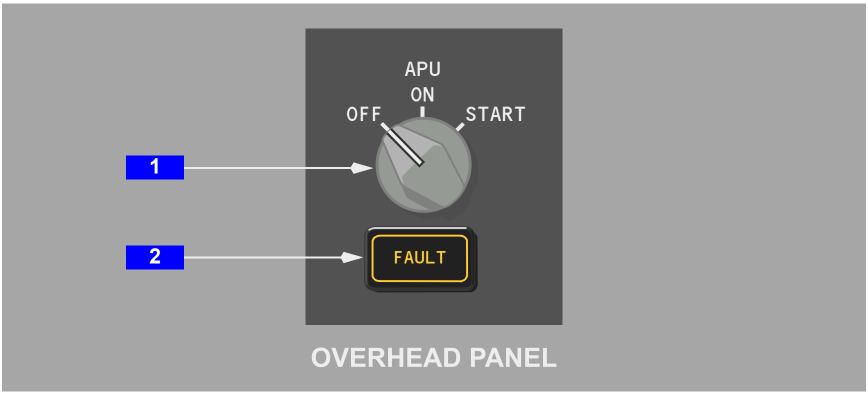
START –

- initiates engine start by commanding the starter motors to energize
- releases to NORM at completion of start

NORM – the starter motor is de-energized

Auxiliary Power Unit (APU)

APU Controls



1 APU Selector

OFF –

- initiates normal shutdown
- resets auto shutdown fault logic

ON (APU operating position) –

- opens the APU fuel valve and inlet door
- activates AC or DC fuel pump
- powers the APU controller

START (momentary position, spring–loaded to ON) –

- initiates automatic start sequence
- opens the APU fuel spar valve

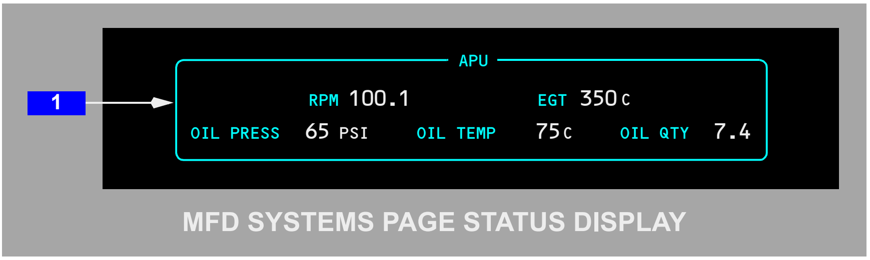
Note: If the common core system is not running, the APU controller delays start until the required common core applications are available.

2 APU FAULT Light

Illuminated (amber):

- APU fault and/or fire is detected
- APU shutdown due to fault and/or fire
- momentarily during APU controller self–test

APU Indications



1 APU Status Display

RPM – APU rotation speed in percent RPM.

EGT – APU exhaust gas temperature.

OIL PRESS – APU oil pressure in PSI.

OIL TEMP – APU oil temperature.
[Option – English / Metric units]
OIL QTY – APU oil quantity (quarts / liters).

Introduction

[Option – GEnx-1B54 engines]

The airplane is powered by two General Electric GEnx-1B54 engines. The engines are rated at 53,200 pounds of takeoff thrust each.

[Option – RR Trent 1000A engines]

The airplane is powered by two Rolls Royce Trent 1000A engines. The engines are rated at 63,800 pounds of takeoff thrust each.

[Option – GE engines]

The engine is a two rotor axial flow turbofan engine of high compression and bypass ratio. The N1 rotor consists of a fan, a low pressure compressor section, and low pressure turbine section on a common shaft. The N2 rotor consists of a high pressure compressor section and a high pressure turbine section on a common shaft. The N1 and N2 rotors are mechanically independent. The engine accessory gearbox is driven by the high speed N2 engine shaft.

[Option – RR engines]

The engines are three-rotor axial flow turbofans of high compression and bypass ratio. The N1 rotor consists of the fan and a low pressure turbine section on a common shaft. The N2 rotor consists of an intermediate pressure compressor section and an intermediate pressure turbine section on a common shaft. The N3 rotor consists of a high pressure compressor section and a high pressure turbine section on a common shaft. The N1, N2, and N3 rotors are mechanically independent from each other. The N2 rotor drives the engine accessory gearbox.

Each engine is controlled by an electronic engine controller (EEC). The EECs monitor autothrottle and flight crew inputs through the thrust levers to automatically control the engines.

Each engine has individual flight deck controls. Thrust is set by positioning the thrust levers. The thrust levers are positioned automatically by the autothrottle system or manually by the flight crew. Refer to Autothrottle System, Chapter 4, Section 20, for a description of automatic thrust lever management.

Engine indications are displayed on the engine indication and crew alerting system (EICAS) display.

Engine Intermix

[Option – GE engines]

Both engines are set to operate at the same thrust rating. Replacement engine thrust rating is increased or decreased to match the thrust rating of the installed engine configuration. An EGT amber band (maximum continuous limit) difference between engines may be indicated, but these indications are normal.

[Option – RR engines]

Both engines are set to operate at the same thrust rating. Replacement engine thrust rating is increased or decreased to match the thrust rating of the installed engine configuration. An EGT red line (maximum takeoff EGT limit) difference between engines may be indicated, but these indications are normal.

Engine Indications

Primary and secondary engine indications are provided only on the EICAS display. The EICAS is normally displayed on the inboard MFD window of the left or right inboard display unit. Refer to Display Selection and Control, Chapter 10, Section 20, for a description of other EICAS display configurations.

Primary Engine Indications

[Option – GE engines]

N1 and EGT are the primary engine indications. The primary engine indications are displayed full-time on the EICAS display.

[Option – RR engines]

TPR, N1, and EGT are the primary engine indications. The primary engine indications are displayed full-time on the EICAS display.

Secondary Engine Indications

[Option – GE engines]

The secondary engine indications are:

- N2
- fuel flow
- oil pressure
- oil temperature
- oil quantity
- engine vibration

[Option – RR engines]

The secondary engine indications are:

- N2
- N3
- fuel flow
- oil pressure
- oil temperature
- oil quantity
- engine vibration

Secondary engine indications are displayed on EICAS below the primary engine indications. The secondary engine indications can be displayed by pushing either secondary engine display switch (ENG on the display select panel). The secondary engine indications are automatically displayed when:

- the displays initially receive electrical power
- a FUEL CONTROL switch is moved to CUTOFF in flight
- an engine fire switch is pulled in flight
- a secondary engine parameter is exceeded

- engine N2 RPM is below idle in flight
- a start selector is in the START position

When secondary engine parameters are automatically displayed on EICAS due to any of the above conditions, they cannot be cleared until the condition is no longer present. After the condition is resolved, the secondary engine parameters can be cleared by pushing the engine display switch.

Display Format

[Option – GE engines]

Primary engine indications and the N2 indications are both digital readouts and round dial/moving pointer indications. The digital readouts display numerical values while the moving pointers indicate relative value.

[Option – RR engines]

Primary engine indications and the N3 indications are both digital readouts and round dial/moving pointer indications. The digital readouts display numerical values while the moving pointers indicate relative value.

[Option – GE engines]

Oil pressure, oil temperature, and vibration indications are both digital readouts and vertical indication/moving pointers. Fuel flow and oil quantity are digital readouts only. All digital readouts are enclosed by boxes. The dial and vertical indications display the normal operating range, caution range, and operating limits (as applicable).

[Option – RR engines]

Oil pressure, oil temperature, and vibration indications are both digital readouts and vertical indication/moving pointers. N3, fuel flow, and oil quantity are digital readouts only. All digital readouts are enclosed by boxes. The dial and vertical indications display the normal operating range, caution range, and operating limits (as applicable).

Normal operating range is displayed on a dial or vertical indication in white.

The oil temperature and oil pressure vertical indication have caution ranges displayed by amber bands. If oil temperature reaches the caution range, the digital readout, digital readout box, and pointer change color to amber. An indication changes color back to white when it returns to the normal operating range.

N1, N2, EGT, oil pressure, and oil temperature indications have operating limits indicated by red lines. If one of these indications reaches the red line, the digital readout, dial, box, and pointer change color to red for that indication. Oil temperature and oil pressure indication changes color back to white when it returns to the normal operating range.

[Option – GE engines]
If an N1, N2, or EGT red line is exceeded, the box enclosing the digital readout remains red after the exceeded limit returns to the normal range. The red box color can be canceled to white or recalled to red by pushing the cancel/recall switch on the display select panel.
[Option – RR engines]
If an N1, N2, N3, or EGT red line is exceeded, the box enclosing the digital readout remains red after the exceeded limit returns to the normal range. The red box color can be canceled to white or recalled to red by pushing the cancel/recall switch on the display select panel.
[Option – RR engines]
The maximum TPR limit is indicated by an amber line at the top of the TPR dial. The TPR indication does not change color when maximum TPR is reached. The reference/target TPR indication displays the FMS reference or target TPR. The commanded TPR indication displays the EEC calculated TPR commanded by thrust lever position.

The EGT indication has a maximum continuous limit represented by an amber band. The maximum continuous limit does not apply during takeoff or go–around. If EGT reaches the maximum continuous limit, the digital indication, box, pointer, and dial all change color to amber. EGT indications are inhibited from changing to amber during takeoff or go–around for five minutes. The EGT indication is often in the amber band during takeoff; this is acceptable. The inhibit is extended to ten minutes for single–engine operation. The EGT indication has a maximum takeoff limit displayed by a red line. If EGT reaches the maximum takeoff limit, the digital indication, box, pointer and dial, all change color to red.

For low oil quantity, the oil quantity digital readout changes to black text on a white background. The white text LO is displayed adjacent to the readout.

For high engine vibration, the vibration digital readout changes to black text on a white background.

Electronic Engine Control (EEC)

[Option – GE engines]
Each EEC has full authority over engine operation. The EEC uses thrust lever inputs to automatically control forward and reverse thrust. The EEC has two control modes: normal and alternate. In both normal and alternate modes, the EEC uses N1 RPM as the controlling parameter.
[Option – RR engines]
Each EEC has full authority over engine operation. The EEC uses thrust lever inputs to automatically control forward and reverse thrust. The EEC has two control modes: normal and alternate. In the normal mode, the EEC uses TPR as the parameter for setting thrust. In the alternate mode, the EEC uses N1 RPM as the controlling parameter.

EEC Normal Mode

[Option – GE engines]

In the normal mode, the EEC sets thrust by controlling N1 based on thrust lever position. N1 is commanded by positioning the thrust levers either automatically with the autothrottles, or manually by the flight crew.

[Option – RR engines]

In the normal mode, the EEC sets thrust by controlling TPR based on thrust lever position. TPR is commanded by positioning the thrust levers either automatically with the autothrottles, or manually by the flight crew.

[Option – GE engines]

Maximum N1 represents the maximum rated thrust available from the engine. The EEC continuously computes maximum N1.

[Option – RR engines]

Maximum TPR represents the maximum rated thrust available from the engine. The EEC continuously computes maximum TPR.

Maximum rated thrust is available in any phase of flight by moving the thrust levers to the full forward positions.

EEC Alternate Mode

If the required signals are not available to operate in the normal mode, the EEC automatically uses the alternate mode. In the alternate mode, the EEC schedules N1 as a function of thrust lever position. The alternate mode provides soft and hard levels of control:

- Soft – When the EEC automatically switches an engine to the alternate mode and the EEC mode switch remains in NORM, the EEC is in the soft alternate mode (the switch position is NORM, the EEC mode is alternate). At a fixed thrust lever position, thrust does not change.
- Hard – When ALTN is manually selected on an EEC mode switch, that engine is switched to the hard alternate mode (the switch position is ALTN, the EEC mode is alternate). Reference and target N1, and maximum and commanded N1 values are displayed on the N1 indication during the hard alternate mode. Thrust may change to set the commanded N1 when ALTN is manually selected.

[Option – GE engines]

For the normal, soft alternate, and hard alternate modes; actual, command, reference/target, maximum and red line N1 information is displayed.

[Option – RR engines]

For the normal, soft alternate, and hard alternate modes, the following TPR and N1 information is displayed:

[Option – RR engines]

EEC mode switch – NORM EEC mode – Normal	EEC mode switch – NORM EEC mode – Soft Alternate	EEC mode switch – ALTN EEC mode – Hard Alternate
• TPR: actual, command, reference/target, maximum • N1: actual, red line	• TPR: blank • N1: actual, red line	• TPR: blank • N1: actual, command, reference/target, maximum, red line

Automatic reversion or manual selection to the alternate mode is indicated by the EICAS advisory message ENG EEC MODE (L, R) and illumination of the EEC alternate (ALTN) light on the associated EEC mode switch. Selecting the alternate mode on both engines eliminates thrust lever stagger at equal thrust settings, or asymmetric thrust when the thrust levers are operated together.

The autothrottles remain engaged whenever the EEC automatically switches to the alternate mode. The alternate mode N1 reference/target values are computed by the FMC.

Note: Autothrottles remains engaged in the soft or hard alternate mode.

The alternate mode schedule (N1 schedule) provides equal or greater thrust than the normal mode for the same thrust lever position.

Thrust protection is not provided in the alternate mode and maximum rated thrust is reached at a thrust lever position less than full forward. As a result, thrust overboost can occur at full forward thrust lever positions. The EICAS caution message ENG LIMIT PROT (L, R) is displayed if the thrust lever position commands an N1 greater than the maximum rated thrust (maximum N1). N1 and N2 red line protection is still available in the alternate control mode.

Overspeed Protection

[Option – GE engines]

The EEC also provides N1 and N2 red line overspeed protection. If N1 or N2 approaches overspeed, the EEC commands reduced fuel flow. The EICAS advisory message ENG RPM LIMITED (L or R) is provided when overspeed protection is provided.

[Option – RR engines]

The EEC also provides N1, N2 and N3 red line overspeed protection. If N1, N2 or N3 approaches overspeed, the EEC commands reduced fuel flow. The EICAS advisory message ENG RPM LIMITED (L or R) is provided when overspeed protection is provided.

If the EECs are in alternate mode, advancing the thrust levers full forward provides some overboost and should be considered only during emergency situations when all other available actions have been taken and terrain contact is imminent.

Thrust Asymmetry Protection

Thrust Asymmetry Protection (TAP) only functions when there is a large thrust asymmetry during takeoff or go-around. TAP automatically reduces thrust on the operating engine when there is a large thrust to weight ratio, but does so while maintaining the required climb performance. The TAP function applied during an engine out takeoff provides directional control protection but only when airspeed drops below the normal operating speeds. The TAP function applied during an engine out go-around is similar to the application of a fixed derate for takeoff, whereby TAP is able to reduce the minimum control speed restriction.

Refer to Alerts Displayed on PFD, Chapter 15, Section 10, for TAMS displayed on the PFD.

Refer to Alerts Displayed on HUD, Chapter 15, Section 10, for TAMS displayed on the HUD.

Refer to Thrust Asymmetry Minimum Speed, Chapter 15, Section 20, for a description of TAMS.

TAP does not reduce thrust during normal all engine operations, or during engine out takeoffs where the correct operational thrust (i.e. throttles are not advanced during a derated takeoff) and speeds are maintained. This applies to all takeoff thrust conditions; full rated thrust, assumed temperature derate, and fixed thrust derate. TAP may encounter conditions during an engine out go-around where it will reduce thrust even when flown at the correct operational speeds.

TAP is available in the Normal and Alternate EEC modes, but only when the flight controls are operating in the Normal mode.

[Option – GE engines]

Flight deck indications, when the thrust is actively being reduced by the TAP function, will be indicated on the EICAS engine display for the operating engine. As TAP reduces thrust, the maximum and commanded N1 tics will move down to the reduced TAP thrust value, and the actual N1 indication will follow. The reference/target N1 indication and the throttles do not move. As TAP increases thrust back to normal, the maximum and commanded N1 tics on the operating engine indication will move up until they again match the reference/target N1 indication.

[Option – RR engines]

Normal mode flight deck indications, when the thrust is actively being reduced by the TAP function, will be indicated on the EICAS engine display for the operating engine. As TAP reduces thrust, the maximum and commanded TPR tics will move down to the reduced TAP thrust value, and the actual TRP indication will follow. The reference/target TPR indication and the throttles do not move. As TAP increases thrust back to normal, the maximum and commanded TPR tics on the operating engine indication will move up until they again match the reference/target TPR indication.

[Option – RR engines]

Alternate mode flight deck indications are similar to the normal mode but use the N1 display on EICAS.

The EICAS caution message THRUST ASYM PROT (L, R) is displayed if the TAP function is inoperative in the respective engine.

EEC Idle Selection

The EEC selects minimum idle or approach idle automatically. Minimum idle is a lower thrust than approach idle. Minimum idle is selected for ground operation and most phases of flight. Approach idle is selected in flight when:

- engine anti–ice is operating, or
- the flaps are commanded to 25 or greater

Approach idle decreases acceleration time for go–around. Approach idle is maintained until after touchdown when the EEC selects minimum idle.

Engine Start and Ignition System

The engines can only be started using the autostart system.

[Option – GE engines]

The electrical system powers two starter motors mechanically connected to the N2 shaft via the accessory gearbox. During engine starts, power to run the starters is drawn from the airplane system electrical power. A minimum of two power sources is necessary and can be provided by the APU (two generators), or ground power (three possible sources). Normally APU power is used to drive the engine starters.

[Option – RR engines]

The electrical system powers two starter motors mechanically connected to the N3 shaft via the accessory gearbox. During engine starts, power to run the starters is drawn from the airplane system electrical power. A minimum of two power sources is necessary and can be provided by the APU (two generators), or ground power (three possible sources). Normally APU power is used to drive the engine starters.

Having three power sources provides additional electrical power to operate cabin systems during engine starting. Some load shed may occur during engine starts depending on available power sources.

The START selectors control the starter motors. Ignition and fuel flow are controlled through the FUEL CONTROL switches.

The EEC monitors the start and commands starter cutout when the engine reaches idle speed. The START selector releases to the NORM position.

[Option – GE engines]

A maximum start limit line (red) is displayed on the EGT indication when the FUEL CONTROL switch is moved to CUTOFF or engine N2 RPM is below idle and the respective fire switch is not pulled. It remains displayed after the FUEL CONTROL switch is moved to RUN and until the engine is stabile at idle. The EGT indication changes color to red if the EGT start limit is reached.

[Option – RR engines]

A maximum start limit line (red) is displayed on the EGT indication when the FUEL CONTROL switch is moved to CUTOFF or the engine is not running and the respective fire switch is not pulled. It remains displayed after the FUEL CONTROL switch is moved to RUN until the engine is stabile at idle. The EGT indication changes color to red if the EGT start limit is reached.

[Option – GE engines]

Autostart

Autostart allows the EEC to control fuel and ignition. The autostart sequence is initiated by rotating the START selector to START and moving the FUEL CONTROL switch to RUN. For in-flight windmill starts the autostart sequence is initiated by moving the FUEL CONTROL switch to RUN.

The START selector applies electrical power to the starter motors to begin dry motoring the engine. Moving the START selector to START or the FUEL CONTROL switch to RUN opens the spar fuel valve. The proper sequencing of fuel and ignition is controlled by the autostart system. With the FUEL CONTROL switch positioned to RUN, the EEC opens the engine fuel valve and energizes the ignitor(s) at the appropriate N2 RPM.

During autostart, the EEC monitors EGT, N2 RPM and other engine parameters until the engine reaches idle speed. Oil pressure is monitored by autostart and no crew action is required during the start. If the EICAS message ENG OIL PRESS is displayed after engine start, accomplish the ENG OIL PRESS checklist.

During ground starts, the autostart system monitors engine parameters and will abort the start for any of the following:

- no N1 rotation (locked rotor)
- insufficient starter power
- impending starter duty cycle exceedance

If one of the above conditions is detected, the EEC aborts the autostart sequence without motoring and will not make another attempt. The starters are de-energized and the START selector returns to the NORM position. The EICAS caution message ENG AUTOSTART (L or R) displays.

During ground starts, the autostart system monitors engine parameters and will attempt to correct the start for any of the following:

- hot start
- hung start
- stalled start
- no lightoff/ignition failure (no EGT rise)

If one of the above conditions is detected, the EEC turns off fuel and ignition and motors the engine for 30 seconds before making a second start attempt. The next attempt uses a decremented fuel schedule and both ignitors are enabled. If the second start attempt fails, a third start attempt is made using the same procedure and parameters as the second attempt. On the ground, if the third attempt fails, the EEC cancels the autostart. Fuel and ignition are shut off and the engine is motored to clear residual fuel. The starters are de-energized and the START selector returns to the NORM position. The EICAS caution message ENG AUTOSTART (L or R) displays. In the air, the EEC does not limit the start attempts.

Note: For in-flight starts, the autostart system discontinues the start temporarily only if a preset EGT between the start and takeoff EGT is reached, or a hung start is detected. Autostart takes corrective action if some start problems are detected, but does not abort the start.

[Option – RR engines]

Autostart

Autostart allows the EEC to control fuel and ignition. The autostart sequence is initiated by rotating the START selector to START and moving the FUEL CONTROL switch to RUN. For in-flight windmill starts the autostart sequence is initiated by moving the FUEL CONTROL switch to RUN.

The START selector applies electrical power to the starter motors to begin dry motoring the engine. Moving the START selector to START or the FUEL CONTROL switch to RUN opens the spar fuel valve. The proper sequencing of fuel and ignition is controlled by the autostart system. With the FUEL CONTROL switch positioned to RUN, the EEC opens the engine fuel valve and energizes the ignitor(s) at the appropriate N3 RPM.

During autostart, the EEC monitors TGT, N2 RPM, N3 RPM, and other engine parameters until the engine reaches idle speed.

During ground starts, the autostart system monitors engine parameters and will abort the start for any of the following:

- no N1 rotation (locked rotor)
- insufficient starter power
- impending starter duty cycle exceedance

If one of the above conditions is detected the EEC aborts the autostart sequence without motoring and will not make a second attempt. The starters are de-energized and the START selector returns to the NORM position. The EICAS caution message ENG AUTOSTART (L or R) displays.

During ground starts, the autostart system monitors engine parameters and will attempt to correct the start for any of the following:

- hot start
- hung start
- stalled start
- no lightoff/ignition failure (no EGT rise)

If one of the above conditions is detected the EEC turns off fuel and ignition and motors the engine for 20 to 30 seconds (depending on the detected condition) before making a second start attempt. The second attempt uses a decremented fuel schedule and both ignitors are enabled. On the ground, if the second attempt fails, the EEC cancels the autostart. Fuel and ignition are shut off and the engine is motored to clear residual fuel. The starters are de-energized and the START selector returns to the NORM position. The EICAS caution message ENG AUTOSTART (L or R) displays. In the air, the EEC does not limit the start attempts.

Note: For in–flight starts, the autostart system temporarily discontinues the start by cutting fuel if the takeoff EGT redline limit is reached, or if a no light–off or a hung start is detected. If one of these conditions is detected, autostart windmill motors the engine for 30 seconds before making another attempt. The starters are re–engaged on the following start attempt. Autostart takes corrective action if some start problems are detected, but does not abort the start. During the second or subsequent start attempts autostart re–introduces fuel and ignition when the EGT falls below 200 degrees C.

In–Flight Start

[Option – GE engines]

In-flight start envelope information is displayed on the EICAS display when an engine is not running in flight (N2 RPM below idle RPM) or when an engine is shut down in flight and the respective engine fire switch is not pulled. The in-flight start envelope indicates the airspeed range necessary to ensure an in-flight start at the current flight level. If the current flight level is above the maximum start altitude, the maximum start altitude and respective airspeed range are displayed.

[Option – RR engines]

In-flight start envelope information is displayed on the EICAS display when an engine is not running in flight (N3 RPM below idle RPM) or when an engine is shut down in flight and the respective engine fire switch is not pulled. The in-flight start envelope indicates the airspeed range necessary to ensure an in-flight start at the current flight level. If the current flight level is above the maximum start altitude, the maximum start altitude and respective airspeed range are displayed.

[Option – GE engines]

Secondary engine indications are automatically displayed in flight when an engine is not running (N2 RPM is below idle with corresponding FUEL CONTROL switch in RUN) or when a FUEL CONTROL switch is moved to CUTOFF. A starter assist indication (X-START) is displayed below the N2 indication if airspeed is below that recommended for a windmilling start.

[Option – RR engines]

Secondary engine indications are automatically displayed in flight when an engine is not running (N3 RPM is below idle with corresponding FUEL CONTROL switch in RUN) or when a FUEL CONTROL switch is moved to CUTOFF. A starter assist indication (X-START) is displayed above the N3 indication if airspeed is below that recommended for a windmilling start.

Refer to Engine In–Flight Start, QRH, Non Normal Checklists Chapter 7, for the in–flight engine start procedure.

For in–flight starts, autostart makes continuous start attempts until the engine either starts or the pilot aborts the start attempt by positioning the FUEL CONTROL switch to CUTOFF (and positioning the START switch to NORM if it was a starter assisted attempt).

During a windmilling in–flight start, the EEC monitors engine parameters to provide the best fuel schedule to ensure the shortest possible start time.

Engine Ignition

Each engine has two ignitors. The EEC automatically selects the appropriate ignitor(s). The EEC alternates ignitors for successive engine ground starts. Dual ignitors are always used for in–flight starts.

PMG generated DC power is the normal power source for ignition. The airplane standby power provides a backup source.

[Option – GE engines]

Auto–Relight

There is no manual continuous ignition selection or automatic continuous ignition function. Engine auto-relight protection is provided for flameout and sub-idle stall recovery. The auto-relight function is activated whenever an engine is at or below idle with the FUEL CONTROL switch in RUN.

If an engine flameout (rapid decrease in N2) or an engine rollback (N2 falls below idle after the engine has achieved idle following the previous start) is detected, the EEC switches on both ignitors in the respective engine in an attempt to recover the engine. The ignitors are switched off when the engine again reaches idle.

If a sub-idle stall is detected, fuel is shut off for one second in an attempt to clear the stall. The fuel schedule is then decremented to help return the engine to idle. The fuel schedule returns to normal when the engine again reaches idle.

The EEC also provides protection against flameout during periods of excessive rain/hail ingestion. When a flameout is detected, the EEC energizes both ignitors.

[Option – RR engines]

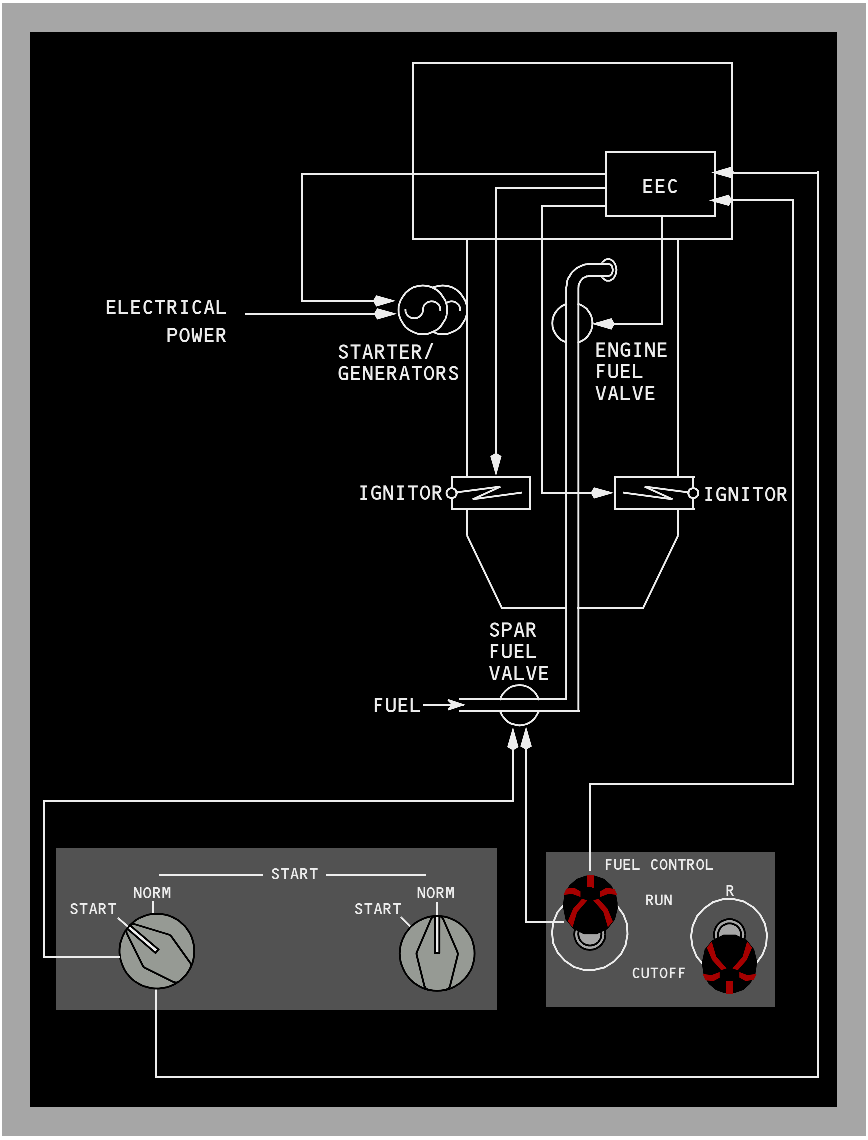
Auto–Relight

There is no manual continuous ignition selection or automatic continuous ignition function. Engine auto-relight protection is provided for flameout recovery. The auto-relight function is activated whenever an engine is at or below idle with the FUEL CONTROL switch in RUN.

When an engine flameout is detected, the EEC switches on both ignitors in the respective engine in an attempt to recover the engine. The ignitors are switched off when the engine again reaches idle. If the engine does not recover and continues to run down below 35% N3, the EEC shuts off fuel and ignition and disables the auto-relight function.

The EEC also provides protection against flameout during periods of excessive rain/hail ingestion. When a flameout is detected, the EEC energizes both ignitors.

Engine Start and Ignition System Schematic



Engine Fuel System

[Option – GE engines]

Fuel is supplied by pumps located in the fuel tanks. The fuel flows through a spar valve located in the main tank. It then passes through the first stage engine fuel pump where additional pressure is added. It flows through a fuel/oil heat exchanger where it is preheated. The fuel then passes through the second stage engine fuel pump where additional pressure is added. A fuel filter removes contaminants before the fuel reaches the fuel metering unit. The fuel metering unit adjusts fuel flow to meet thrust requirements. The fuel then flows through the engine fuel valve into the engine.

[Option – RR engines]

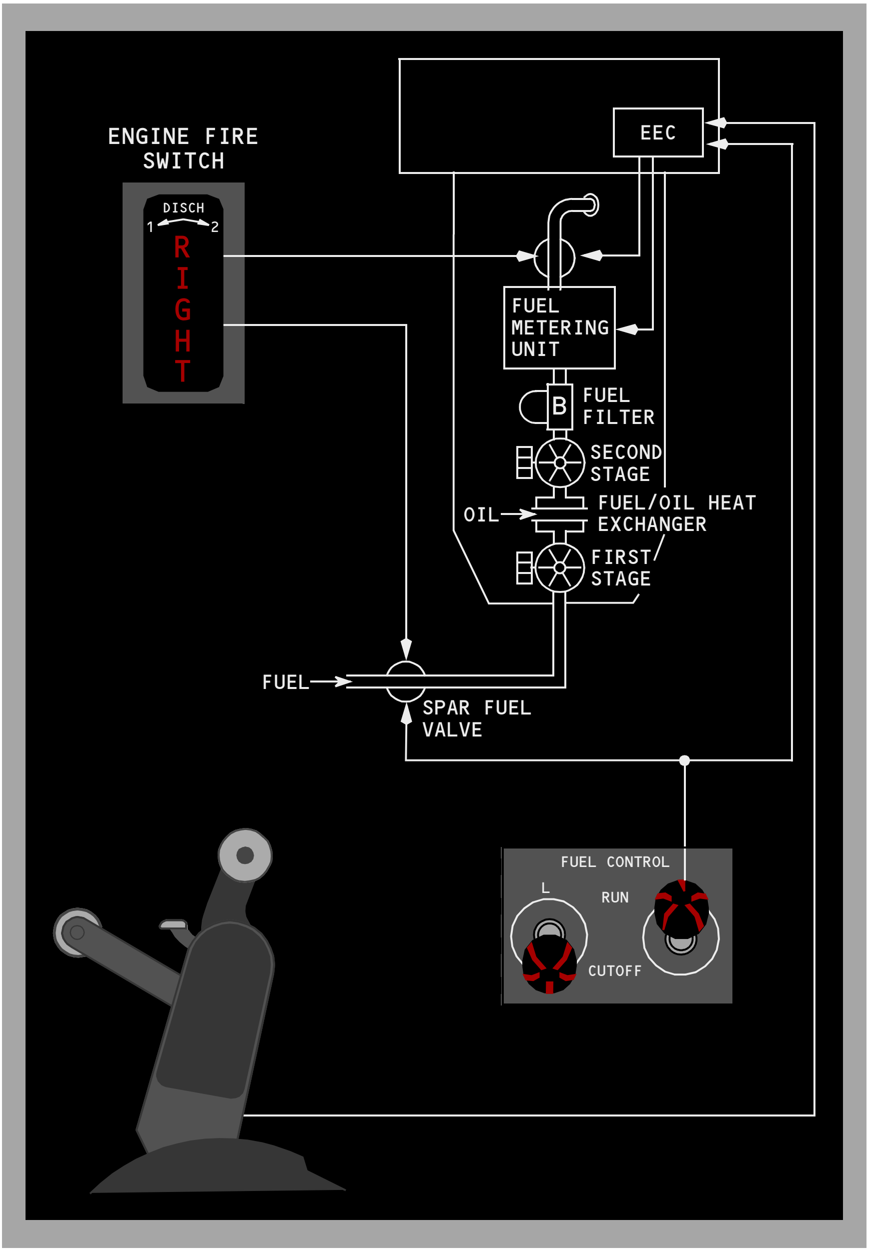
Fuel is supplied by pumps located in the fuel tanks. The fuel flows through a spar valve located in the main tank. It then passes through the first stage engine fuel pump where additional pressure is added. It flows through a fuel/oil heat exchanger where it is preheated. A fuel filter removes contaminants. The second stage of the engine fuel pump adds more pressure before the fuel reaches the fuel metering unit. The fuel metering unit adjusts fuel flow to meet thrust requirements. The fuel then flows through the engine fuel valve into the engine.

The spar and engine fuel valves allow fuel flow to the engine when both valves are open. The spar valve opens when the engine fire switch is IN and either the START selector is in START or the FUEL CONTROL switch is in RUN. The engine fuel valve opens when the engine fire switch is IN and the FUEL CONTROL switch is in RUN. Both valves close when the engine fire switch is OUT, or the FUEL CONTROL switch is in CUTOFF and the START selector is in NORM.

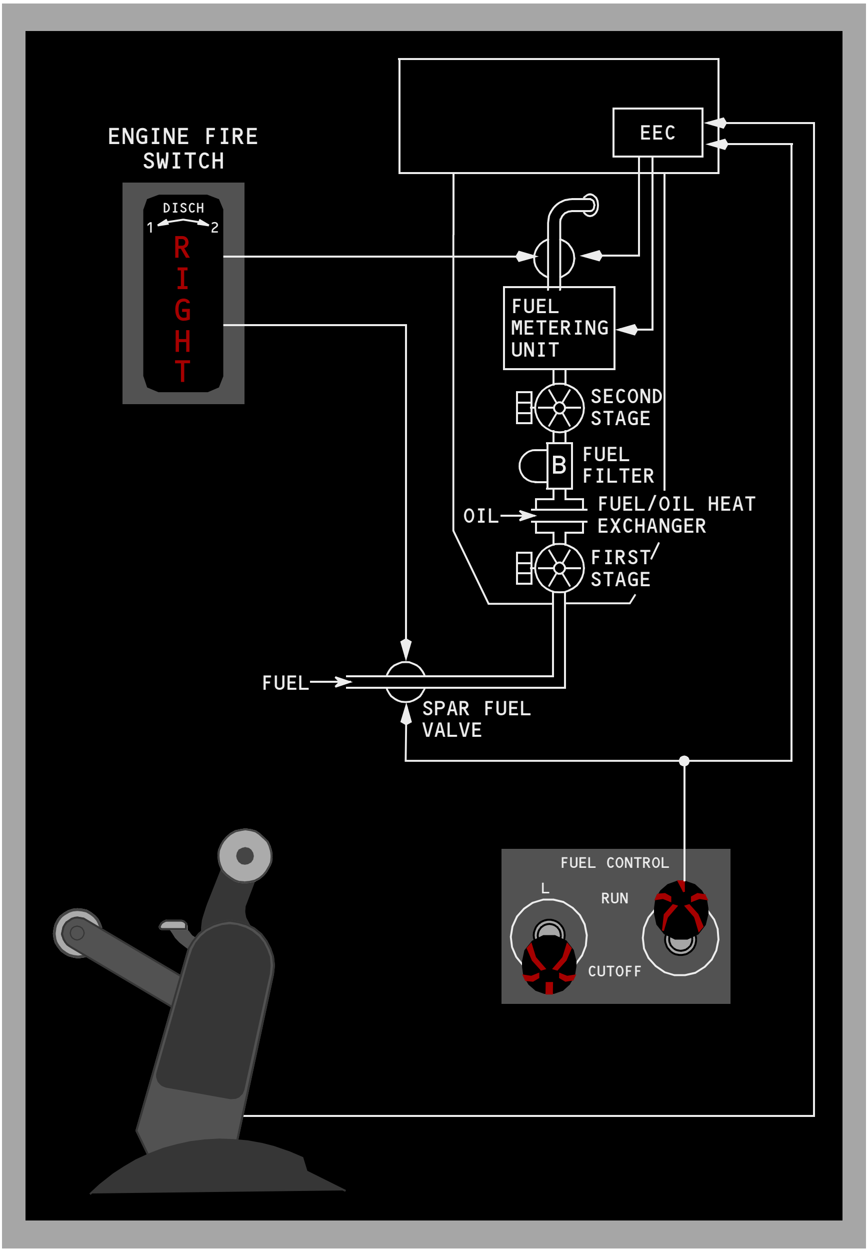
Fuel flow is measured after passing through the engine fuel valve. Fuel flow is displayed on the secondary engine display. Fuel flow information is also provided to the FMS.

Engine Fuel System Schematic

[Option – GE engines]



[Option – RR engines]



Engine Oil System

The oil system provides pressurized oil to lubricate and cool the engine main bearings, gears and accessory drives. The oil system also provides automatic fuel heating for fuel system icing protection.

[Option – GE engines]

Oil is pressurized by an engine–driven oil pump. From the pump, the oil flows through the oil filter. The engine oil is cooled primarily by a fuel/oil heat exchanger. Under conditions of low fuel flow or high fuel temperatures the excess engine oil heat is absorbed by finned air/oil surface heat exchangers. Oil is then delivered to the various components. A scavenge pump returns the oil to the reservoir.

[Option – RR engines]

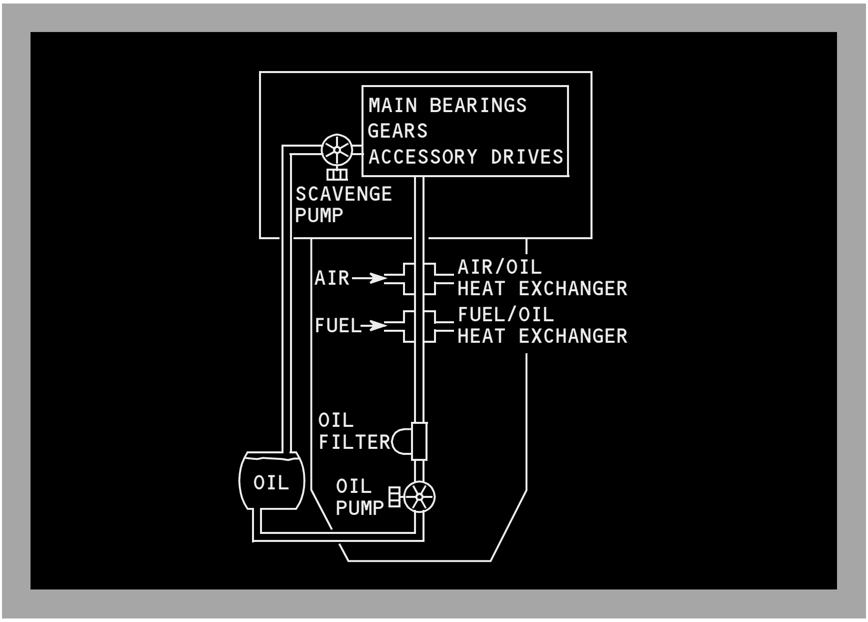
Oil is pressurized by an engine–driven oil pump. From the pump, the oil flows through the high pressure oil filter. The engine oil is cooled primarily by a fuel/oil heat exchanger. Under conditions of low fuel flow or high fuel temperatures the excess engine oil heat is absorbed by finned air/oil surface heat exchangers. Oil is then delivered to the various components. A scavenge pump returns the oil to the reservoir. Prior to the reservoir, the oil flows through a scavenge oil filter. If the scavenge oil filter becomes clogged, the EICAS advisory message ENG OIL FILTER (L or R) is displayed and oil bypasses the filter.

Oil pressure, temperature, and quantity are displayed on the engine display. Oil pressure is measured prior to entering the engine by dual oil pressure transmitters (there is no discrete low pressure switch). The EICAS caution message ENG OIL PRESS L or R is displayed if pressure decreases below the operating limit. Oil temperature is measured prior to entering the engine by dual oil temperature transmitters. The EICAS advisory message ENG OIL TEMP L or R is displayed when oil temperature exceeds the high point on the amber band.

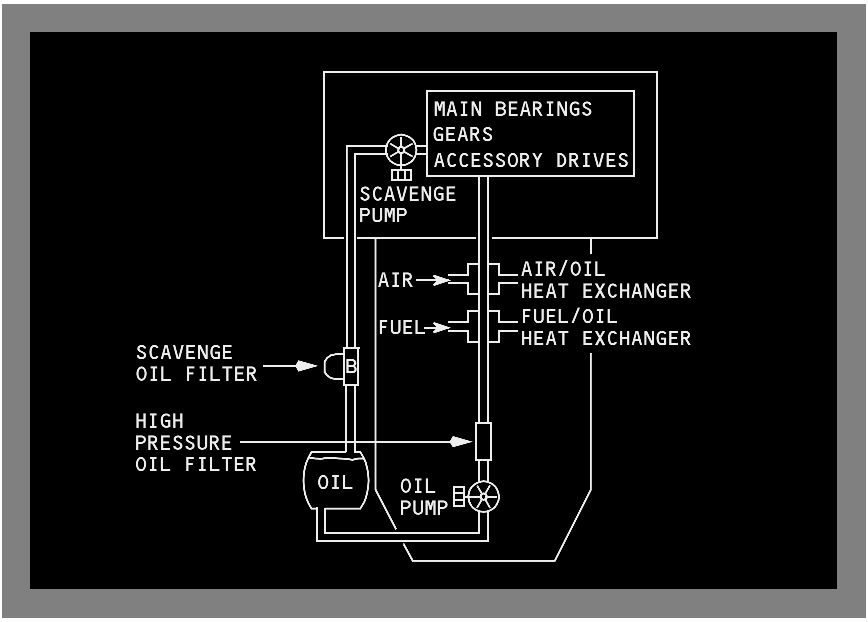
There is no minimum oil quantity limit (no amber or red line limit); however, a low oil quantity causes automatic display of the secondary engine display and reverses the display indication to show black numbers on a white background. There are no operating limitations for the engine oil quantity; therefore, there are no flight crew procedures based solely on a response to low oil quantity.

Engine Oil System Schematic

[Option – GE engines]



[Option – RR engines]



Thrust Reverser System

Each engine has a hydraulically actuated fan air thrust reverser. Reverse thrust is available only on the ground.

The reverse thrust levers can be raised only when the forward thrust levers are in the idle position. When the reverse thrust levers are raised, the EEC opens the reverser isolation valve. The EEC inhibits reverser isolation valve actuation and reverser deployment unless the airplane is on the ground with the engine running. The EECs also control thrust limits during reverser operation.

There is a physical interlock located in the aisle stand to prevent movement of the reverse thrust lever beyond the reverse idle position until the cowl is partially deployed. The interlock provides tactile feedback to the pilot that the thrust reverser is or is not deployed.

When the reverse thrust levers are pulled aft to the interlock position:

- the autothrottle disengages
- the auto speedbrakes deploy

When the reverser system is activated:

- the reverser translating sleeves hydraulically move aft
- the fan flow blocker doors rotate into place to direct fan air through stationary cascade guide vanes

[Option – GE engines]

- the reverser indication REV is displayed in amber above each digital N1 indication (REV is displayed in amber when the reverser is in transit)

[Option – RR engines]

- the reverser indication REV is displayed in amber above each digital TPR indication (REV is displayed in amber when the reverser is in transit)

When the interlock releases:

- the reverse thrust levers can be raised to the maximum reverse thrust position
- the REV indication changes to green when the reverser is fully deployed.

Pushing the reverse thrust levers to the full down position retracts the reversers to the stowed and locked position. The thrust levers cannot be moved forward until the reverse thrust levers are fully down.

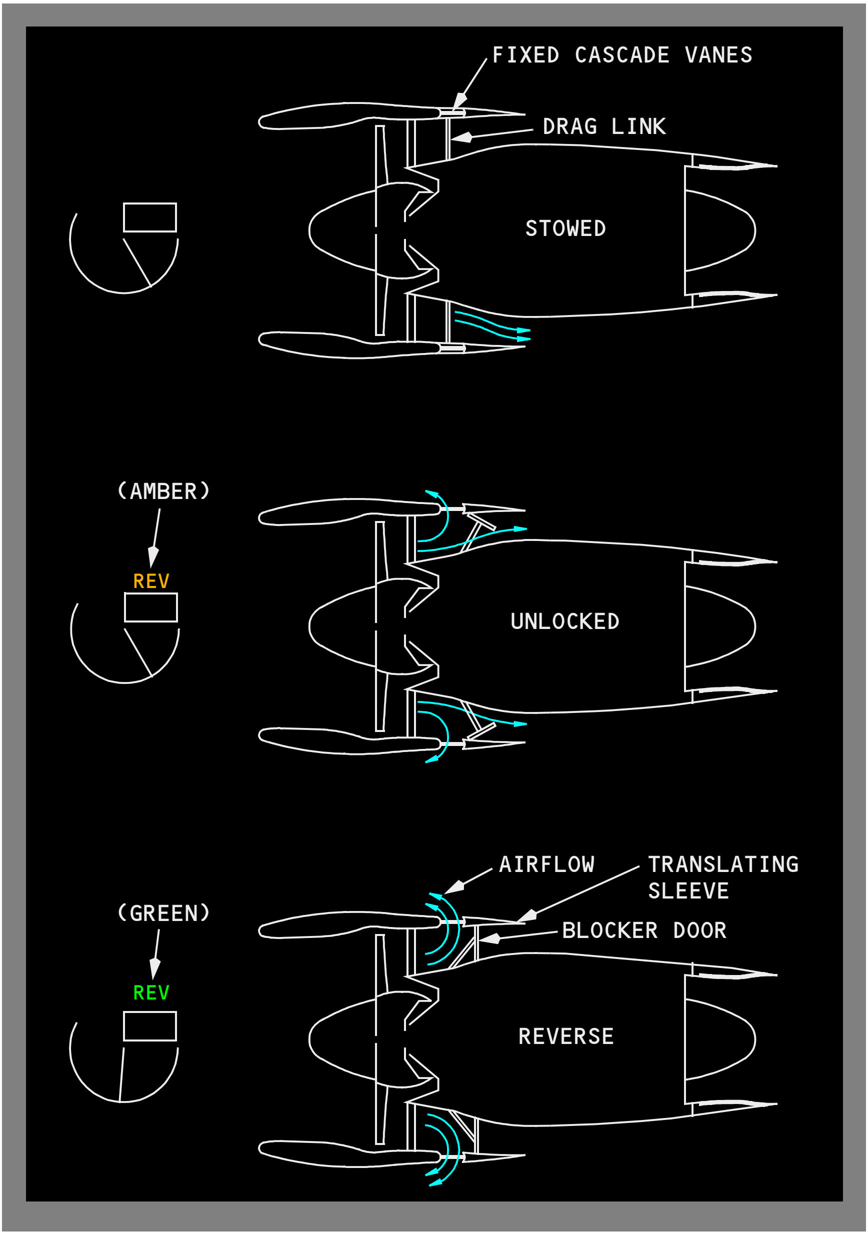
The EICAS advisory message ENG REV LIMITED (L or R) is displayed if the reverser cannot deploy when commanded, or can deploy only with reverse thrust limited to idle. Not all conditions limiting or preventing reverse thrust can be detected before reverse thrust selection. For these conditions, the reverse thrust levers cannot be moved beyond the interlock position.

The EICAS advisory message ENG REVERSER (L or R) is displayed on the ground to indicate a reverser system fault.

The EICAS caution message ENG REV AIR/GND is displayed when the air/ground logic that prevents in-flight thrust reverser deployment has failed.

The EICAS caution message ENG REV COMMANDED (L or R) is displayed when the left or right reverse thrust lever is not in the down position in flight.

Thrust Reverser Schematic



Airborne Vibration Monitoring System

[Option – GE engines]

The engine monitor unit tracks engine vibration levels. The vibration indications are displayed on the secondary engine display. The vibration source indication (N1, N2, or BB) is also displayed. If the vibration monitoring system cannot determine the source, BB (broadband) is displayed for the affected engine. Broadband vibration is the average vibration detected.

[Option – RR engines]

The engine monitor unit tracks engine vibration levels. The vibration indications are displayed on the secondary engine display. The vibration source indication (N1, N2, N3, or BB) is also displayed. If the vibration monitoring system cannot determine the source, BB (broadband) is displayed for the affected engine. Broadband vibration is the average vibration detected.

[Option – GE engines]

The airborne vibration monitoring feature is primarily intended to track rotor imbalance, but is also a useful tool for isolating and determining corrective action for engine anomalies. There is no certified vibration limit, but when a vibration value of 5 units is reached, the secondary engine parameters are automatically displayed and the digital vibration readout is displayed in reverse (black digits on white background). Since there are no operating limits, there are no specific flight crew actions (or procedures) based solely on vibration indication. High N1 vibration would most likely be accompanied by tactile vibration where as high N2 vibration may not be felt. Both N1 and N2 high vibrations may be accompanied by anomalies in other engine parameters and will usually respond to thrust lever adjustment.

[Option – RR engines]

The airborne vibration monitoring feature is primarily intended to track rotor imbalance, but is also a useful tool for isolating and determining corrective action for engine anomalies. There is no certified vibration limit, but when a vibration value of 5 units is reached, the secondary engine parameters are automatically displayed and the digital vibration readout is displayed in reverse (black digits on white background). Since there are no operating limits, there are no specific flight crew actions (or procedures) based solely on vibration indication. High N1 vibration would most likely be accompanied by tactile vibration where as high N2 or N3 vibration may not be felt. N1, N2 and N3 high vibrations may be accompanied by anomalies in other engine parameters and will usually respond to thrust lever adjustment.

Engine Failure Alert System

The engine failure alert system provides alerts when actual engine performance is less than commanded engine performance during a part of the takeoff and for other phases of flight.

A red ENG FAIL is displayed on both PFDs and both HUDs if actual thrust is less than commanded thrust during takeoff with airspeed between 65 knots and 6 knots prior to V1. The PFD and HUD displays are accompanied by the voice annunciation “Engine Fail,” and the Master WARNING lights illuminating.

The EICAS caution message ENG FAIL (L or R) is displayed if an engine unexpectedly decelerates to less than idle speed. The message remains displayed until the engine recovers or the fuel control switch is moved to CUTOFF.

The EICAS caution message ENG THRUST (L or R) is displayed if:

- the engine is producing less than commanded thrust, and actual thrust is not satisfactorily increasing towards the commanded thrust, or
- the engine is producing more than commanded thrust, and actual thrust is not satisfactorily decreasing towards the commanded thrust
- and, the current airspeed is greater than 6 knots prior to V1

The EICAS caution message ENG THRUST (L or R) is accompanied by:

- the thrust command arc is filled amber, and
- the Master CAUTION light and beeper aural

Engines, APU — Chapter 7
APU System Description — Section 30

Introduction

The auxiliary power unit (APU) is a self–contained gas turbine engine located in the airplane tail cone.

The APU can be started and operated to the airplane maximum certified altitude.

The APU supplies electrical power which is available throughout the airplane operating envelope.

Refer to the following for additional information regarding the APU:
- Chapter 6, Electrical, for a description of APU electrical operation
- APU Fire Protection, Chapter 8, Section 20, for a description of the APU fire protection system
- APU Fuel Feed, Chapter 12, Section 20, for a description of the APU fuel system

APU Operation

APU Start

The APU is started by either the left or right APU starter.

Either starter can be powered by forward external power or an engine generator. The right starter is also powered by the APU battery. The APU battery also powers the air inlet door and the main airplane battery powers the APU fuel spar valve, DC fuel pump, and fire detection system. The APU controller (APUC) is powered by either the APU battery or the main airplane battery, whichever has the higher voltage.

Rotating the APU selector to START begins the automatic start sequence. The START signal is latched in the APUC, and the APUC commands the air inlet door to open. If starting the APU from an unpowered airplane (battery switch recently moved to ON), the APUC waits until the common core system (CCS) applications are available before proceeding with the start. The CCS is required as both the fire detection and fuel management applications are necessary to start the APU.

Note: On battery power, the required CCS applications for starting the APU are available when the CDU page format is visible on the lower display unit.

APU fuel is supplied from the left fuel manifold by any operating AC fuel pump, or by the DC fuel pump. With AC power available and the APU selector in the ON position, the left aft fuel pump is commanded on regardless of flight deck switch position.

If AC power is not available or no AC pump pressurizes the left fuel manifold, the DC pump in the left main tank provides APU fuel. The DC pump continues to run until either the APU is shut down or an AC pump supplies fuel pressure. On the ground, the APU is designed to be started with no pumps operating.

When the APU air inlet door reaches the full open position, and the required CCS programs are running, the starter engages. Starter selection is automatic. The right starter is the primary APU starter. After the APU reaches the proper speed, APUC commands ignition and fuel. When the APU reaches starter cutout speed (approximately 50% rpm), the starter disengages and ignition is turned off.

When the APU is running (95% of target speed + 2 seconds), the EICAS memo message APU RUNNING is displayed and the APU is ready to power the airplane.

If the start fails, the APU shuts down automatically. The EICAS advisory message APU SHUTDOWN is displayed. Moving the APU selector from ON to OFF clears the message and resets the shutdown system to enable a restart attempt.

Note: On battery power, the CCS applications are limited and only the lower display unit is available. In this situation the APU still shuts down automatically, however the EICAS message can not be displayed.

APU Automatic Start

In flight, if three or more engine generators go offline, the APU automatically starts, regardless of APU selector position. When the automatic start condition is no longer valid, the APU can be shut down by positioning the selector to ON, then OFF. When the automatic start condition is valid, the APU can only be shut down by pulling the APU fire switch.

APU Shutdown

When the APU selector is rotated to OFF, the APUC initiates a normal shutdown sequence. The APU continues running in a two minute cooldown cycle. The EICAS memo message APU COOLDOWN is displayed. At any time during the cooldown period, the APU may be returned to its running condition by placing the APU selector back to ON. When the cooldown period finishes, an APU overspeed condition is simulated to test the overspeed and fuel shutoff protection. This shuts off fuel and the APU shuts down. The APUC then commands the APU spar valve to close and the CCS fuel management application turns off fuel pumps as applicable. At 15% rpm, the APUC commands the air inlet door to close and the normal shutdown sequence is complete.

APU Operating Modes

The APU has attended and unattended operating modes. The attended mode operates when either engine is starting or running, or when the airplane is in flight. The unattended mode operates in all other configurations on the ground.

APU Attended Mode

In the attended mode, any of the following faults cause the APU to shut down immediately:

- APU fire/inlet overtemperature
- overspeed/loss of overspeed protection
- APU controller failure
- speed droop
- APU start failure
- Air inlet door failed closed

There is no cool down period. The EICAS advisory message, APU SHUTDOWN, displays.

For the following faults, the APU continues to operate and the EICAS caution message APU LIMIT displays:

- high EGT
- high oil temperature
- low oil pressure

There is no cooldown period when the APU is manually shut down after the APU LIMIT message is displayed.

APU Unattended Mode

In the unattended mode, any of the following faults cause the APU to shutdown immediately:

- APU fire/inlet overtemperature
- overspeed/loss of overspeed protection
- high EGT/loss of EGT signal
- low oil pressure
- high oil temperature
- APU starter/generator oil filter approaching bypass
- Air inlet door failed closed
- APU controller failure
- speed droop
- APU starting failure

There is no cool down period. The EICAS advisory message, APU SHUTDOWN, displays.

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Engines, APU EICAS Messages

The following EICAS messages can be displayed.

APU

Message	Level	Aural	Condition
APU COOLDOWN	Memo		The APU is running in the cooldown mode.
APU LIMIT	Caution	Beeper	An APU limit exceedance occurs.
APU RUNNING	Memo		The APU is running.
APU SHUTDOWN	Advisory		An APU automatic shutdown occurs.

Engine

Control

Message	Level	Aural	Condition
ENG CONTROL L, R	Advisory		An EEC system fault occurs.
ENG EEC MODE L, R	Advisory		An EEC is in the alternate control mode.
ENG FAIL L, R	Caution	Beeper	Engine speed is below idle.

[Option – RR engines]

ENG HP VALVE L, R	Advisory		The high pressure air valve is failed in the open position.

ENG IDLE DISAGREE	Advisory		One engine is at approach idle and the other engine is at minimum idle.
ENG LIMIT EXCEED L, R	Caution		An engine limit exceedance occurs.
ENG LIMIT PROT L, R	Caution	Beeper	The EEC is in the alternate mode and command N1 is more than the limit.

Message	Level	Aural	Condition

[Option – RR engines]

Message	Level	Aural	Condition
ENG LPC ANTI-ICE L, R	Advisory		An engine anti-ice fault occurs.
ENG REV AIR/GND	Caution		The air/ground thrust reverser logic is failed.
ENG REV COMMANDED L, R	Caution		The reverse thrust lever is not in the down position in flight.

Control (continued)

Message	Level	Aural	Condition
ENG REV LIMITED L, R	Advisory		One of these will occur after landing: • The thrust reverser will not deploy • Only idle reverse thrust will be available
ENG REVERSER L, R	Advisory		A fault occurs in the thrust reverser system.
ENG RPM LIMITED L, R	Advisory		Engine control is limiting affected engine thrust to prevent N1 or N2 from exceeding the RPM operating limit.
ENG SHUTDOWN	Caution		Both engines were shut down by the fuel control switches or the engine fire switches.
ENG SHUTDOWN L, R	Caution		The engine was shut down by the fuel control switch or the engine fire switch.
ENG SURGE L, R	Caution		An engine surge or stall is detected.
ENG THRUST L, R	Caution		One of these occurs: • The engine thrust is more than the commanded thrust • The engine thrust is less than the commanded thrust

[Option – RR engines]

ENG THRUST HIGH L, R	Warning		The high pressure air valve is failed in the open position and actual thrust is higher than the reduced thrust limit.

[Option – RR engines]

ENG THRUST LIMIT L, R	Advisory		The high pressure air valve is failed in the open position and the engine thrust is limited.

Start

Message	Level	Aural	Condition
ENG AUTOSTART L, R	Caution	Beeper	Autostart did not start the engine.
ENG START CUTOUT L, R	Advisory		The start selector stays in START and the engine is running.
ENG STARTERS L, R	Advisory		Engine starters are inoperative.

Fuel

Message	Level	Aural	Condition
ENG FUEL FILTER L, R	Advisory		Fuel contamination can cause fuel to bypass the fuel filter.
ENG FUEL LIMITED L, R	Advisory		The engine fuel nozzle controller is failed to a low fuel flow setting. Thrust available is reduced.
ENG FUEL VALVE L, R	Advisory		One or more of these occur: • The engine fuel valve is not in the commanded position • The fuel spar valve is not in the commanded position

Oil

Message	Level	Aural	Condition
ENG OIL FILTER L, R	Advisory		Oil filter contamination can cause oil to bypass the oil filter.
ENG OIL PRESS L, R	Caution	Beeper	Oil pressure is low.
ENG OIL TEMP L, R	Advisory		The oil temperature is high.

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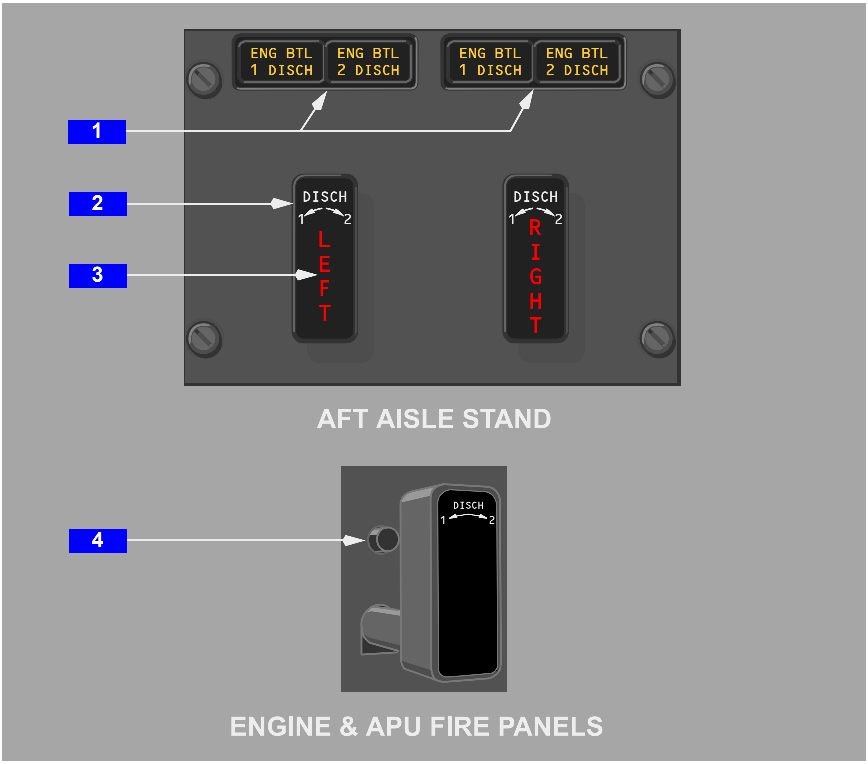
Fire Protection — Chapter 8
Table of Contents — Section 0

Engine Fire Protection

Engine Fire Panel



1 Engine Bottle Discharged (ENG BTL DISCH) Lights

Illuminated (amber) – the extinguisher bottle is discharged or has low pressure.

2 Engine Fire Switches

In (normal position, mechanically locked) – unlocks automatically for a fire warning, or when the FUEL CONTROL switch is in CUTOFF.

Out –

- arms both engine fire extinguishers
- closes the associated engine and spar fuel valves
- closes the associated engine anti-ice valves
- trips the associated engine generators off

- shuts off hydraulic fluid to the associated engine–driven hydraulic pump
- depressurizes the associated engine–driven hydraulic pump
- removes power to the thrust reverser isolation valve

Rotate to position 1 or 2 – discharges the selected fire extinguisher into the engine.

3 Engine Fire Warning Lights

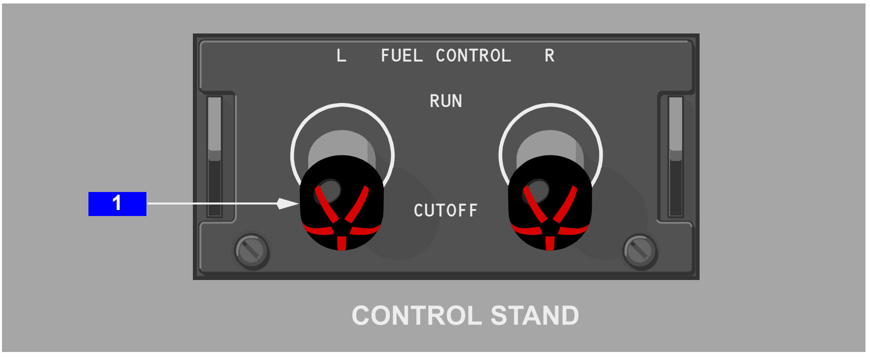
Illuminated (red) –

- an engine fire is detected, or
- the FIRE/OVERHEAT TEST switch is pushed

4 Engine and APU Fire Override Switches

Push – unlocks the fire switch.

Fuel Control Switches

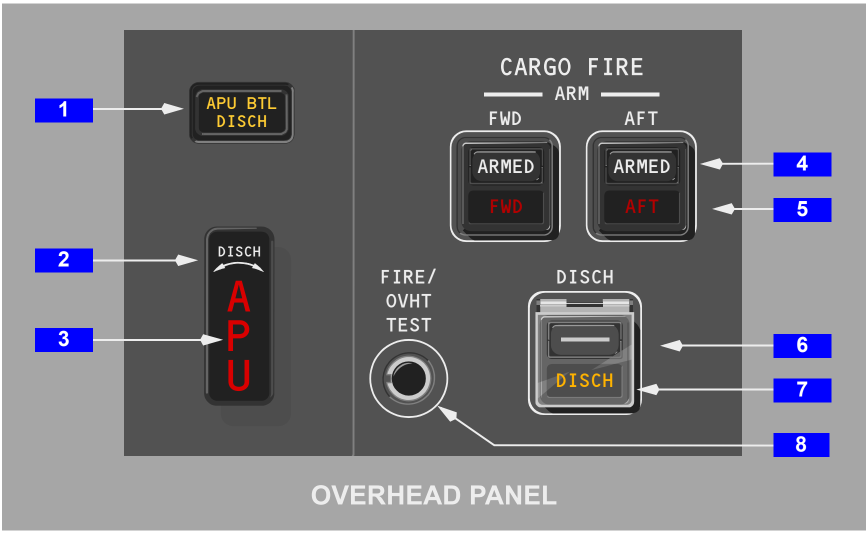


1 FUEL CONTROL Switch Fire Warning Lights

Illuminated (red) –

- an associated engine fire is detected, or
- the FIRE/OVERHEAT TEST switch is pushed

APU and Cargo Fire Panel



1 APU Bottle Discharge (APU BTL DISCH) Light

Illuminated (amber) – the extinguisher bottle is discharged or has low pressure.

2 APU Fire Switch

In – normal position, mechanically locked; unlocks automatically for a fire warning.

Out –

- arms the APU fire extinguisher bottle
- closes the APU fuel valve
- closes the APU air inlet door
- trips the APU generator field and generator breaker
- shuts down the APU (if automatic shutdown does not occur)

Rotate – either direction discharges the APU fire extinguisher into the APU compartment.

3 APU Fire Warning Light

Illuminated (red) –

- an APU fire is detected, or
- the FIRE/OVERHEAT TEST switch is pushed

The APU automatically shuts down for a detected fire.

4 CARGO FIRE ARM Switches

ARMED –

- arms all cargo fire extinguisher bottles
- arms the selected compartment extinguisher valve
- turns off both lower recirculation fans
- shuts down cargo heat
- commands the packs to provide the minimum air flow required to provide pressurization
- shuts down the bulk cargo compartment ventilation system operation (aft cargo fire only)
- shuts down the lavatory/galley vent fan (aft cargo fire only)
- puts associated (fwd or aft) equipment cooling system into the override mode
- turns off miscellaneous equipment cooling fan (forward cargo fire only)
- shuts off inflight entertainment equipment (IFE) cooling
- turns off nitrogen inerting system
- shuts off door 4 galley chiller units (aft cargo fire only)
- outflow valves move to 50/50 flow split for air flow stability
- turns off de-humidification fans

Off (blank) – normal position.

5 CARGO FIRE Warning Lights

Illuminated (red) –

- associated cargo compartment smoke is detected, or
- the FIRE/OVERHEAT TEST switch is pushed

6 CARGO FIRE Discharge (DISCH) Switch

Push – discharges the fire extinguisher bottles into the ARMED cargo compartment.

7 CARGO FIRE Discharge (DISCH) Light

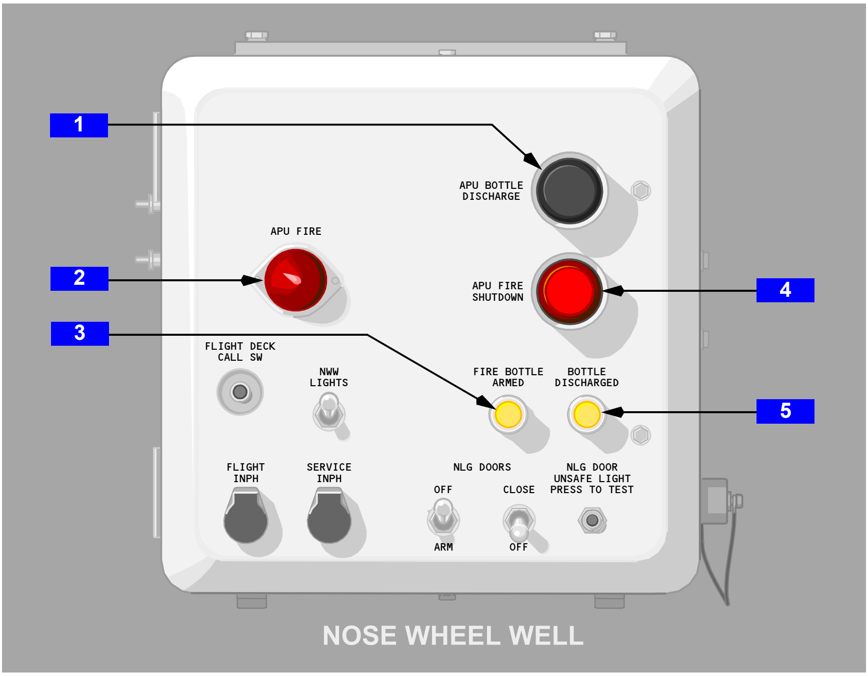
Illuminated (amber) – the fire extinguishers have discharged.

8 FIRE/OVERHEAT TEST Switch

Push and hold –

- sends fire/overheat test signals to the engine, APU, wheel well, and cargo compartment fire detector systems
- tests flight deck fire and overheat indications (see Fire and Overheat Detection System Manual Fault Test, Section 20)

APU Ground Control Fire Protection Panel



1 APU BOTTLE DISCHARGE Switch

Push – discharges the APU fire extinguisher into the APU compartment.

2 APU FIRE Light

Illuminated (red) –

- an APU fire is detected, or
- a fire/overheat test is in progress

The APU automatically shuts down for a detected fire.

3 APU FIRE BOTTLE ARMED Light

Illuminated (amber) – the APU fire extinguisher is armed.

4 APU FIRE SHUTDOWN Switch

Push (red) –

- shuts down the APU
- arms the APU fire extinguisher

5 APU BOTTLE DISCHARGED Light

Illuminated (amber) – the extinguisher bottle pressure is low.

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Introduction

There are fire detection and extinguishing systems for the:

- APU
- cargo compartments
- engines
- lavatories

The engines also have overheat detection systems.

The main gear wheel wells have a fire detection system, but no fire extinguishing system.

[Option – Overhead Flight Crew Rest]
The overhead flight crew rest compartment has a fire detection system, but no fire extinguishing system.

[Option – Overhead Flight Attendant Rest]
The overhead flight attendant rest compartment has a fire detection system, but no fire extinguishing system.

Refer to the following chapters for additional information:

- Chapter 2 – Air Systems, for descriptions of equipment smoke evacuation
- Chapter 3 – Anti–Ice, Rain, for a description of engine anti–ice system duct leak protection

Engine Fire Protection

Engine fire protection consists of these systems:

- engine fire and overheat detection
- engine fire extinguishing

Engine Fire and Overheat Detection

There are multiple dual-channel detector assemblies in each engine nacelle. Each detector channel provides both fire and overheat detection. Normally, at least one element on each channel must detect a fire or overheat condition to cause an engine fire warning or overheat caution.

If a fault is detected in one channel, the remaining channel element automatically switches to single channel operation. If the operating channel senses a fire or overheat, the system provides the appropriate fire warning or overheat caution.

If both main engine detector elements on a single assembly are faulted, no fire or overheat detection is provided. The EICAS advisory message DET FIRE ENG (L or R) is displayed if the engine fire detection system fails.

[Option – RR engines]
Turbine overheat detection is provided in addition to engine fire and engine overheat detection. A turbine overheat event is annunciated with the same flight deck indications as an engine fire (FIRE ENG L, R).

Engine Fire Warning

The indications of an engine fire are:

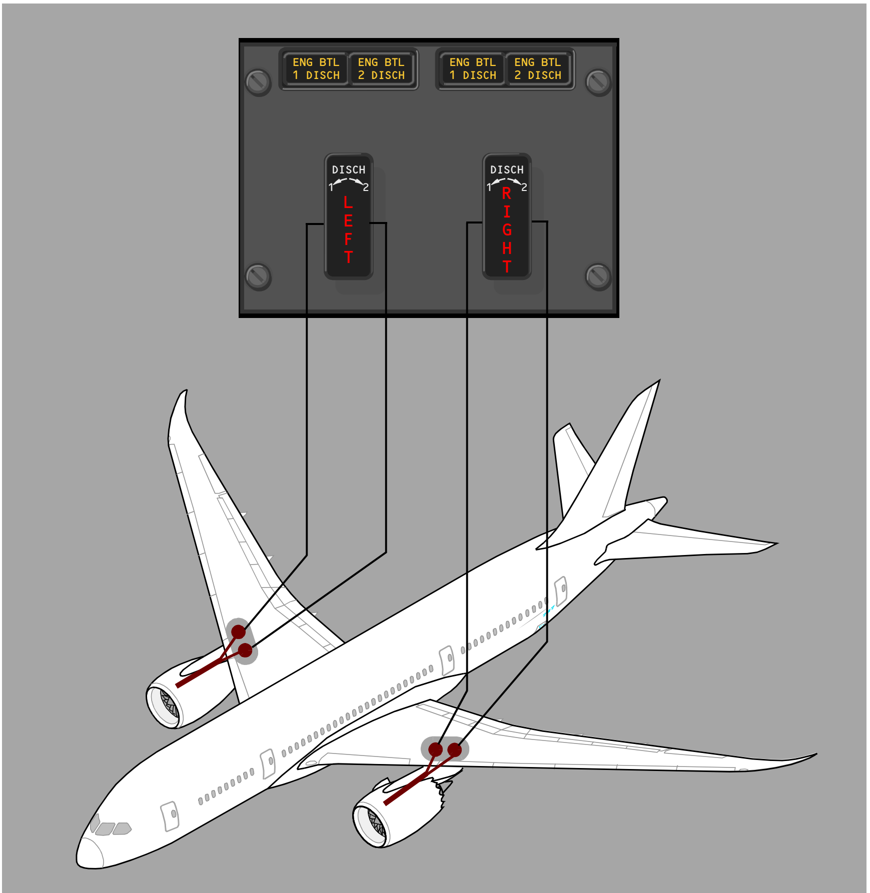
- the fire bell sounds
- the master WARNING lights illuminate
- the EICAS warning message FIRE ENG (L or R) is displayed
- the engine fire switch LEFT or RIGHT fire warning light illuminates
- the engine fire switch unlocks
- the engine FUEL CONTROL (L or R) switch fire warning light illuminates

Engine Overheat Caution

The indications of an engine overheat are:

- the caution beeper sounds
- the master CAUTION lights illuminate
- the EICAS caution message OVERHEAT ENG (L or R) is displayed

Engine Fire Extinguishing



ENGINE FIRE EXTINGUISHING SYSTEM

There are two fire extinguisher bottles for each engine. One or both bottles can be discharged into the engine.

When the engine fire switch is pulled out, rotating the fire switch in either direction discharges a single extinguisher bottle into the associated engine. Rotating the engine fire switch in the other direction discharges the remaining extinguisher bottle into the same engine.

If an extinguisher bottle is discharged or has low pressure:

- the ENG BTL (1 or 2) DISCH light illuminates
- the EICAS advisory message(s) BTL (1 or 2) DISCH ENG (L or R) display

APU Fire Protection

APU fire protection consists of these systems:

- APU fire detection
- APU fire extinguishing

APU Fire Detection

The APU compartment has dual fire detector loops. There is no APU overheat detection.

Normally, both loops must detect a fire to produce a fire warning. An APU fire warning automatically shuts down the APU.

If a fault is detected in one loop, the system automatically switches to single loop operation. If the operating loop detects a fire, an APU fire warning occurs and the APU shuts down.

The EICAS advisory message DET FIRE APU is displayed if the APU fire detection system fails.

APU Fire Warning

The indications of an APU fire warning are:

- the fire bell sounds
- the master WARNING lights illuminate
- the EICAS warning message FIRE APU is displayed
- the APU fire switch fire warning light illuminates
- the APU fire switch unlocks

APU Fire Extinguishing

There is one APU fire extinguisher bottle. When the APU fire switch is pulled out, rotating the switch in either direction discharges the extinguisher bottle into the APU compartment. If the bottle is discharged or has low pressure:

- the APU BTL DISCH light illuminates
- the EICAS advisory message BOTTLE DISCH APU is displayed

An APU fire signal from either APU fire detector loop causes APU shutdown and an automatic extinguisher bottle discharge after 10 second delay.

Main Wheel Well Fire Protection

The main wheel well has fire detection only. There is no fire extinguishing system. The nose wheel well does not have a fire detection system.

Main Wheel Well Fire Detection

The main wheel well fire detection system consists of dual fire detector channels.

Main Wheel Well Fire Warning

The indications for a main wheel well fire are:

- the fire bell sounds
- the EICAS warning message FIRE WHEEL WELL is displayed
- the master WARNING lights illuminate

Cargo Compartment Fire Protection

Cargo compartment fire protection consists of these systems:

- cargo compartment smoke detection
- cargo compartment fire extinguishing

Cargo Compartment Smoke Detection

The forward and aft cargo compartments each have smoke detectors. Each compartment is divided into three detection zones. If smoke is detected in any zone, a fire warning occurs.

Whenever cargo compartment smoke detection is inoperative, the EICAS advisory message DET FIRE CARGO (FWD or AFT) is displayed.

Cargo Compartment Fire Warning

The indications of a cargo compartment fire are:

- the fire bell sounds
- the master WARNING lights illuminate
- the EICAS warning message FIRE CARGO (FWD or AFT) is displayed
- the CARGO FIRE (FWD or AFT) fire warning light illuminates

Cargo Compartment Fire Extinguishing

[Option – 180 min protection]

Five fire extinguisher bottles are installed for cargo compartment fire extinguishing. Pushing the FWD or AFT CARGO FIRE ARM switch (ARMED visible) arms the extinguishers.

[Option – 180 min protection]

In flight with one engine running, a fire warning from the cargo fire detection system causes the immediate total discharge of two extinguisher bottles into the affected compartment. After a 15 minute time delay, the remaining three extinguisher bottles discharge at a reduced flow rate into the affected compartment. If the airplane lands within the 15 minute time delay, only one of the remaining bottles discharges at the reduced rate on touchdown.

In flight, pushing the CARGO FIRE DISCHARGE switch also activates the extinguishing system.

On the ground, if a CARGO FIRE DISCHARGE switch is pushed, three extinguisher bottles discharge simultaneously into the selected compartment, with the third bottle discharging at a reduced flow rate.

When cargo fire extinguisher bottle discharge is initiated:

- the CARGO FIRE DISCHARGE switch light illuminates when the first two extinguisher bottles begin to discharge
- the EICAS advisory message BOTTLE DISCH CARGO is displayed when the first two extinguisher bottles have completely discharged

Crew Rest Compartment Fire Protection

Overhead Flight Crew Rest Compartment Smoke Detection

[Option – Overhead Flight Crew Rest]

Smoke detectors are installed in the overhead flight crew rest compartment. The EICAS caution message SMOKE REST UPR DR 1 indicates smoke in the compartment.

Overhead Flight Attendant Rest Compartment Smoke Detection

[Option – Overhead Flight Attendant Rest]

Smoke detectors are installed in the overhead flight attendant rest compartment. The EICAS caution message SMOKE REST UPR DR 4 indicates smoke in the compartment.

Lavatory Fire Protection

Lavatory fire protection consists of these systems:

- lavatory fire detection
- lavatory waste container fire extinguishing

Lavatory Fire Detection

Each lavatory has a single smoke detector. If smoke is detected, an aural alert sounds in the lavatory and in the cabin. In addition, the lavatory call light flashes and the master call light at the associated attendant station illuminates. The EICAS advisory message SMOKE LAVATORY is displayed.

Lavatory Fire Extinguishing

Each lavatory has one fire extinguisher bottle. The bottle discharges through two nozzles into the waste container. Extinguisher operation is automatic. There is no flight deck indication.

Fire and Overheat Detection System Fault Test

The fire and overheat detection system has automatic and manual fault testing.

Fire and Overheat Detection System Automatic Fault Test

Fire and overheat detection system testing is automatic. The engine and APU systems continuously monitor the fire/overheat detector loops for faults. The cargo and wheel well systems continuously monitor for any system faults.

If a fault is detected, the system automatically reconfigures for single loop operation. Complete system failures are indicated by an EICAS advisory message for the failed system:

- DET FIRE ENG (L or R)
- DET FIRE APU
- DET FIRE CARGO (FWD or AFT)

Fire and Overheat Detection System Manual Fault Test

The fire and overheat detection systems can be tested manually by pushing and holding the FIRE/OVERHEAT TEST switch.

The indications for a manual fire and overheat detection system test are:

- the fire bell sounds
- the nose wheel well crew call horn sounds (on the ground)
- the EICAS warning message FIRE TEST IN PROG is displayed
- these lights illuminate:
  - the master WARNING lights
  - the LEFT and RIGHT engine fire warning lights
  - the APU fire warning light
  - the nose wheel well APU fire warning light
  - the FWD and AFT CARGO FIRE warning lights
  - the LEFT and RIGHT FUEL CONTROL switch fire warning lights

When the test is complete, the EICAS warning message FIRE TEST PASS or FIRE TEST FAIL replaces the FIRE TEST IN PROG message; the switch can be released. The appropriate system EICAS messages are displayed with the FIRE TEST FAIL message:

- DET FIRE ENG (L or R)
- DET FIRE APU
- DET FIRE CARGO (FWD or AFT)
- DET FIRE WHEEL WELL

All test messages clear when the test switch is released. If the switch is released with the FIRE TEST IN PROG message displayed, the test ends without completing.

Intentionally
Blank

Fire Protection EICAS Messages

The following EICAS messages can be displayed.

Airplane System EICAS Messages

Message	Level	Aural	Condition
BOTTLE 1, 2 DISCH ENG	Advisory		The fire bottle pressure is low.
BOTTLE DISCH APU	Advisory		The fire bottle pressure is low.
BOTTLE DISCH CARGO	Advisory		Both rapid discharge fire bottle pressures are low.
DET FIRE APU	Advisory		The APU fire detection system is failed.
DET FIRE CARGO AFT, FWD	Advisory		Cargo compartment smoke detection is inoperative.
DET FIRE ENG L, R	Advisory		An engine fire detection system fault occurs.
FIRE APU	Warning	Fire Bell	Fire is detected in the APU.
FIRE CARGO AFT, FWD	Warning	Fire Bell	Smoke is detected in the cargo compartment.
FIRE ENG L, R	Warning	Fire Bell	Fire is detected in the engine.
FIRE WHEEL WELL	Warning	Fire Bell	Fire is detected in a main wheel well.
OVERHEAT ENG L, R	Caution	Beeper	An overheat is detected in the engine.
OVERHEAT WHEEL WELL	Advisory		An overheat is detected in either the left or right wheel well.

Cabin System EICAS Messages

Cabin

Message	Level	Aural	Condition
SMOKE EQUIP CLG AFT, FWD	Caution	Beeper	Smoke is detected in the affected equipment cooling system.
SMOKE EQUIP CLG MISC	Caution	Beeper	Smoke is detected in the miscellaneous equipment cooling system.
SMOKE LAVATORY	Advisory		Smoke is detected in one or more lavatories.
SMOKE LAV/COMPT	Advisory	Beeper	Smoke is detected in a lavatory, or other enclosed compartment.

Crew Rest Area

Message	Level	Aural	Condition
SMOKE REST UPR DR 1	Caution	Beeper	Smoke is detected in a crew rest area.
SMOKE REST UPR DR 4	Caution	Beeper	Smoke is detected in a crew rest area.

System Test Messages

The following messages are associated with the manually initiated fire test.

Message	Level	Aural	Condition
DET FIRE WHEEL WELL	Advisory		Wheel well fire detection system is failed.
FIRE TEST FAIL	Warning		One or more fire/overheat detection systems have failed to successfully complete the manually initiated fire/overheat test.
FIRE TEST IN PROG	Warning		A manually initiated fire/overheat detection system test is in progress.
FIRE TEST PASS	Warning		A manually initiated test of the fire/overheat detection system has been completed.

Flight Controls — Chapter 9

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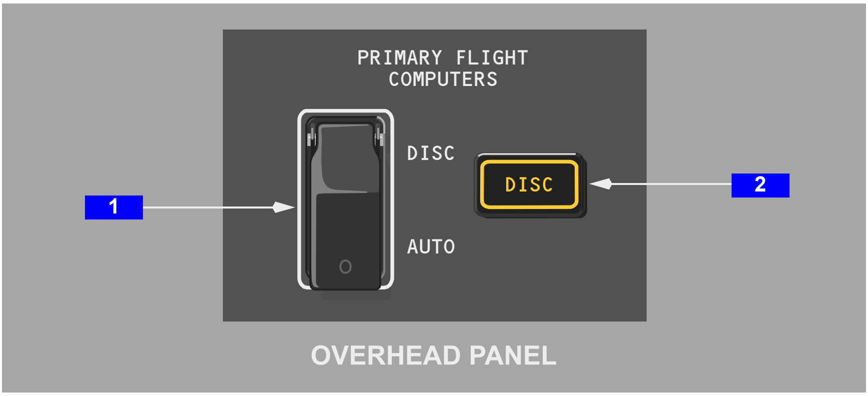
Controls and Indicators — Section 10

Primary Flight Computers Control



1 PRIMARY FLIGHT COMPUTERS Disconnect Switch

DISC –

- disconnects the primary flight computers (PFCs) from the flight control system
- puts the flight control system in the direct mode
- AUTO can be reselected to attempt restoration of secondary or normal mode operation

AUTO –

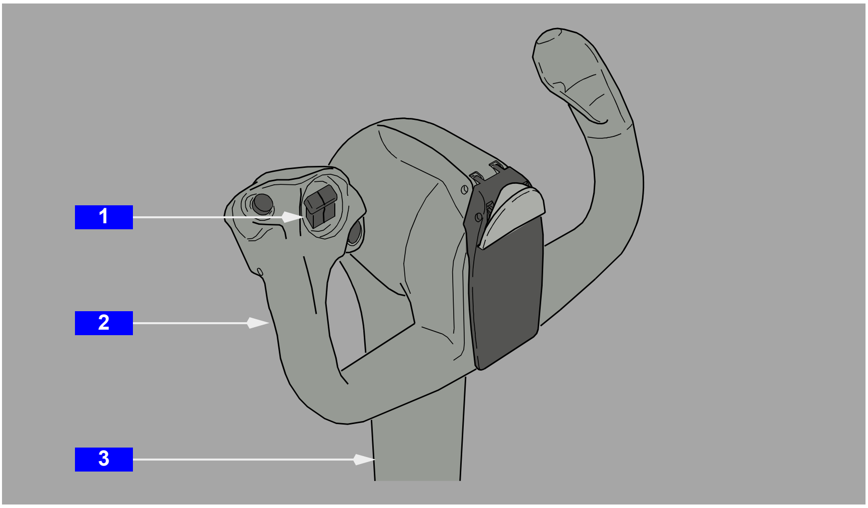
- the flight control system operates in the normal mode
- system faults automatically cause the system to switch to the secondary or direct modes

2 PRIMARY FLIGHT COMPUTERS Disconnect (DISC) Light

Illuminated (amber) – the primary flight computers are disconnected either automatically or manually and the system is in the direct mode.

Pitch and Stabilizer Trim Systems

Control Wheel and Column



1 Pitch Trim Switches

Spring-loaded to neutral.

Push (both switches) –

- on the ground, directly moves the stabilizer
- in the air in normal mode, changes the trim reference airspeed
- in the air in the secondary and direct modes, directly moves the stabilizer

2 Control Wheel

Rotate – deflects the ailerons, flaperons, and spoilers in the desired direction.

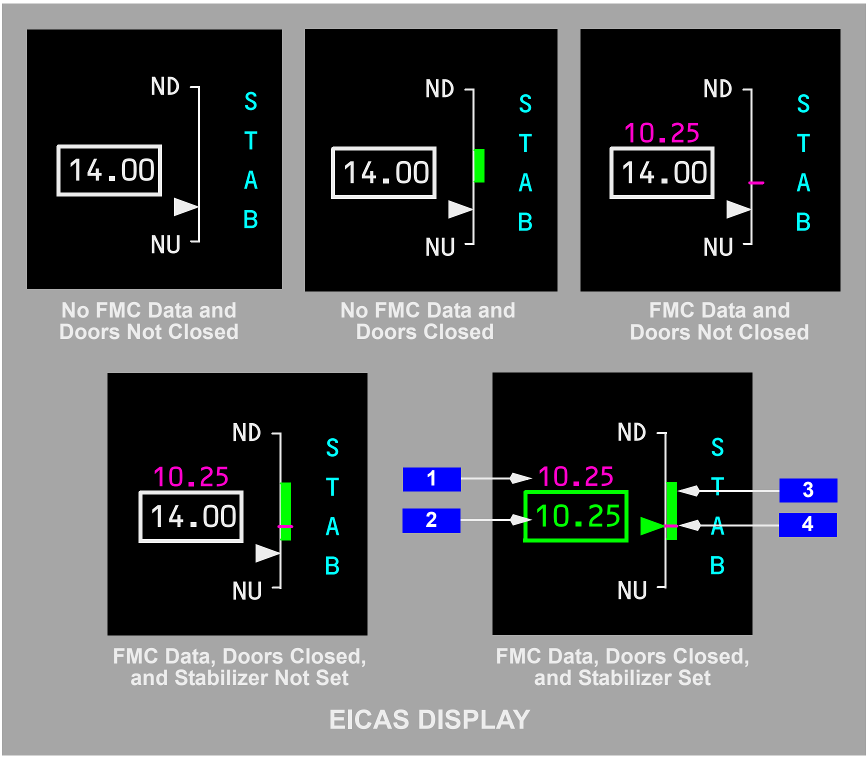
3 Control Column

Push/pull – commands the airplane to pitch in the desired direction:

- in the normal mode, deflects the elevator and horizontal stabilizer
- in the secondary and direct modes, deflects the elevator

Does not move with pitch trim operation.

Stabilizer Trim System



1 FMC Stabilizer Takeoff Setting

Displays (magenta) the FMC calculated stabilizer takeoff setting in units of trim.

When FMC data is not present or is invalid, the digital readout is not displayed.

2 Stabilizer (STAB) Position Indicator

Displays actual stabilizer position in 0.25 increments from 0.0 to 17.0 units of trim. Corresponding pointer position is displayed on the ND/NU (nose down/nose up) scale.

Box, digital readout and pointer display white prior to all passenger doors closed, or anytime the trim pointer is outside the greenband.

Box, digital readout and pointer display green when FMC performance data is entered, all passenger doors are closed, and trim pointer is within the greenband.

When the stabilizer signal is not present or is invalid, the digital readout and pointer are not displayed on the stabilizer position indicator.

When the stabilizer trim is inoperative, the digital readout is replaced with an "X". The box, the "X" and the pointer display amber. The pointer remains on the scale at the last known trim position.

3 **Takeoff Trim Greenband**

The greenband indicates the allowable takeoff trim range, based on gross weight and CG information from the FMC.

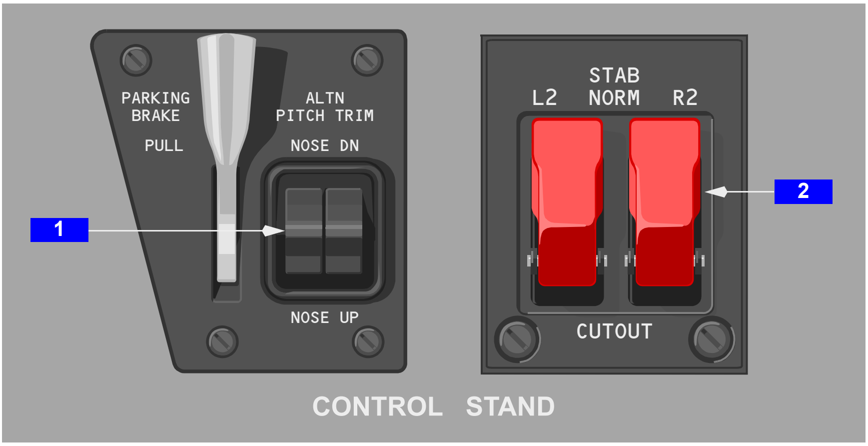
A default greenband is displayed after all passenger doors are closed and before performance data has been entered into the FMC.

When the greenband signal is not present or is invalid, the greenband is not displayed.

4 **Calculated Takeoff Setting Indicator**

The stabilizer takeoff setting, as calculated by the FMC, is also indicated by a magenta tick mark on the ND/NU scale.

When FMC data is not present or is invalid, the tick mark is not displayed.



1 **Alternate (ALTN) PITCH TRIM Switches**

Spring-loaded to neutral.

Push (both switches) –

- on the ground, directly moves the stabilizer
- in the air in normal mode, changes the trim reference airspeed
- in the air in the secondary and direct modes, directly moves the stabilizer

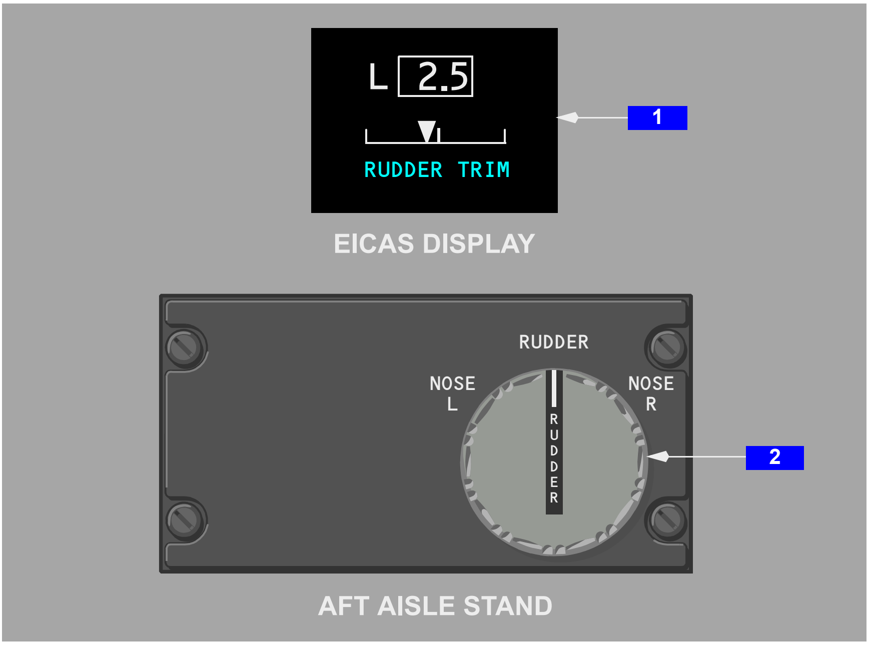
2 **Stabilizer (STAB) Cutout Switches**

NORM –

- electrical power is supplied to the related stabilizer control unit
- if unscheduled stabilizer motion is detected, electrical power to the related stabilizer control unit is automatically shut off

CUTOUT – shuts off electrical power to the related stabilizer control unit.

Rudder Trim Control



1 RUDDER TRIM Indicator

Digital readout displays rudder position in 0.2 increments from 0.0 to 1.0 unit and in 0.5 increments between 1.0 and 17.0 units of trim. An L or R is displayed to the left or right of the box for any non-zero rudder trim. Corresponding pointer position is displayed on the line scale below.

When the rudder signal is not present or is invalid, the digital readout, left/right indication and pointer are not displayed on the rudder position indicator.

When the rudder trim is inoperative, the digital readout is replaced with an "X". The box, the "X" and the pointer display amber. The pointer remains on the scale at the last known trim position.

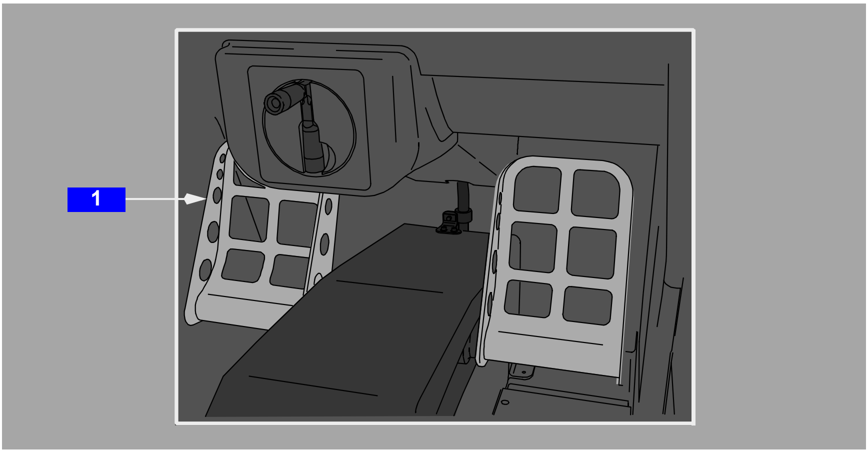
2 RUDDER Trim Selector

Spring-loaded to neutral.

Rotate –

- trims the rudder in the desired direction
- in either direction the trim runs at low speed with the knob rotated to the detent, and high speed with the knob rotated past the detent
- the rudder pedals move with rudder trim operation

Rudder/Brake Pedals



1 Rudder Pedals

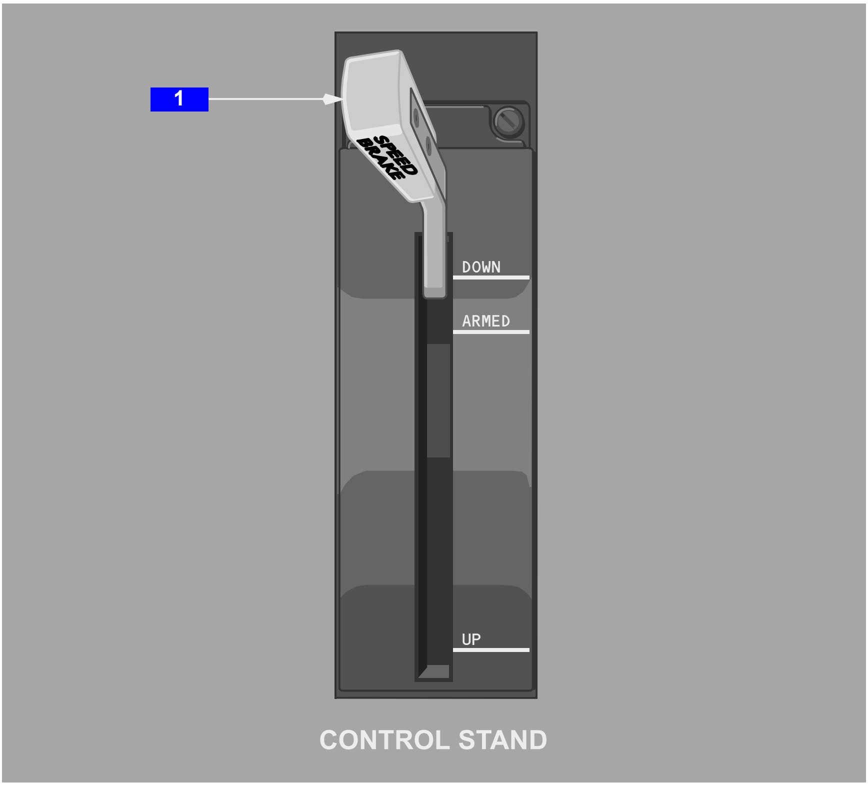
Push – deflects the rudder in the desired direction.

Refer to Chapter 14, Landing Gear, for brakes and nose wheel steering description.

Speedbrake Lever

On the ground:

- the speedbrake lever moves to DOWN and all spoiler panels retract if either thrust lever is advanced to the takeoff thrust position
- the speedbrake lever moves to UP and all spoiler panels extend if either reverse thrust lever is raised to the reverse idle detent



1 Speedbrake Lever

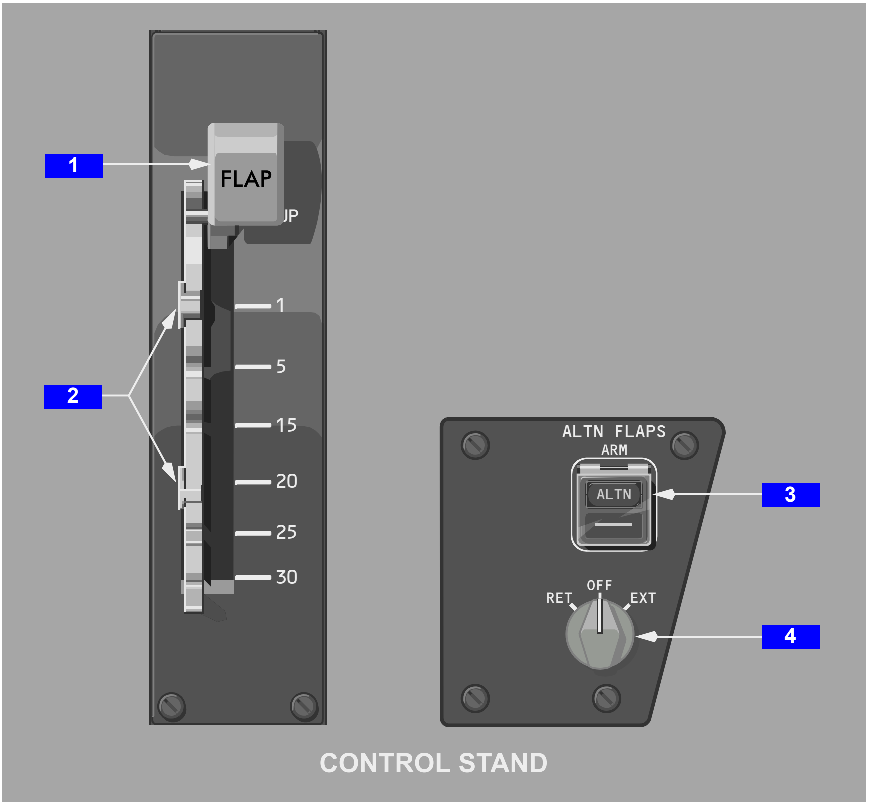
DOWN (detent) – all spoiler panels are retracted.

ARMED – the auto speedbrake system is armed.

UP – the required spoiler panels extend to their maximum in–flight or on–ground position (intermediate positions can be selected).

Flap System

Flap Controls



1 Flap Lever

Primary mode – positions the slats and flaps hydraulically.

Secondary mode – positions the slats and/or flaps electrically if hydraulic operation fails.

2 Flap Gates

1 – prevents inadvertent retraction of the slats.

20 – prevents inadvertent retraction of the flaps past the go–around position.

3 Alternate Flaps Arm (ALTN FLAPS ARM) Switch

Push (ALTN displayed) –

- arms the alternate flap control mode
- arms the alternate flaps selector

- disables primary and secondary flap/slat mode operation
- asymmetry/skew and uncommanded motion protection, slat autogap, and flap/slat load relief are not available
- the flap lever is inoperative

4 Alternate Flaps Selector

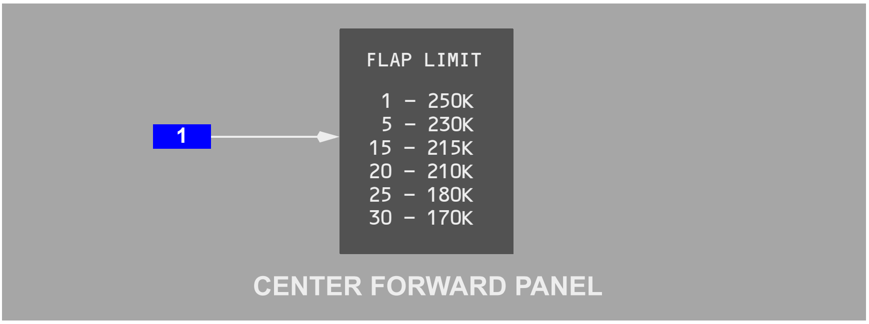
RET – retraction is accomplished electrically and sequenced so that full flap retraction occurs before the slats begin to retract.

OFF – alternate flaps are deactivated.

EXT –

- the slats and flaps are electrically extended
- maximum extension is flaps 20, with the slats at the midrange position

Flap Limit Placard



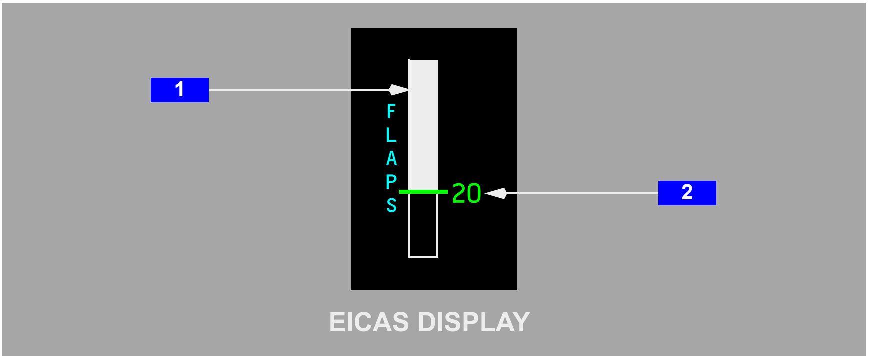
1 Flap Limit Placard

Flaps extended speed limits.

Normal Flap Position Indication

Displays combined flap and slat positions when all surfaces are operating normally and control is in the primary (hydraulic) mode. The indicator shows continuous motion.

The indication is no longer displayed 10 seconds after slat retraction.



1 Flap Position (white)

UP – the slats and flaps are retracted.

1 – the slats extend to the midrange position.

5, 15, and 20 –

- the slats remain in the midrange position
- the flaps extend to the commanded position

25 – the slats extend to the fully extended position. The flaps do not move.

30 – the flaps extend to the commanded position.

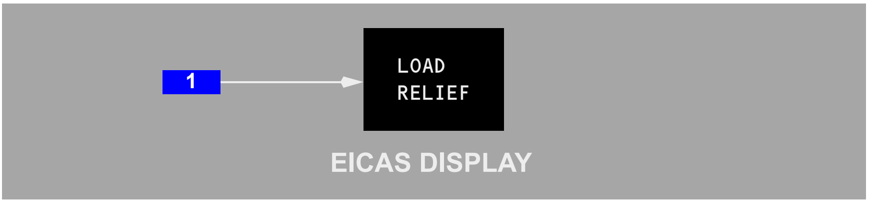
2 Flap Lever Position (line and number)

The line and number change color.

Magenta – the slats or flaps are in transit to the commanded position.

Green – the slats or flaps are in the commanded position.

Flap Load Relief Indication



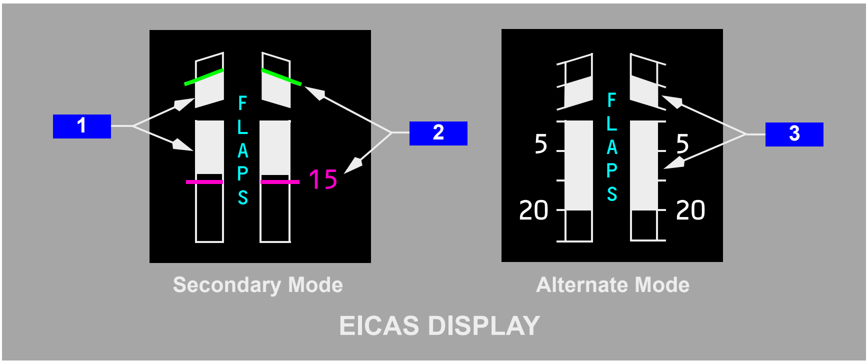
1 Flap LOAD RELIEF Indication

Displayed (white) – flap load relief is retracting the flaps, or inhibiting extension, as required to prevent air load damage due to excessive airspeed.

Expanded Flap and Slat Position Indication

If any flap/slat is non–normal or if control is in the secondary mode, slat and flap positions are shown independently. Each wing is also shown separately.

Indicator motion is continuous between flap detents.



1 **Expanded Flap and Slat Position Indications**

The slat indication fills up (forward) for extension.

The flap indication fills down (aft) for extension.

Indication colors of outline and fill are:

- white when operating in secondary mode
- amber when the respective FLAPS DRIVE or SLATS DRIVE EICAS message is displayed

Loss of position information is shown as a white outline with no fill and no flap lever position indication.

2 **Flap Lever Position (line and number)**

Magenta – the slats or flaps are in transit to the commanded position.

Green – the slats or flaps are in the commanded position.

The numbers are shown next to the flap position indicator only.

3 **Alternate Flap and Slat Position Indications (white)**

In the alternate mode, extension is limited to slats midrange and flaps 20.

Displayed automatically when the alternate control mode is armed.

Slats – displays the position of the slats.

Flaps – displays the position of the flaps.

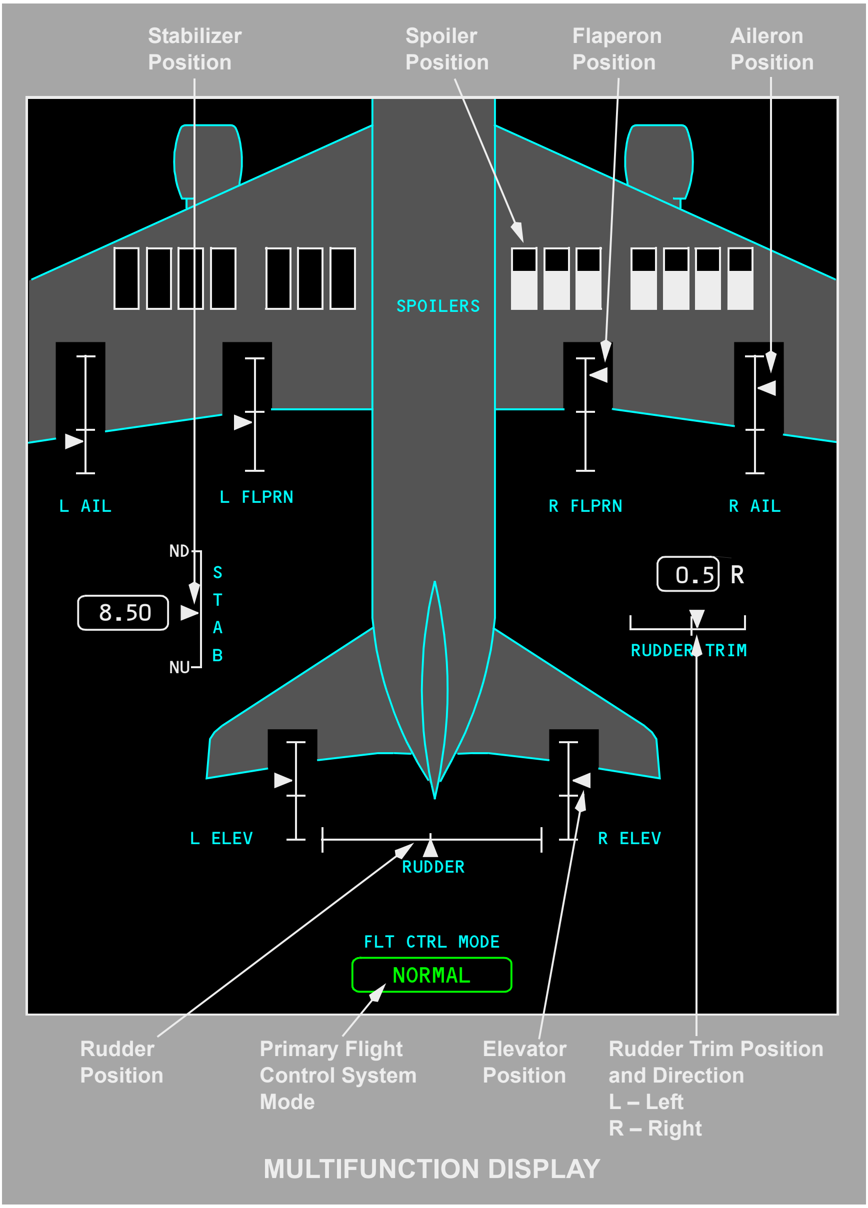
Flap position index marks – reference flaps 5 and 20.

Loss of position information is indicated as a white outline with no fill and no position index marks or numbers.

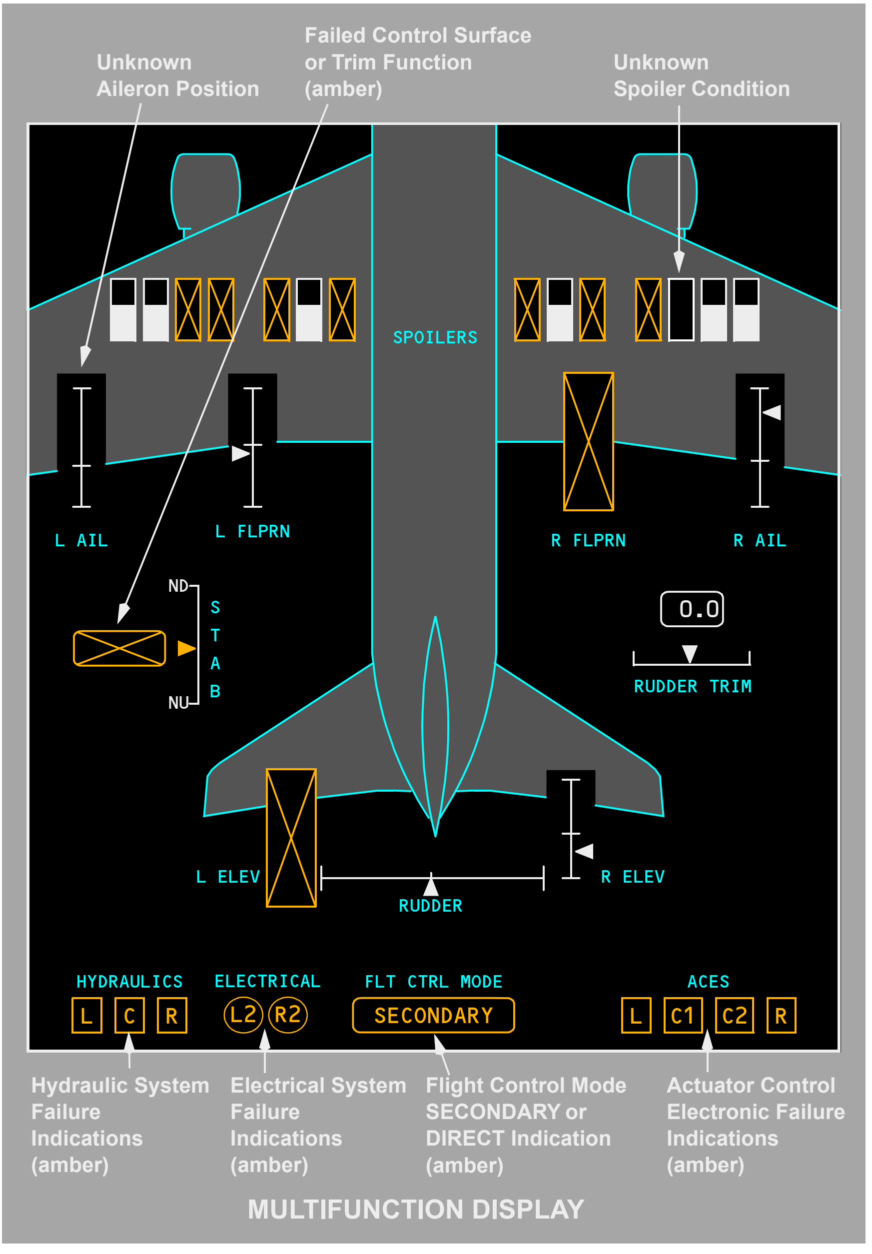
Flight Control Synoptic Displays

The flight controls synoptic is displayed by pushing the systems (SYS) display switch on the display select panel, and then selecting the FCTL synoptic key from the menu page. Display select panel operation is described in Chapter 10, Flight Instruments, Displays.

Normal Flight Control Synoptic



Non–Normal Flight Control Synoptic



Flight Controls — Chapter 9
System Description — Section 20

Introduction

The primary flight control system uses conventional control wheel, column, and pedal inputs from the pilot to electronically command the flight control surfaces. The system provides conventional control feel and pitch responses to speed and trim changes. The system electronic components provide enhanced handling qualities and reduce pilot workload.

The primary flight control system is highly redundant, with three operating modes: normal mode, secondary mode, and direct mode.

Pilot Controls

The pilot controls consist of:

- two control columns
- two control wheels
- two pairs of rudder pedals
- control wheel pitch trim switches
- the speedbrake lever
- the flap lever
- rudder trim selector
- alternate pitch trim switches

The columns, wheels, and rudder pedals are connected through jam override mechanisms. If a jam occurs in a column, wheel, or rudder pedals the pilots can maintain control by applying force to the other column, wheel, or rudder pedals to overcome the jam.

The speedbrake lever allows manual or automatic symmetric actuation of the spoilers.

The EICAS caution message FLIGHT CONTROLS is displayed if:

- multiple flight control surfaces are inoperative, or
- other significant flight control system faults are detected

The autopilot sends commands through the flight control system to produce control surface movements. Refer to Autopilot Flight Director System, Chapter 4, Section 20, for autopilot information.

Non-Normal Operation

In the unlikely event of the loss of all hydraulic power, the electrically actuated stabilizer and two spoiler pairs allow pilot control of pitch and roll using the alternate pitch trim switches and the control wheel.

If there is a complete loss of flight control signaling, direct wiring from the flight deck to the stabilizer and a spoiler pair allow pilot control of pitch and roll using the alternate pitch trim switches and the control wheel.

Flight Control Surfaces

Pitch control is provided by:

- two elevators
- a movable horizontal stabilizer

Roll control is provided by:

- two flaperons
- two ailerons
- fourteen spoilers

[787 without partial span tab]

Yaw control is provided by a single rudder.

The two elevators and horizontal stabilizer work together to provide pitch control.

The flaperons and ailerons provide roll control, assisted by asymmetric spoilers.

The flaperons are located between the inboard and outboard flaps on both wings. In the normal mode, they are used for roll control with the flaps either retracted or extended. The flaperons also droop with the trailing edge flaps to improve slow speed performance.

The ailerons are located outboard of the outboard flaps on each wing. The ailerons droop with the trailing edge flaps to improve slow speed performance.

The ailerons are locked out during high speed flight where the flaperons and spoilers provide sufficient roll control. During low speed flight, the ailerons operate to augment roll control.

[787 without partial span tab]

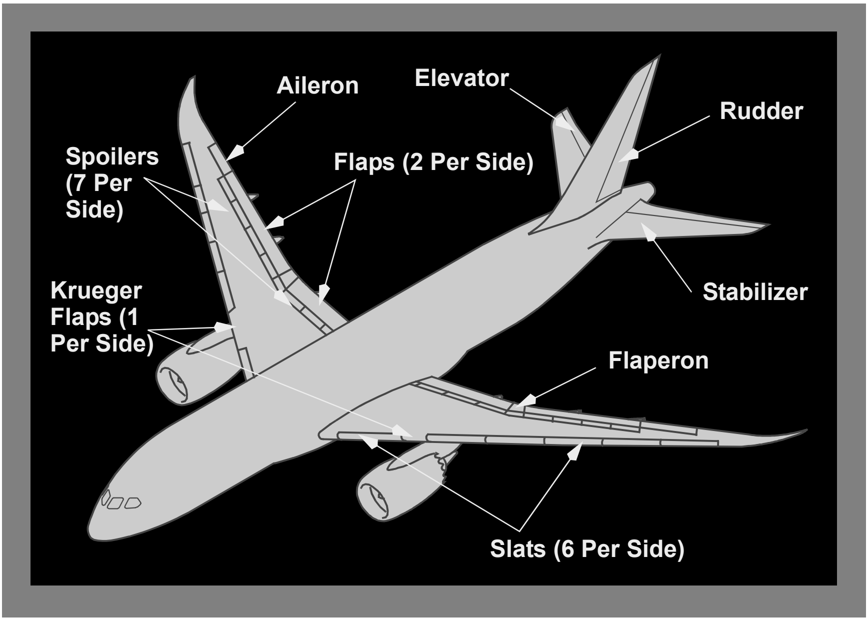
Yaw control is provided by a single rudder. During takeoff, the rudder becomes aerodynamically effective at approximately 60 knots.

Flaps and slats provide high lift for takeoff, approach, and landing.

Symmetric spoilers are used as speedbrakes.

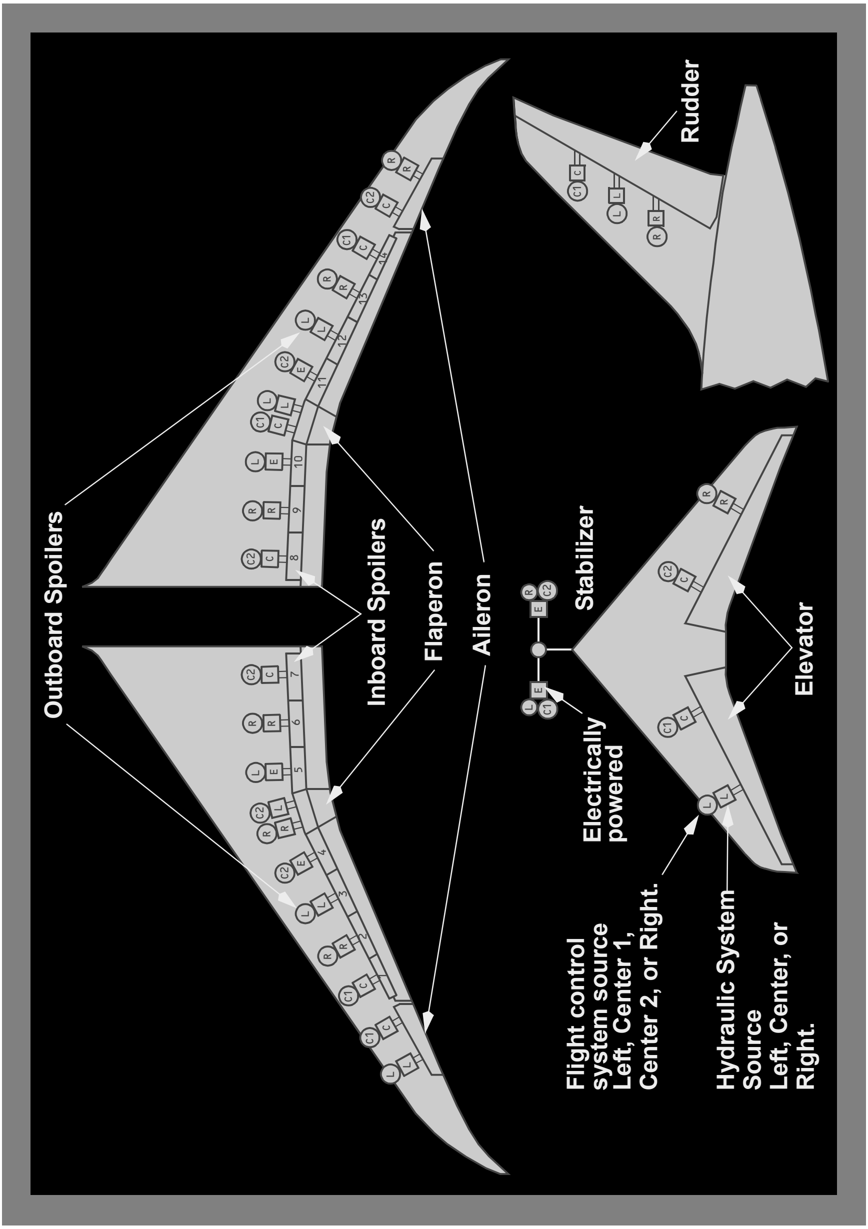
Flight Control Surface Locations

[787 without partial span tab]



Flight Control System & Electric/Hydraulic Power Distribution

[787 without partial span tab]



Primary Flight Control System Modes

There are three primary flight control system modes (flap and slat system modes are described later in this section):

- normal
- secondary
- direct

All the modes use the same pilot controls and flight control surfaces.

Flight Control System Normal Mode

In the normal mode during manual flight, the flight control system receives pilot control inputs, verifies the signals with information from other airplane systems, and sends control surface commands to the flight control surface actuators.

When the autopilot is engaged, the autopilot system sends control surface commands to the flight control system which generates signals to move the flight control surface actuators. The autopilot backdrives the pilot controls to provide awareness of what the autopilot is doing. If the pilot overrides the autopilot with control inputs, the autopilot disconnects and the flight control system uses the pilot control inputs. The autopilot is only available during normal mode operation. Refer to Autopilot Flight Director System, Chapter 4, Section 20, for autopilot information.

After landing, when the hydraulic systems are shut down as part of the normal shutdown procedure, the flight control system initiates a self-test. During the test, various EICAS alert and status messages display, the trim indication blinks, and various failures display on the flight controls synoptic. When the self-test is complete, the EICAS messages are removed, and the trim indicator and synoptic display return to normal. The test is complete about two minutes after the EICAS caution message HYD PRESS SYS L+C+R is displayed.

Flight Envelope Protection

The flight envelope protection system reduces the possibility of inadvertently exceeding the airplane's flight envelope. The flight envelope protection system provides crew awareness of envelope margins through tactile, aural, and visual cues. The protection functions do not reduce pilot control authority. The protection functions are described later in this section and include:

- stall protection
- overspeed protection
- roll/bank angle protection

Flight Control System Secondary Mode

When the flight control system can no longer support the normal mode due to internal faults or lack of required information from other airplane systems, it automatically reverts to the secondary mode. The flight control system continues to receive and process pilot control inputs, however it now uses simplified computations to generate flight control surfaces commands. These simplified commands are then sent to the control surface actuators and affect airplane handling qualities. All flight control surfaces remain operable. The elevator and rudder are more sensitive at some airspeeds.

The following functions are not available in the secondary mode:

- autopilot
- auto speedbrakes
- roll envelope bank angle protection
- gust suppression
- roll/yaw asymmetry compensation
- tail strike protection
- yaw damping is degraded

The EICAS caution message FLIGHT CONTROL MODE is displayed when the primary flight control system is in the secondary mode. The secondary mode cannot be manually selected.

Flight Control System Direct Mode

The flight control system automatically transitions to the direct mode when it detects multiple component failures or lost communications within the system. The direct mode can also be manually selected by moving the PRIMARY FLIGHT COMPUTERS disconnect switch to DISC.

In the direct mode, the flight control system continues to receive and process pilot control inputs, however it now uses simplified computations to generate flight control surfaces commands.

The direct mode provides full airplane control for continued safe flight and landing. Airplane handling qualities are approximately the same as in the secondary mode. The EICAS caution message PRI FLIGHT COMPUTERS is displayed when the system is in the direct mode.

In the direct mode, the following functions are not available:

- autopilot
- auto speedbrakes
- roll envelope bank angle protection
- gust suppression
- roll/yaw asymmetry compensation
- tail strike protection
- yaw damping is degraded

Normal Mode Pitch Control

In the normal mode, the airplane pitch control characteristics are similar to conventional airplanes. The control column input commands a pitch maneuver where the rate is dependant on column displacement. The flight control system automatically positions the elevator and stabilizer to generate the commanded maneuver. The flight control system constantly monitors airplane response to pilot commands and repositions the elevator and stabilizer accordingly. Airplane pitch responses to thrust changes, gear configuration changes, and turbulence are minimized by automatic control surface commands.

The flight control system also provides compensation for flap and speedbrake configuration changes, and turns up to 30° of bank. Automatic pitch control is used to maintain a relatively constant flight path eliminating pilot control column inputs to compensate for these factors. For turns up to 30° of bank, the pilot does not need to add additional column back pressure to maintain altitude. For turns of more than 30° of bank, additional column back pressure is required.

As airspeed changes, the flight control system provides conventional pitch control characteristics by requiring the pilot to make control column inputs or trim changes to maintain a constant flight path.

Primary Pitch Trim Control

Primary pitch trim is controlled by the dual pitch trim switches on each control wheel. Both switches must be moved to command trim changes. The primary pitch trim switches are inhibited when the autopilot is engaged. Pitch trim does not move the control column.

In the normal mode, primary pitch trim operates differently on the ground than it does in flight. On the ground, the stabilizer is directly positioned when the pilot uses the pitch trim switches. In flight, the pitch trim switches do not position the stabilizer directly, but change the trim reference speed. The trim reference speed is the speed at which the airplane would eventually stabilize if there were no control column inputs. Once the control column forces are trimmed to zero, the airplane maintains a constant speed with no column inputs. Thrust changes result in a relatively constant indicated airspeed climb or descent, with no trim inputs needed unless airspeed changes.

When pilot trim inputs are made, the flight control system automatically moves the elevators to achieve the trim change, then moves the stabilizer to streamline the elevator. Stabilizer motion may also automatically occur to streamline the stabilizer and elevator for thrust and configuration changes.

In the secondary or direct modes, primary pitch trim operates the same on the ground and in flight; the stabilizer is directly positioned when the pilot uses the primary pitch trim switches.

Alternate Pitch Trim

Alternate pitch trim is controlled by the dual pitch trim switches located on the control stand. Both switches must be moved to command trim changes. The switches are linked electrically to the horizontal stabilizer trim actuator and then mechanically to the stabilizer. Alternate pitch trim commands have priority over primary pitch trim commands in all flight control modes. Pitch trim does not move the control column.

In the normal mode, alternate pitch trim operates differently on the ground than it does in flight. On the ground, the stabilizer is directly positioned when the pilot uses the alternate pitch trim switches. In flight, the alternate pitch trim switches make changes to the trim reference speed. This is the same normal operation as the primary pitch trim switches (refer to Primary Pitch Trim Control in this section for operation description).

In the secondary or direct modes, alternate pitch trim operates the same on the ground and in flight; the stabilizer is directly positioned when the pilot uses the alternate pitch trim switches.

Pitch Envelope Protection

The pitch envelope protection functions include:

- stall protection
- overspeed protection

Stall Protection

Stall protection reduces the likelihood of inadvertently exceeding the stall angle of attack by providing enhanced crew awareness of the approach to a stall or to a stalled condition.

Stall protection limits the speed to which the airplane can be trimmed. At approximately the minimum maneuvering speed, the trim reference speed is limited by inhibiting trim in the nose up direction. The pilot must apply continuous aft column pressure, at twice the normal force, to maintain airspeed below the minimum maneuvering speed.

The autothrottle can support stall protection if armed and not engaged. If speed decreases to near stick shaker activation, the autothrottle engages in SPD mode and advances thrust to maintain minimum maneuvering speed (approximately the top of the amber band) or the speed set in the mode control panel speed window, whichever is greater. The EICAS message AIRSPEED LOW is displayed.

Note: When the pitch mode is FLCH or TOGA, or the airplane is below 400 feet above the airport on takeoff, or below 100 feet radio altitude on approach, the autothrottle does not automatically engage.

Note: During a descent in VNAV SPD, the autothrottle may activate in HOLD mode and does not support stall protection.

Refer to PFD Indications, Chapter 10, Section 10, for flight mode annunciation displays.

Refer to MCP Mode Selection, Chapter 4, Section 20, for an explanation of mode control panel operation.

Refer to AFDS Flight Mode Annunciations, Chapter 4, Section 20, for an explanation of PFD flight mode annunciations.

Overspeed Protection

Overspeed protection reduces the likelihood of inadvertently exceeding VMO or MMO by providing enhanced crew awareness of the approach to an overspeed condition.

Overspeed protection limits the speed to which the airplane can be trimmed. At VMO/MMO, the trim reference speed is limited by inhibiting trim in the nose down direction. The pilot must apply continuous forward column pressure, at twice the normal force, to maintain airspeed above VMO/MMO.

Elevator Variable Feel

The flight control system calculates feel commands based on airspeed. In general, control column forces increase:

- as airspeed increases for a given column displacement, or
- as column displacement increases

Tail Strike Protection

During takeoff or landing, the flight control system calculates if a tail strike is imminent and decreases elevator deflection, if required, to reduce the potential for tail contact with the ground. Activation of tail strike protection does not provide feedback to the control column. Authority is limited so that pilot input can override its effect and rotate to tail contact attitude via additional column force. Protection does not degrade takeoff performance and is compatible with the autoland system.

Secondary and Direct Mode Pitch Control

In the secondary and direct flight control modes, the flight control system continues to receive and process pilot control inputs, however it now uses simplified computations to generate flight control surface commands. The control columns command a proportional elevator deflection instead of a maneuver command. Secondary and direct modes do not provide automatic pitch compensation for:

- thrust changes
- gear configuration changes
- turbulence
- flap and speedbrake configuration changes
- turns to 30° bank angle

In secondary and direct modes, the elevator variable feel system provides feel force levels based on flap position instead of a continuous variation with airspeed. With the flaps up, the feel forces provide maneuver force levels that discourage over control in the pitch axis at high speeds. With the flaps not up, the feel forces decrease to provide force levels appropriate for approach and landing.

In the secondary and direct modes there is no trim reference speed. Both the primary and alternate pitch trim switches move the stabilizer directly.

Stabilizer Electric Power and Non–Normal Operation

Stabilizer position commands are processed through two independent channels within the flight control system. The commands come from the primary or alternate pitch trim switches and move the stabilizer using an electric control unit powered by the L2 and R2 AC buses.

Stabilizer Shutdown

If uncommanded stabilizer motion is sensed, the stabilizer channel that caused the motion is automatically shut down. If a channel is inoperative due to automatic shutdown or failure, the EICAS advisory message STABILIZER L2 or STABILIZER R2 is displayed. The stabilizer remains operative through the remaining channel. If the affected channel can not be isolated, both channels are shut down.

If both stabilizer channels automatically shut down or fail, the EICAS warning message STABILIZER is displayed. This warning is also displayed if automatic shutdown fails to stop the uncommanded motion.

The L2 and R2 stabilizer cutout switches, located on the aisle stand, control electric power to the independent stabilizer channels. Placing both switches in the CUTOUT position removes all power from the stabilizer and the EICAS advisory message STABILIZER CUTOUT is displayed. With both switches in the CUTOUT position the STABILIZER warning message is not displayed.

In the normal mode, when the stabilizer is manually shut down or has failed, pitch trim is still available through the elevators. Pitch trim commands from the primary or alternate pitch trim switches change the trim reference speed. The elevators then trim the airplane but the stabilizer does not move.

The control column can be used to interrupt pitch trim commands from the primary and alternate pitch trim switches. When the control column is moved in the opposite direction to the pitch trim command, the trim stops. This feature allows the pilot to quickly stop trim changes due to stuck pitch trim switches.

Stabilizer Position Indication and Greenband Monitor

Stabilizer position is displayed on EICAS and on the flight controls synoptic. The EICAS stabilizer position indication includes a takeoff greenband. The indication on the synoptic is constantly displayed. The EICAS indication blanks when either of the following conditions are satisfied:

- gear up for 10 seconds, or
- 60 seconds after liftoff

The EICAS stabilizer position indication automatically displays if any of the following conditions are satisfied:

- on ground and any pair of pitch trim switches are used, or
- after landing and groundspeed is less than 40 knots, or
- in the air and any of the following EICAS messages are active:
  - PRI FLIGHT COMPUTERS
  - FLIGHT CONTROL MODE
  - STABILIZER
  - STABILIZER CUTOUT

- PITCH UP AUTHORITY
- PITCH DOWN AUTHORITY

The stabilizer greenband monitor is part of the crew alerting function and helps confirm that the greenband displayed on the stabilizer position indicator is correct for the actual takeoff weight and CG. Based on the gross weight and CG entries in the FMC the crew alerting function computes a greenband. Two nose gear pressure transducers provide actual airplane gross weight and CG information. The nose gear pressure data is used to determine two separate sets of validation limits (one for each transducer). The FMC calculated stabilizer greenband is then compared to the validation limits from the transducers. The EICAS advisory message STAB GREENBAND is displayed when:

- computed greenband disagrees with nose gear pressure transducer data, or
- the two transducer values do not match within 2%, or
- either transducer has failed

Normal Mode Roll Control

In the normal mode, airplane roll control characteristics are similar to conventional airplanes. However unlike conventional airplanes, the control wheel does not directly position the lateral surfaces in flight, it instead commands a roll maneuver with the rate dependent on wheel displacement. The flight control system automatically positions the ailerons, flaperons, and spoilers to generate the commanded maneuver. It constantly monitors airplane response to pilot inputs and repositions the lateral surfaces to carry out these commands. Control wheel forces increase as control displacement increases. Control wheel forces do not change with airspeed changes. Airplane roll response to turbulence is minimized by automatic control surface commands. The ailerons are locked out at high speeds.

Roll Envelope Bank Angle Protection

Bank angle protection reduces the likelihood of exceeding the bank angle boundary due to external disturbances, system failures, or inappropriate pilot action.

In the normal mode bank angle protection provides roll control wheel inputs when airplane bank angle exceeds the bank angle protection boundary of approximately 35°. If the boundary is exceeded, the control wheel force rolls the airplane back within 30° of bank. This roll command can be overridden by the pilot. Maximum control wheel deflection always commands maximum roll authority. The autopilot disengage bar disables bank angle protection.

Excessive bank angles are indicated on the PFD bank indicator. The indicator changes color to amber at bank angles exceeding 35°. Refer to PFD Attitude Indications, Chapter 10, Section 10, for PFD bank angle indications.

Secondary and Direct Mode Roll Control

Airplane roll control is different in the secondary and direct flight control modes. The flight control system continues to receive and process pilot control inputs, however it now uses simplified computations to generate flight control surface commands. Roll envelope bank angle protection is not available in the secondary or direct modes.

Normal Mode Yaw Control

In the normal mode, airplane yaw control characteristics are similar to conventional airplanes. However unlike conventional airplanes, the rudder pedals do not directly position the rudder surface in flight, they instead command a sideslip maneuver with the rate dependant on pedal displacement. The flight control system automatically positions the rudder to generate the commanded maneuver. It constantly monitors airplane response to pilot inputs and repositions the rudder to carry out these commands. Airplane sideslip response to turbulence is minimized by automatic control surface commands.

Pedal forces increase as pedal displacement increases. Pedal forces do not change with airspeed changes. The flight control system automatically reduces sideslip (for a given pedal input) as airspeed increases. Sufficient rudder authority is provided at all airspeeds to maintain airplane control in engine failure conditions, and during takeoffs and landings in crosswinds.

On the ground above 65 knots groundspeed, the flight control system attempts to maintain a yaw rate near zero by commanding rudder to counter the majority of the yawing moment due to an engine failure. The capability to counter a thrust asymmetry is an inherent part of the flight control system. The pilot can still recognize the initial onset of an engine failure through the airplane yaw cue and rudder pedal movement.

In flight, when a roll/yaw asymmetry condition exists for any reason (not only thrust related), the flight control system initially attempts to maintain zero roll rate and sideslip. An automatic rudder input counters the yawing moment and an automatic lateral control input counters the rolling moment. After the initial inputs, the system off loads any steady state lateral control input to the rudder, resulting in a small sideslip. The rudder pedals move to give the pilot awareness of the automatic function and the resulting rudder trim indication is automatically shown on the EICAS display.

This off load increases sideslip on the airplane, therefore the off load has limits based on the severity of the asymmetry. For large asymmetry conditions a greater sideslip is permitted, but some automatic lateral control input may remain after the off load stops. For large asymmetries the EICAS caution message ROLL/YAW ASYMMETRY is displayed.

For severe asymmetric conditions where the initial automatic lateral control input is very large, the EICAS caution message ROLL LEFT/RIGHT AUTHORITY, is displayed to inform the crew of the limited roll control available.

Automatic lateral and rudder inputs are only available in the normal flight control mode and can be overridden by manual control wheel or rudder pedal inputs.

Wheel to Rudder Cross–Tie

The wheel to rudder cross–tie function is available in the secondary and direct modes. This function reduces maximum sideslip and vertical fin loads.

In the normal mode, wheel to rudder cross-tie is not required, the flight control system automatically controls sideslip and fin loads.

Yaw Damping

In the normal mode, the yaw damping function provides turn coordination and Dutch roll damping.

Gust Suppression

Vertical gust suppression enhances ride quality in the presence of vertical gusts and turbulence. It utilizes symmetric deflection of the flaperons and elevators to alleviate gust acceleration. This function is active only with the autopilot engaged in Altitude Hold or VNAV flight modes.

Lateral gust suppression improves ride quality and can reduce pilot work load on approach by automatic application of discrete yaw commands in response to lateral gusts and turbulence.

Operation of vertical and lateral gust suppression does not result in control wheel, control column, or rudder pedal movement.

Vertical and lateral gust suppression are not available in Secondary and Direct modes.

Rudder Trim

Manual rudder trim operation is provided in all three flight control modes by a rudder trim selector located on the aft aisle stand. Two rudder trim rates are available. A low rate is commanded with the selector rotated to the detent, and a high rate is commanded when rotated past the detent. Any manual trim inputs are automatically zeroed when groundspeed exceeds 30 knots, and further manual trim inputs are inhibited until in the air. Manual rudder trim is also inhibited with the autopilot yaw engaged (LAND 3) on approach. To provide pilot awareness, the pedals move to reflect the amount of manual rudder trim applied.

Automatic rudder trim is provided in the normal flight control mode. For pilot awareness of any asymmetric condition on the ground or in the air, the system automatically moves the rudder pedals to reflect the rudder position being commanded. This trim position is also shown on the rudder trim indicator and the flight control synoptic. If the rudder deflection is minimal, the rudder trim remains centered. This prevents running the trim for normal situations such as to coordinate a turn.

On landing, automatic and manual rudder trim inputs are zeroed so they do not provide a yaw command when the airplane transitions from the air mode (sideslip maneuver) to the ground mode (yaw maneuver).

Rudder trim is displayed on EICAS and the flight controls synoptic. The indication on the synoptic is constantly displayed. The EICAS indication blanks when either of the following conditions are satisfied:

- gear up for 10 seconds, or
- 60 seconds after liftoff

The EICAS rudder trim indication automatically displays if any of the following conditions are satisfied:

- after landing and groundspeed is less than 40 knots, or
- in the air and any of the following EICAS messages are active:
  - PRI FLIGHT COMPUTERS
  - FLIGHT CONTROL MODE
  - ENG SHUTDOWN L (or R)
  - ENG FAIL L (or R)
  - ENG THRUST L (or R)

Secondary and Direct Mode Yaw Control

Airplane yaw control is different in the secondary and direct flight control modes. The flight control system continues to receive and process pilot control inputs, however it now uses simplified computations to generate flight control surface commands. The rudder pedals command a proportional rudder deflection instead of a maneuver command. Pedal feel forces are unchanged from normal mode; however, rudder response is slightly different.

In secondary and direct modes, the rudder ratio changer is based on flap position. With flaps up, the rudder response to pedal inputs is less than the response when the flaps are not up.

In the secondary and direct modes:

- flight envelope protection is inoperative
- gust/modal suppression is inoperative

- asymmetry compensation is inoperative
- yaw damping is degraded

Spoilers

There are 7 sets of spoilers, 4 outboard and 3 inboard of the flaperons, on the upper surface of each wing. The spoilers are numbered from left to right, 1 through 14. Spoilers on opposing wings are symmetrically paired.

Spoiler panels are used as speedbrakes to increase drag and reduce lift, both in flight and on the ground. The spoilers also supplement roll control in response to control wheel commands.

All three hydraulic systems supply 5 pairs of spoilers. Each hydraulic system is dedicated to a different set of spoiler pairs to provide isolation and maintain symmetric operation in the event of hydraulic system failure. The remaining two spoiler pairs are individually powered by two electrical buses.

Failure of two spoiler panels in the air, or failure of one not down and locked spoiler panel on the ground, causes the EICAS advisory message SPOILERS to display. Failure of three or more spoiler panels causes the EICAS advisory message SPOILER PAIRS to display.

Spoiler Speedbrake Operation

The 14 spoiler panels are used as speedbrakes.

The speedbrake spoilers are controlled by the speedbrake lever located on the control stand. The speedbrake lever has three marked positions:

- DOWN
- ARMED
- UP

The speedbrake lever can be placed in intermediate positions between ARMED and UP.

In the ARMED position, the spoilers extend and the speedbrake lever is driven aft to the UP position on landing when the main gear trucks untilt and both throttles are not in the takeoff range.

When the speedbrake lever is not in the ARMED position, the spoilers still automatically extend and the speedbrake lever is driven to the UP position when either of the following conditions occur:

- on the ground with groundspeed above 85 knots, either thrust lever was previously in the takeoff range, then both thrust levers are moved to the idle range (refused takeoff), or
- on the ground and both thrust reverse levers are moved to the reverse idle detent

The spoilers automatically retract and the speedbrake lever is driven forward to the DOWN position, when any of the following conditions occur:

- on the ground, when either thrust lever is moved to the takeoff range, or
- on the ground, if there is a transition to in the air, or
- in the air, when either thrust lever is beyond 90% full travel

Automatic speedbrakes are not available in the secondary and direct modes.

Flaps and Slats

The flaps and slats are high lift devices that increase wing lift and decrease stall speed during takeoff, approach, and landing.

The airplane has an inboard and an outboard flap on the trailing edge of each wing, and one inboard and five outboard slats on the leading edge. A two-position Krueger flap provides a seal between the inboard slat and the engine nacelle on each wing.

In the flaps 1 position, only the slats move. Flaps 5, 15, and 20 are takeoff flap positions. Flaps 25 and 30 are landing flaps positions. Flaps 20 is used for some non–normal landing conditions.

To protect against inadvertent deployment during cruise, flap and slat extension from the UP position is inhibited when speed is more than 260 knots or altitude is above approximately 20,000 feet. This inhibit is only available in normal mode.

Flap and Slat Sequencing

When the flap lever is in the UP detent, all flaps and slats are commanded to the retracted position. Moving the flap lever aft allows selection of flap detent positions 1, 5, 15, 20, 25 and 30. The flaps and slats sequence so that the slats extend first and retract last.

Starting from flaps UP, selection of flaps 1 commands the slats to move to the midrange position. The flaps remain retracted.

Selection of the flaps 5, 15, and 20 positions commands the flaps to move to the position selected. The slats remain in the midrange position.

Selection of flaps 25 commands the slats to move to the fully extended position. The flaps do not move.

Selection of flaps 30 commands the flaps to extend to the primary landing position.

During retraction, flap and slat sequencing is reversed.

The mechanical gate at the flaps 20 detent prevents inadvertent retraction of the flaps past the go–around flap setting. The mechanical gate at flaps 1 prevents inadvertent retraction of the slats past the midrange position.

Flap and Slat Modes

There are three modes of flap and slat operation:

- primary
- secondary
- alternate

In the primary mode, the flaps and slats are controlled together and positioned using center hydraulic system motors. Autogap and flap load relief operate in the primary mode.

The secondary mode is automatically engaged when any of the following conditions occur:

- center hydraulic system failed, or
- flap or slat primary control failure, or
- primary mode fails to move the flaps or slats to the selected position, or
- control surfaces travel at less than 50% of the normal rate, or
- uncommanded motion or disagree is detected

In the secondary mode the slats and flaps are controlled separately and can be positioned by hydraulic or electric motors. For example, if the slats hydraulic control fails, the flaps are still driven hydraulically but the slats are now powered electrically. Pilot control is through the flap lever but operation in secondary mode is limited to flaps 20 by non-normal procedures.

Slat autogap and flap load relief are unavailable in secondary mode where as slat pre-gap and slat load relief are operational. Slats are fully extended at all flap positions if airspeed is less than 230 knots to improve stall handling characteristics. If airspeed exceeds 230 knots the slats either do not extend beyond, or retract to, the midrange position.

The three–position alternate flaps selector extends and retracts the flaps and slats. The flaps and slats extend simultaneously, but slat retraction is inhibited until the flaps are up. Alternate mode flap and slat extension is limited to slats midrange and flaps 20. Asymmetry and uncommanded motion protection, slat autogap and pre-gap, and flap and slat load relief are not available in alternate mode.

The alternate mode must be manually selected. Slat and flap operation time in the secondary and alternate modes is greatly increased.

Flap/Slat Load Relief

In the primary mode, the flap load relief system protects the flaps from excessive air loads. If flap airspeed placard limits are exceeded with the flaps in the 15 through 30 position, LOAD RELIEF is displayed and the flaps automatically retract to a position appropriate to the airspeed. Load relief retraction is limited to flaps 5.

When airspeed is reduced, the flaps automatically re–extend as airspeed allows. Re–extension is limited to the commanded flap position.

If a flap overspeed exists, load relief prevents flap extension beyond the 5, 15, or 20/25 positions until airspeed is sufficiently reduced. Flap load relief is available only in the primary mode. The EICAS flap display indicates an in–transit flap condition and shows actual flap position. The flap lever does not move during flap load relief operation. Load relief for slats is not required in the primary or alternate modes.

Slat load relief is available in the secondary mode. If airspeed exceeds 230 knots with the slats fully extended, they retract to midrange and LOAD RELIEF is displayed. For all lever positions except Up, the slats are driven to their extend position when the airspeed is below 230 knots.

Slat Autogap and Slat Pre-gap

The slat autogap function is only available in primary mode when the slats are in their mid-range position and the airspeed is below 230 knots. At a high angle of attack, autogap extends the slats to increase the wing camber, thus increasing the lift and margin to stall. The slats return to their mid-range position after the angle of attack decreases. The angle of attack threshold is a function of speed and flaps.

In the secondary mode the system is too slow to respond to an autogap request, so a pre-gap function exists. The slats automatically move to the extended position from mid-range when the flap lever is not in the up position and airspeed is less than 230 knots. The slats remain in the extended position until the flap lever is in the up position or airspeed is above 230 knots.

Cruise Flaps

Cruise flaps is an automated function that improves the airplane’s cruise performance by symmetrically moving the flaps, ailerons, flaperons, and spoilers based on various airplane parameters such as weight, airspeed and altitude. Cruise flaps optimizes performance in cruise by varying the camber of the wing and thus reducing drag. Control surface movements are very minor and no pilot interaction is required. The advisory message CRUISE FLAPS SYS is displayed if the system fails with the flaps in an increased drag condition.

Flap and Slat Asymmetry Detection

In primary and secondary modes the flap and slat systems are designed to shutdown when a skew condition or asymmetric deployment is detected. When the system is shutdown, the corresponding EICAS message FLAPS DRIVE and/or SLATS DRIVE is annunciated.

Uncommanded Flap or Slat Motion

Uncommanded motion is detected when the flaps or slats:

- move away from the commanded position
- continue to move after reaching a commanded position
- or move in a direction opposite to that commanded

If the flap or slat is operating in the primary mode, uncommanded motion first causes an automatic transfer to the secondary mode. The EICAS message FLAPS PRIMARY FAIL and/or SLATS PRIMARY FAIL is displayed. If motion continues, the system shuts down. The EICAS message FLAPS DRIVE and/or SLATS DRIVE is displayed.

Flap or Slat Disagree

A disagree is detected when the flaps or slats do not move or move too slowly after a commanded input. If the flap or slat is operating in the primary mode, and the rate of motion is less than half the normal rate, an automatic transfer to the secondary mode occurs. The EICAS message FLAPS PRIMARY FAIL and/or SLATS PRIMARY FAIL is displayed. If motion continues at less than half the normal rate, the system shuts down. The EICAS message FLAPS DRIVE and/or SLATS DRIVE is displayed.

Flap Indications

Flap position indications are displayed on the primary EICAS display. In primary mode a single vertical indicator displays combined flap and slat position. The position commanded by the flap lever is also displayed. Ten seconds after all flaps and slats are up, the entire indication is no longer displayed. A loss of position sensing removes the tape fill and flap lever position indications.

If flap/slat control is in the secondary or alternate mode, or if any non–normal condition is detected, an expanded flap indication is displayed automatically. The position of the left and right flaps and slats are separately indicated. In the alternate mode, the position commanded by the flap lever is replaced by flap position index marks at all flap and slat positions, and numbers at flaps 5 and flaps 20. The index marks are used as a guide to position the flaps to the desired setting.

Flight Control System EICAS Messages

The following EICAS messages can be displayed.

Note: Configuration (CONFIG) warning messages are described in Chapter 15, Warning Systems.

Message	Level	Aural	Condition
AUTO SPEEDBRAKE	Advisory		An automatic speedbrake fault occurs.
CRUISE FLAPS SYS	Advisory		The cruise flaps system is not in the correct position.
FLAPS DRIVE	Caution	Beeper	The flap drive mechanism is failed.
FLAPS PRIMARY FAIL	Caution	Beeper	The flaps primary mode is failed.
FLAP/SLAT CONTROL	Caution	Beeper	The flap/slat electronics units are failed.
FLIGHT CONTROL MODE	Caution	Beeper	The flight control system is in the secondary mode.
FLIGHT CONTROLS	Caution	Beeper	One or more of these occur: • Two or more flight control surfaces are inoperative • Other faults in the flight control system are detected
FLT CONTROLS LOCKED	Advisory		One or both flight control surface lock switches are in the locked position.
PITCH DOWN AUTHORITY	Caution	Beeper	Pitch down authority is restricted.
PITCH UP AUTHORITY	Caution	Beeper	Pitch up and flare authority are restricted.
PRI FLIGHT COMPUTERS	Caution	Beeper	The flight control system is operating in the direct mode.
ROLL LEFT AUTHORITY	Caution	Beeper	Roll left authority is restricted.

Message	Level	Aural	Condition
ROLL RIGHT AUTHORITY	Caution	Beeper	Roll right authority is restricted.
ROLL/YAW ASYMMETRY	Caution	Beeper	An airplane roll or yaw asymmetry occurs.
SLATS DRIVE	Caution	Beeper	The slat drive mechanism is failed.
SLATS PRIMARY FAIL	Caution	Beeper	The slats primary mode is failed.
SPEEDBRAKE EXTENDED	Caution	Beeper	The speedbrakes are extended and one or more of these occur: • The radio altitude is between 15 and 800 feet • The flap lever is in a landing setting • A thrust lever is not at idle
SPEEDBRAKES ARMED	Memo		The speedbrakes are armed.
SPOILER DRAG	Advisory		Some spoilers are not stowed because center hydraulic system pressure is low.
SPOILER PAIRS	Advisory		Two spoiler pairs are failed.
SPOILERS	Advisory		One or more spoiler pairs are failed.
STAB GREENBAND	Advisory		One of these occurs: • The nose gear pressure switch disagrees with the computed stabilizer greenband • The nose gear pressure switch is failed
STABILIZER	Warning	Siren	One of these occurs: • Stabilizer movement without a signal to trim • The stabilizer is failed
STABILIZER CUTOUT	Advisory		Both stabilizer cutout switches are in CUTOUT.
STABILIZER L2	Advisory		The left stabilizer control path is failed.
STABILIZER R2	Advisory		The right stabilizer control path is failed.

Message	Level	Aural	Condition
STALL PROTECTION	Advisory		A stall protection fault occurs.

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Flight Instruments, Displays — Chapter 10

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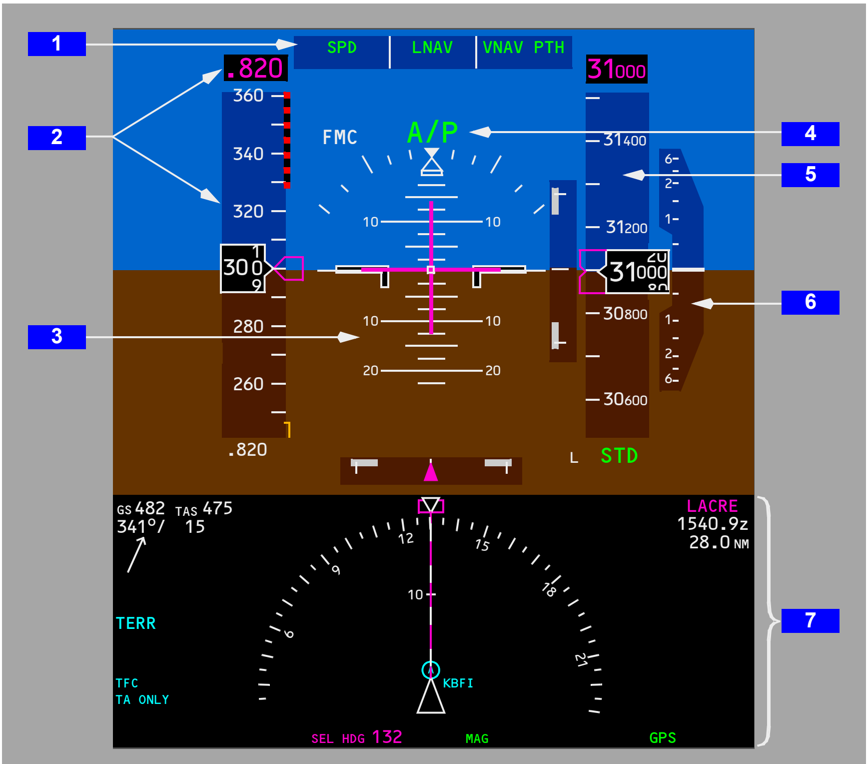
Primary Flight Display (PFD)

PFD Indications

[Option – Split cue]



LEFT AND RIGHT FORWARD PANELS

1 Flight Mode Annunciations

Refer to Chapter 4, Automatic Flight.

2 Airspeed/Mach Indications

Displays air data reference system (ADRS) airspeed information and other airspeed related information.

3 Attitude, Steering, and Miscellaneous Indications

Displays Inertial Reference System (IRS) attitude information.

4 **Autopilot, Flight Director System Status**

Refer to Chapter 4, Automatic Flight.

5 **Altitude Indications**

Displays ADRS altitude and other altitude–related information.

6 **Vertical Speed Indication**

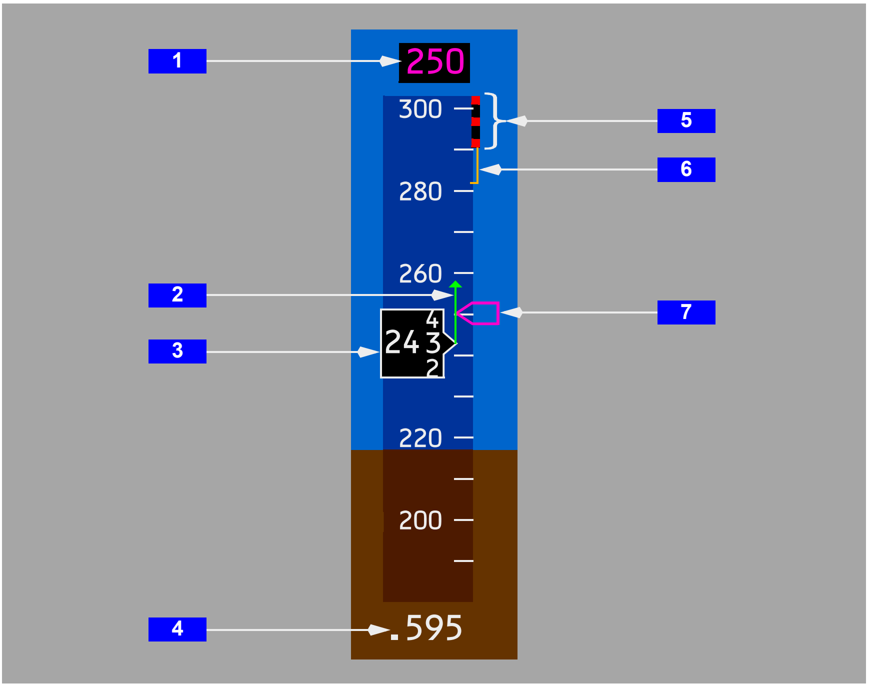
Displays ADRS vertical speed and other vertical speed information.

7 **Mini-map**

Displays current IRS heading, track and other heading information.

Displays the flight plan with associated information. Refer to the Navigation Displays section of this chapter for specific symbology.

PFD Airspeed Indications



1 **Selected Speed**

Displays the airspeed/Mach selected in the mode control panel MCP IAS/MACH window (refer to Chapter 4, Automatic Flight).

Displays the FMC–computed airspeed/Mach when the MCP IAS/MACH window is blank.

2 **Speed Trend Vector**

Indicates predicted airspeed in ten seconds based on current acceleration or deceleration.

3 **Current Airspeed**

Indicates current ADRS airspeed.

The box around the current airspeed indication turns amber when airspeed is below minimum maneuvering speed.

4 **Current Mach**

Displays current ADRS Mach.

5 **Maximum Speed**

Indicates maximum permissible airspeed as limited by the lowest of the following:

- Vmo/Mmo
- landing gear placard speed, or
- flap placard speed

6 **Maximum Maneuvering Speed**

When displayed, indicates maneuver margin to buffet. May be displayed when operating at high altitude at relatively high gross weights.

- when flaps are up, bottom of amber bar indicates airspeed that provides a 0.3g maneuver margin to high speed buffet
- when flaps are not up, bottom of amber bar indicates flap extension placard speed for the next normal flap setting
- removed when flap is moved to landing flap selected on FMC APPROACH REF or when flap lever is at flaps 30

7 **Selected speed Bug**

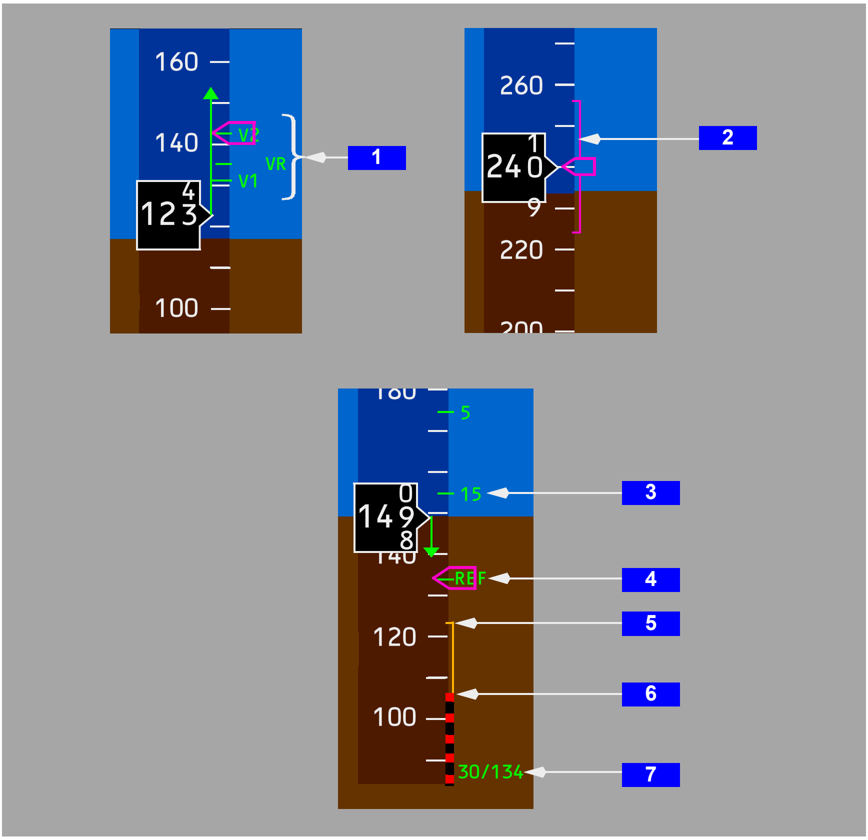
Points to the airspeed/Mach selected in the MCP IAS/MACH window.

Indicates FMC-computed airspeed when the MCP IAS/MACH window is blank.

The bug is five knots in height.

When the selected speed is off scale, the bug is parked at the top or bottom of the tape, with only one half the bug visible.

PFD Reference Speeds



1 Takeoff Reference Speeds

Displays the takeoff reference speeds V1, VR (displays R if VR is within 4 knots of V1 or V2), and V2, selected on the CDU (refer to Chapter 11, Flight Management, Navigation):

- displayed for takeoff
- NO V SPD is displayed if V speeds are not selected on the CDU
- V1 is displayed at the top of the airspeed indication when selected and if the value is off the scale
- V1 and VR are removed at lift–off
- V2 is removed on climb–out:
  - when flap retraction begins, or
  - after 10 minutes have passed without flap lever movement, or
  - after VREF has been selected (for a turn–back)

2 **VNAV Speed Band**

Indicates speed range for VNAV path (VNAV PTH).

- upper limit is speed at which VNAV changes from VNAV PTH to VNAV SPD
- lower limit is speed at which autothrottle adds thrust above FMC-computed descent thrust

Displayed after top of descent with flaps up.

3 **Flap Maneuvering Speeds**

Indicates flap maneuvering speed for flap retraction or extension.

Not displayed above approximately 20,000 feet altitude.

4 **Landing Reference Speed**

Displays the VREF speed as selected on the CDU (refer to Chapter 11, Flight Management, Navigation).

VREF speed is displayed at the bottom of the airspeed indication when the value is off the scale.

5 **Minimum Maneuvering Speed**

Indicates maneuver speed margin to stick shaker or low speed buffet.

6 **Minimum Speed**

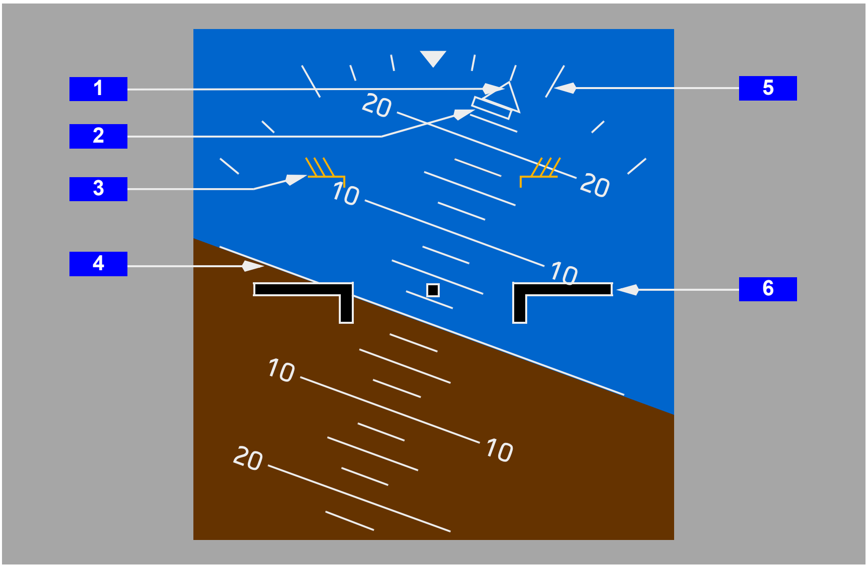
Indicates the airspeed where stick shaker activates.

7 **Landing Flap and VREF Speed**

Displays landing flap position and landing reference speed.

PFD Attitude Indications

[Option – Split cue]



1 Bank Pointer

Indicates ADRS bank in reference to the bank scale.

Fills and turns amber if bank angle is 35 degrees or more.

2 Slip/Skid Indication

Displaces beneath the bank pointer to indicate slip or skid.

Fills white at full scale deflection.

Turns amber if bank angle is 35 degrees or more; fills amber if the slip/skid indication is also at full deflection.

3 Pitch Limit Indication

Indicates pitch limit (stick shaker activation point for the existing flight conditions).

Displayed when the flaps are not up, or at slow speeds with the flaps up.

4 Horizon Line and Pitch Scale

Indicates the IRS horizon relative to the airplane symbol.

Pitch scale is in 2.5 degree increments.

5 Bank Scale

Fixed reference for the bank pointer.

Scale marks are at 0, 10, 20, 30, 45, and 60 degrees.

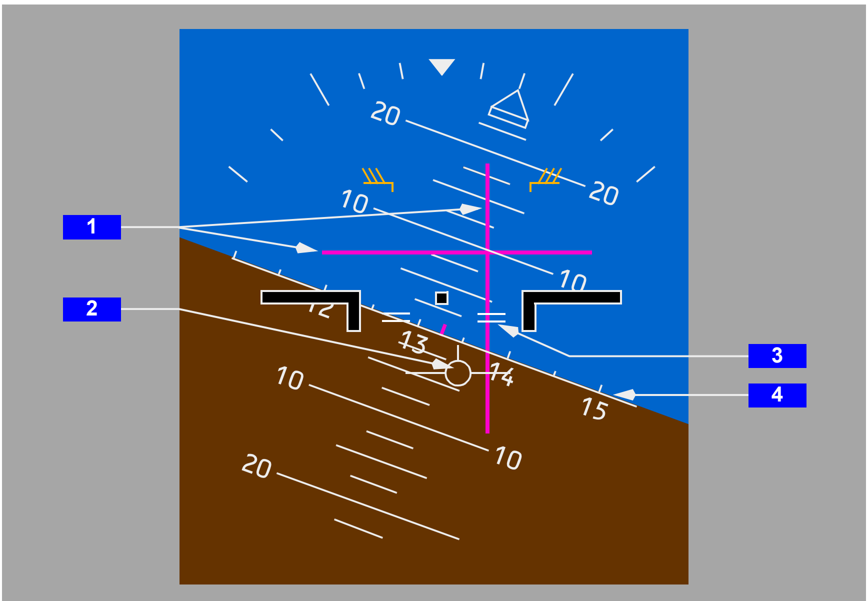
6 **Airplane Symbol**

Indicates airplane attitude with reference to the IRS horizon.

PFD Steering Indications

Note: Refer to Chapter 15, Warning Systems, for TCAS PFD Vertical Guidance and Alerts Displayed on the PFD.

[Option – Split cue, Horizon line heading scale]



[Option – Split cue]

1 **Flight Director Pitch and Roll Bars**

Indicates flight director pitch and roll steering commands.

Refer to Chapter 4, Automatic Flight.

2 **Flight Path Vector (FPV)**

Displays flight path angle and drift angle if:

- FPV is selected on the EFIS control panel, or
- FPA (flight path angle) is selected on the MCP

Flight path angle is displayed relative to the horizon line.

Drift angle is represented by the perpendicular distance from the centerline of the pitch scale to the FPV symbol.

3 **Selected Flight Path Angle (FPA)**

Indicates the selected flight path angle when FPA is selected on the MCP.

[Option – Horizon line heading scale]

4 **Horizon Line Heading Scale**

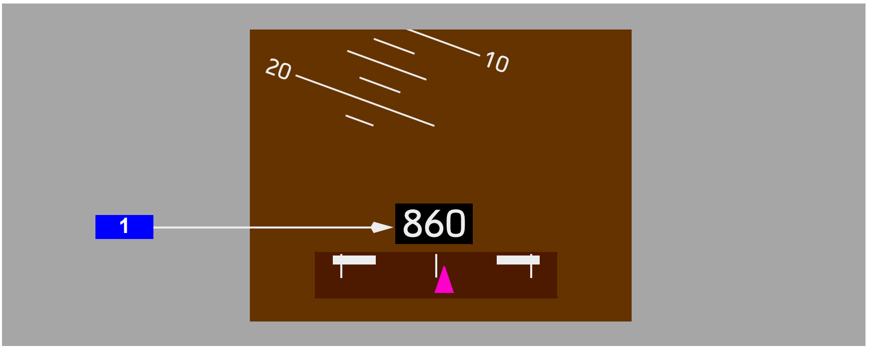
Displays when:

- FPV is selected on the EFIS control panel, or
- FPA (flight path angle) is selected on the MCP, and
- current bank angle is less than 50 degrees, and
- absolute pitch angle is less than 20 degrees

A magenta selected heading bug is displayed which reflects the MCP selected heading value.

PFD Radio Altitude Indications

[Option – Digital RA display]



1 **Radio Altitude**

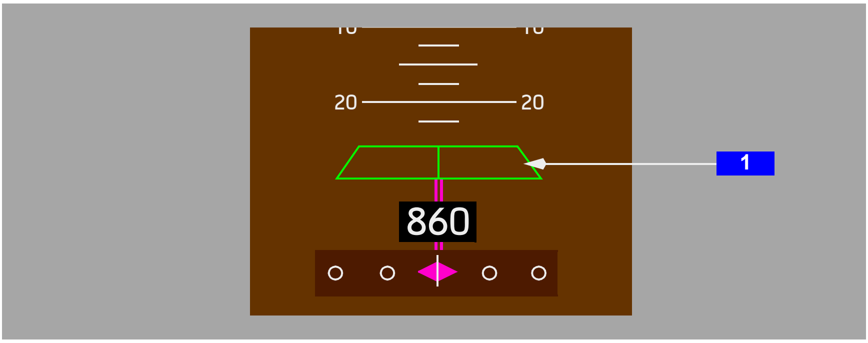
Displays radio altitude below 2500 feet AGL.

The display box is highlighted in white for 10 seconds when passing below 2500 feet.

Turns amber when below radio altitude minimums.

PFD Rising Runway Indications

[Option – Rising runway display]



1 Rising Runway

Displayed below 2500 feet altitude when the localizer pointer is in view for both front and back courses.

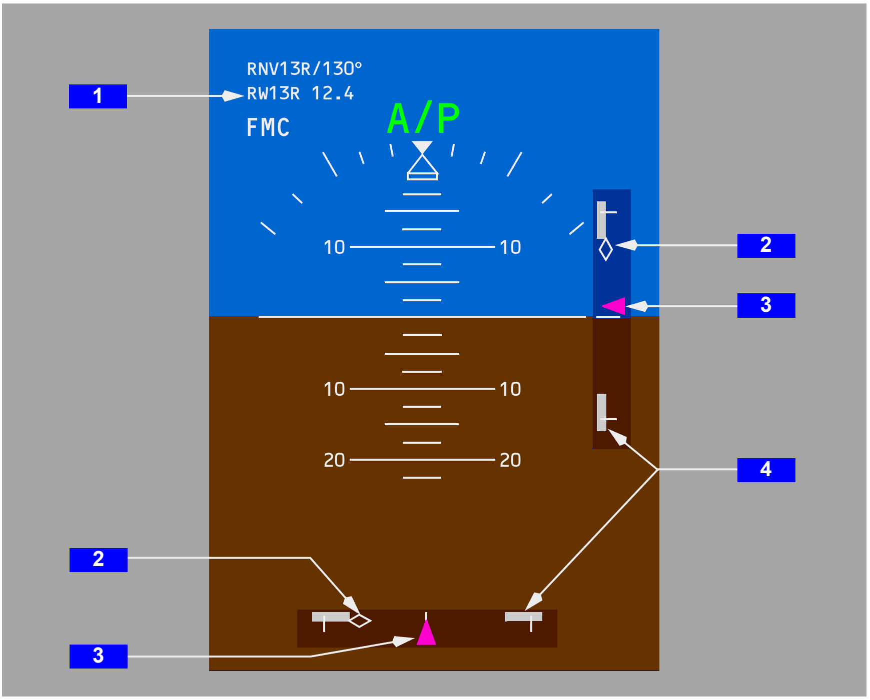
Moves toward the airplane symbol below 200 feet radio altitude.

The stem of the rising runway symbol flashes when localizer deviations cause the diamond to flash.

PFD Navigation Performance Indications

Actual Navigation Performance (ANP) and Required Navigation Performance (RNP) scales are displayed when:

- LNAV is armed or active, or
- VNAV is active, or
- TO/GA is active



1 Navigation Source Reference

Displays the source of navigation performance for the navigation scales.

Possible combinations:

Horizontal Scale	Vertical Scale	Scale Source Text
NPS	NPS	FMC
NPS	IAN Glidepath	FMC
IAN Final Approach Course	IAN Glidepath	FMC
ILS Localizer	ILS Glideslope	ILS
GLS Localizer	GLS Glideslope	GLS
ILS Localizer	NPS	ILS/FMC
ILS Localizer	IAN Glidepath	ILS/FMC
GLS Localizer	NPS	FMC/GPS

2 Deviation Pointer (armed)

Represents the relative position of the path for the selected and activated approach.

- unfilled white diamond for LOC or G/S
- unfilled white triangle for FAC or G/P
- if engaged lateral mode subsequently transitions to LOC or IAN FAC, lateral NPS deviation indications are removed and normal ILS localizer or IAN FAC indications are displayed
- if engaged vertical mode subsequently transitions to G/S or IAN G/P, vertical NPS deviation indications are removed and normal ILS G/S or IAN G/P indications are displayed

3 Deviation Pointer (captured)

Pointer:

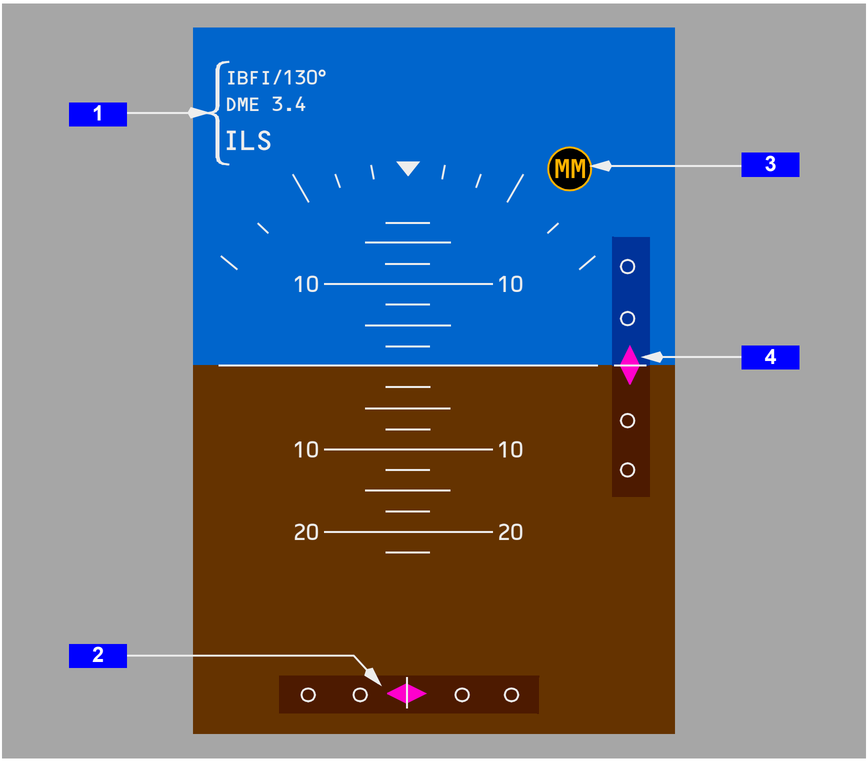
- unfilled magenta symbol when parked at deflection limit
- filled magenta when not parked at deflection limit
- indicates relative position from the annunciated navigation source
- flashes for ten seconds if pointer migrates into bar area for five seconds or ANP bars meet in the middle of the deviation scale

4 Deviation Scale

Deviation:

- bars represent difference between RNP and ANP
- area between bars indicates margin available to remain within RNP criteria
- if ANP equals RNP the white bars meet in the middle and turn amber indicating RNP operations can no longer be maintained and the NAV UNABLE RNP EICAS message is shown
- turns amber if pointer migrates into bar area for five seconds or ANP bars meet in the middle of the deviation scale

PFD Instrument Landing System Indications



1 **Approach Reference**

Displays the selected ILS/GLS identifier or frequency, approach front course, ILS/GLS DME distance, and source annunciation.

If the tuned ILS/GLS frequencies disagree, the frequency turns amber with an amber horizontal line through it.

If the approach courses in the ILS/GLS receivers disagree, the course turns amber with an amber horizontal line through it.

2 **Localizer Pointer and Scale**

The localizer pointer:

- indicates localizer position relative to the airplane
- is in view when the localizer signal is received
- fills in solid when within 2 1/2 dots from the center

The scale is in view after the frequency is tuned if LNAV is not in use. If LNAV is in use, the NPS indications remain in view until localizer capture.

At low radio altitudes, with the autopilot or flight director engaged, the scale turns amber and the pointer flashes to indicate excessive localizer deviation.

At low altitudes, with LNAV engaged and LOC armed, the localizer scale turns amber and the pointer flashes if the localizer is not captured.

3 Marker Beacon Indication

The marker beacon indication appears flashing when over one of the marker beacon transmitters:

- IM – an airway or inner marker beacon
- MM – a middle marker beacon
- OM – an outer marker beacon

The indication flashes in cadence with the beacon identifier.

4 Glideslope Pointer and Scale

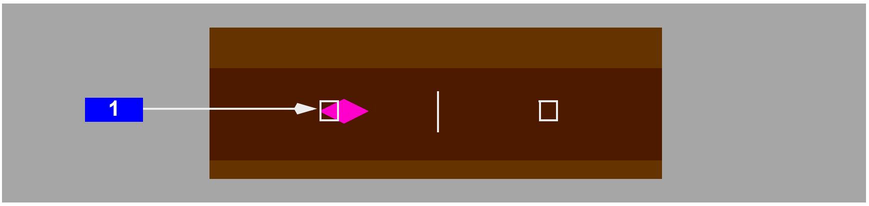
The glideslope pointer:

- indicates glideslope position relative to the airplane, and:
  - is in view when the glideslope signal is received
  - fills in solid when within 2 1/2 dots from the scale center

The scale is in view after the frequency is tuned. If VNAV is in use, the NPS indications remain in view until glideslope capture.

At low radio altitudes, with the autopilot or flight director engaged, the scale turns amber and the pointer flashes to indicate excessive glideslope deviation.

PFD Expanded Localizer Indications

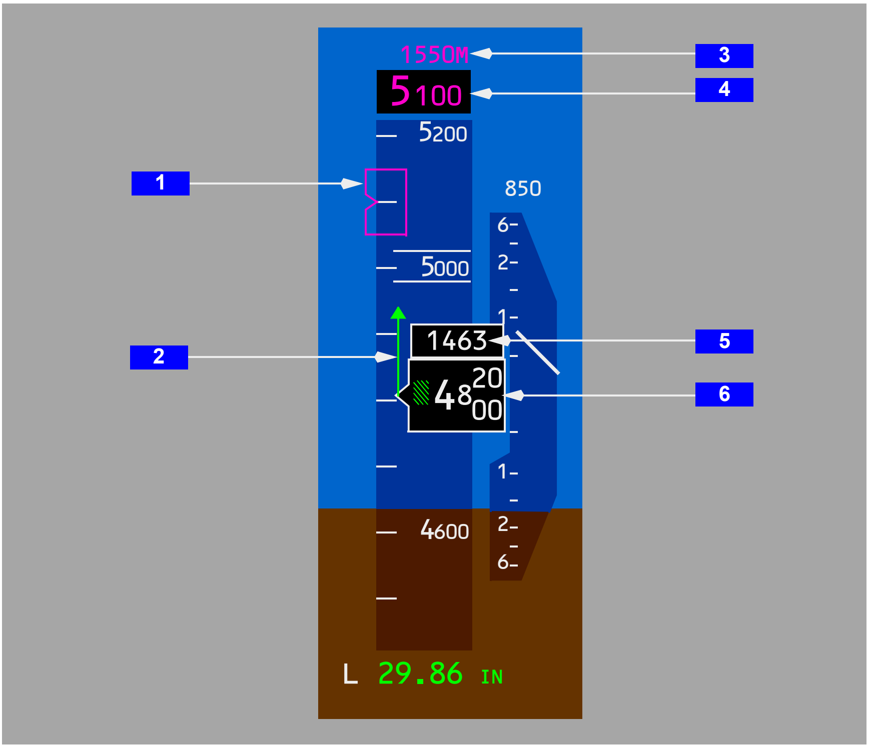


1 Expanded Localizer Scale

Displays when the autopilot or flight director is in LOC mode and the airplane is close to the runway center line. Provides a more sensitive display.

A rectangle equals 1/2 dot deviation.

PFD Altitude Indications



1 Selected Altitude Bug

Indicates the altitude set in the MCP altitude window.

When the selected altitude is off scale, the bug is parked at the top or bottom of the tape, with only one half the bug visible.

2 Altitude Trend Vector

Indicates expected altitude six seconds ahead in time based on the current vertical speed.

3 Selected Altitude – Meters

Displayed when MTRS is selected on the EFIS control panel MTRS switch.

Indicates selected altitude in meters (selected in feet in the MCP altitude window).

Displays in 10 meter increments.

4 Selected Altitude

Displays the altitude set in the MCP altitude window.

The selected altitude box is highlighted in white between 900 feet and 200 feet prior to reaching the selected altitude.

5 **Current Altitude – Meters**

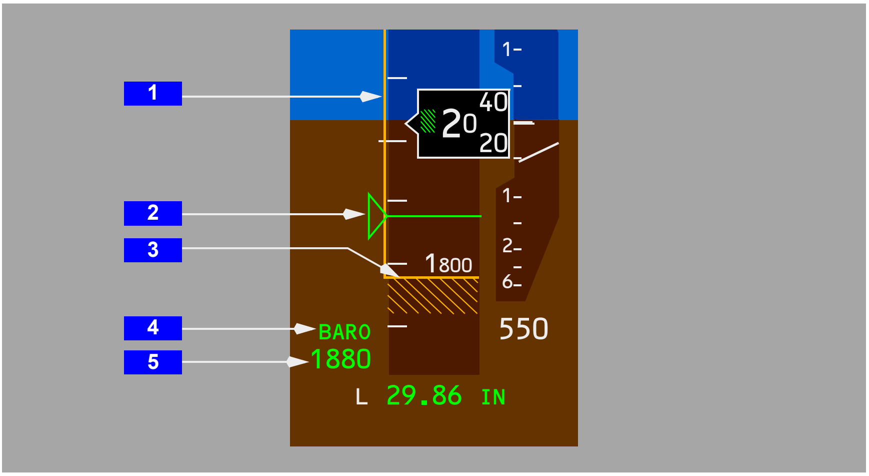
Displayed when MTRS is selected on the EFIS control panel MTRS switch.

Displays altitude in meters.

6 **Current Altitude**

Indicates current ADRS altitude.

PFD Landing Altitude/Minimums Indications



1 **Landing Altitude Reference Bar**

Indicates the height above touchdown.

White bar – 500 to 1000 feet above landing altitude.

Amber bar – 0 to 500 feet above landing altitude.

2 **BARO Minimums Pointer**

When BARO minimums are displayed, the number is also represented as a pointer and line on the altitude scale.

When RA minimums are displayed after BARO minimums are selected, the pointer remains on the altitude scale.

Turns steady amber when the airplane descends below baro minimums.

3 **Landing Altitude Indication**

The crosshatched area indicates the FMC landing altitude for the destination runway or airport.

Indicates the landing altitude for the departure runway or airport until 400 NM or one–half the distance to the destination, whichever occurs first.

4 Minimums Reference

Displays BARO when the EFIS control panel MINS reference selector is set to BARO.

Displays RADIO when the EFIS control panel MINS reference selector is set to RADIO (no corresponding pointer or line on the altitude scale).

Turns amber and flashes for 3 seconds when the airplane descends below selected minimum altitude.

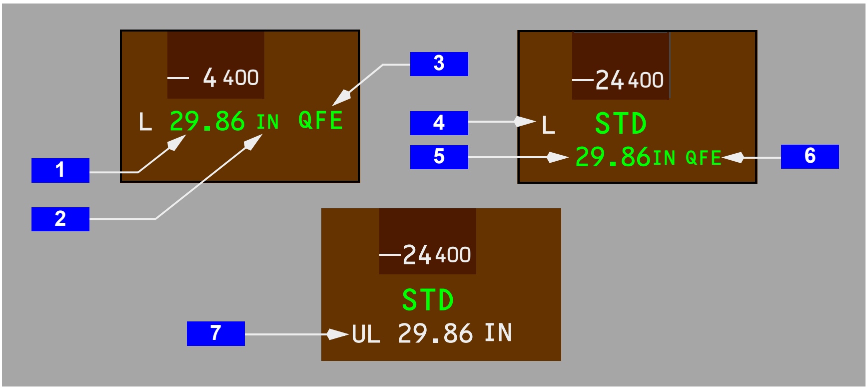
5 Minimums

Displays the approach minimums altitude set using the EFIS control panel MINS selector:

- BARO minimums are feet MSL
- RADIO minimums are radio altitude feet AGL

Turns amber and flashes for 3 seconds when the airplane descends below selected minimum altitude.

PFD Barometric Indications



1 Barometric Setting

Indicates the barometric setting selected on the EFIS control panel barometric selector.

STD is displayed when STD is selected on the EFIS control panel barometric STD switch.

The display is boxed and changes to amber if a barometric setting is set and altitude climbs above the transition altitude, or if STD is set and altitude descends below the transition flight level.

2 Barometric Reference

Indicates the barometric setting units selected on the EFIS control panel barometric reference selector:

- IN is inches of mercury
- HPA is Hectopascals

3 QFE Altitude Reference

Indicates QFE altitude reference selected on the CDU APPROACH REF page.

When selected, QFE is boxed for 10 seconds.

The altitude tape is shaded green during QFE operation.

When QNH is selected, the green shading is removed; QNH is displayed for 10 seconds, then blanks.

4 Autopilot/Flight Director Barometric Source

L or R indicates that the left or right EFIS control panel is the barometric setting reference for the autopilot or flight director (the same indication is displayed on both PFDs).

Displayed when a flight director switch is ON or the autopilot is engaged.

- F/D – one turned on and one not on determines L or R
- F/D – both on – L is displayed
- A/P – first one pushed on determines L or R

5 Preselected Barometric Setting

A barometric setting can be preselected when STD is displayed.

The preset barometric setting is selected on the EFIS control panel barometric selector and is displayed below STD.

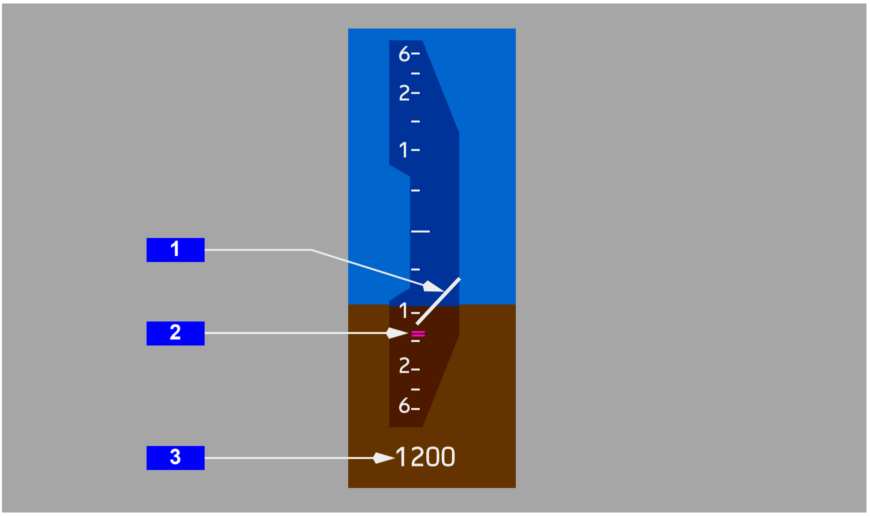
6 QFE

When STD is selected, a small QFE appears when QFE is selected.

7 Uplinked Barometric Setting

The annunciation UL is displayed to the left of the barometric preselect field when a barometric setting uplink is accepted.

PFD Vertical Speed Indications



1 Vertical Speed Pointer

Indicates current vertical speed.

2 Selected Vertical Speed Bug

Indicates the speed selected in the MCP vertical speed window with the V/S pitch mode engaged.

3 Vertical Speed

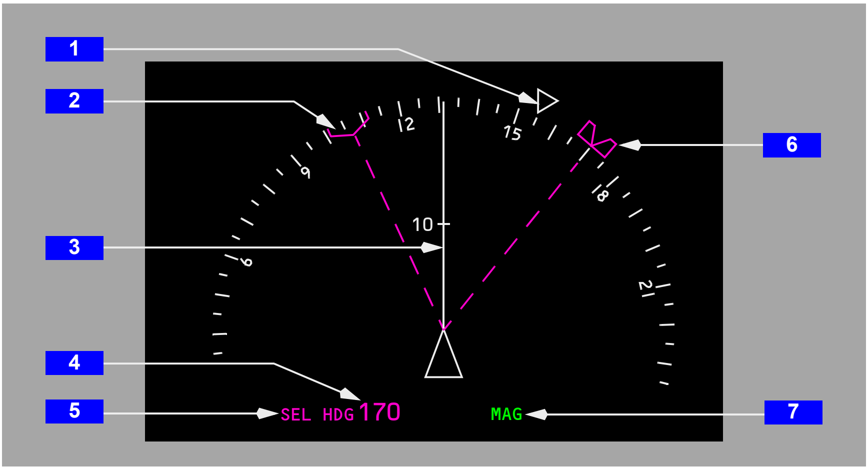
Displays vertical speed when greater than 400 feet per minute.

The display is located above the vertical speed indication when climbing and below when descending.

PFD Heading/Track Indications

Note: The selected track bug and selected heading bug are not displayed at the same time.

[Option – Track up]



1 Current Heading Pointer

Indicates current heading.

2 Selected Track Bug (MCP Selection)

The selected track bug is displayed on the inside of the compass rose.

If selected track exceeds display range, the bug parks on the side of the compass rose in the direction of the shorter turn to the track.

3 Track Line

Indicates the current track.

4 Selected Heading/Track (MCP Selection)

Digital display of the selected heading or track bug.

5 Selected Heading/Track Reference (MCP Selection)

When HDG (heading) is selected, SEL HDG is displayed.

When TRK (track) is selected, SEL TRK is displayed.

6 Selected Heading Bug (MCP Selection)

The selected heading bug is displayed on the outside of the compass rose.

If selected heading exceeds display range, the bug parks on the side of the compass rose in the direction of the shorter turn to the heading.

7 Heading/Track Reference

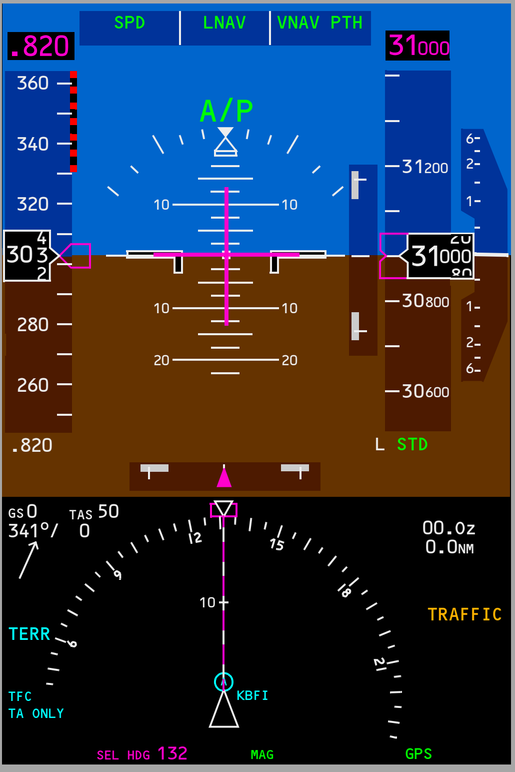
Displays the automatic or manually selected heading/track reference:

- MAG (magnetic north)
- TRU (true north)

PFD Reversion Mode

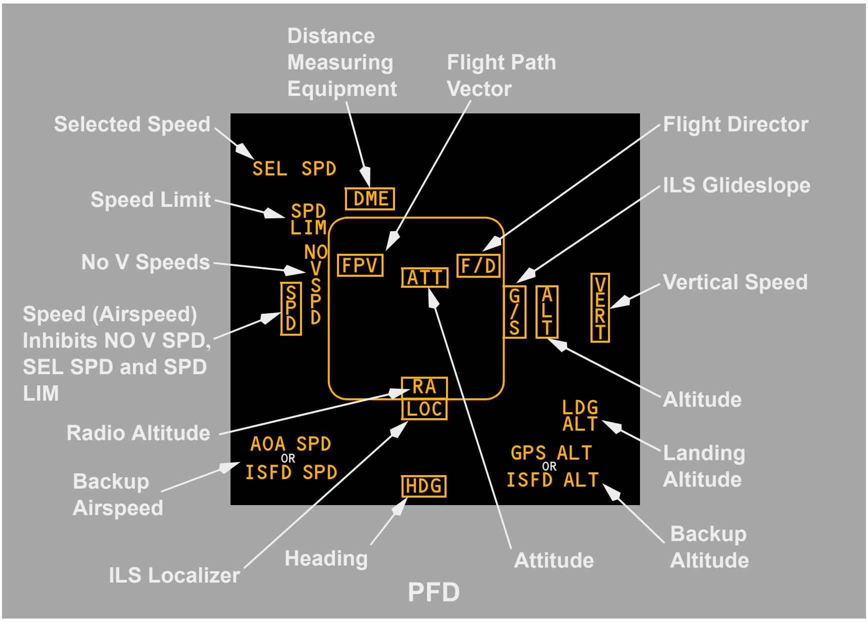
Note: The PFD is shown in reversion mode for some display failures. The PFD with mini-map is condensed to fit within an MFD window (one half of a Display Unit). All PFD symbology remains in the same relative position referenced to the airplane symbol center.

[Option – Split cue, no ADF]



PFD Failure Flags

Note: PFD failure flags replace the appropriate display to indicate source system failure, or lack of computed information.

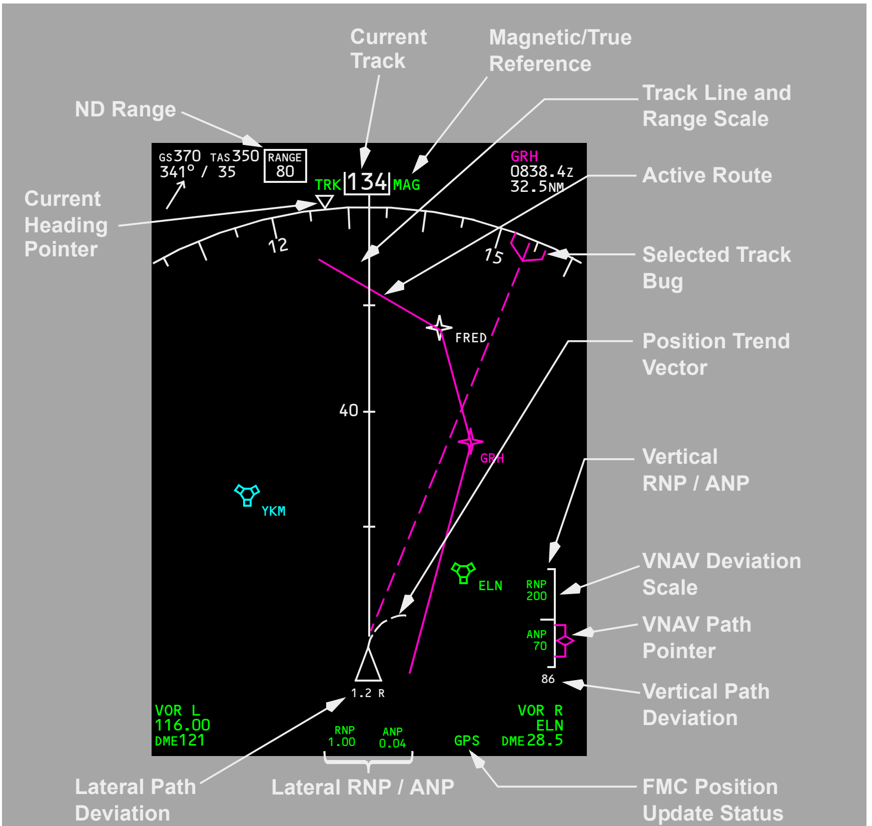

Distance
Measuring
Equipment
Flight Path
Vector
Selected Speed
Flight Director
SEL SPD
DME
ILS Glideslope
Speed Limit
SPD
LIM
No V Speeds
NO
V
SPD
FPV
ATT
F/D
Vertical Speed
SPD
G/S
ALT
VERT
Speed (Airspeed)
Inhibits NO V SPD,
SEL SPD and SPD
LIM
RA
LOC
Altitude
LDG
ALT
Radio Altitude
AOA SPD
OR
ISFD SPD
GPS ALT
OR
ISFD ALT
Landing
Altitude
Backup
Airspeed
HDG
Backup
Altitude
Heading
Attitude
ILS Localizer
PFD

Navigation Display (ND)

Note: Refer to the Navigation Display section of this chapter for a detailed explanation of the ND symbology shown on the following pages.

ND Map Mode

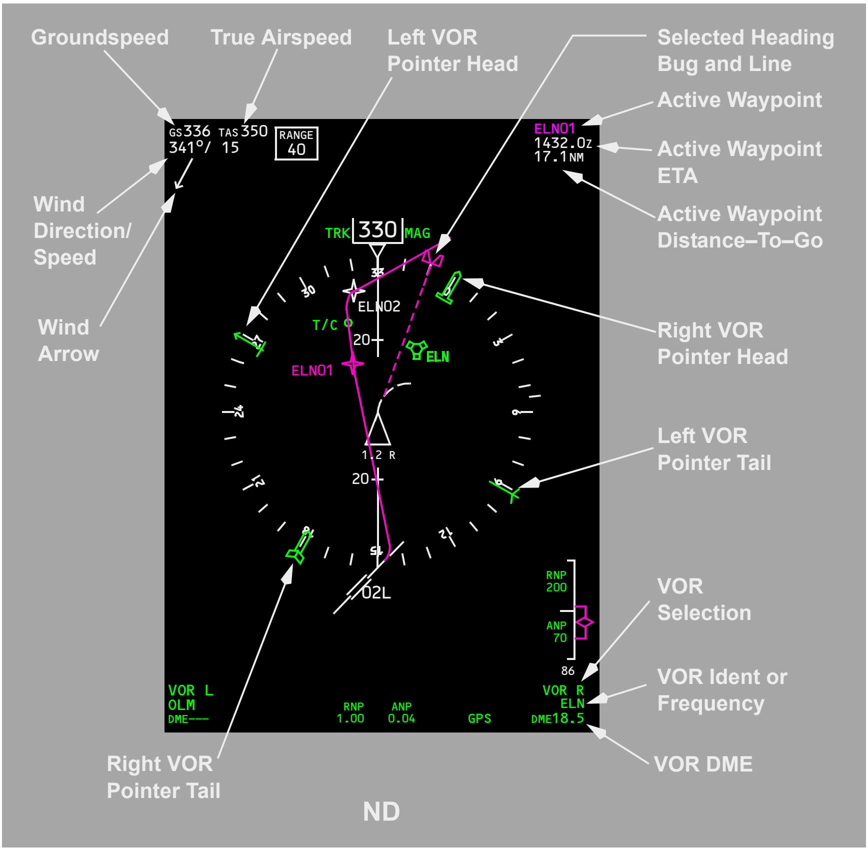
Expanded Map Mode
[Option – Track up]



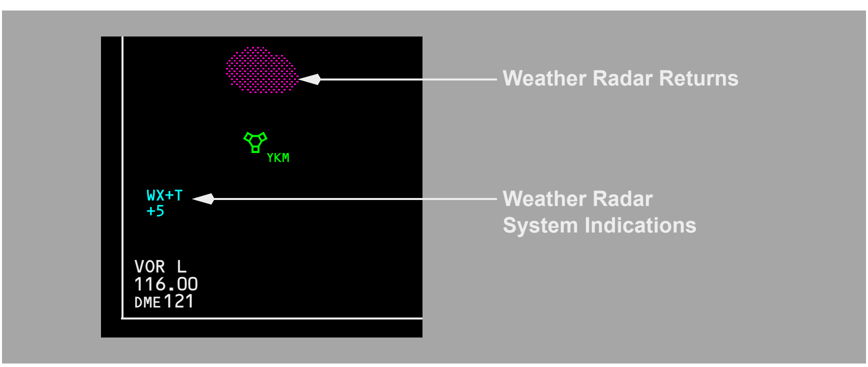
ND

Centered Map Mode

[Option – Track up]

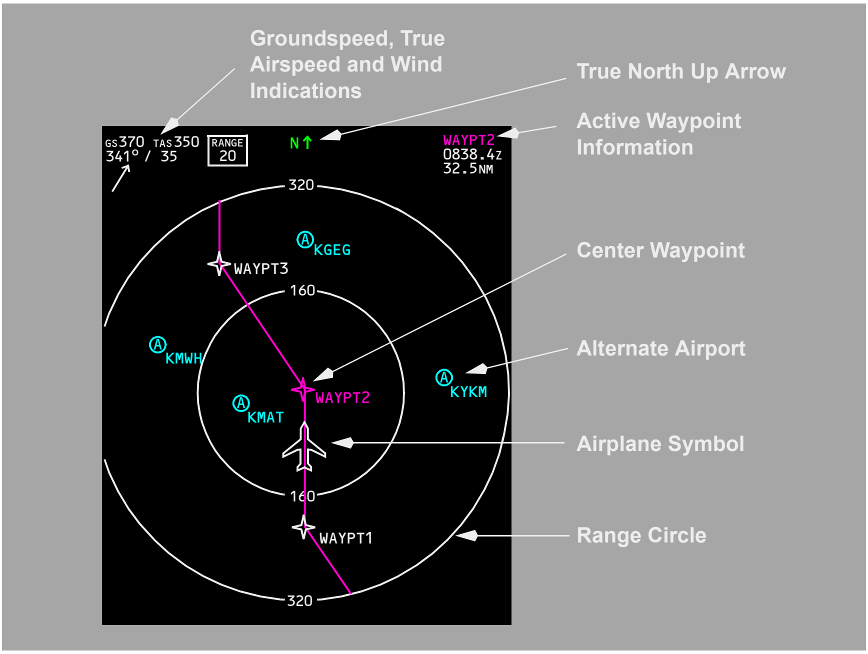


ND Weather Radar System Display Indications



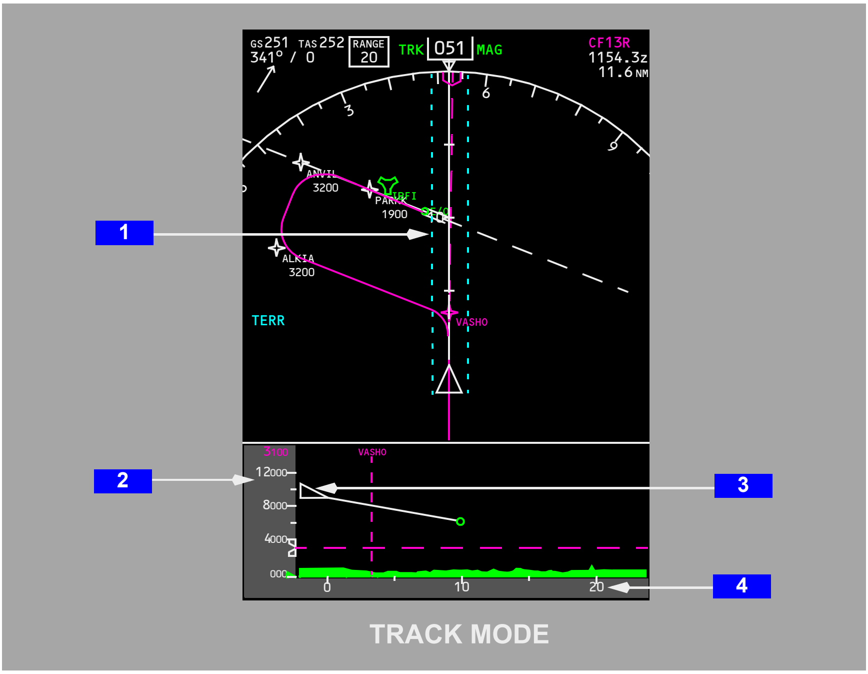
[Option – Range arcs]

ND Plan Mode

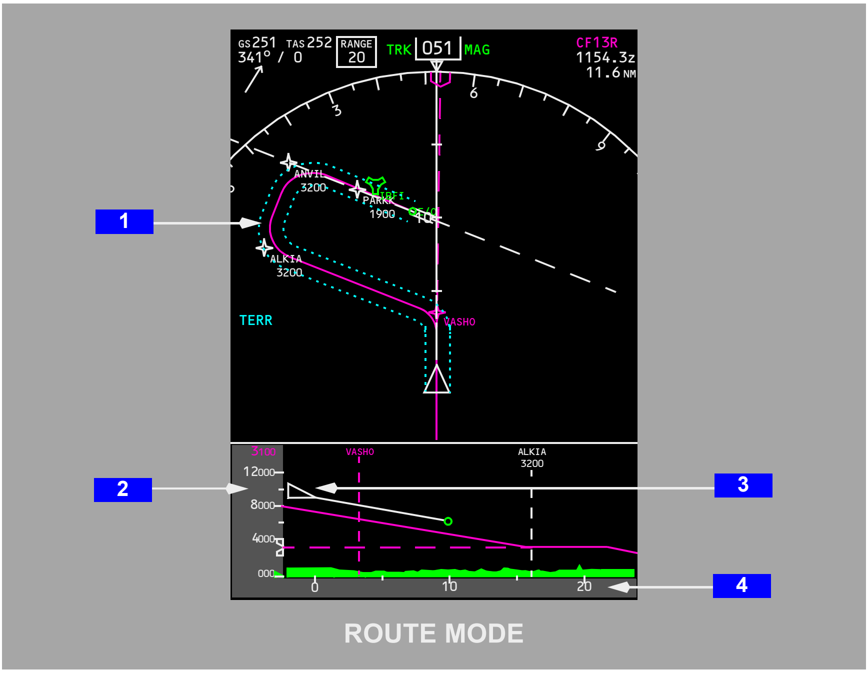

Groundspeed, True Airspeed and Wind Indications
True North Up Arrow
Active Waypoint Information
Center Waypoint
Alternate Airport
Airplane Symbol
Range Circle
GS370 TAS350
341° / 35
RANGE
20
N
WAYPT2
0838.4Z
32.5NM
320
KGEG
WAYPT3
160
KMWH
KYKM
WAYPT2
KMAT
160
WAYPT1
320

Vertical Situation Display (VSD)

[Option – Track up]



[Option – Track up]



1 Enroute Corridor

Displayed (cyan) – indicates area mapped by the VSD.

Track mode (default) – Dashed lines are offset by 1 RNP from instantaneous track of airplane.

Route mode – Dashed lines are offset by 1 RNP from the Flight Management Flight Plan. Automatically selected when:

- airplane is on ground
  - an active flight plan has been entered and
  - a departure runway has been selected and
  - LNAV is armed
- airplane is in air
  - airplane is in any path-based mode such as LNAV, LOC, or FAC, and
  - lateral path deviation is less than RNP

2 Altitude Reference Scale

Displays altitude in reference to the vertical position of the airplane symbol, terrain, and other objects in the VSD background display.

3 **Airplane Symbol**

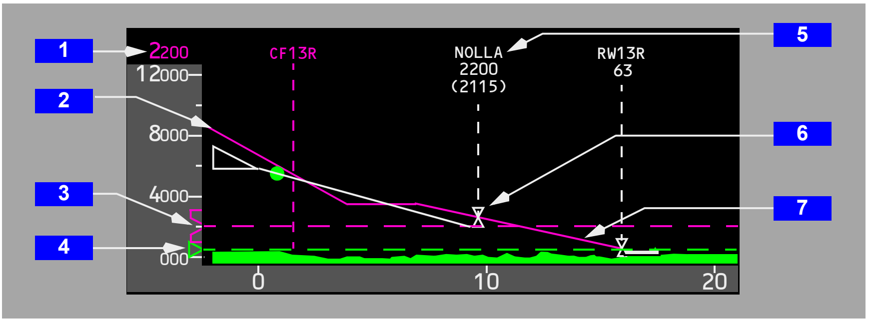
Indicates current airplane altitude (bottom of the triangle) and lateral position (point of the triangle) relative to terrain.

4 **Horizontal Reference Scale**

Displays range in nautical miles.

The scale is the full range selected on the EFIS control panel when the Normal-display ND is used. The scale is twice the full range selected when the Full-display ND is used.

Vertical Situation Display (VSD) – General Background



1 **MCP Selected Altitude Readout**

Displays the altitude set in the MCP altitude window.

2 **Active Vertical Path**

Displays the path that VNAV commands if it is engaged.

During climbs, there is no VNAV path, so the line extends from the nose of the airplane to the predicted altitudes at each waypoint in the climb.

3 **Selected Altitude Bug**

Indicates the altitude set in the MCP altitude window.

When the selected altitude is off scale, the bug is parked at the top or bottom, with only one half the bug visible. The dashed line does not park.

4 **BARO Minimums Pointer**

Indicates the barometric minimums selected on the EFIS control panel:

- pointer and dashed line turn amber when airplane descends below selected minimum altitude
- reset with the RST switch on the EFIS control panel

5 Waypoint ID and Anchor Line

Displayed with any altitude constraint directly beneath.

- dashed vertical line depicts lateral position
- during QFE operations, altitude constraints are shown in parentheses below the QNH values

6 Altitude Constraint Symbol

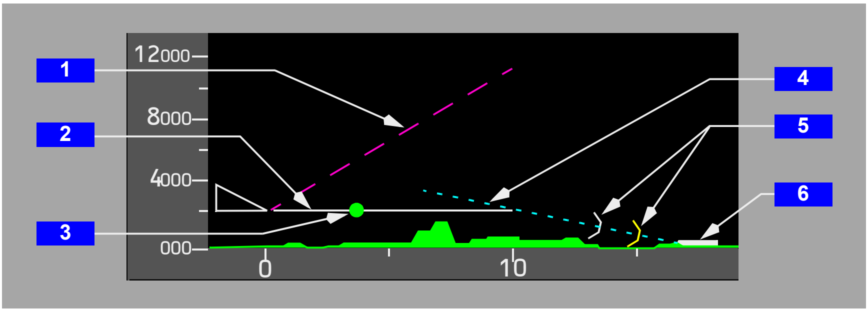
Displayed as triangle(s) on waypoint anchor line.

7 FMC Approach Glidepath Angle Line

Displayed for approaches that have a designated approach angle.

- extends 10 NM for situational awareness
- anchored to the missed approach waypoint, not the runway

Vertical Situation Display (VSD) – Flight Path Background



1 MCP Selected Vertical Speed (V/S)

Displays the selected vertical speed as a dashed target angle line when the MCP V/S mode is selected.

2 Vertical Flight Path Vector

Indicates current flight path angle as a function of vertical speed and groundspeed. The length of the vector is fixed at one half of the VSD range.

3 Range to Target Speed Dot (RTSD)

Indicates where the airplane will achieve the FMC or MCP target speed:

- dot is blanked within 5 knots of target speed
- dot reappears if speed increases 10 knots or more faster than target speed
- dot is unfilled and placed at the end of the vertical flight path vector line if the speed will not be achieved in the distance of the vertical flight path vector line
- dot is unfilled and placed at the edge of the display along the vertical flight path vector line if the speed will not be achieved within the display area
- reset with the RST switch on the EFIS control panel

4 **3-Degree Reference Line**

Displayed for approaches that do not have a designated approach angle:

- dashed line extends 10 NM for situational awareness
- anchored to the runway threshold
- for reference only, line may intersect terrain

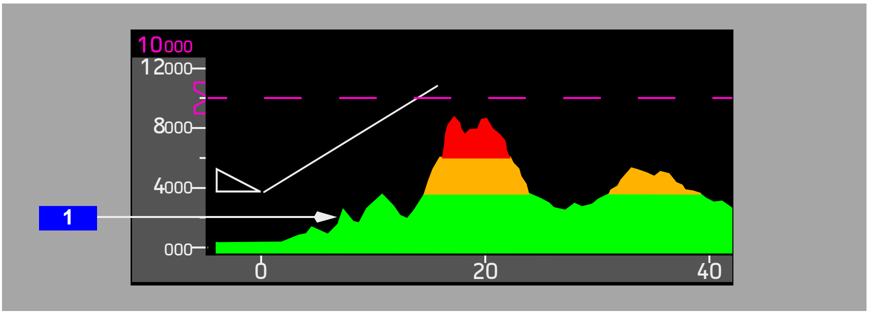
5 **Decision Gates**

Displayed on the FMC approach glidepath angle line or 3 degree reference line at 500 feet and 1000 feet above field elevation.

6 **Runway**

Represents the selected runway. Runway length is scaled to the selected range.

Vertical Situation Display (VSD) – Terrain Background



1 **Terrain Profile Line**

Represents the highest terrain within the enroute swath.

- highest points of the terrain below and ahead of the airplane
- terrain is depicted so the true altitude separation between the airplane and terrain is shown
- terrain behind the airplane is drawn equal to the terrain at the current position
- VSD terrain uses the same color coding that is used to depict GPWS on the lateral map:
  - green: terrain 250-500 feet or more below the airplane
  - amber: terrain from 250-500 below to 2000 feet above the airplane
  - red: terrain more than 2,000 feet above the airplane

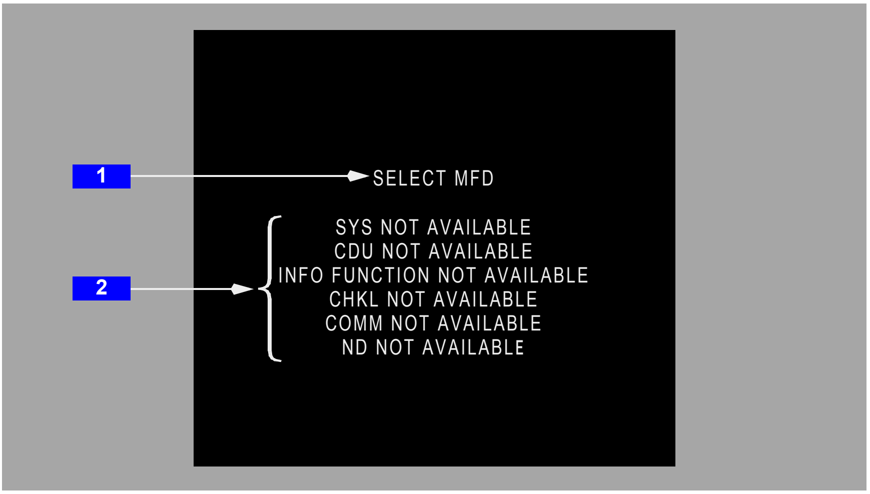
Airport Map Display

[Option – Track up]

ND

INFO PAGE

MFD Messages



1 Select MFD

The number of instances requested for a display format exceeds the maximum available.

Maximum number of instances for each format –

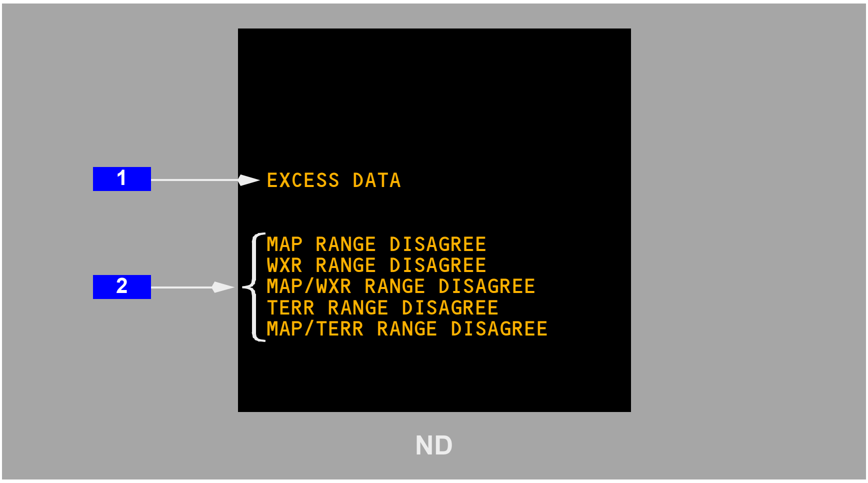
- SYS (2 per side, independent)
- CDU (1 per side, independent)
- INFO (2 per side, independent)
- CHKL (1 per side, synchronized)
- COMM (1 per side, independent)
- ND (1 per side, independent)

2 Display Format Not Available

The DU is operating normally, but the display format is not available.

ND Failure Indications and Flags

ND Failure Messages



1 Excess Data

The amount of map information sent to the primary display system is too great to display.

2 MAP/WXR Range Disagree

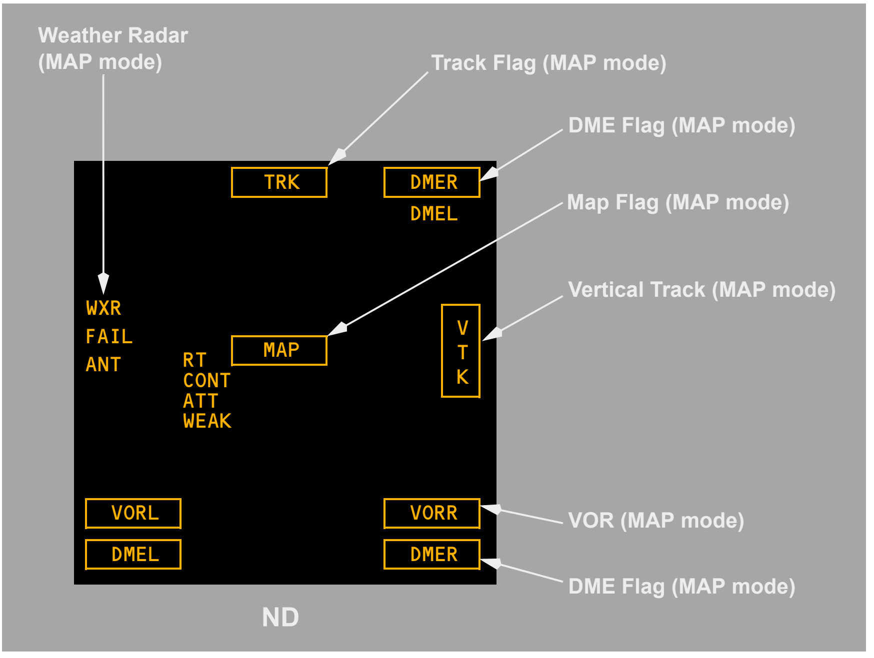
The selected range and range of display information disagree.

Map information is removed.

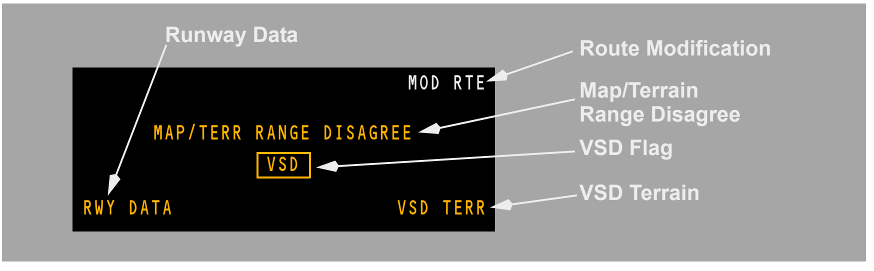
ND Failure Flags

Dashes replace numbers if there is no computed information. Failure flags replace symbols or failure messages are displayed, as appropriate. Flag location varies, depending on the ND mode selected.

[Option – Track up]



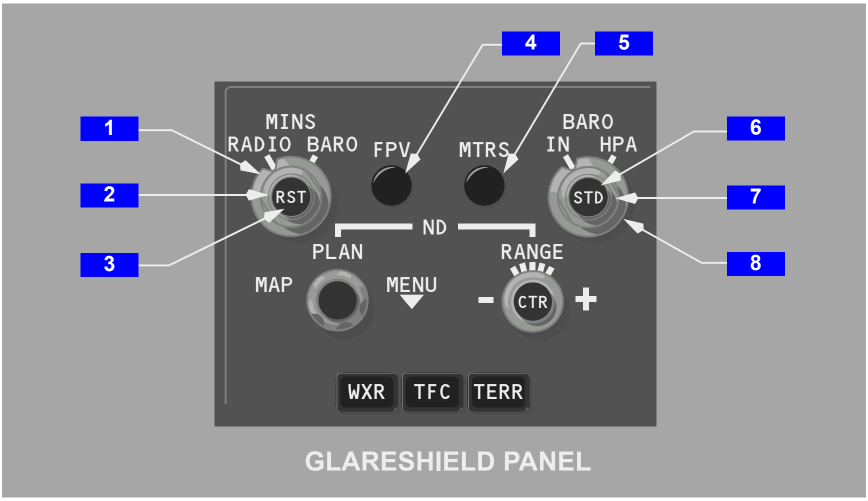
VSD



EFIS Control Panels

The left EFIS control panel controls the left PFD and ND. The right EFIS control panel controls the right PFD and ND.

EFIS Control Panel PFD Controls



1 Minimums (MINS) Reference Selector (outer)

RADIO – selects radio altitude as the PFD minimums reference.

BARO – selects barometric altitude as the PFD minimums reference.

2 Minimums (MINS) Selector (middle)

Rotate (slew)– adjusts the PFD radio or baro minimums altitude.

3 Minimums Reset (MINS RST) Switch (inner)

Push –

- resets the PFD minimums alert display
- blanks the minimums display when green

4 Flight Path Vector (FPV) Switch

Push – displays the PFD flight path vector.

5 Meters (MTRS) Switch

Push – displays PFD altitude meters indications.

6 Barometric Standard (BARO STD) Switch (inner)

Push –

- selects the standard barometric setting (29.92 inches Hg/1013 HPA) for the PFD barometric reference
- if STD is displayed, selects the preselected barometric setting
- if no preselected barometric setting is displayed, displays the last value before STD was selected

7 **Barometric (BARO) Selector (middle)**

Rotate (slew) – adjusts the PFD barometric reference.

8 **Barometric (BARO) Reference Selector (outer)**

IN – selects inches of mercury as the PFD barometric reference.

HPA – selects Hectopascals as the PFD barometric reference.

EFIS Control Panel ND Controls

GLARESHIELD PANEL

1 **ND Mode Selector (outer)**

Moves the highlight box to the desired ND map display or map information selection.

MAP –

- displays a moving, track-up route depiction
- displays FMC-generated route and map information, airplane position, heading, and track
- displays waypoints, including the active waypoint, within the selected range
- displays VNAV path deviation

PLAN –

- displays a nonmoving, true north-up, route depiction
- allows route step-through using the CDU legs page
- weather radar and TCAS are not displayed in PLAN mode

MENU – rotate to move highlight between Map Information Selections

2 **ND Mode Select Switch (inner)**

Push to select the highlighted key on the ND.

3 Map Switches

The map switches:

- select detailed ND and mini-map information displays
- displays can be shown simultaneously
- second push removes the information

WXR (Weather Radar) – displays weather radar information (refer to Chapter 11, Flight Management, Navigation).

TFC (Traffic) – displays TCAS information. (Refer to Chapter 15, Warning Systems.)

TERR (Terrain) – displays terrain data. (Refer to Chapter 15, Warning Systems.)

4 ND Range Selector (outer)

Selects the desired ND nautical mile range scale.

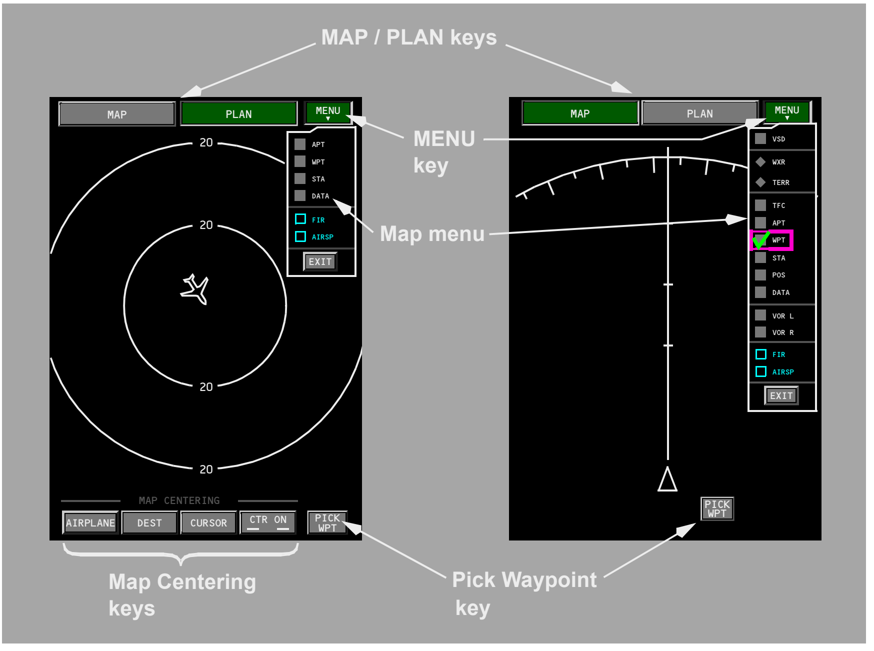
- increment/decrement knob
- rotating clockwise/counter-clockwise increases/decreases ND range respectively

5 ND Center (CTR) Switch (inner)

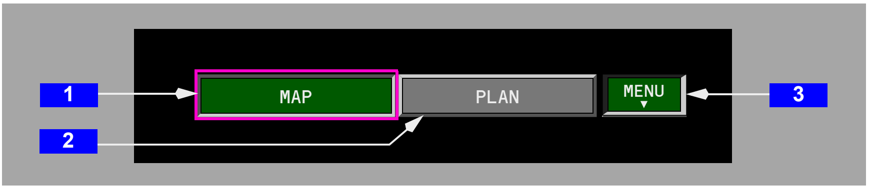
Push –

- displays the full compass rose (centered) for MAP mode
- subsequent pushes alternate between expanded and centered displays

Map Keys and Information Selections



Map keys are selectable with the ND Mode Selector on the EFIS control panel, the CCD, or the MFD Cursor Control Selector on the MFK. Each key is gray when available for selection and green when currently selected. Each key is cyan when disabled. Each selection on the drop-down menus shows a green check when currently selected. All map keys and information selections are highlighted by a magenta box when the cursor is placed on top of the item.



1 MAP Key

When selected –

- displays a moving, track-up route depiction
- displays FMC-generated route and map information, airplane position, heading, and track

- displays waypoints, including the active waypoint, within the selected range
- displays VNAV path deviation

2 **PLAN Key**

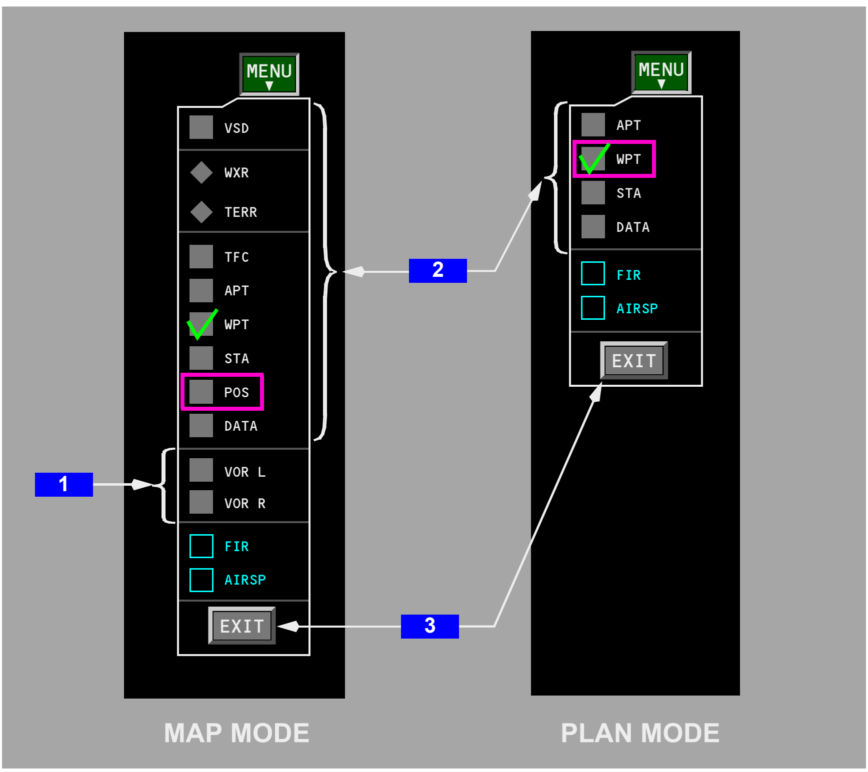
When selected –

- displays a nonmoving, true north-up, route depiction
- allows route step-through using the CDU legs page
- weather radar and TCAS are not displayed in PLAN mode

3 **MENU Key**

Selected – displays a drop-down menu containing map information selections

De-selected – removes menu from ND display



1 **VOR Keys**

Displays the respective VOR pointer, VOR frequency or identification, and associated DME information.

2 Map Information Selections

Note: WXR and TERR are not selectable at the same time.

Note: Selections that are common to both MAP and PLAN modes retain their states when changing between the two formats. Selections also retain their states when changing to a different MFD display and then back to a ND mode.

VSD – Vertical Situation Display.

WXR (Weather Radar) – displays weather radar information. (refer to Chapter 11, Flight Management, Navigation).

TERR (Terrain) – displays terrain data. (Refer to Chapter 15, Warning Systems.)

TFC (Traffic) – displays TCAS information. (Refer to Chapter 15, Warning Systems.)

APT (Airport) – displays airports on all ranges.

WPT (Waypoint) – displays waypoints when the ND is in the 10, 20 or 40 NM range.

STA (Stations) –

- displays high and low altitude navigation aids, when the ND is in the 10, 20 or 40 NM range
- displays high altitude navigation aids, when the ND is in the 80, 160, 320, or 640 NM range

POS (Position) –

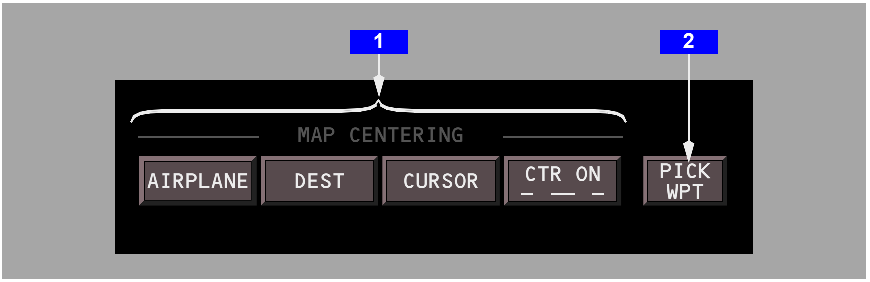
- displays IRS and GPS positions
- displays VOR raw data radials extended from the nose of the airplane to the stations displayed on the CDU NAV RAD page

DATA (Data) –

- displays the entered or procedural altitude and ETAs at each waypoint
- times are based on distance to go and groundspeed. They do not consider FMC performance predictions and may differ from other FMC ETAs that do

3 EXIT Key

Selected (momentary) – removes menu from ND display.



1 **Map Centering Keys (PLAN Mode only)**

AIRPLANE (momentary push) –

- centers the map on the current latitude and longitude of the airplane
- the map does not continually recenter on the airplane

DEST (momentary push) –

- places the airplane on the center of the destination airport
- displayed cyan if no destination airport is entered in the flight plan

CURSOR (toggle on/off) –

- when activated, recenters airplane on the position where the cursor clicks
- cursor changes shape when mode is active
- deactivated when any of the other centering keys are selected, the center on CURSOR key is re-selected, or the cursor leaves the ND

CTR ON – – – – (momentary push) – centers on any database item (STA, WPT, APT) or latitude/longitude coordinate already entered in the scratchpad.

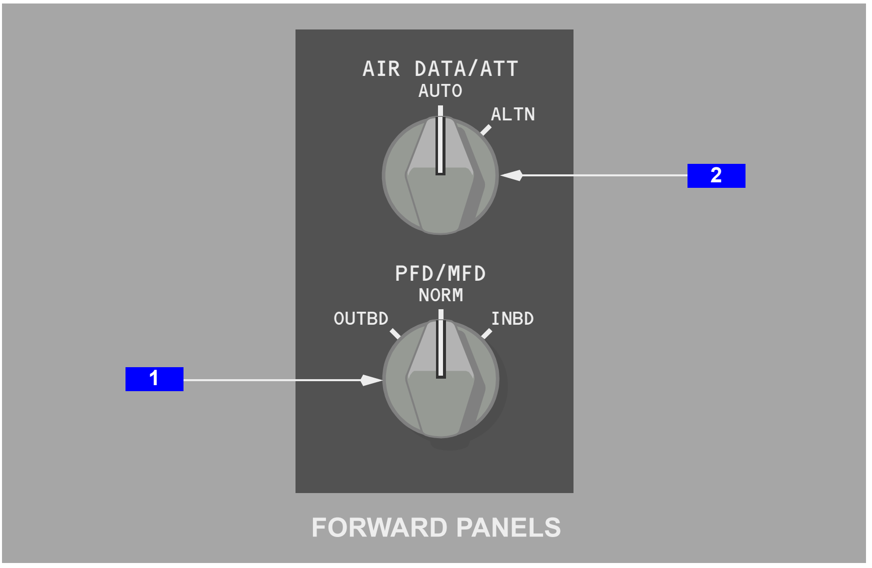
2 **Pick Waypoint (PICK WPT) Key (MAP and PLAN modes)**

Allows the pilot to graphically create a latitude/longitude point or select a visible waypoint, airport, or navigation aid.

- visible when the cursor is on the ND map area
- enabled when the scratchpad is empty
- disabled when the scratchpad contains data
- when activated, the PICK WPT key label changes to CANCEL

Instrument Source Select Panels

The instrument source switches are provided for use if a display–related failure is not detected by automatic system monitors. Normally, the display system automatically reconfigures for failures without the pilot having to use these switches.



1 PFD/MFD Selector

NORM – normal position:

INBD DU – non-normal position. When the selector is in this position:

- the outboard DU is blanked
- the inboard DU displays the PFD in reversion mode and EICAS if EICAS was displayed on this side

OUTBD DU – non-normal position. When the selector is in this position:

- the inboard DU is blanked
- the outboard half of the outboard DU displays the PFD in reversion mode and EICAS if EICAS was displayed on this side

2 Air Data / Attitude (AIR DATA/ATT) Source Selector

AUTO – normal position:

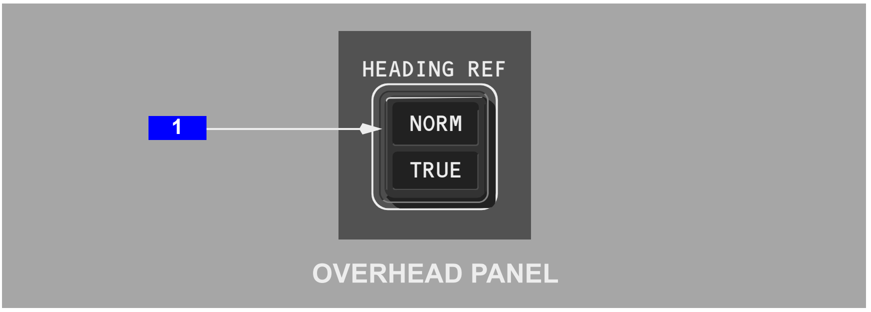
- the ADRS provides air data to the PFD and HUD
- backup airspeed and altitude, based on AOA and inertial data, are automatically provided as required
- the IRS provides attitude data to the PFD and HUD
- backup attitude data from the ISFD sources are automatically provided as required

ALTN – non-normal position. The PFD and HUD alternate air data/attitude source is selected as follows:

- air data – backup airspeed and altitude are displayed on the onside PFD, HUD and ND
- attitude – ISFD attitude displayed on the onside PFD and HUD

Heading Reference

Heading Reference Controls



1 Heading Reference (HDG REF) Switch

Pushing alternately selects the heading reference for the PFDs, NDs, AFDS, and FMCs.

NORM –

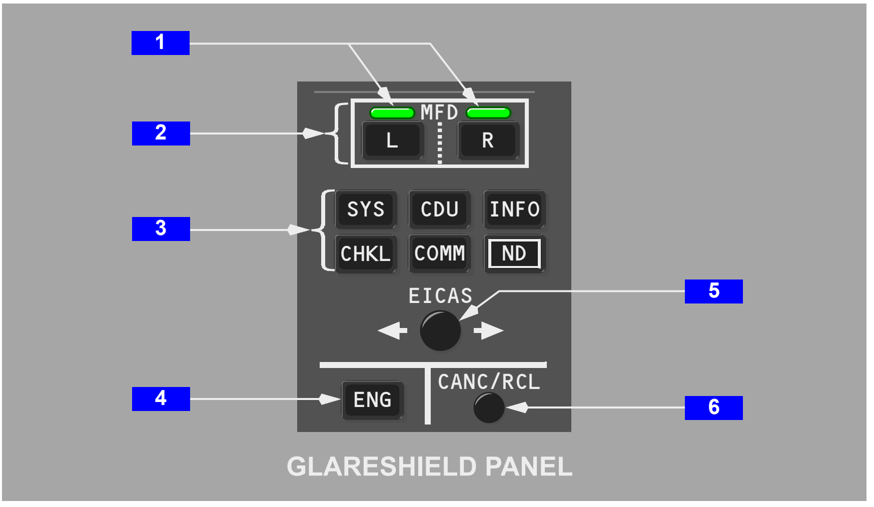
- normally references magnetic north
- automatically references true north when north of 82°N or south of 82°S latitude or within the vicinity of the magnetic poles (PFDs, NDs, and FMCs)
- provides no reference for AFDS roll modes other than LNAV when north of 82°N or south of 82°S latitude or in the vicinity of the magnetic poles

TRUE – references true north regardless of latitude.

When the AFDS roll mode is HDG SEL, switching the heading reference switch from NORM to TRUE or TRUE to NORM engages the HDG HOLD mode.

When the AFDS roll mode is TRK SEL, switching the heading reference switch from NORM to TRUE or TRUE to NORM engages the TRK HOLD mode.

Display Select Panel



1 Display Lights

Illuminates to show the MFD window the display select panel controls.

2 Multifunction Display (MFD) Switches

Selects the on-side MFD location (left or right window on each upper display unit) that is affected by pressing display switch(es).

3 Upper Display Switches

Pushing the switch displays the associated format. Pushing the same switch a second time causes the MFD format to be removed and the default format to be displayed.

SYS – system synoptics and maintenance information:

- status messages for dispatch determination (Ch. 15)
- electrical system indications (Ch. 6)
- hydraulic system indications (Ch. 13)
- fuel system indications (Ch. 12)
- air system indications (Ch. 2)
- door system indications (Ch. 1)
- landing gear and brake system indications (Ch. 14)
- flight controls system indications (Ch. 9)
- EFIS / DSP backup control functions (this chapter)
- maintenance functions
- circuit breaker functions

CHKL – checklist (this chapter).

CDU – display emulation of the FMC CDU (Ch. 11).

COMM – communications (Ch. 5).

INFO – airport map database cycles (this chapter).

ND – navigation display (this chapter).

4 ENG Display Switch

Pushing the switch displays the secondary engine information on EICAS. Pushing the switch a second time blanks secondary engine information.

5 EICAS Transfer Switch

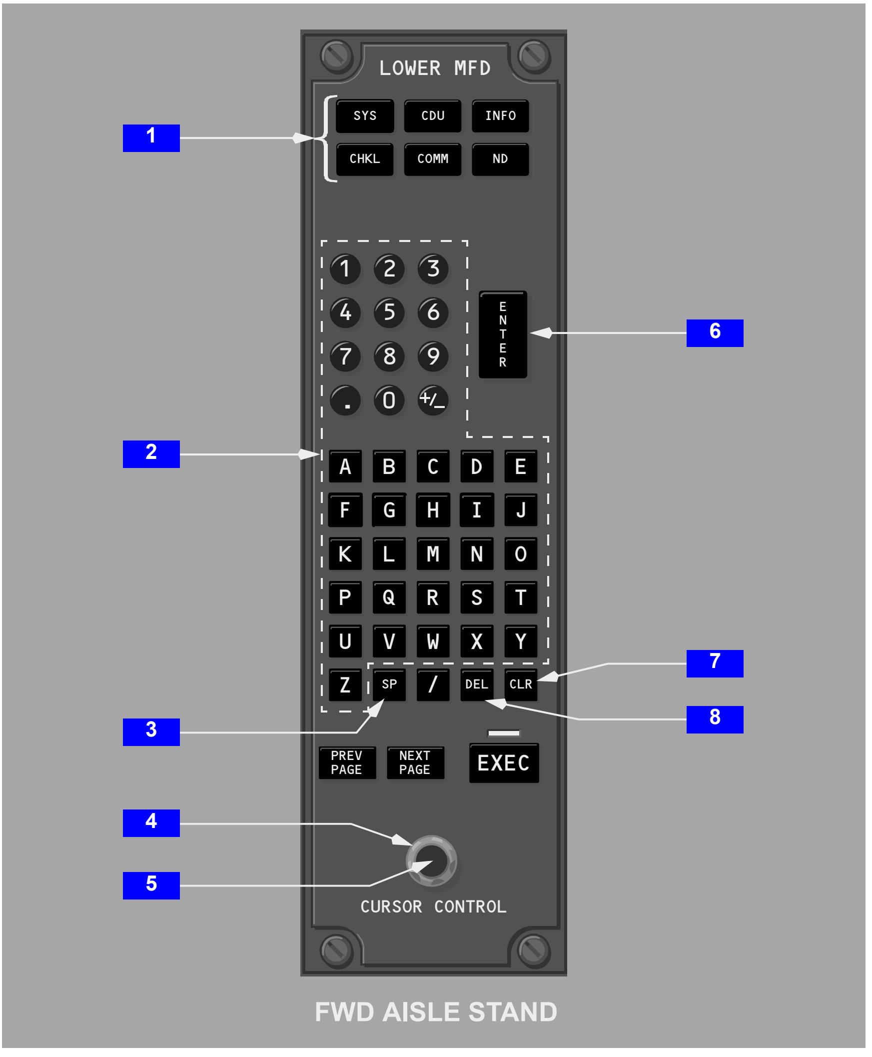
Transfers EICAS format between the Captain and First Officer inboard display units.

6 Cancel/Recall (CANC/RCL) Switch

Refer to Warning Systems, Chapter 15.

Multifunction Keypad (MFK)

The left MFK controls the left inboard DU and the lower center display unit cursor position and operation.



1 Lower Display Switches

Pushing the switch displays the associated format. Pushing the same switch a second time causes the MFD format to be removed and the default format to be displayed.

SYS – system synoptics and maintenance information:

- status messages for dispatch determination (Ch. 15)
- electrical system indications (Ch. 6)
- hydraulic system indications (Ch. 13)

- fuel system indications (Ch. 12)
- air system indications (Ch. 2)
- door system indications (Ch. 1)
- landing gear and brake system indications (Ch. 14)
- flight controls system indications (Ch. 9)
- EFIS / DSP backup control functions (this chapter)
- maintenance functions
- circuit breaker functions

CHKL – checklist (this chapter).

CDU – display emulation of the FMC CDU (Ch. 11).

COMM – communications (Ch. 5).

INFO – airport map database cycles (this chapter).

ND – navigation display (this chapter).

2 Alpha/Numeric Keys

Push –

- puts selected character in scratchpad
- Slash (/) key – enters "/" in scratchpad
- Plus Minus (+/-) key – first push enters "-" in scratchpad. Subsequent pushes alternate between "+" and "-"

3 Space (SP) Key

Push – enters space in scratchpad

4 Cursor Control Selector (outer)

Rotate – moves the highlight in a predetermined path to another selection on the active MFD.

5 Cursor Select Switch (inner)

Push – selects the highlighted key on the MFD.

6 ENTER Key

Push – performs an associated action to the highlighted field.

7 Clear (CLR) Key

Push – clears last character of data in the scratchpad.

Push and hold – clears all scratchpad data.

8 ENTER Key

Push – activates the area of the screen that the cursor is currently in, such as a menu item or command button. The area is highlighted by a magenta border to indicate it can be selected.

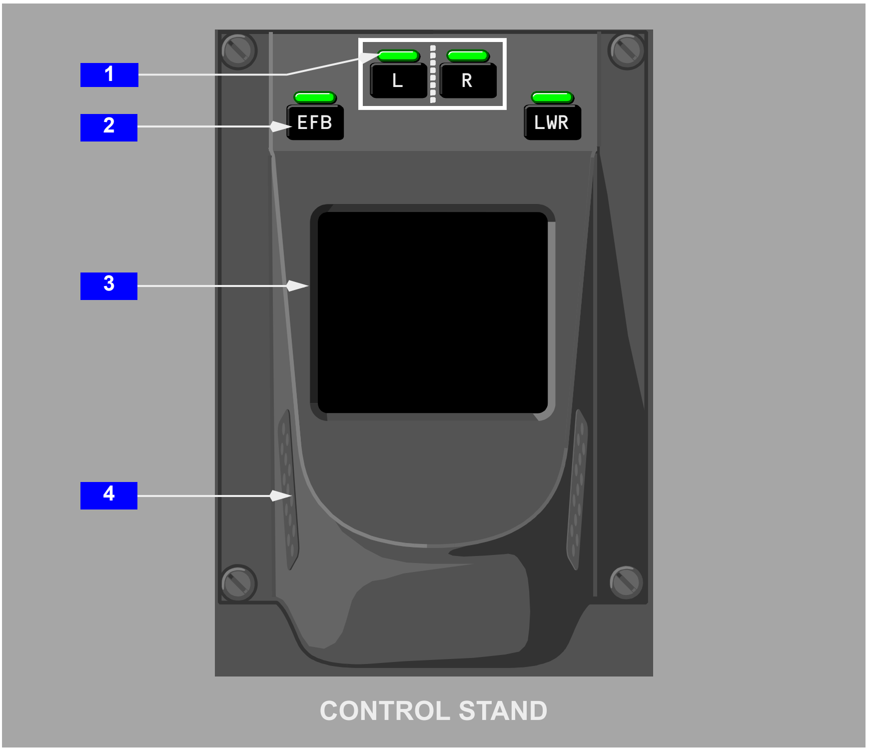
The switch is used to select menus, checklists, checklist steps, and other functions.

Cursor Control Device (CCD)

The left CCD controls the left inboard display unit and the lower display unit cursor position and operation.

The right CCD controls the right inboard display unit and the lower display unit cursor position and operation.

The left CCD is shown; the right CCD is similar, except the cursor select switch, the EFB switch, and the LWR switch are located on the opposite side of the CCD.



1 Cursor Location Lights

The associated annunciator light illuminates to indicate where the cursor appears.

2 Cursor Location Switches

Selects the display where the cursor appears (EFB, left MFD, right MFD, or lower MFD) and automatically deselects the previous display.

3 **Touch Pad**

Finger movement on the touch pad moves the cursor on the selected display. Lifting the finger off the pad and putting it back down in a different location (except the corner areas) does not move the cursor. The cursor only moves when the finger is moved on the touch pad surface.

Corner areas – placing a finger in one of the four corners puts the cursor in that respective corner of the screen. Moving the cursor into a corner region without lifting the finger from the pad does not have this effect.

4 **Cursor Select Switch**

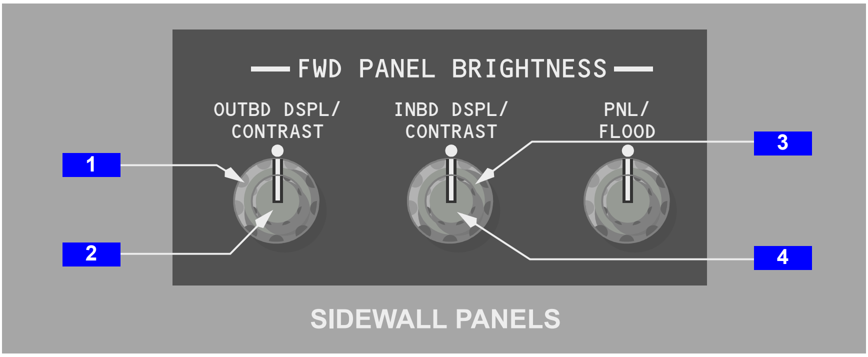
Push – activates the area of the screen that the cursor is currently in, such as a menu item or command button. The area is highlighted by a magenta border to indicate it can be selected.

The switch is used to select menus, checklists, checklist steps, and other functions.

Display Brightness Controls

Forward Panel Brightness Controls

The left panel is shown.



1 **Outboard Display (OUTBD DSPL) Brightness Control (outer)**

Rotate – adjusts the brightness of the outboard display unit.

2 **Outboard Display (OUTBD DSPL) Brightness Control (inner)**

Rotate – adjusts weather radar/terrain brightness on outboard display.

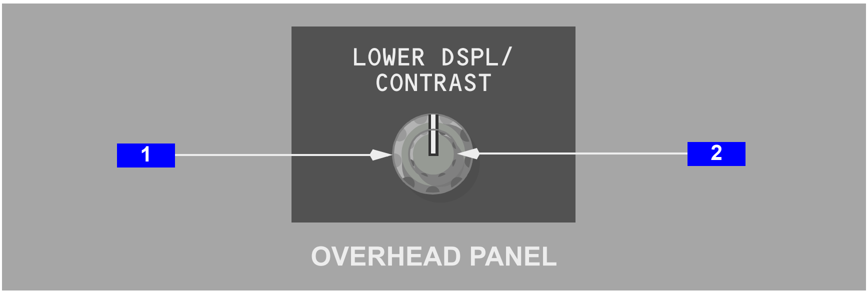
3 **Inboard Display (INBD DSPL) Brightness Control (outer)**

Rotate – adjusts the brightness of the inboard display unit.

4 **Inboard Display (INBD DSPL) Brightness Control (inner)**

Rotate – adjusts weather radar/terrain brightness on inboard unit.

Lower Display Brightness Controls



1 Lower Display (LWR DSPL/CONTRAST) Brightness Control (outer)

Rotate – adjusts the brightness of the lower center display unit.

2 Lower Display (LWR DSPL/CONTRAST) Brightness Control (inner)

Rotate – adjusts weather radar or terrain display brightness on the lower center display unit.

Weather radar and terrain data cannot be displayed at the same time.

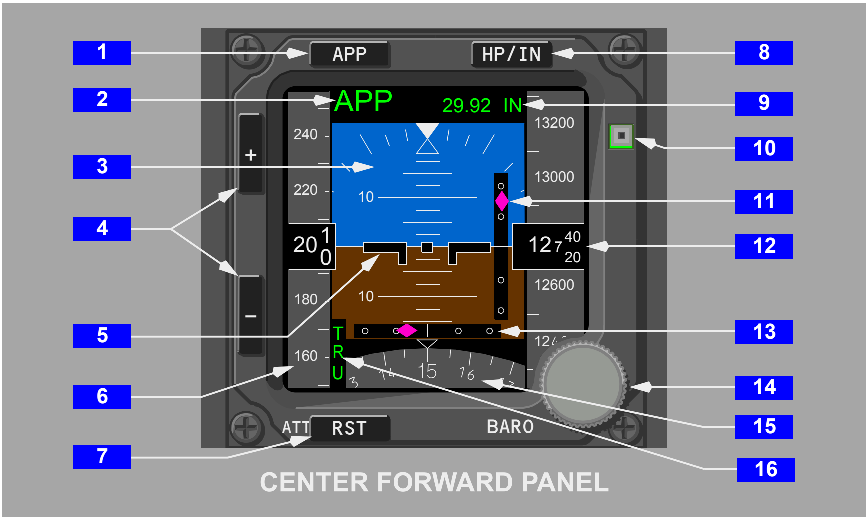
Standby Flight Instruments

The standby flight instruments include the:

- integrated standby flight display
- standby magnetic compass

Integrated Standby Flight Display (ISFD)

Provides an independent source of attitude, airspeed, and altitude information.



1 Approach (APP) Switch

Push –

- when blank, selects APP
- when APP displayed, selects B/CRS
- when B/CRS displayed, blanks

2 Approach Mode Annunciation

Indicates approach mode selected.

Blank – no approach deviation data displayed.

APP – ILS localizer and glideslope deviation data displayed.

BCRS (back course) – reverses sensing for localizer pointer during back course approaches.

3 Attitude Display

Displays airplane attitude.

Indicates bank in reference to the bank scale.

Indicates the horizon relative to the airplane symbol.

Beyond 30 degrees pitch, large red arrowheads (V-shaped) indicate the attitude has become excessive and the direction to the horizon line.

4 Display Brightness Switches

Push –

- \+ increases display brightness
- \- decreases display brightness

5 Airplane Symbol

Indicates airplane position with reference to the horizon.

6 Airspeed Indications

Indicates airspeed when above 30 knots.

7 Attitude Reset (ATT RST) Switch

Push and hold at least two seconds –

- aligns horizon with the airplane symbol
- reset takes approximately ten seconds
- starts new initialization sequence if previous attempt failed (ground only)

8 Hectopascal/Inch (HP/IN) Switch

Push – changes units of barometric reference.

9 Barometric Setting

Indicates the barometric setting selected with the barometric selector.

STD is displayed when selected with the barometric selector.

10 Ambient Light Sensor

Automatically adjusts display intensity for ambient lighting condition.

11 Glideslope Pointer and Scale

The glideslope pointer indicates glideslope position relative to the airplane –

- the pointer is in view when the glideslope signal is received
- the scale is in view when the APP mode is selected
- the pointer and scale are removed when the B/CRS mode is selected

12 Current Altitude

13 Localizer Pointer and Deviation Scale

The localizer pointer indicates localizer position relative to the airplane –

- the pointer is in view when the localizer signal is received
- the scale is in view when either the APP or B/CRS mode is selected

14 Barometric Selector (BARO)

Rotate – changes barometric setting.

Push –

- selects standard barometric setting (29.92 inches Hg/1013 HPA)
- if STD displayed, selects the preselected barometric setting

15 Heading Indication

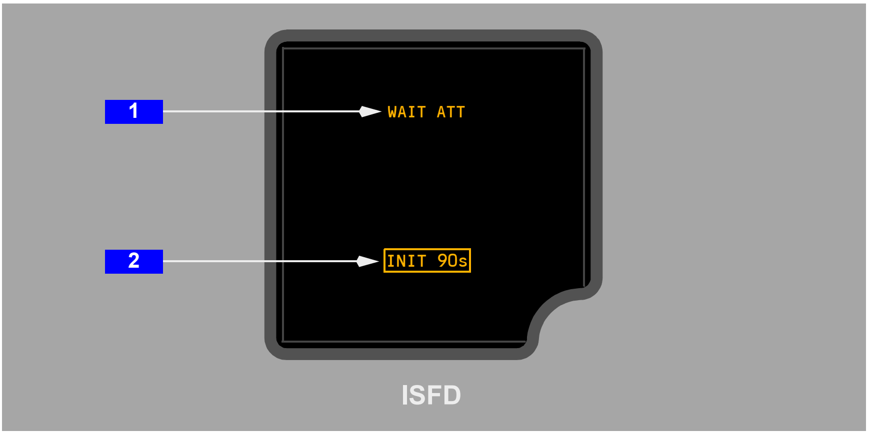
Displays airplane heading.

16 Heading Source

TRU – true heading

Blank – magnetic heading.

ISFD Messages



1 **Attitude Messages**

Indicates attitude display status.

ATT:RST (amber) – attitude must be reset using the attitude reset switch.

ATT 10s (amber) – 10 second attitude realignment in progress.

WAIT ATT (amber) – indicates temporary self correcting loss of attitude.

2 **Initialization message**

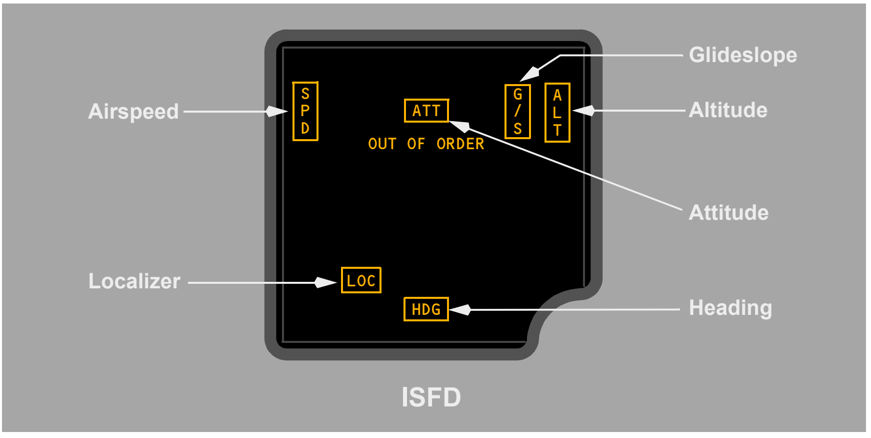
INIT 90s (amber) – countdown of 90 second initialization –

- countdown stops if excessive motion is detected
- countdown resumes when motion stops
- ATT:RST displays if initialization is not complete within six minutes

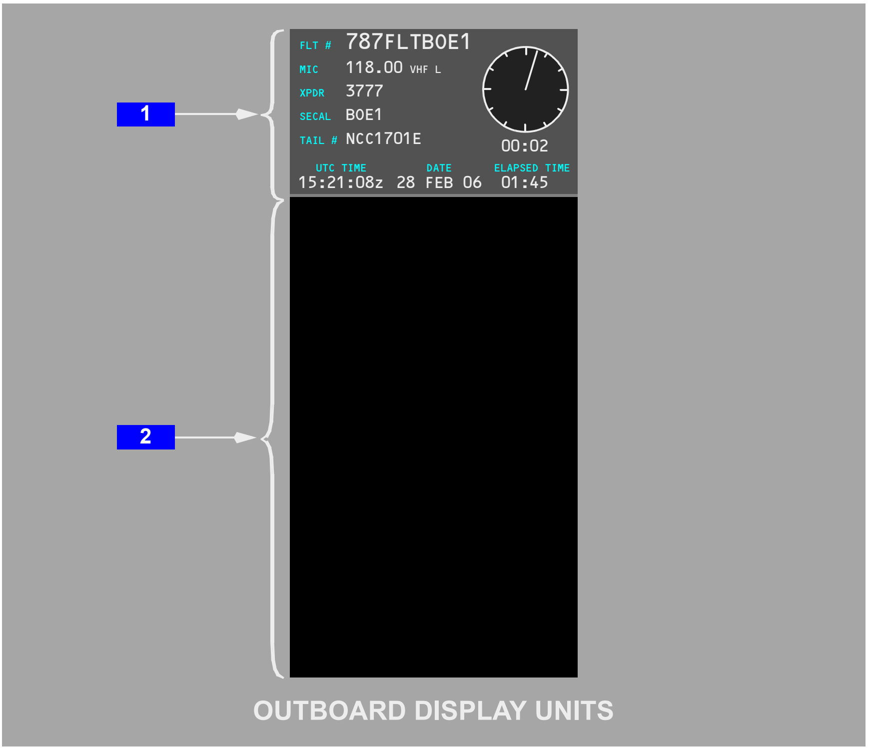
ISFD Failure Flags

Failure flag replaces appropriate display.

OUT OF ORDER indicates instrument system failure.



Auxiliary (AUX) Display



1 Flight Data Block

Refer to Communications, Chapter 5.

2 ATC Message Block

Refer to Communications, Chapter 5.

Standby Magnetic Compass

CENTER POST ABOVE GLARESHIELD

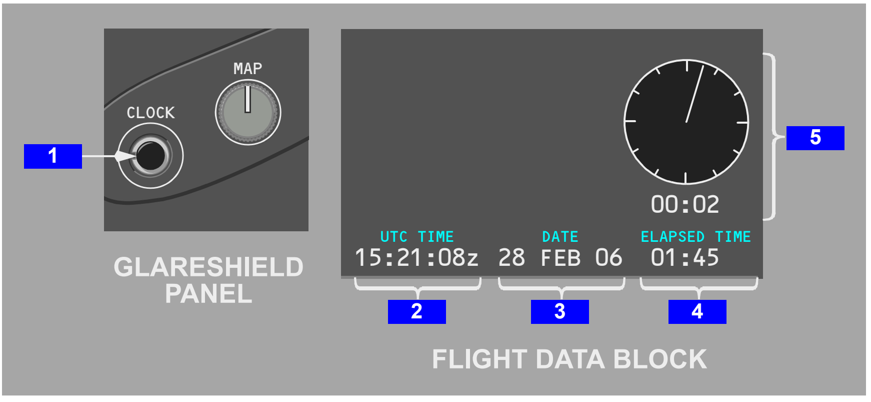
1 Standby Magnetic Compass

Displays magnetic heading.

2 Standby Magnetic Compass Correction Card

Provides appropriate heading corrections.

Clock



1 CLOCK Switch

Push – subsequent pushing starts, stops, removes the chronograph from display.

2 UTC Time

Displays current UTC time (hours, minutes, seconds) using GPS inputs.

3 Date

Indicates current date (day, month, year) using GPS inputs.

4 Elapsed Time

Displays elapsed flight time (hours, minutes, seconds).

Automatic start-stop logic:

- timer begins at weight off wheels
- timer ends at weight on wheels plus 30 seconds

5 Chronograph Function

Analog dial and sweep second hand – displays elapsed time (minutes, seconds).

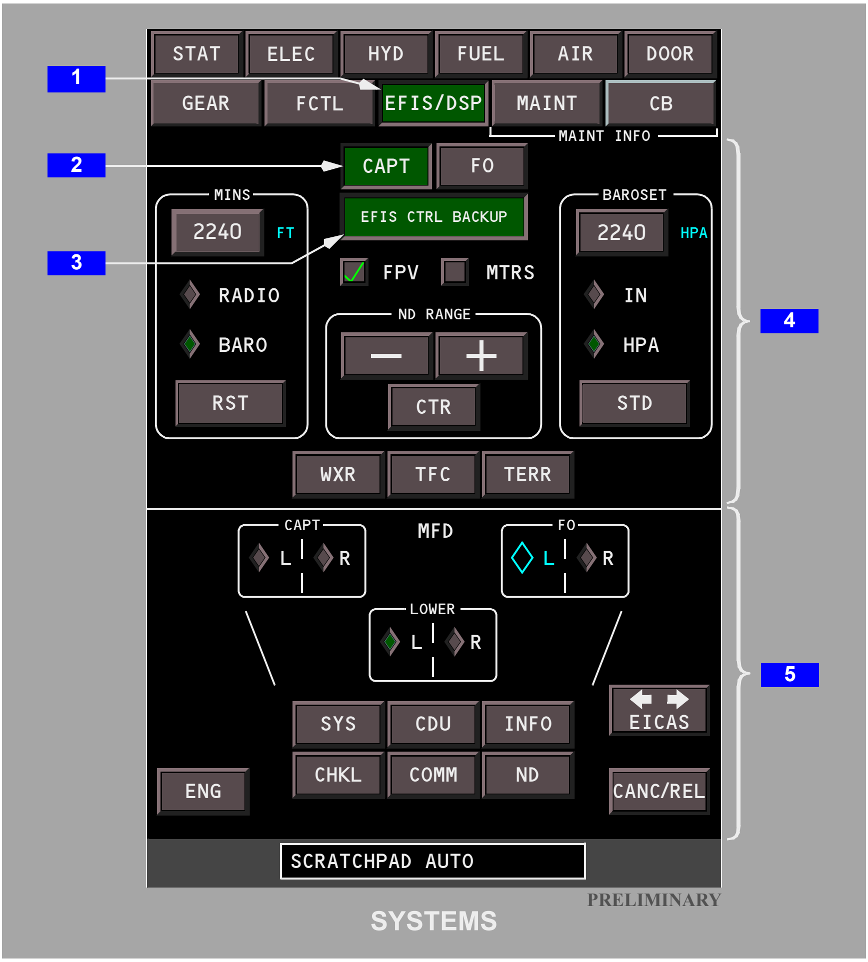
Digital readout – displays.

EFIS Control Panels and Display Select Panel (DSP) – Systems MFD Alternate Control

The backup EFIS/DSP provides an alternate way to control the functions of the EFIS control panel and/or the display select panel. This display is selected on the SYS page. The backup DSP controls are available full time while the EFIS controls must be enabled prior to activation.

Note: The control callouts on the following pages correspond to the control names on the EFIS control panels and the display select panel. Explanations of the CDU functions are the same as on the related control panels.

Systems MFD Control Selection



1 **Backup EFIS/DSP Select Key**

Displays backup EFIS/DSP control keys.

2 **CAPT/FO Keys**

Allows manual reconfiguration to control off-side EFIS/DSP control panels.

3 **EFIS Control Backup Key**

Push – enables EFIS backup controls.

4 **Backup EFIS Controls**

Need to be enabled before functional.

When enabled, initially configured to control on-side EFIS control panel.

When enabled, overrides functional EFIS control panel.

5 **Backup DSP Controls**

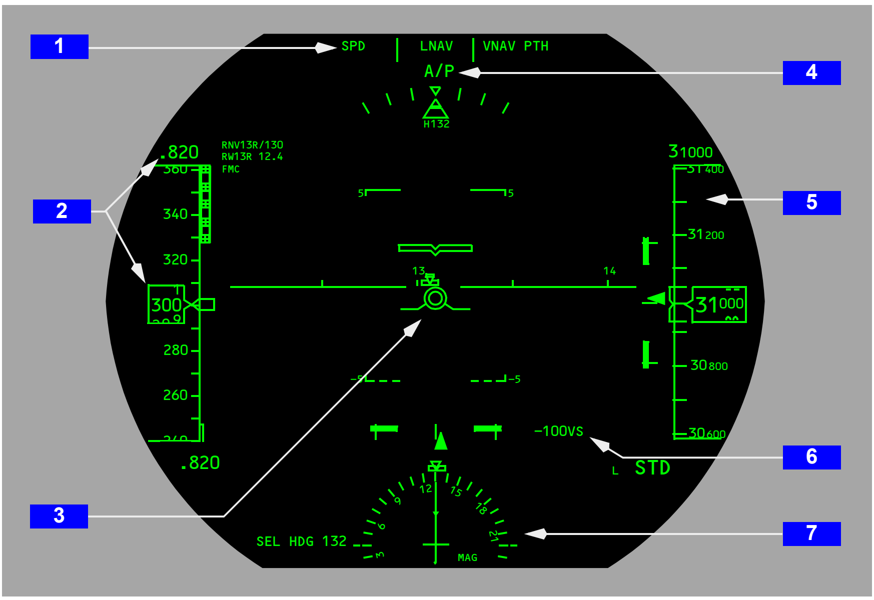
Do not need to be enabled for backup controls to be functional.

Does not override DSP if DSP is still functional.

Head-Up Display (HUD)

Most HUD symbology is the same as the PFD symbology. See Section 10 of this chapter for detailed descriptions. If differences do exist in symbology or function, the detailed description is included here in its entirety.

Full Symbology Mode



1 Flight Mode Annunciations

2 Airspeed/Mach Indications

3 Attitude, Steering, and Miscellaneous Indications

4 Autopilot, Flight Director System Status

5 Altitude Indications

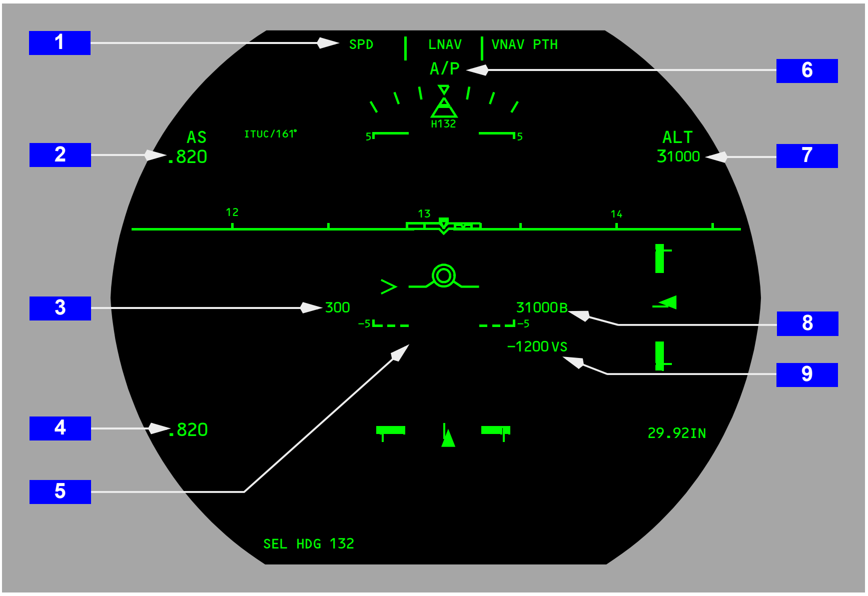
6 Vertical Speed Indication

Displays ADRS vertical speed.

7 Compass Rose

Displays current IRS heading, track, and other related information.

Decluttered Symbology Mode



1 **Flight Mode Annunciations**

2 **Selected Speed**

3 **Current Airspeed**

4 **Current Groundspeed/Mach**

5 **Attitude, Steering, and Miscellaneous Indications**

6 **Autopilot, Flight Director System Status**

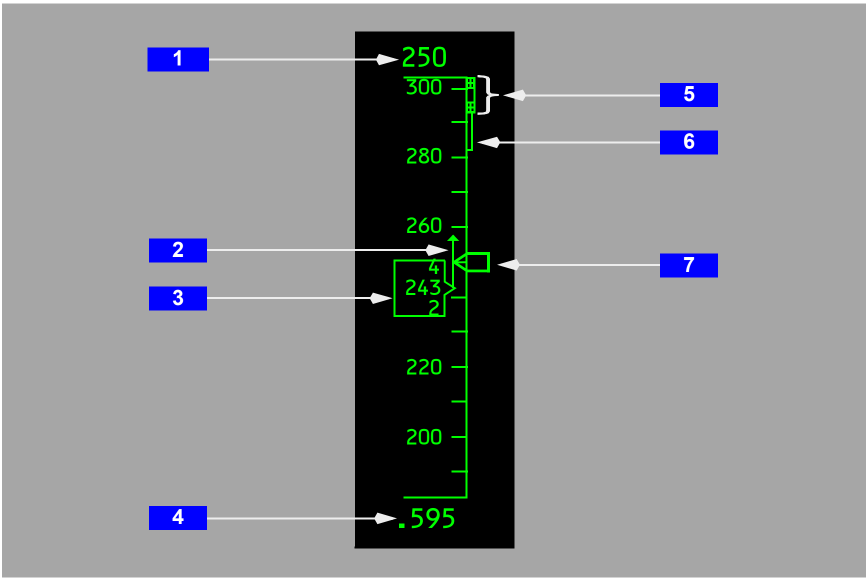
7 **Selected Altitude**

8 **Current Altitude**

9 **Vertical Speed Indication**

Displays current ADRS vertical speed.

HUD Airspeed Indications



1 Selected Speed

2 Speed Trend Vector

3 Current Airspeed

Indicates current ADRS airspeed.

The box around the current airspeed indication flashes when airspeed is below minimum maneuvering speed.

4 Current Groundspeed/Mach

Displays current groundspeed or Mach (if Mach is 0.40 or greater).

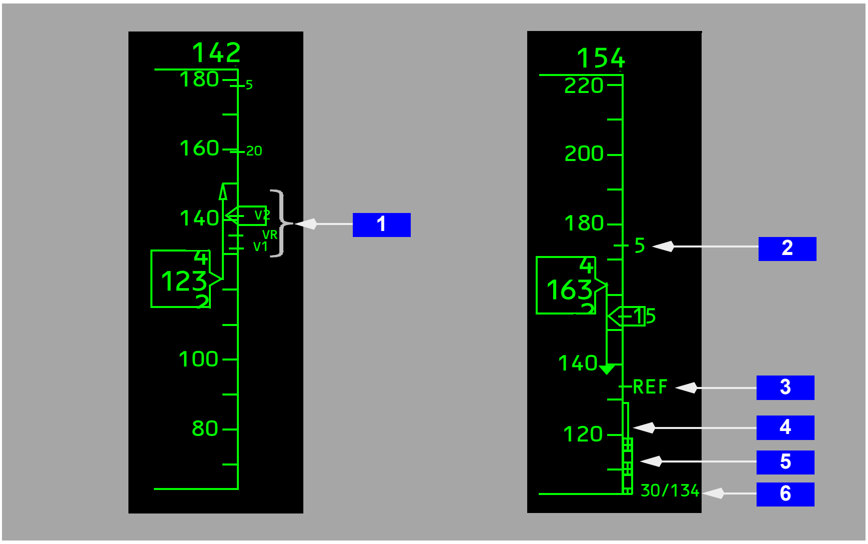
When a transition occurs between the display of groundspeed and Mach number, the new display is highlighted with a box for 10 seconds.

5 Maximum Speed

6 Maximum Maneuvering Speed

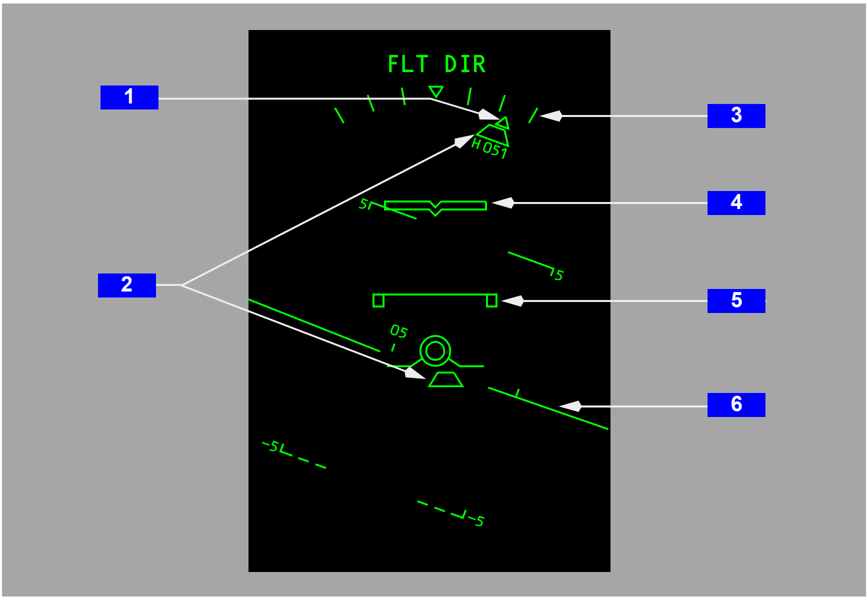
7 Speed Bug

HUD Reference Speeds



1	Takeoff Reference Speeds
2	Flap Maneuvering Speeds
3	Landing Reference Speed
4	Minimum Maneuvering Speed
5	Minimum Speed
6	Landing Flap and VREF Speed

HUD Attitude Indications



1 Bank Pointer

Indicates ADRS bank in reference to the bank scale.

Fills if bank angle is 35 degrees or more.

2 Slip/Skid Indications

Displaces to indicate slip or skid.

Fills at full scale deflection.

3 Bank Scale

Fixed reference for the bank pointer.

Scale marks are at 0, 10, 20, 30 degrees.

Enhanced scale marks at 45 and 60 degrees are added to the scale if the airplane bank is within 10 degrees of those bank angles.

4 Airplane Symbol

5 Angle of Attack Limit

Referenced to the flight path vector symbol. The distance between the AOA limit symbol and the flight path vector symbol represents the margin available to stick shaker.

Displayed during any of the following:

- angle-of-attack is within 5 degrees of stick shaker, or
- whenever stick shaker is active, or
- whenever windshear (solid) guidance cue is displayed

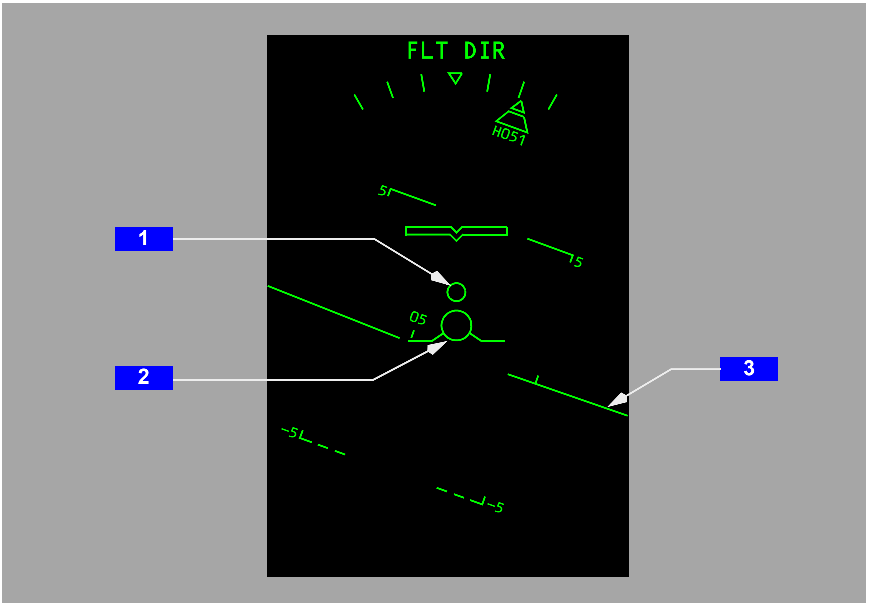
6 Horizon Line and Pitch Scale

Indicates the IRS horizon and degrees of pitch.

Pitch scale displays 5 degree increments.

HUD Steering Indications

Refer to Chapter 15, Warning Systems, for TCAS HUD Vertical Guidance and Alerts Displayed on the HUD.



1 Flight Director Guidance Cue

Indicates flight director pitch and roll steering commands.

Refer to Chapter 4, Automatic Flight, for more information on the flight director system.

2 Flight Path Vector Symbol

Displays during flight.

Displays current flight path angle and drift angle.

Flight path angle is depicted by the flight path vector symbol position on the pitch scale.

Drift angle is represented by the perpendicular distance from the centerline of the pitch scale to the center of the flight path vector symbol.

3 Horizon Line Heading Scale

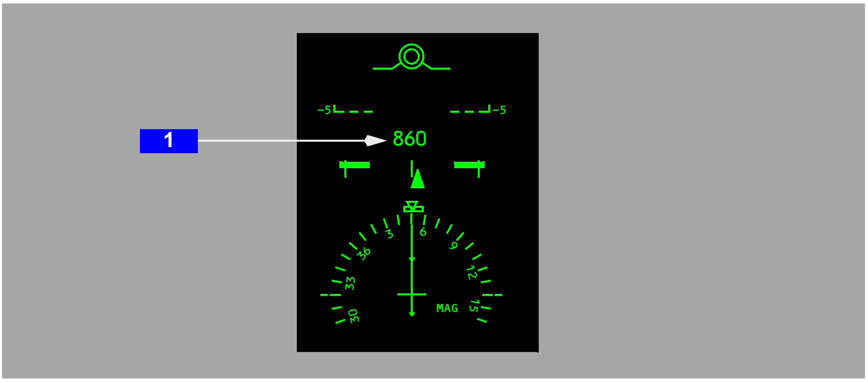
Displays heading, flight path angle, and drift angle.

Current heading is centered on horizon line.

Flight path angle is displayed relative to the horizon line.

Drift angle is represented by the perpendicular distance from the centerline of the pitch scale to the FPV symbol.

HUD Radio Altitude Indications

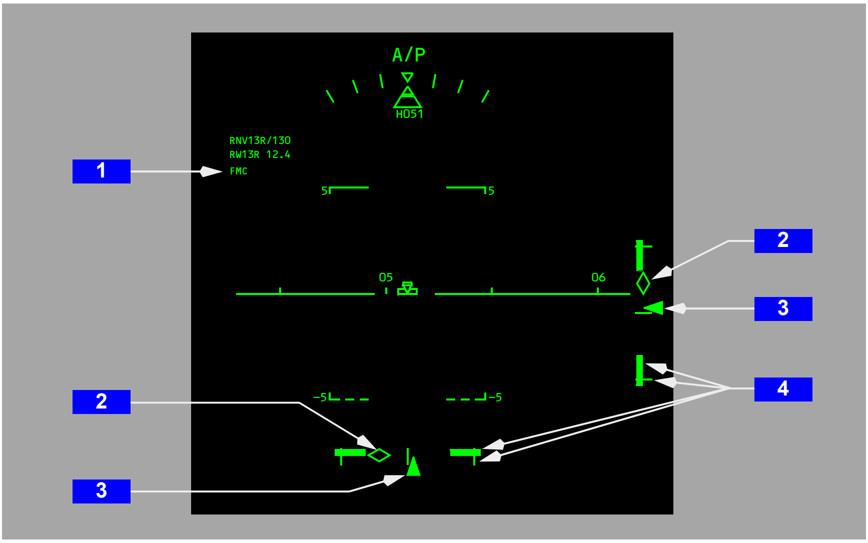


1 Radio Altitude

Displays radio altitude below 2500 feet AGL.

The displayed radio altitude flashes for 3 seconds, then steady when below radio altitude minimums.

HUD Navigation Performance Indications



1 Navigation Source Reference

2 Approach Deviation Pointers

Indicates the selected (armed or unarmed) approach path position relative to the airplane.

- unfilled (until capture) diamond for:
  - LOC deviation pointer
  - G/S deviation pointer
- unfilled (until capture) triangle for:
  - FAC deviation pointer
  - G/P deviation pointer
- if engaged roll mode then transitions to LOC, ILS localizer indications display
- if engaged roll mode then transitions to FAC, IAN final approach course indications display
- if engaged pitch mode then transitions to G/S, ILS glideslope indications display
- if engaged pitch mode then transitions to G/P, IAN glide path indications display

3 NPS Deviation Pointer

Pointer:

- indicates relative position from the annunciated navigation path
- filled triangle symbol denotes FMC directed guidance

- unfilled symbol when parked at deflection limit
- filled symbol when not parked at deflection limit
- flashes for ten seconds if pointer migrates into bar area for five seconds or ANP bars meet in the middle of the deviation scale
- is replaced by approach deviation pointers upon approach capture

4 Deviation Scale

Deviation:

- bars represent difference between RNP and ANP
- area between bars indicate margin available to remain within RNP criteria

If ANP equals RNP:

- solid bars meet in the middle and hollow (unfilled)
- RNP operations can no longer be maintained
- NAV UNABLE RNP EICAS message is displayed

If pointer migrates into bar area for five seconds:

- bars and indices flash for 3 seconds, then steady
- solid bars remain hollow (unfilled) as long as alert is active

HUD Instrument Landing System Indications

1 Approach Reference

Displays the selected ILS identifier or frequency, approach front course, and ILS DME distance, and source annunciation.

If the tuned ILS frequencies disagree, the frequency displayed has a horizontal line through it.

If the approach courses in the ILS receivers disagree, the course displayed has a horizontal line through it.

2 Localizer Pointer and Scale

The localizer pointer:

- indicates localizer position relative to the airplane
- is in view when the localizer signal is received
- fills in solid when within 2 1/2 dots from the center

The scale is in view after the frequency is tuned if LNAV is not in use. If LNAV is in use, the NPS indications remain in view until localizer capture.

At low radio altitudes with the autopilot or flight director engaged, the pointer flashes to indicate excessive localizer deviation.

At low altitudes, with LNAV engaged and LOC armed, the pointer flashes if the localizer is not captured.

3 Marker Beacon Indication

4 Glideslope Pointer and Scale

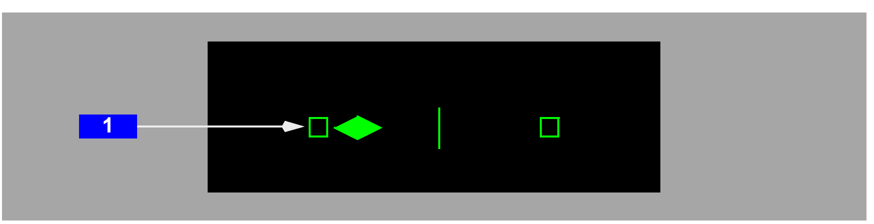
The glideslope pointer:

- indicates glideslope position relative to the airplane, and:
  - is in view when the glideslope signal is received
  - fills in solid when within 2 1/2 dots from the scale center

The scale is in view after the frequency is tuned.

At low radio altitudes, with the autopilot or flight director engaged, the pointer flashes to indicate excessive glideslope deviation.

HUD Expanded Localizer Indications



1 Expanded Localizer Scale

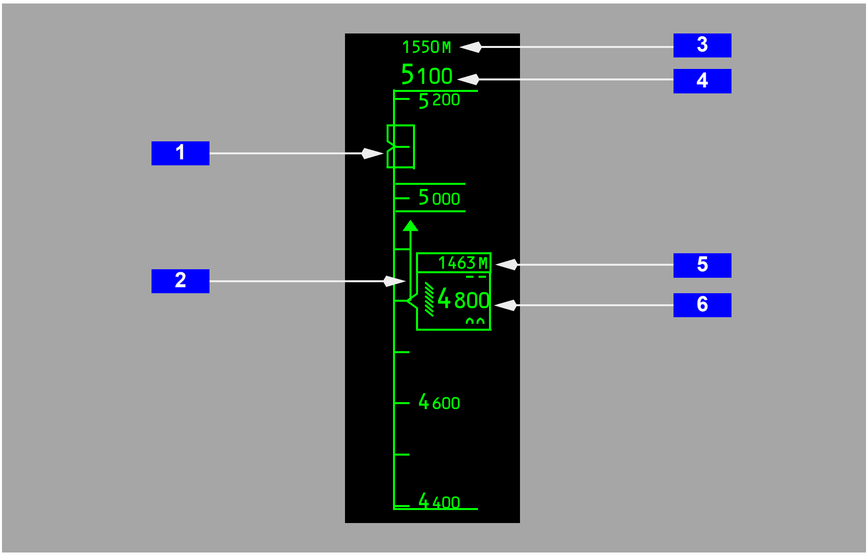
[Option – Autopilot or Flight Director ON]

Displays when the autopilot or flight director is in LOC mode and the airplane is close to the runway center line. Provides a more sensitive display.

[Option – HUD low visibility takeoff]
Expanded localizer indications also display during HUD low visibility takeoff operations.

A rectangle equals 1/2 dot deviation.

HUD Altitude Indications



1 **Selected Altitude Bug**

2 **Altitude Trend Vector**

3 **Selected Altitude – Meters**

4 **Selected Altitude**

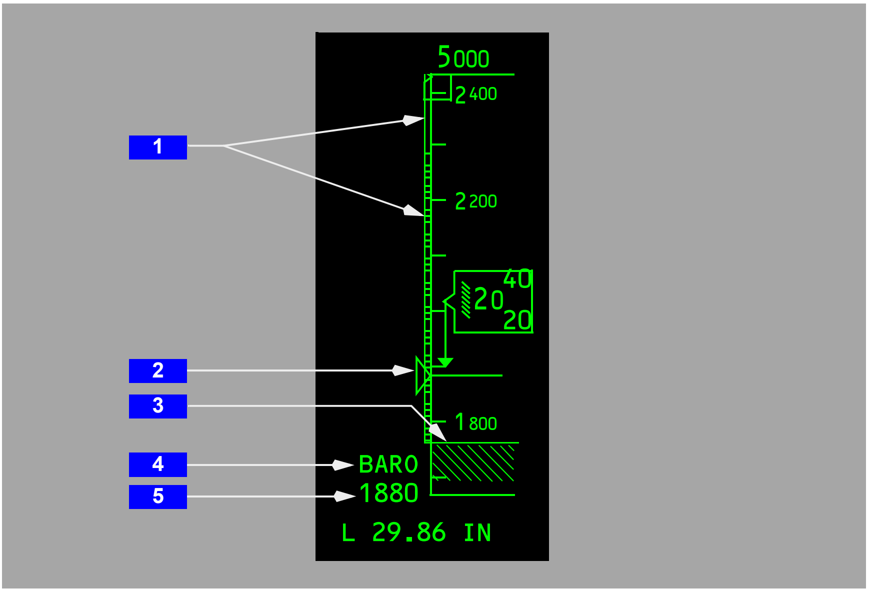
Displays the altitude set in the MCP altitude window.

The selected altitude is boxed between 900 feet and 200 feet prior to reaching the selected altitude.

5 **Current Altitude – Meters**

6 **Current Altitude**

HUD Landing Altitude/Minimums Indications



1 Landing Altitude Reference Bar

Indicates height above touchdown.

(filled bar) – 500 to 1000 feet above landing altitude.

(hollow bar) – 0 to 500 feet above landing altitude.

2 BARO Minimums Pointer

When BARO minimums are displayed, the number is also represented as a pointer and line on the altitude scale.

Flashes for 3 seconds, then steady when the airplane descends below baro minimums.

3 Landing Altitude Indication

4 Minimums Reference

Displays BARO when the EFIS control panel MINS reference selector is set to BARO.

Displays RADIO when the EFIS control panel MINS reference selector is set to RADIO (no corresponding pointer or line on the altitude scale).

Flashes for 3 seconds, then steady when the airplane descends below selected minimum altitude.

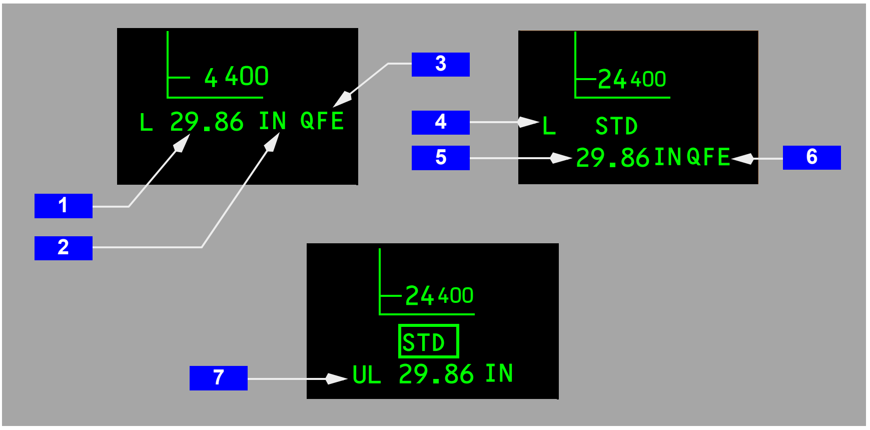
5 Minimums

Displays the approach minimums altitude set using the EFIS control panel MINS selector:

- BARO minimums are feet MSL
- RADIO minimums are radio altitude feet AGL

Flashes for 3 seconds, then steady when the airplane descends below selected minimum altitude.

HUD Barometric Indications



1 Barometric Setting

Indicates the barometric setting selected on the EFIS control panel barometric selector.

STD is displayed when STD is selected on the EFIS control panel barometric STD switch.

The display is boxed if a barometric setting is set and altitude climbs above the transition altitude, or if STD is set and altitude descends below the transition flight level.

2 Barometric Reference

3 QFE Altitude Reference

Indicates QFE altitude reference selected on the CDU APPROACH REF page.

When selected, QFE is boxed for 10 seconds.

When QNH is selected QNH is displayed for 10 seconds, then blanks.

4 Autopilot/Flight Director Barometric Source

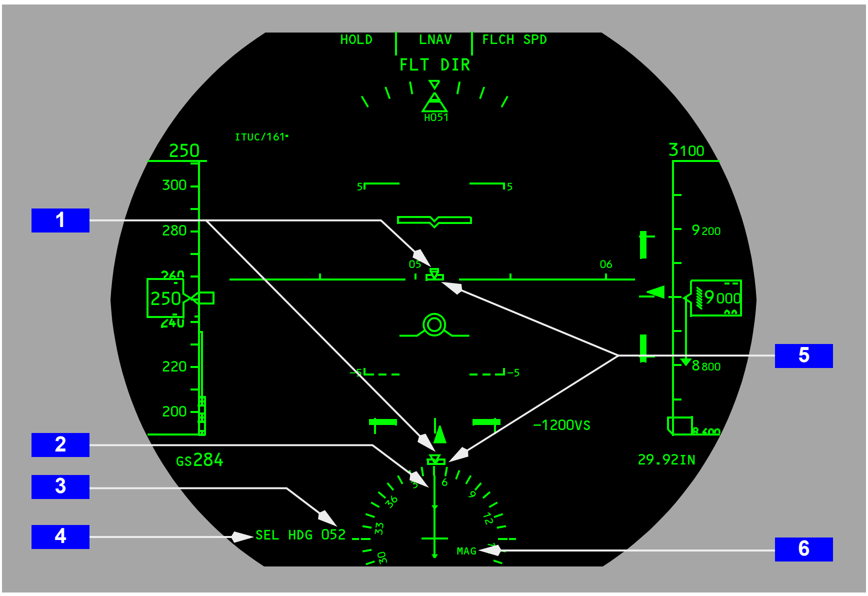
5 Preselected Barometric Setting

6 QFE

7 **Uplinked Barometric Setting**

HUD Heading/Track Indications

Note: The selected track bug and selected heading bug are not displayed at the same time.



1 **Current Heading Pointer**

2 **Track Line**

Indicates the current track and drift angle.

3 **Selected Heading/Track (MCP Selection)**

Digital display of the selected heading or track bug.

4 **Selected Heading/Track Reference (MCP Selection)**

When HDG (heading) is selected, SEL HDG is displayed.

When TRK (track) is selected, SEL TRK is displayed.

If selected heading/track exceeds display range, the bug parks on the side of the compass rose and horizon line heading scale, in the direction of the shorter turn to the heading. The symbol's outline is depicted with dashed lines, indicating that it can no longer display the selected heading/track.

5 **Selected Heading/Track Bug (MCP Selection)**

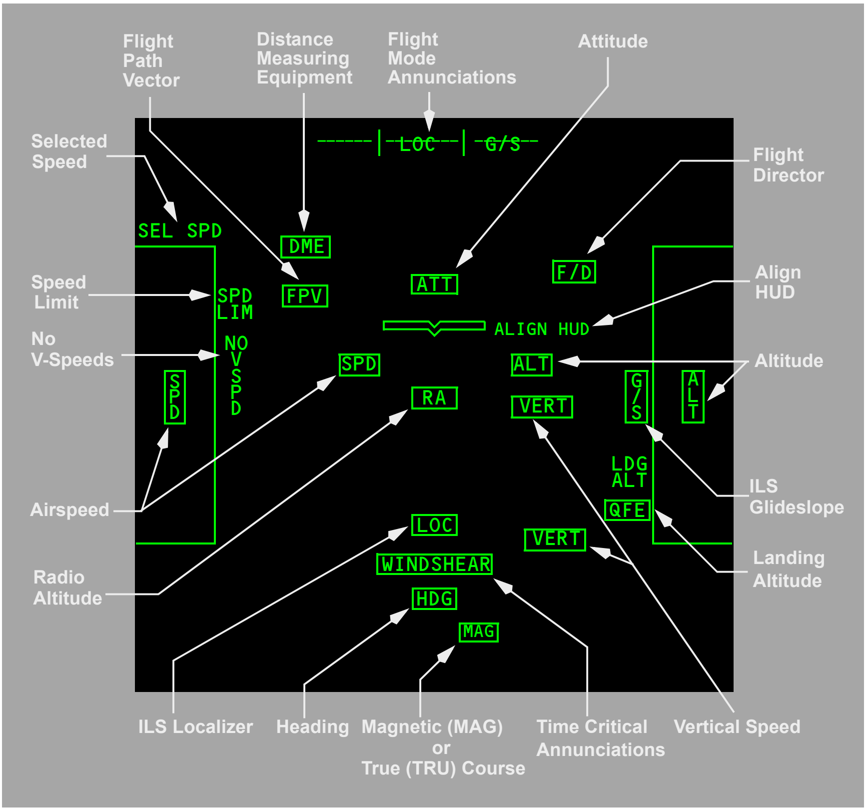
6 Heading/Track Reference

Displays the automatic or manually selected heading/track reference:

- MAG (magnetic north)
- TRU (true north)

HUD Failure Flags

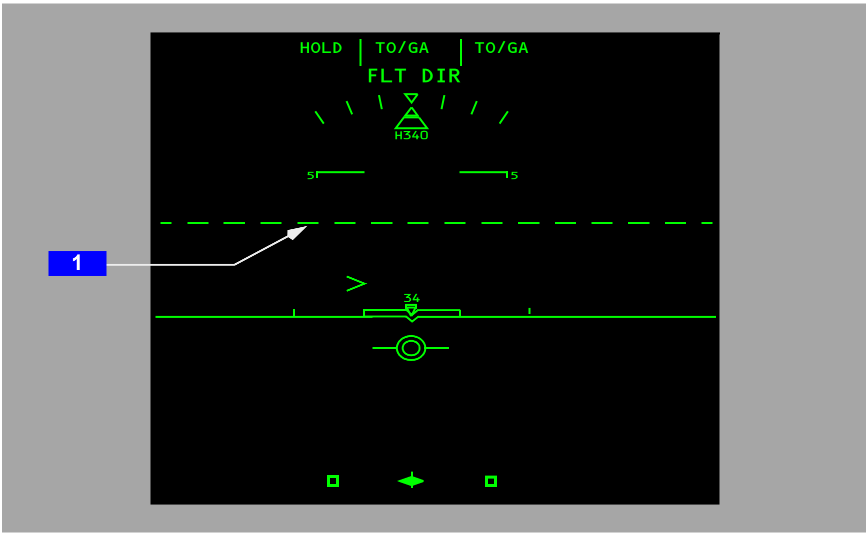
Note: HUD failure flags replace the appropriate display to indicate source system failure, or lack of computed information.



HUD-Unique Indications and Symbology

The HUD does have some unique indications not found on the PFD. Those indications are described in detail here.

TO/GA Reference Line



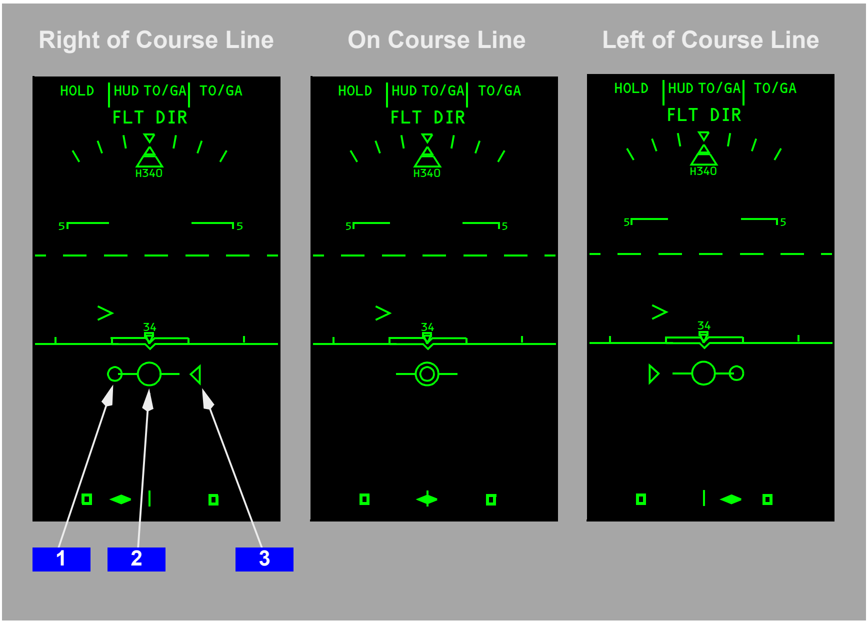
1 TO/GA Reference Line

Displayed during takeoff roll if:

- flight director TO/GA mode is active, and
- groundspeed is greater than 65 knots, or pitch command is greater than 10 degrees

Ground Deviation Indications - Low Visibility Takeoff

[Option – HUD low visibility takeoff]



1 (Airplane) Ground Reference Cue

Displays airplane position relative to the flight director guidance cue directed (ILS/GLS) course line. Objective is to keep guidance cue circle inside of ground reference cue circle.

For additional information refer to Chapter 4 – Automatic Flight, and Chapter 11 – Flight Management, Navigation.

2 Flight Director Guidance Cue

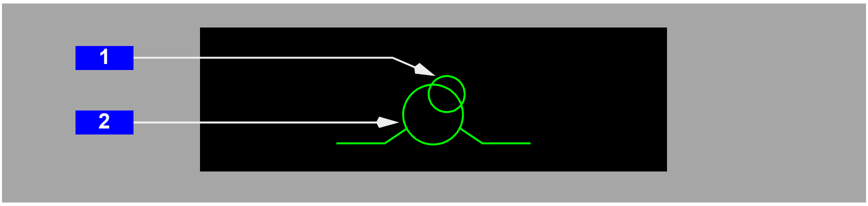
Displays (ILS/GLS) flight director guidance cue directed course line position relative to the airplane position. Objective is to keep guidance cue circle inside of ground reference circle.

For additional information refer to Chapter 4 – Automatic Flight, and Chapter 11 – Flight Management, Navigation.

3 Ground Excessive Deviation Symbol

Indicates excessive localizer deviation during takeoff roll. Flashing triangle points in direction of runway centerline.

Flight Path Vector Symbol with Guidance Cue



1 (Flight Director) Guidance Cue

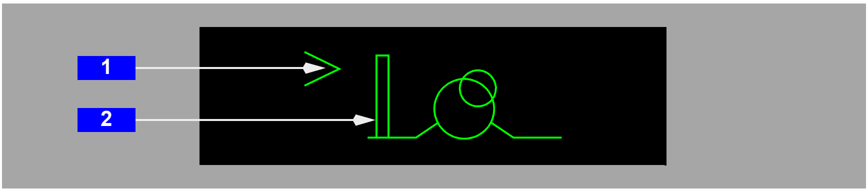
A flight director guidance cue commanding a particular input from pilot. Displayed only when flight directors are turned on. Fills (solid) during windshear alerting.

Windshear alerting is described in Chapter 15, Warning Systems.

2 Flight Path Vector Symbol

Displays actual flight path vector of the airplane as derived from IRS.

Speed Error Tape and Flight Path Acceleration



1 Flight Path Acceleration symbol

Indicates the inertial acceleration (or deceleration) of the airplane along the flight path.

Removed from the display when a low-level, decreasing performance windshear is detected below 400 feet AGL.

When symbol is above the wing of the flight path vector symbol, the airplane is accelerating. When it is below the flight path vector symbol wing, the airplane is decelerating.

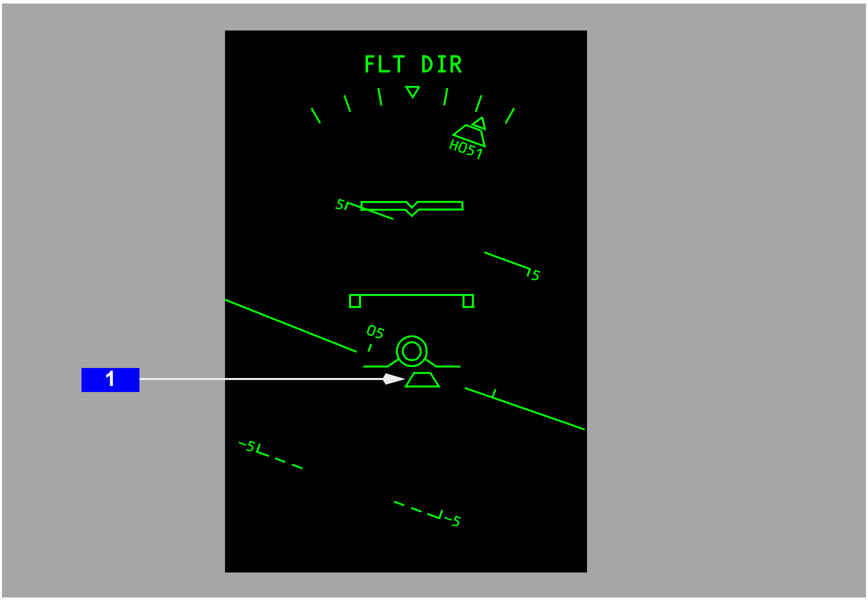
2 Speed Error Tape

Displays difference between the indicated airspeed and the selected airspeed on the Mode Control Panel.

Symbol not displayed until first flap retraction.

If the indicated airspeed is faster than the selected speed, the Speed Error Tape rises above the wing. Likewise, if the airspeed is slower than the selected speed, the Speed Error Tape falls below the wing.

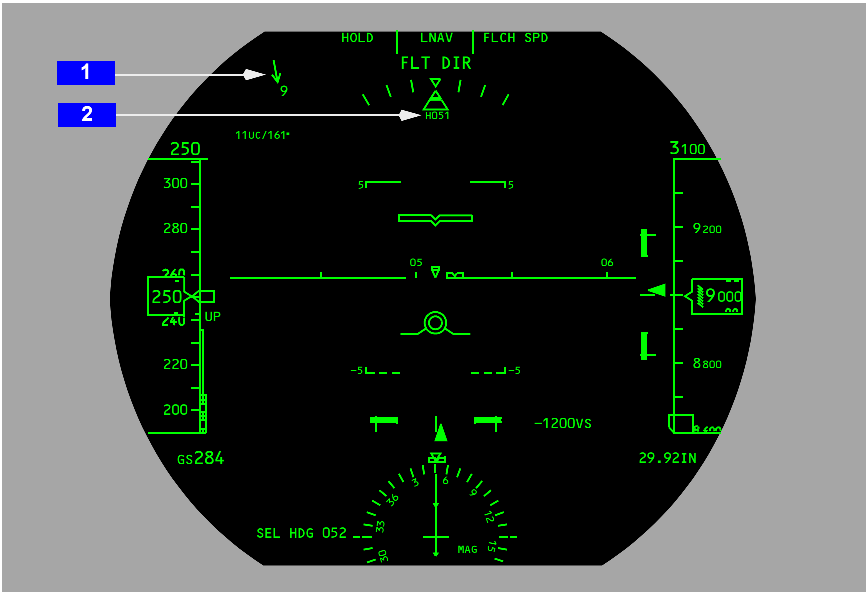
Slip/Skid Indication



1 Slip/Skid Indicator – Flight Path

Referenced to the flight path vector symbol. Only displayed during takeoff or low altitude go-around to provide yaw reference in the event of engine failure.

Wind Speed, Wind Direction, and Digital Heading



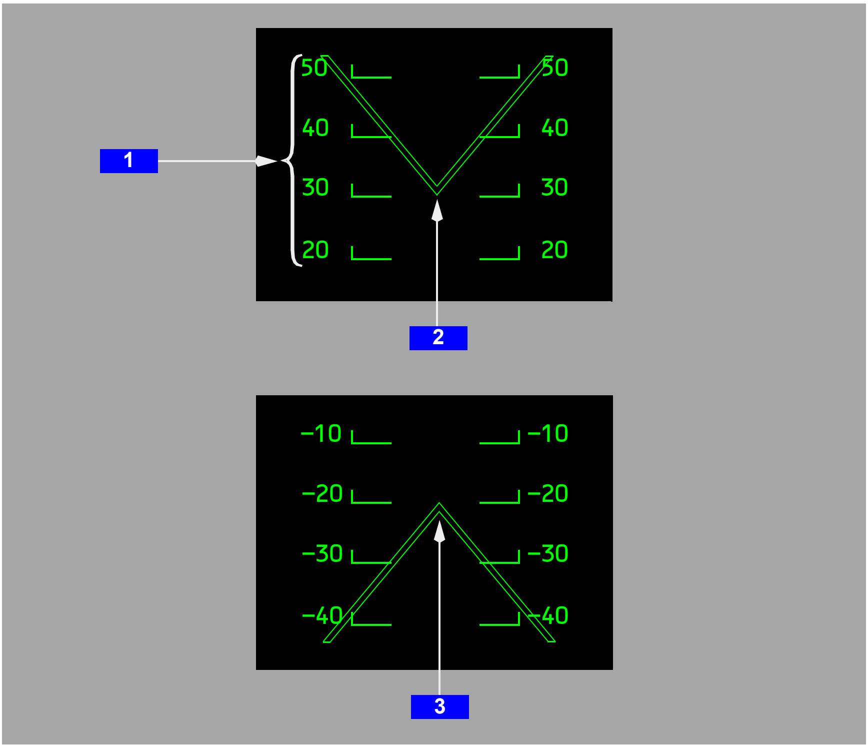
1 **Wind Speed and Direction**

Indicates wind speed and direction with respect to display orientation. Displays when wind speed exceeds 6 knots, and airspeed exceeds 100 knots.

2 **Digital Heading**

Digital heading displays current heading and corresponds to the heading on the horizon reference line.

Pitch Scale Chevrons and Pitch Scale Compression



1 Pitch Scale Compression

Pitch scale will compress if the horizon reference line or the flight path vector symbol cannot be shown in the display because of excessive pitch angle.

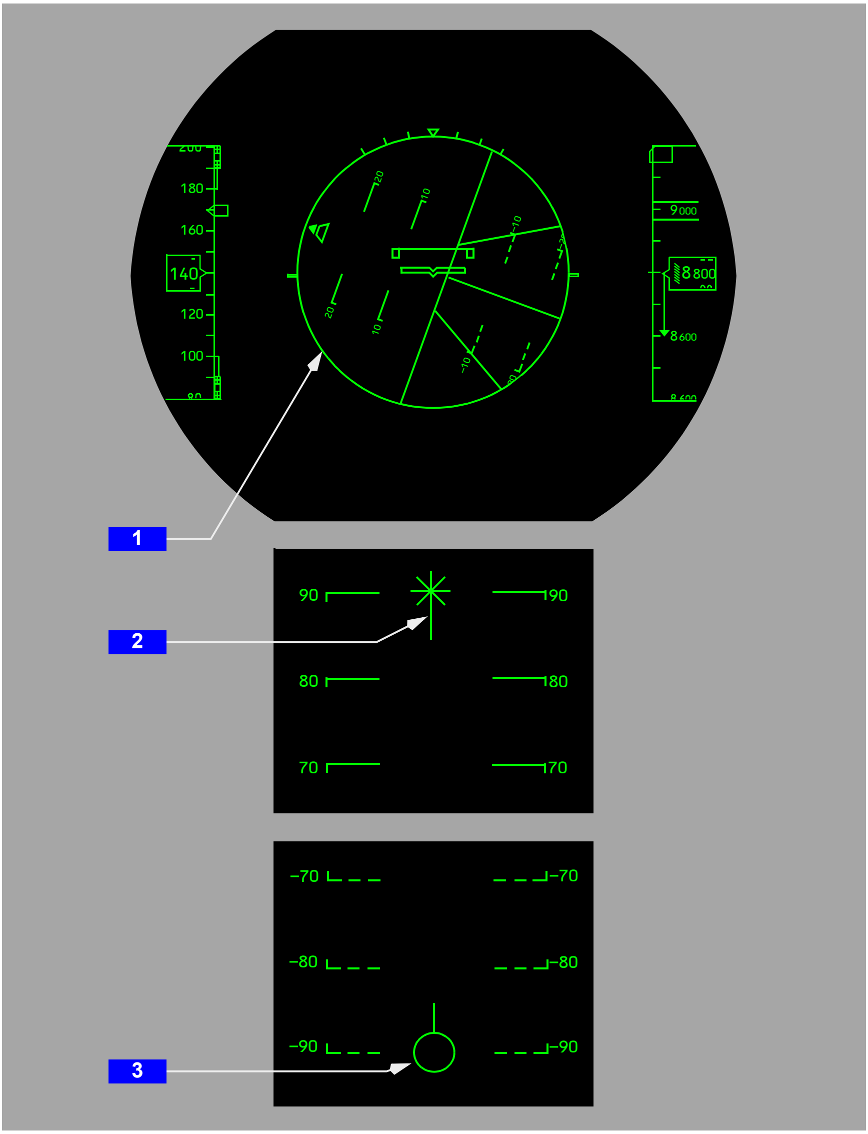
2 Pitch Scale Chevron (Upper)

Overlays compressed pitch scale with tip at +30 degrees, directing pilot to apply pitch down.

3 Pitch Scale Chevron (Lower)

Overlays compressed pitch scale with tip at -20 degrees, directing pilot to apply pitch up.

Unusual Attitude



1 Unusual Attitude symbology

The Unusual Attitude (UA) symbology is displayed when:

- pitch is less than -20 degrees, or
- pitch is greater than + 35 degrees, or
- roll exceeds 55 degrees in either direction

The Unusual Attitude (UA) symbology will remain displayed until:

- pitch angle is between -5 degrees and 10 degrees (relative to horizon) for 5 seconds, and
- roll angle is less than 10 degrees for 5 seconds

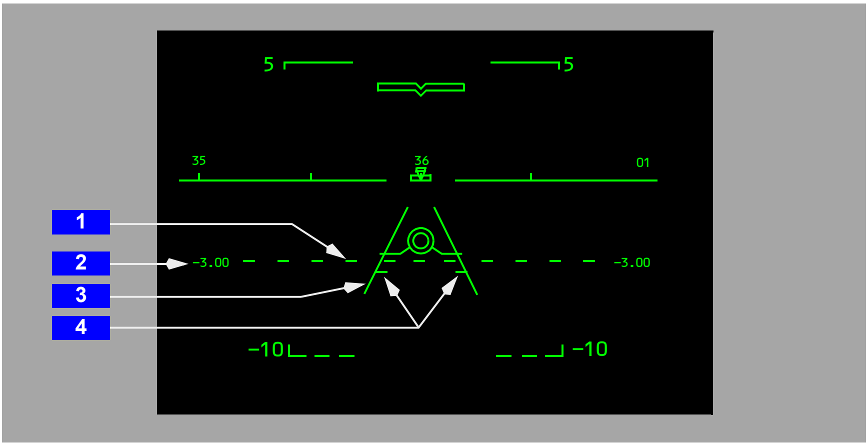
2 **Zenith Symbol**

Displayed in center of HUD pitch scale at +90 degree pitch line.

3 **Nadir Symbol**

Displayed in center of HUD pitch scale at -90 degree pitch line.

Runway Edge Lines and Glideslope Reference Line



1 **Glideslope Reference Line**

Display of the glideslope value associated with the active approach.

2 **Digital Glideslope Value**

Digital glideslope value representing the active approach glideslope angle.

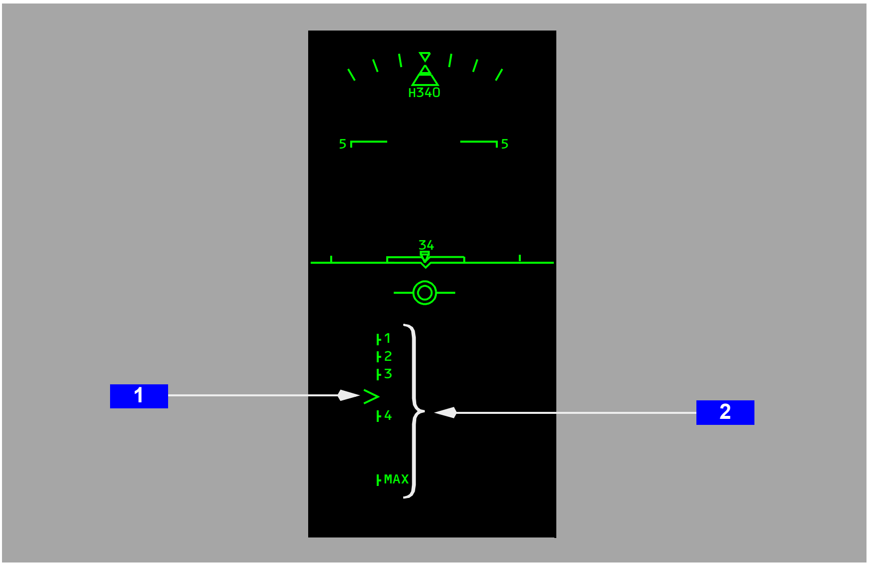
3 **Runway Symbol**

Calculated position of runway edgelines.

4 **Touchdown aiming point**

Tick marks on runway edge lines correspond to the touchdown aiming point.

Ground Deceleration Scale



1 Flight Path Acceleration symbol

Vertical position of symbol along ground deceleration scale indicates the actual inertial deceleration rate of the airplane.

2 Ground Deceleration Scale

Vertical indexed scale and pointer indicate the actual deceleration rate being achieved, as provided by the corresponding autobrake setting (1, 2, 3, 4, MAX AUTO).

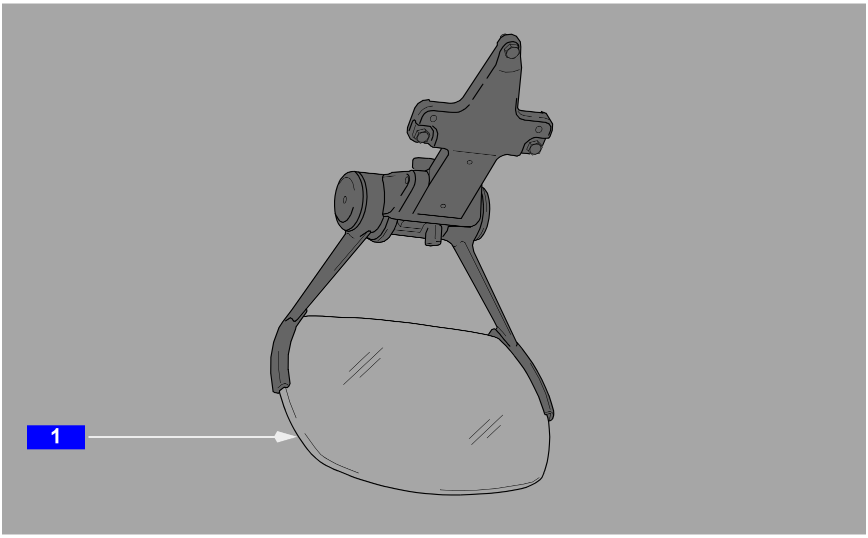
Displayed on landing. Also displayed on takeoff if a deceleration is sensed with the groundspeed above 50 knots, and airplane is still on ground.

Once displayed, it is removed when:

- groundspeed decreases below 25 knots, or
- airplane begins accelerating, or
- airplane lifts off

HUD Controls

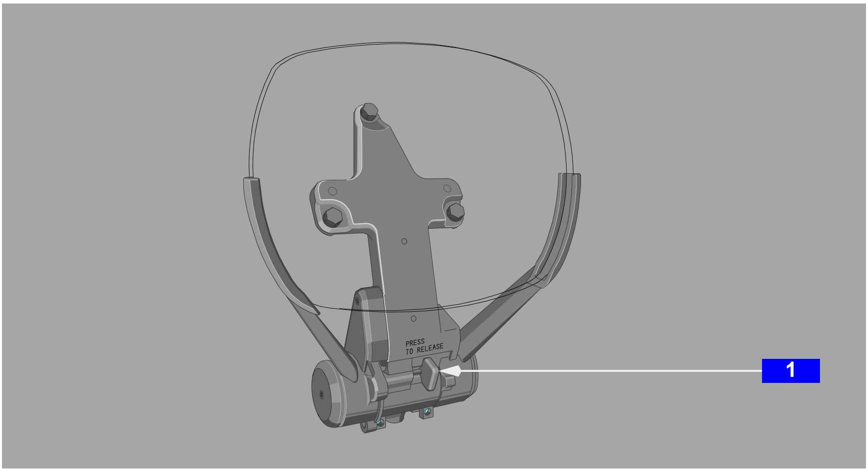
Combiner



1 Combiner

Combines the overhead unit projected flight symbology with the pilot’s view through forward window.

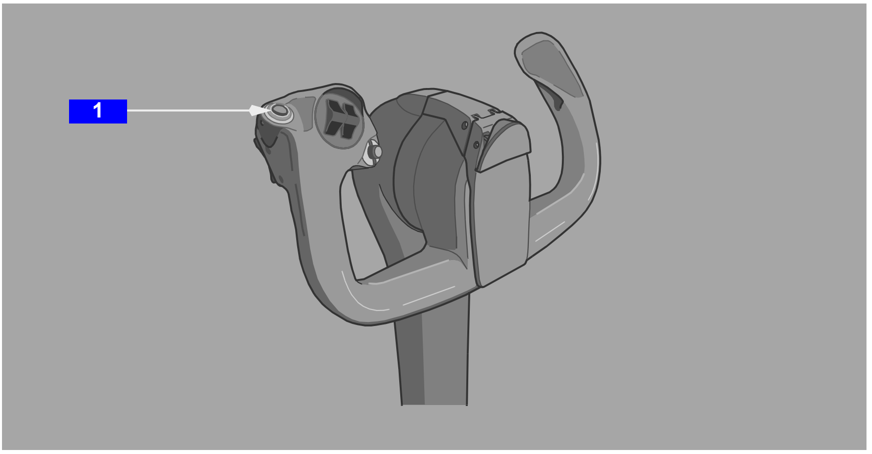
Combiner Locking Lever



1 Combiner Locking Lever (stowed position shown)

Folding combiner upward towards the overhead panel engages locking mechanism. Push lock release to right to release combiner assembly for deployment.

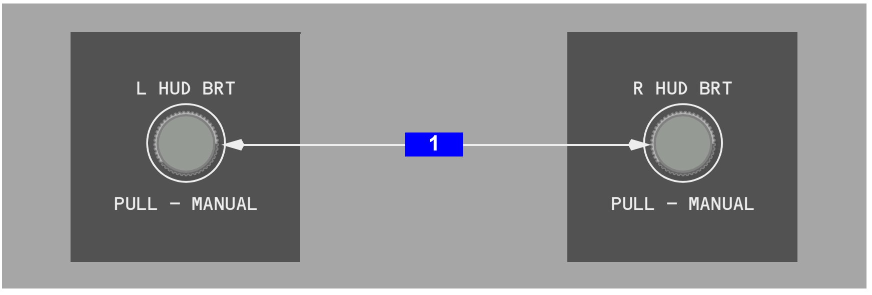
Symbology Control Switch



1 HUD Symbology Control Switch

PUSH – Alternates between full-symbology and decluttered symbology modes.

HUD Brightness



1 HUD Brightness (BRT) Control

Pull – Sets the HUD brightness control to manual mode.

Push – Sets the HUD brightness control to automatic mode.

Rotate – adjusts HUD light brightness.

Flight Instruments, Displays — Chapter 10
System Description — Section 20

Introduction

The flight instruments and displays supply information to the flight crew on five flat panel liquid crystal display units. The units display five primary groups of information:

- the primary flight display (PFD) with mini-map
- the navigation display (ND)
- the engine indication and crew alerting system (EICAS)
- the auxiliary display (AUX)
- the multifunction display (MFD)

Detailed information on the following subjects is found in other sections of this chapter:

- HUD – Sections 12, 22
- PFD – Section 30
- ND – Section 40
- Electronic Checklist – Sections 50 and 60

Display Selection and Control

During normal operations:

- the PFD/MFD selectors are set to NORM
- PFDs are displayed on the two outboard display units
- a normal-display ND is shown on the left MFD of the Captain inboard display unit
- a full-display ND is shown on the First Officer inboard display unit
- EICAS is displayed on the right MFD window of the Captain inboard display unit
- the CDU is displayed on each MFD window of the lower display unit

Multifunction Display Management

There are a total of five MFDs available at any one time on the flight deck. However, five displays of the same MFD cannot be shown at the same time. If a display is currently shown, additional instances are managed in one of three ways:

- Synchronized – a copy of an instance that is already displayed. Any change on one instance affects all other instances of that display.
- Independent – not linked to any other instance on the flight deck. Can be changed without affecting or being affected by other instances of that display.
- Blank – when the selected display exceeds the maximum number of instances allowed, an existing instance of that display becomes blank with a message “Select MFD.” Additional pilot selection is required to replace the blank display with another display, unless the default display for that location is not already shown.

The maximum number of instances each display format may be shown are:

- SYS (2 per side, independent)
- CDU (1 per side, independent)
- INFO (2 per side, independent)
- CHKL (1 per side, synchronized)
- COMM (1 per side, independent)
- ND (1 per side, independent)

EFIS Control Panels

The EFIS control panels control display options, mode, and range for the respective PFDs and NDs. Refer to the PFD and ND sections of this chapter.

If an EFIS control panel fails, the displays can be controlled through the backup EFIS/DSP display on the SYS page. The backup EFIS capability is available at all times, but inhibits inputs from the respective EFIS control panel.

The EFIS Control Panel controls any on-side ND display. Both pilots have access to the lower DU. However, whichever pilot chooses first to display the ND on the lower DU owns the ND when the other pilot chooses to display an ND on the other half of the lower DU. This results in a full-display ND on the lower DU which the first pilot controls.

Display Select Panel

The display select panels (one for each pilot) on the glareshield provide control of the MFDs for the on-side inboard DU. Each DU has a left and right window. The currently selected MFD window (left or right) is indicated by the illuminated annunciator light above the corresponding display switch (L or R).

After a display unit is selected, the appropriate display is selected (SYS, CDU, INFO, CHKL, COMM, or ND). The ENG switch toggles the display of secondary engine formation on the EICAS display. The EICAS transfer switch toggles the EICAS display between the inboard half of the Captain and First Officer inboard DUs.

Each pilot also has a display select panel next to the lower display unit. These DSPs provide each pilot control of their half of the lower DU. This allows the selection of the same MFDs as on the upper DUs. However, these DSPs do not include the ENG, CANC/RCL, or EICAS transfer switches.

Display select panel control is also available through the backup EFIS/DSP display on the SYS page. This capability is available at all times. The DSP hardware controls remain active when the EFIS backup is enabled if the DSP is still functional. Any available MFD window may be selected.

Display Brightness Control

The MASTER BRIGHTNESS control provides simultaneous brightness adjustment for all displays and panel lighting. Also, each display unit has an individual control with limited range control when master brightness is on, and full range control when master brightness is off.

Two remote light sensors, located left and right on the top of the glareshield, measure brightness in the forward field of view and adjust the overall display brightness as required. Individual sensors on the front of each display unit also affect display brightness. The CDUs, mode control panel displays, standby flight instruments, and aisle stand panel displays are also controlled by the automatic display brightness control system.

PFD/MFD Source Selector

The PFD/MFD selector is used to switch displays if there is undetected display unit failure.

When the selector is in the inboard position (INBD DU), the outboard display unit is blanked and the inboard display unit shows the cropped PFD and EICAS if EICAS was previously displayed on this side. Otherwise, whichever display that was shown in place of EICAS before the failure is shown.

When the selector is in the outboard position (OUTBD DU), the inboard display unit is blanked. The outboard half of the outboard display unit shows the cropped PFD. The inboard half displays EICAS if EICAS was previously shown on that side of the flight deck. Otherwise, whichever display that was shown in place of EICAS before the failure is shown.

Instrument Display Source Selection

The display system automatically reconfigures to compensate for most faults. The Air Data/Attitude (AIR DATA/ATT) Source Selector is provided for the pilots to use if certain faults are not corrected automatically.

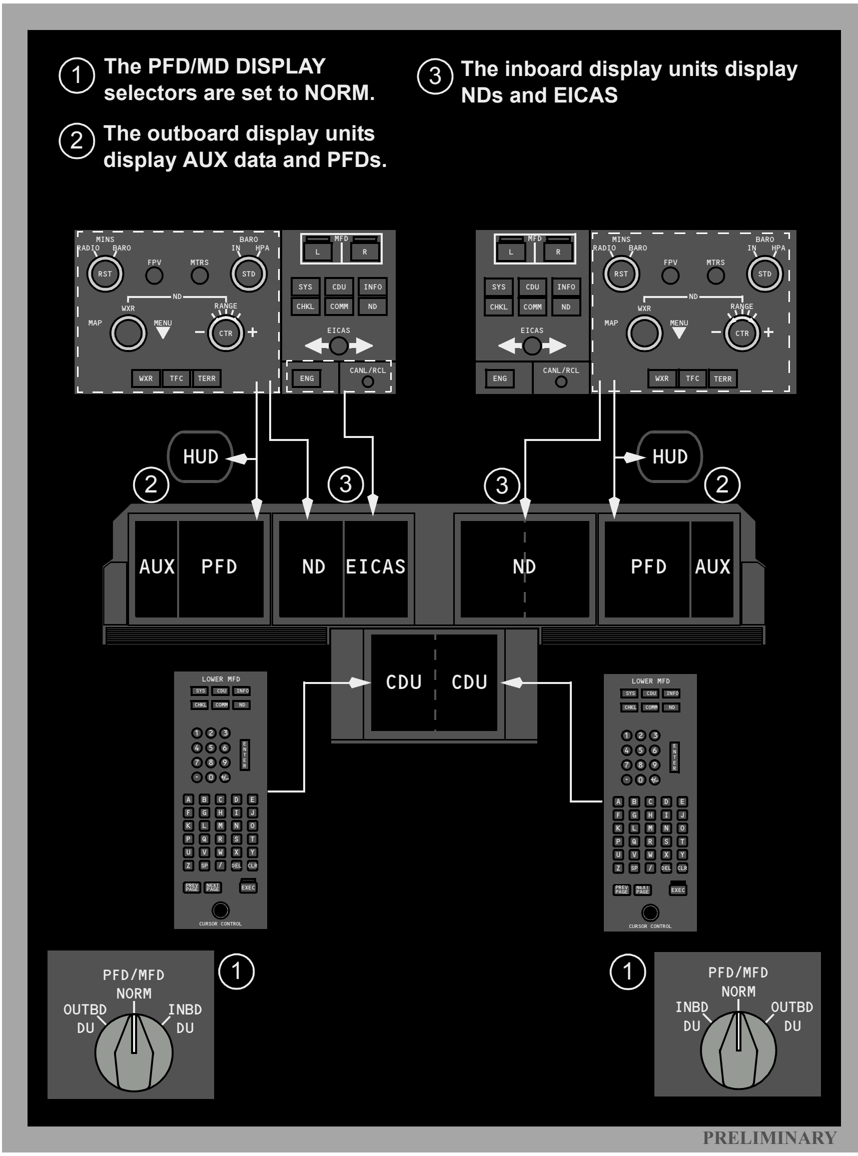
The AIR DATA/ATT source selector controls the source of airspeed, altitude and attitude information for the associated PFD and HUD. They have no effect on the autoflight or navigation system.

If there is an undetected source failure, the non-normal (ALTN) position provides the capability for manual selection of PFD and HUD sources.

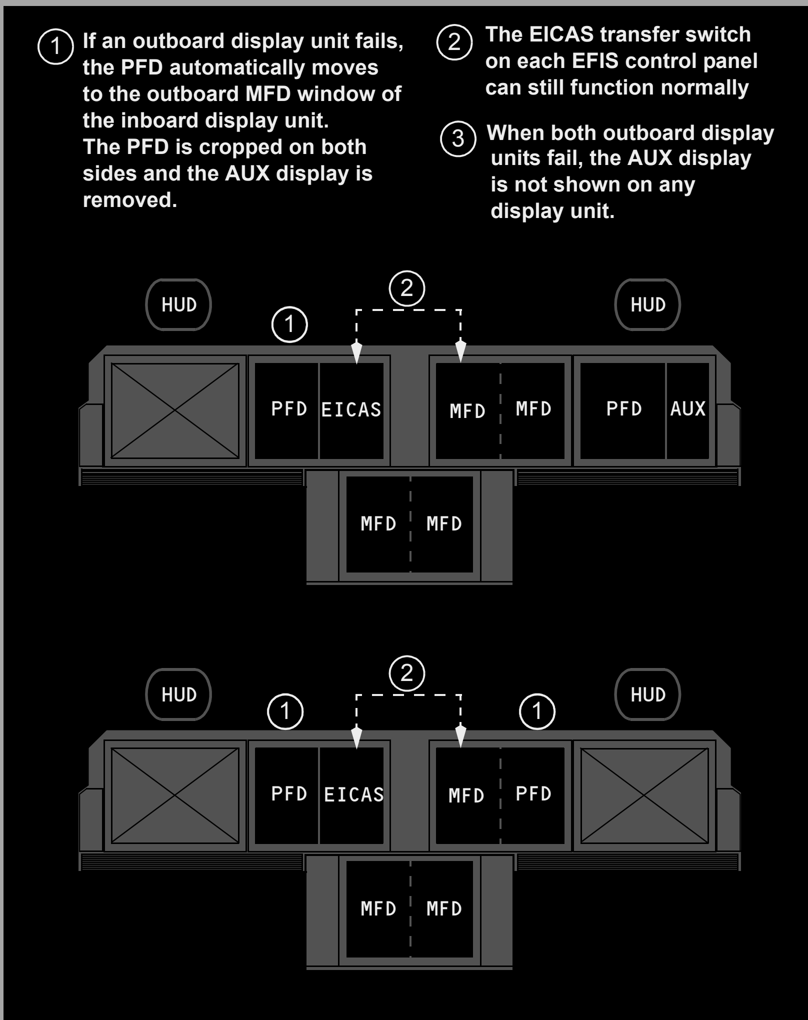
Display Selection and Control Examples

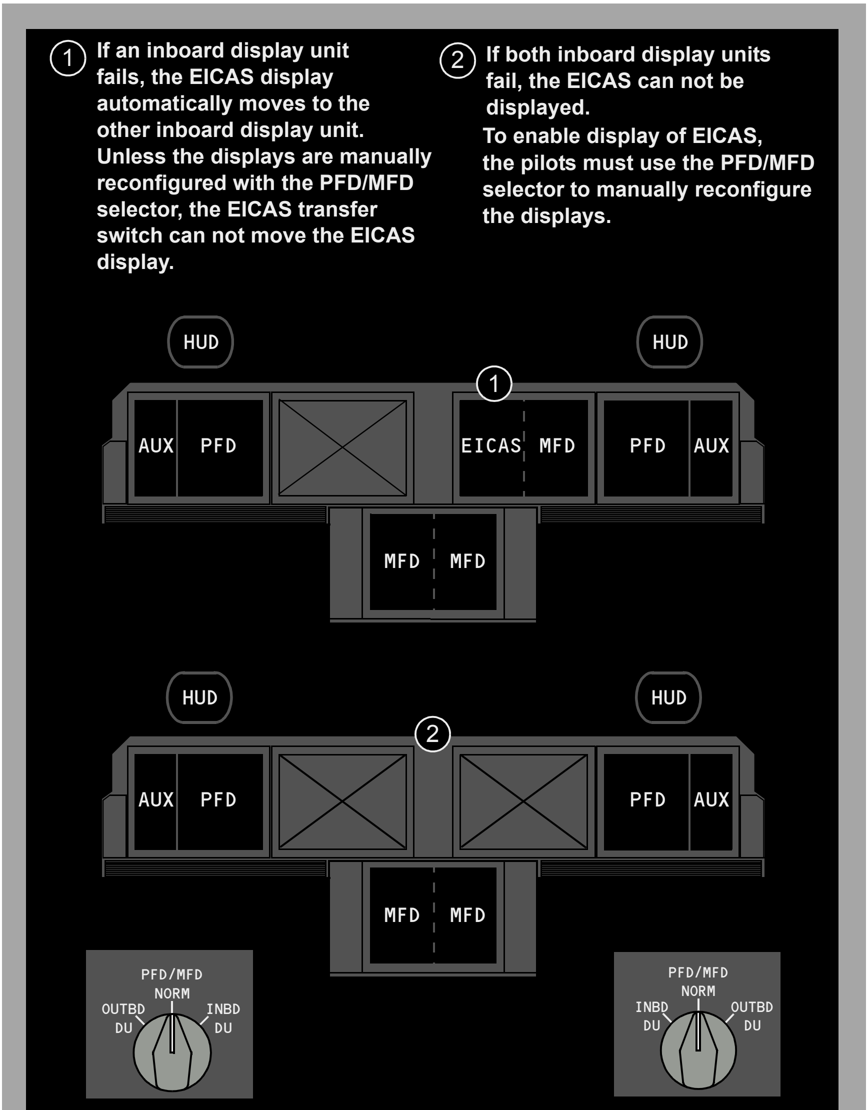
The following examples show display selections.

Default Display Configuration

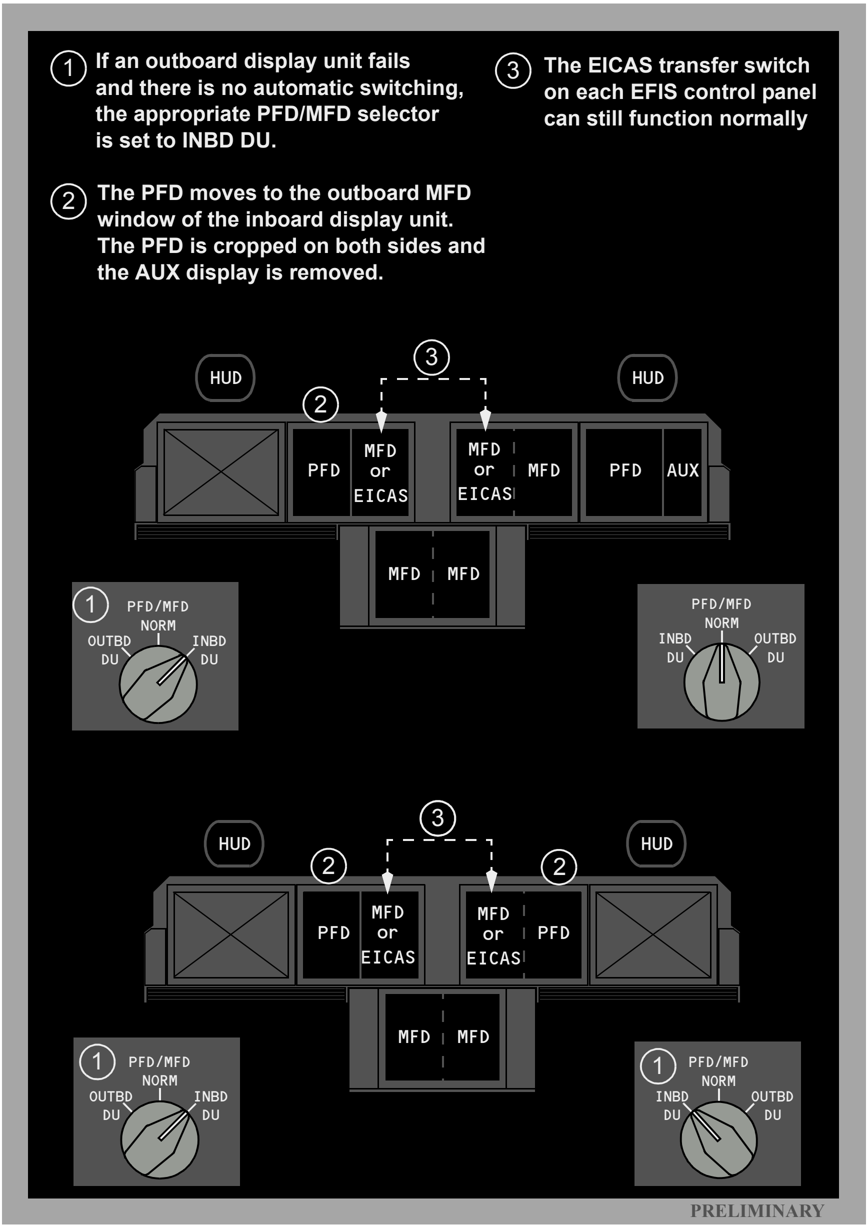


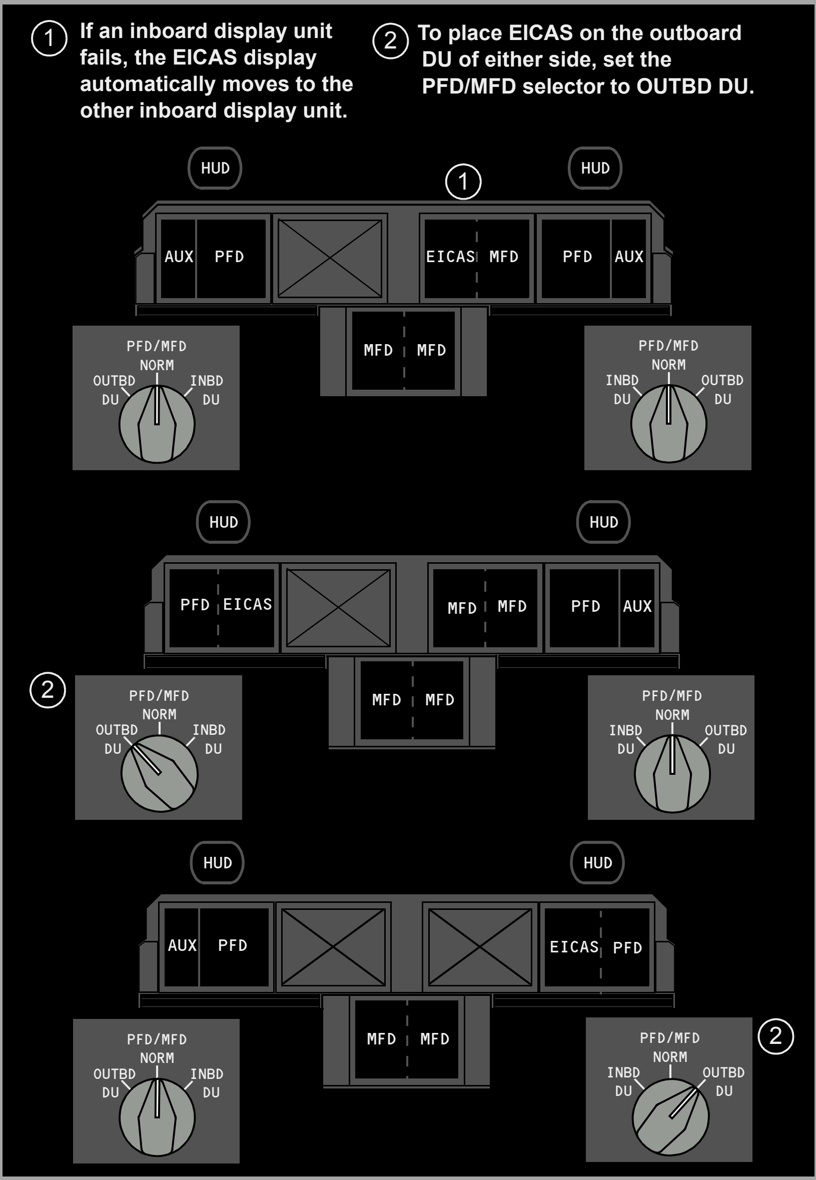
Display Unit Failure Automatic Switching




1
If an inboard display unit fails, the EICAS display automatically moves to the other inboard display unit. Unless the displays are manually reconfigured with the PFD/MFD selector, the EICAS transfer switch can not move the EICAS display.
2
If both inboard display units fail, the EICAS can not be displayed.
To enable display of EICAS, the pilots must use the PFD/MFD selector to manually reconfigure the displays.
HUD
HUD
1
AUX
PFD
EICAS
MFD
PFD
AUX
MFD
MFD
HUD
HUD
2
AUX
PFD
PFD
AUX
MFD
MFD
PFD/MFD
NORM
OUTBD DU
INBD DU
PFD/MFD
NORM
INBD DU
OUTBD DU

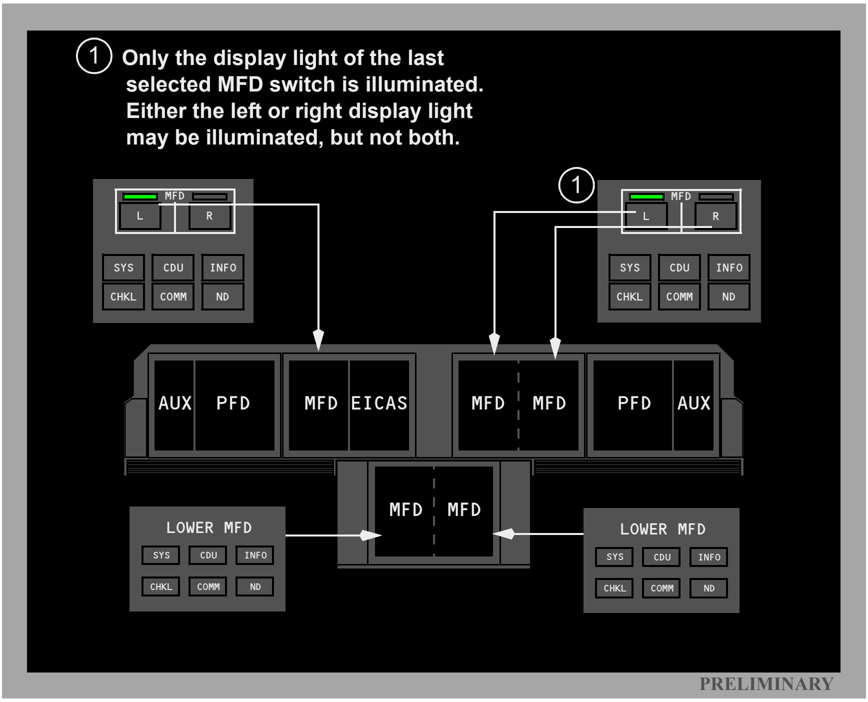
Display Unit Failure Manual Switching





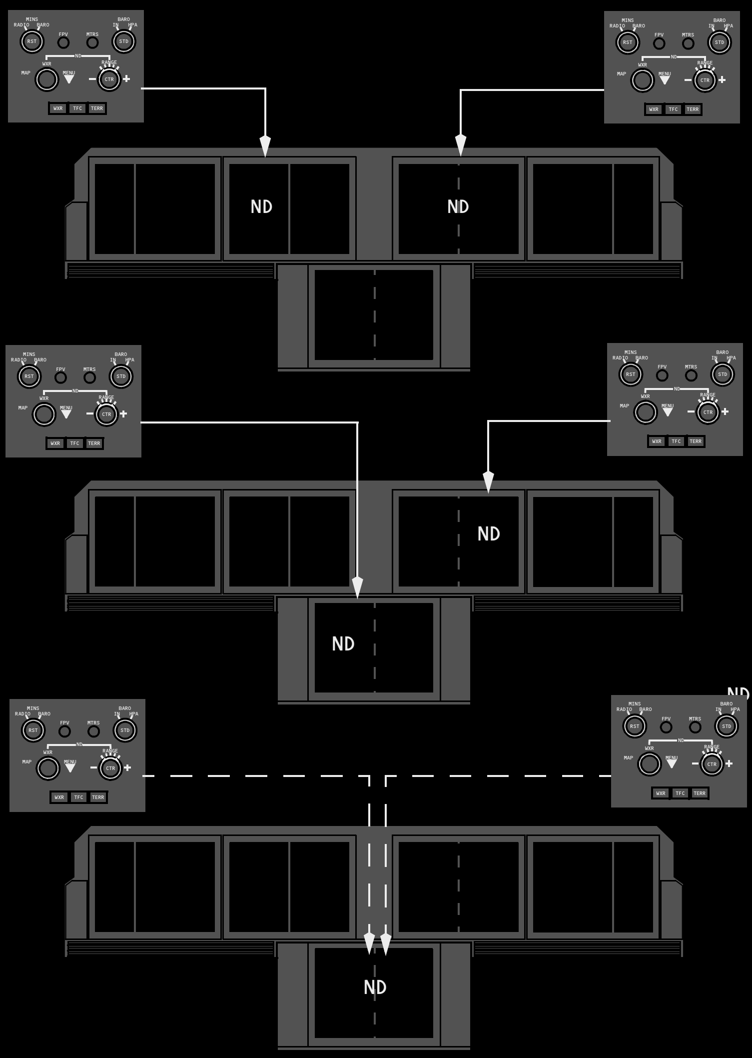
PRELIMINARY

Display Select Panel MFD Selection

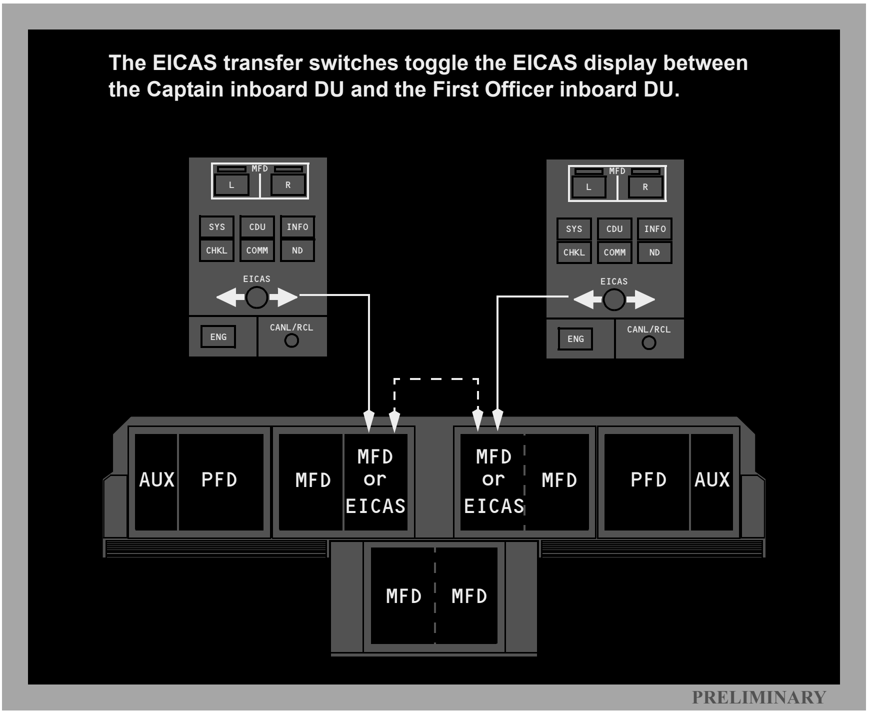


EFIS Control Panel Multiple ND Control

Each EFIS control panel controls the ND on the same side. If an ND is displayed on both MFD windows of the lower display unit, the 2 normal-display NDs combine to form a single full-display ND. The EFIS control panel used to first select the ND on the lower DU is used to control the full-display ND.



EICAS Transfer Switching



Cursor Location Control

The Cursor Control Devices (CCD), Multifunction Keypads (MFK), and EFIS control panels provide control of the display cursor. Each pilot has an identical set of controls for their respective sides of the flight deck. Cursor symbols access only MFDs and EFB displays.

The on-side cursor is automatically pulled to any display only if the pilot requests that particular display. However, if a default display is shown because another display was deselected, the cursor is not pulled to the default display.

For detailed information on the following subjects, refer to:

- Chapter 5, Communications
- Chapter 11, Flight Management, Navigation
- the Electronic Checklist sections in this chapter
- the Electronic Flight Bag section in this chapter

Cursor Control Device (CCD)

The CCD uses a touch pad. The cursor moves relative to finger movement across the touch pad. Except for the four corners of the touch pad, lifting the finger off the touch pad and touching a different location does not move the cursor. Only finger motion in contact with the touch pad moves the cursor.

Touching a corner immediately places the cursor in the corresponding corner of the display. This helps the pilot quickly locate the cursor and speeds access to the selections at the four corners of the display.

Multifunction Keypad (MFK)

The MFKs include the rotary Cursor Control Selector and the Cursor Select Switch. Rotate the Cursor Control Selector to move the cursor between active areas in a display. Push the Cursor Select Switch to select the highlighted area in a display.

EFIS Control Panel

The EFIS control panel provides cursor control of any on-side ND. Rotate the ND Mode Selector to move the highlight between MAP and PLAN modes for the ND. Items on the ND pull-down menu are also highlighted with the ND Mode Selector. Push the ND Mode Select switch to select the highlighted key on the ND.

The cursor follows a predetermined path over selectable keys. To exit the pull-down menu, the MENU or EXIT keys must be highlighted and then selected.

Standby Flight Instruments

The standby flight instruments include:

- integrated standby flight display
- standby magnetic compass

Integrated Standby Flight Display (ISFD)

The ISFD displays attitude, airspeed, altitude, ILS, GLS, and heading information. The ISFD receives airspeed and altitude from the center pitot and static air data modules. Attitude information is provided by internal inertial sensors. ILS or GLS information is provided by the left INR receiver. The display receives its heading information from the same source as the captain’s primary flight display.

Detection of a momentary out-of-limit ISFD condition may cause the attitude display to blank and the WAIT ATT or ATT:RST message to display. When the ATT:RST message displays, pushing the Attitude Reset switch resets the horizon line with the airplane symbol.

On the ground, pushing the Attitude Reset switch must be accomplished with the airplane stationary. In flight, pushing the Attitude Reset switch must be accomplished with the airplane in wings level, non-accelerated flight. During attitude reset, the ATT 10s message displays. Failure to maintain straight and level flight for 10 seconds may result in an ATT:RST message. If attitude reset is unsuccessful, the ATT:RST message remains displayed and the attitude is not displayed.

Standby Magnetic Compass

A standard liquid–damped magnetic standby compass is provided. A card located near the compass provides heading correction factors.

Clocks

A clock is located on each AUX display. Each clock displays UTC time and date automatically generated from GPS. In addition to time, the clocks also provide elapsed time and chronograph functions. Elapsed flight time starts automatically at weight off wheels and ends at weight on wheels plus 30 seconds. All clock functions except the chrono function are identical between the two pilot stations. The pilots have independent control of the chrono displays.

Display System Information Sources

Inertial Reference System (IRS)

The IRS is the primary source for attitude and inertial navigation position information. The major components of the IRS are:

- two inertial reference units (IRU)
- two attitude heading reference units (AHRU)

Inertial Reference Units (IRU)

The IRU is the primary source for independent inertial navigation position information. The IRU processes information measured by its internal gyros and accelerometers and GPS inputs.

The IRUs are described in Chapter 11, Flight Management, Navigation.

Attitude Heading Reference Units (AHRU)

The AHRUs are the primary source for attitude and heading information. The AHRUs are described in Chapter 11, Flight Management, Navigation.

Air Data Reference System (ADRS)

The ADRS provides primary, secondary, and standby air data. The major components of the ADRS are:

- six air data modules
- six static ports
- three pitot probes
- two angle–of–attack vanes
- one total air temperature probe.

Air Data

Three static ports are located on the left side of the airplane and three static ports are located on the right side of the airplane. Left and right static ports are paired through pneumatic tubing to each of the left, center and right air data modules. The air data modules convert static air pressure to a digital output for use by other systems. The center static ports are also connected to an independent air data module to provide static pressure to the standby airspeed indicator and the standby altimeter.

Two pitot probes (right and center) are mounted on the right forward section of the airplane. One pitot probe (left) is mounted on the left forward section of the airplane. An air data module is connected to each pitot probe. These air data modules convert dynamic air pressure to a digital output for use by other systems. The center pitot probe also provides dynamic pressure to the standby air data module.

Angle–of–Attack

There are two angle–of–attack vanes, one located on each side of the forward fuselage. The vanes measure airplane angle–of–attack relative to the air mass.

Total Air Temperature

A total air temperature probe is mounted outside the airplane to sense air mass temperature. The temperature sensed by the probe is used by the ADRS to compute total air temperature. The ADRS also receives TAT measurements from each of the EEC TAT sensors for a total of six inputs. These inputs are used to derive a weighted average, trusted TAT.

Static Air Temperature

Static air temperature, displayed on the CDU PROGRESS page, comes from the ADRS, using total air temperature probe information.

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Introduction

The airplane is equipped with two head-up displays (HUD); one for each pilot. These displays operate independently from each other.

The system projects flight data symbology onto a transparent glass "combiner" screen in the pilot's forward field of vision. This allows the pilot see the data while looking through the forward windscreen.

The HUD and PFD receive flight data from the same sources, thus HUD indications will match (repeat) PFD indications, though data format and symbology may differ.

HUD Components

Overhead Unit (OHU)

The OHUs are located above the head of each pilot. The OHU contains an LCD projector and the optics necessary to display flight data symbology onto the combiner glass.

The HUD projector is monochromatic (green), so all information displayed on the HUD combiner is green.

HUD Controls

Symbology and brightness controls are the only dedicated HUD controls. Manipulation of the FMS, EFIS, and MCP controls determine data output on both the HUD and PFD.

Symbology Control Switch

Symbology control switches located on the outboard side of each control wheel allow the pilot to alternate between the two display modes. The switches control the respective pilot's side only.

Brightness Control

The brightness control has two modes; manual (MAN) and automatic (AUTO).

The MAN mode is selected by pulling the brightness control knob outward. Display brightness is then adjusted by rotating the control left or right as desired.

In the AUTO position, a light sensor will detect the amount of ambient light and automatically adjust the brightness level to maintain a constant display contrast.

Combiner

Glass combiner screens are attached above the forward windscreen on a rotating dual arm assembly. Combiner deployment is accomplished by pushing down, then forward on the combiner assembly until it reaches a physical stop. A locking mechanism is used to secure the combiner in the stowed position.

An ALIGN HUD alerting message will display on the combiner screen if it is not properly aligned with the projector. Ensuring the combiner is positioned at the stop removes the message.

The HUD system does not have an ON-OFF switch. The projector turns on by deploying the combiner, and turns off by stowing the combiner.

If there is a sudden and sustained deceleration, the combiner will rotate forward and lock in a breakaway position. This is to prevent the pilot's head from impacting the combiner. To release the combiner, push forward to relieve pressure on the latch. Then slide the locking lever to the right, releasing the combiner. Then reposition the combiner to the desired position.

Combiner Display Symbology

The data format and symbology displayed on the HUD closely resembles the symbology on the PFD, though some differences do exist.

One of the major differences between the HUD and PFD is that the HUD is capable of displaying two alternate symbology modes; full symbology and decluttered. The full symbology mode shares many common elements with the PFD. These include speed and altitude tapes, lateral and vertical navigation performance scales, bank angle indicator, and flight mode annunciations (FMA). A partial compass rose is also at the bottom of the full symbology HUD display. The decluttered mode eliminates airspeed and altitude tapes, displaying only digital values. The partial compass rose is also removed.

Due to the monochromatic limitation of the HUD display, many alerting functions that use color (usually amber) symbology on the PFD may use only flashing symbology on the HUD, or have no distinct HUD alert.

HUD-Unique Indications and Symbology

The HUD has some unique symbology not found on the PFD. This section details those symbols and their function.

Pitch Scale Compression and Chevrons

The HUD pitch scale normally displays 5 degree lined increments above and below the horizon reference line, and conform with the outside world. For example, as the pilot looks through the HUD, the horizon reference line on the HUD pitch scale should rest at or near the actual horizon outside the airplane. At higher altitudes, the HUD horizon reference line may appear slightly above the actual horizon due to curvature of the earth.

If the HUD horizon reference line or the flight path vector symbol cannot be shown on the display when it conforms with the outside world (excessive pitch up or pitch down), the pitch scale will compress to make room for these symbols. The pitch scale then displays 10 degree increments.

At excessively high or low pitch angles, chevrons are displayed directing the pilot to pitch the airplane back toward the horizon. For example, if the airplane pitch angle is excessively high, a downward pointing chevron positioned on the +30 degree pitch scale line comes into view, directing a pitch-down command to the pilot. Likewise, if the airplane pitch angle is excessively low, an upward pointing chevron positioned on the -20 degree pitch scale line comes into view, directing a pitch-up command to the pilot.

Unusual Attitude (UA)

The UA symbology displays when airplane pitch angle exceeds -20 or +35 degrees, or if roll exceeds 55 degrees in either direction. Only symbology necessary to help recover from the situation is displayed. This unique display will replace the normal full or decluttered display modes if previously displayed. This display will also replace a pitch scale compression and chevron display that may have preceded it.

The UA symbology remains displayed until the airplane pitch angle is between -5 degrees and +10 degrees (relative to horizon) for 5 seconds, and roll angle is less than 10 degrees for 5 seconds. Once the recovery maneuver is within these limits, the UA symbology is replaced by the full-symbology mode, regardless of the mode the HUD was in before encountering the unusual attitude.

The UA symbology includes a zenith symbol centered on the +90 degree pitch scale line, and a nadir symbol centered on the -90 degree pitch scale line.

Digital Heading

A numerical digital heading value displays current heading below the roll scale slip/skid indicator. This value corresponds to the heading on the horizon reference line of the pitch scale.

Ground Excessive Deviation – Low Visibility Takeoff

[Option – HUD low visibility takeoff]

The ground excessive deviation symbol indicates localizer deviation during the takeoff roll. This guidance is available when low visibility takeoff guidance has been selected on the FMC. Once the airplane has deviated beyond a particular criterion (TBD), a flashing triangle pointing in the direction of the runway centerline will appear to assist in correcting for the deviation.

For additional information refer to Chapter 4 – Automatic Flight.

Runway Edge Lines

Runway edge lines is a projection of an 8,000 foot long, 200 foot wide runway, displaying the calculated position of the actual runway. The runway edge lines symbol is composed of the runway edge lines with two tick marks that correspond to the touchdown aiming point (glideslope intercept point). The symbol is enabled at a radio altimeter altitude of 300 feet, and removed at 60 feet.

The calculations depend on the selected course for the ILS/GLS/IAN approach, as well as inputs from pitch, roll, heading, barometric altitude, localizer deviation, glideslope deviation, and the glideslope angle and elevation from the FMS.

Flight Path Vector Symbol with Guidance Cue

The flight path vector symbol is derived from the inertial sources, and provides an indication of where the airplane is going. The flight path angle is indicated by the position of the center of the flight path circle relative to the pitch scale.

The flight path vector symbol’s "gull wing" wing roots are angled downward 30 degrees to the horizontal. In a 30 degree bank angle, the upward wing’s wing root will be parallel with the HUD horizon and pitch scale lines.

The flight path vector symbol is only displayed in flight, and has display priority over all other symbols except the guidance cue. If any portion of another symbol (excluding guidance cue) is positioned inside the circle of the flight path vector symbol, that portion of the other symbol is not displayed.

The flight path vector symbol appearance can be limited laterally by other symbology such as speed and altitude tapes, or the display field-of-view. When this occurs, the flight path vector symbol is displayed with a dashed outline rather than a solid outline. This indicates that the flight path vector symbol is parked, and can no longer indicate the airplane’s current path.

The guidance (small circle) cue is associated with the flight path vector symbol. This guidance cue represents flight director guidance, and is displayed when the flight directors are turned on. To track the guidance cue, position the circular body of the flight path vector symbol around the guidance cue.

During a windshear alert condition, the guidance cue will transform from hollow to solid (filled). For information on windshear alerting, refer to Chapter 15 – Warning Systems.

TO/GA Reference Line

In TO/GA mode, flight director vertical guidance is depicted as a horizontal dashed (pitch target) line across the HUD pitch scale. To comply with this guidance, place the airplane reference symbol on the TO/GA reference line.

During takeoff roll, this line is initially fixed at the top of the display. A flight director pitch up command is displayed when the TO/GA reference line is positioned above the airplane reference symbol. Likewise, a pitch down command is displayed when the TO/GA reference line is positioned below the airplane reference symbol.

A TO/GA reference line is displayed when all of the following conditions are true:

- flight director TO/GA mode is active, and
- groundspeed is greater than 65 knots, or pitch command is greater than 10 degrees

Once in flight, the spacing between the TO/GA reference line and the airplane reference symbol is equal to the spacing between the flight path vector symbol and the guidance cue.

Glideslope Reference Line

During approach, a horizontal dashed line across the HUD pitch scale depicts the projected glideslope angle of the active approach. The glideslope angle numerical value is digitally displayed adjacent to the glideslope reference line.

During visual approaches, a precise descent angle to the runway is maintained by overlaying the glideslope reference line on the runway touchdown zone. Then maintain the flight path vector symbol on the glideslope reference line.

Angle-of-Attack Limit Symbol

The airplane's angle-of-attack (AOA) limit is depicted on the HUD by the angle-of-attack limit symbol. The distance between the AOA limit symbol and the flight path vector symbol represents the margin available before stick shaker will occur. When the AOA limit symbol is positioned on the flight path vector symbol (boxed ends set on the flight path vector symbol wings), the airplane is at the stick shaker angle of attack.

The PFD contains a similar symbol called the pitch limit indicator (PLI). However, on the PFD, the PLI is displayed relative to the airplane reference symbol, not to the flight path vector.

The AOA limit symbol is displayed during any of the following:

- angle of attack is within 5 degrees of stick shaker, or
- stick shaker is active, or
- windshear alerting with (solid) guidance cue displayed

Slip/Skid Indicators

The Slip/Skid symbology consists of two symbols:

- roll scale slip/skid indicator is referenced to and rotated with the roll scale pointer (or referenced to the UA roll scale pointer, whichever is displayed).
- flight path slip/skid indicator referenced to the flight path vector symbol

The flight path slip/skid indicator is only displayed during a takeoff, or a low-altitude go-around, providing additional yaw reference in the case of an engine failure. At low altitude, the sensitivity of the slip/skid indicators is enhanced to provide additional awareness.

TCAS Fly-To Symbology

A corrective advisory is displayed on the HUD by a double lined box called the "fly-to box". The fly-to box is an indication of where the flight path vector symbol should be positioned in order to obtain vertical separation from traffic, directing an evasive maneuver.

TCAS operation is described in Chapter 15, Warning Systems.

Speed Error Tape and Flight Path Acceleration

The speed error tape shows the difference between the indicated airspeed and the selected airspeed on the mode control panel. Selected airspeed on takeoff is V2, whereas flight director guidance airspeed is V2 + 15. In order to prevent an incorrect interpretation of the speed error tape, the symbol is not displayed until the first flap retraction.

The speed error tape is positioned on the left wing of the flight path vector symbol, adjacent to the flight path acceleration symbol. If the indicated airspeed is faster than the selected speed, the speed error tape rises above the wing. Likewise, if the indicated airspeed is slower than the selected speed, the speed error tape falls below the wing. Each one-degree of speed error tape length (approximately the diameter of the flight path vector symbol circle) represents approximately 5 knots of airspeed error. The tape length is limited to a 15 knot error indication.

The inertial acceleration (or deceleration) of the airplane along the flight path is indicated by the flight path acceleration symbol " > ". This symbol is an indication of the total sum of all forces affecting the airplane.

In flight, the flight path acceleration symbol is positioned to the left of the flight path vector symbol. When flight path acceleration symbol is above the wing of the flight path vector symbol, the airplane is accelerating. When it is below the flight path vector symbol wing, the airplane is decelerating. To maintain a steady state (neither accelerating nor decelerating), the flight path acceleration symbol is positioned directly to the left of the left flight path vector symbol wing. When the airplane is not in flight, or the flight path vector symbol is not displayed, then the flight path acceleration symbol is referenced to the airplane reference symbol.

To avoid confusion in controlling airplane thrust, the flight path acceleration symbol is removed from the display when a low-level, decreasing performance windshear is detected below 400 feet AGL.

Ground Deceleration (Rate) Scale

A ground deceleration rate scale is shown on landing or when a deceleration is sensed on takeoff. A vertical indexed scale and pointer indicate the actual deceleration rate being achieved, as provided by the corresponding autobrake setting (1, 2, 3, 4, MAX AUTO).

During takeoff, the scale is not displayed, but is added to the display if a deceleration is sensed when the groundspeed is above 50 knots, and the airplane is still on the ground. Once displayed, the scale is removed when groundspeed decreases below 25 knots, the airplane begins accelerating, or the airplane lifts off.

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Flight Instruments, Displays — Chapter 10
Primary Flight Displays (PFDs) — Section 30

Introduction

The PFDs present a dynamic color display of all the parameters necessary for flight path control. The PFDs provide the following information:

- flight mode annunciation
- airspeed
- altitude
- vertical speed
- attitude
- steering information
- radio altitude
- instrument landing system display
- approach minimums
- heading/track indications
- engine fail, GPWS, and PWS alerts

The mini-maps present a tactical display map with a fixed range of 20 nautical miles. They provide immediate target and threat information and are placed below the PFDs directly in front of each pilot. The mini-maps display the flight plan with all of its associated information such as the following:

- flight path
- flight plan waypoints with ID and constraints
- altitude profile points
- alternate airports
- runway information
- TCAS targets
- Terrain depiction and alert patterns
- weather radar return patterns
- heading/track indications

The mini-maps do not display information such as untuned navaids, background waypoints, and background airports. Refer to the Navigation Displays section of this chapter for specific symbology.

Failure flags are displayed for airplane system failures. Displayed information is removed or replaced by dashes if no valid information is available to the display system (because of out–of–range or malfunctioning navigation aids). Displays are removed when a source fails or when no system source information is available.

Flight mode annunciations are described in Chapter 4, Automatic Flight.

Airspeed

Airspeed is displayed on a tape and in a digital window on the left side of the PFD. The current Mach number is digitally displayed below the speed tape when the current Mach number is greater than 0.40. An airspeed trend vector indicates predicted airspeed in 10 seconds. Selected airspeed is displayed above the speed tape.

Takeoff and landing reference speeds and flap maneuvering speeds are shown along the right edge of the speed tape. Maximum and minimum airspeeds are also displayed along the right edge of the speed tape.

Altitude

Altitude is displayed on an altitude tape along the right side of the PFD. It is also shown digitally in a window in the middle of the tape. An altitude trend vector indicates predicted altitude in six seconds.

When meters is selected on the EFIS control panel:

- current altitude in meters is also shown above the altitude window
- selected altitude in meters is displayed above the altitude tape

Selected altitude is displayed above the altitude tape and is boxed when approaching the selected altitude. Selected altitude is also depicted with a bug on the altitude tape.

The selected barometric approach minimum is indicated on the altitude tape with a triangular pointer and green line.

A landing altitude reference bar is displayed along the inner edge of the altitude indication. The reference bar indicates the height above touchdown. A white bar is displayed from 1000 to 500 feet above landing altitude. An amber bar is displayed from 500 feet to the landing altitude.

The current barometric reference is displayed below the altitude tape. A preselected barometric reference can be displayed when STD is displayed.

Landing reference is selectable between QNH and QFE on the APPROACH REF page of the FMC. QNH is the normal operating mode. Selecting QFE sets the destination landing altitude indication to zero altitude. With the landing reference set to QFE, changing the barometric setting from STD to QFE changes the PFD altitude tape background color to green. With QFE selected and climb mode active, changing the barometric setting from QFE to STD causes the landing reference to toggle from QFE to QNH and the altitude tape background color changing from green back to normal. A description of QFE operation is contained in the Landing Reference description in Chapter 11, Flight Management, Navigation.

Vertical Speed

Vertical speed is displayed to the right of the altitude tape with a tape and pointer. Vertical speed is digitally displayed above or below the vertical speed display when vertical speed is greater than 400 feet per minute. It is displayed above with positive vertical speed and below with negative vertical speed. The selected vertical speed bug shows the selected vertical speed when in the AFDS vertical speed (V/S) pitch mode.

Attitude

The attitude indication displays the airplane pitch and roll attitude referenced to the horizon.

Pitch attitude is displayed by an airplane symbol against a pitch scale. The pitch scale is in 2.5 degree increments.

A pointer indicates bank angle in increments of 10, 20, and 30 degrees. Single marks indicate 45 and 60 degrees of bank. A small rectangle under the bank angle pointer indicates slip and skid conditions. Bank angle is also represented by the attitude of the airplane symbol against the horizon line and pitch scale.

A pitch limit indication is displayed at low speeds when the flaps are up and at all times when the flaps are down.

Steering Indications

The flight director steering indications are displayed when the associated flight director switch is on.

TCAS resolution advisories are displayed in the attitude indication area. Refer to Chapter 15, Warning Systems.

The flight path vector (FPV) symbol represents airplane flight path angle vertically and drift angle laterally. The flight path vector is displayed on the PFD when the EFIS control panel FPV switch is selected on, or the MCP FPA reference switch is selected on. The FPV shows the Flight Path Angle (FPA) above or below the horizon line and drift angle left or right of the pitch scale's center. The FPA uses inertial and barometric altitude inputs. The vertical FPA is unreliable with unreliable primary altitude displays.

The flight path angle (FPA) symbol shows the selected flight path angle when the MCP FPA reference switch is selected on and either the flight director or autopilot is engaged.

The FPV and FPA symbols are displayed in two sizes and brightness levels. The large, bright FPV/FPA symbols are displayed when the previously stated selections are made and the flight director is off. The small, dim FPV/FPA symbols are displayed when the previously stated selections are made and the flight director is displayed.

Radio Altitude

The current radio altitude is displayed in the bottom center of the attitude indication area when radio altitude is below 2,500 feet AGL.

Instrument Landing System Indications

ILS glideslope and localizer deviation, frequency/identification, DME, course, and marker beacon indications are provided.

The approach reference information appears above and to the left of the attitude display. The ILS station identification or frequency, course, and (if available) DME are displayed.

The marker beacon indication (OM – outer marker, IM – inner marker, or MM – middle marker) is displayed in the upper right corner of the attitude display area.

The glideslope pointer and scale appear on the right side of the attitude indication.

The localizer pointer and scale appear at the bottom of the attitude indication.

Integrated Approach Navigation (IAN) Indications

FMC glidepath and FAC deviation, approach identifier, distance, and course are provided.

The approach reference information appears above and to the left of the attitude display. The IAN deviation source annunciation is below the approach data.

IAN glide path and FAC deviation indications and alerts are displayed like ILS. Deviation indications appear when a valid IAN approach is selected. IAN approach deviations are not available with QFE selected in the FMC.

Approach Minimums

The selected radio altitude or barometric approach minimums set on the EFIS control panel are displayed near the bottom left of the altitude display.

Heading/Track Indications

Selected heading/track information is displayed in the bottom section of the PFD on the mini-map. Current heading is displayed under a pointer at the top of the compass rose. The MCP selected heading bug is displayed on the outside of the compass rose. The MCP selected track bug is displayed on the inside of the compass rose.

Heading or track is displayed based on the position of the MCP HDG/TRK reference switch. The selected heading or selected track is annunciated below and to the left of the airplane symbol. The current heading/track reference (MAG/TRU) is shown below and to the right of the airplane symbol. A line drawn perpendicular to the edge of the compass rose from the invisible center depicts the current airplane track.

[Option – Horizon line heading scale]
Heading or track information is also displayed on the Horizon Line Heading Scale.

Engine Fail, GPWS, and PWS Alerts

Engine fail, GPWS, and PWS alerts are displayed in large capital letters between the attitude display and the heading/track compass rose. Refer to Chapter 15, Warning Systems.

Typical PFD Displays

Typical PFD configurations for six phases of flight follow. The autopilot, LNAV, and VNAV are engaged for climb, cruise, descent, approach, and landing. The AFDS approach mode is used for approach and landing.

PFD Takeoff Display

[Option – Split cue]

PFD Climb Display

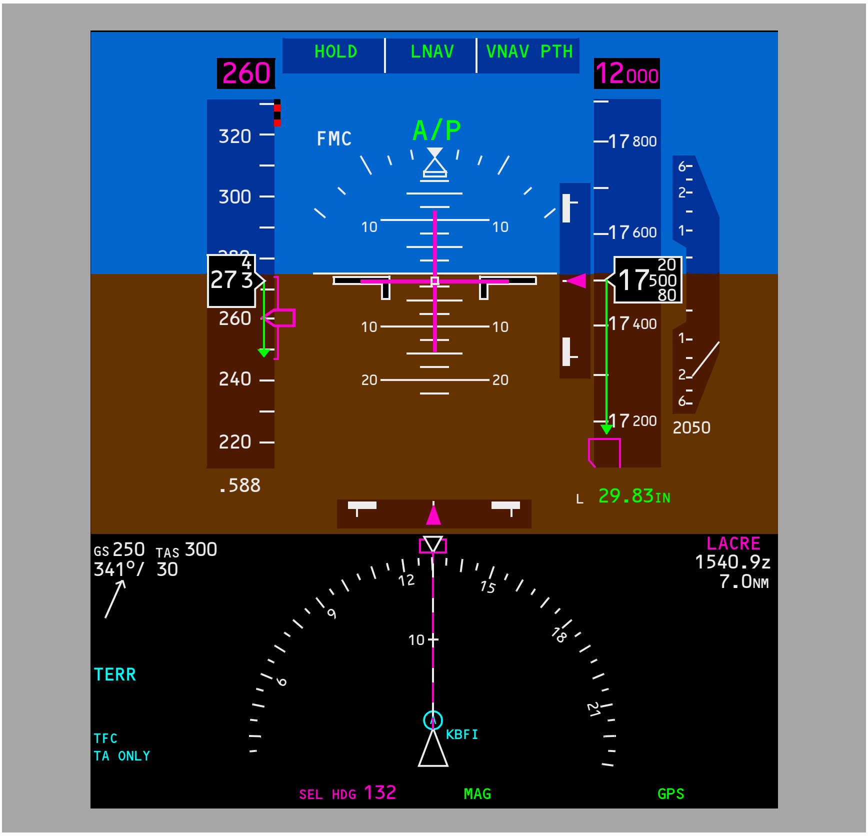
[Option – Split cue]

PFD Cruise Display

[Option – Split cue]

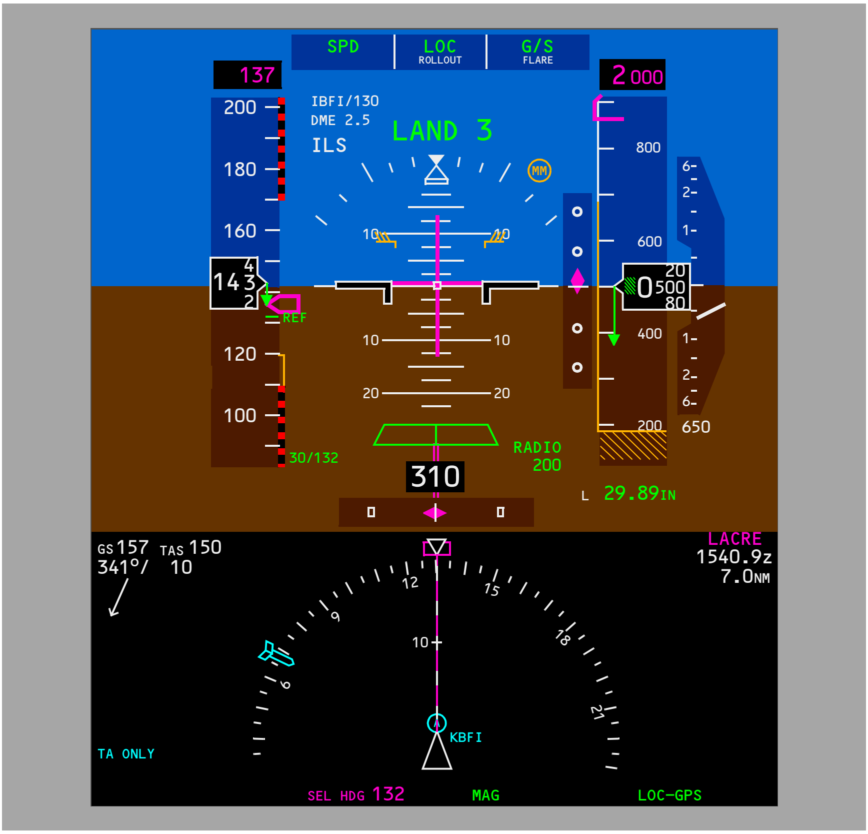
PFD Descent Display

[Option – Split cue]



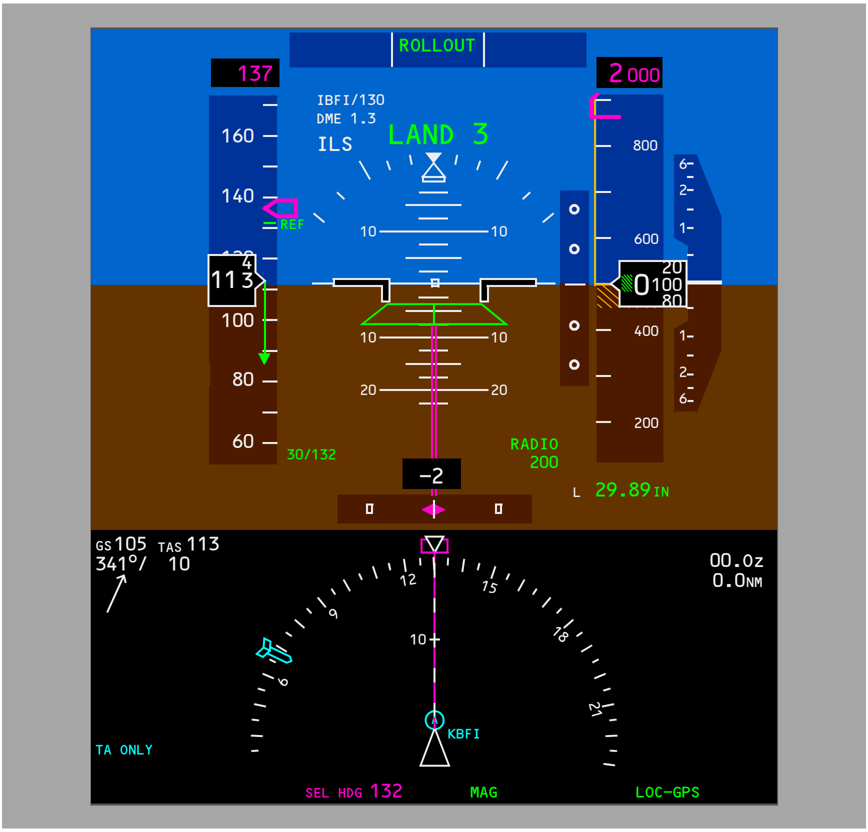
PFD Approach Display

[Option – Split cue, Rising Runway]



PFD Landing Display

[Option – Split cue, Rising runway]



Intentionally
Blank

Introduction

The NDs provide a mode–selectable color flight progress display. The modes are:

- MAP
- PLAN

The MAP mode can be switched between an expanded mode with a partial compass rose and a centered mode with a full compass rose. Both MAP and PLAN modes can be shown in Normal and Full-display format. Refer to the System Description section of this chapter for more information on display management.

Map Mode

The MAP mode is recommended for most phases of flight.

[Option – Track up]

Presented track-up, this mode shows airplane position relative to the route of flight against a moving map background.

Displayed information can include:

- selected and current track
- selected and current heading
- position trend vector
- range to selected altitude
- map range scale
- groundspeed
- true airspeed
- wind direction and speed
- next waypoint distance
- waypoint estimated time of arrival
- selected navigation data points

Navigation Data Points

Additional navigation facility (STA), waypoint (WPT), airport (APT), route progress (DATA) and position (POS) data are available for display on the ND in both the expanded and center map modes.

Plan Mode

The PLAN mode is presented true north up. The active route may be viewed using the STEP prompt on the CDU LEGS pages.

ND Information

Heading

Heading is supplied by the FMC or inertial reference system (IRS). The ND compass rose can be referenced to magnetic north or true north. The heading reference switch is used to manually select magnetic or true reference. The compass display is automatically referenced to true north when the airplane is north of 82° north or south of 82° south latitude, or near the magnetic poles with the heading reference switch in NORM.

Track

Track is supplied by the FMC during normal operation and by the Tuning and Control Panel (TCP) when in alternate navigation.

Traffic

Traffic information from the TCAS can be displayed on the ND and the mini-map. TCAS is described in Chapter 15, Warning Systems.

Weather Radar

Weather radar information can be displayed on the ND and mini-map. The weather radar system is described in Chapter 11, Flight Management, Navigation.

Airport Map

The Airport Map is integrated with the ND and consists of runways, taxiways, aprons and buildings with the appropriate labels. The FMC provides the position of the airplane. The Airport Map is automatically displayed when the following conditions are met:

- the airport is either the ORIGIN or DESTINATION airport as specified in the active flight plan
- the airport is in the Airport Map database
- the ND range is 5NM or less

The Airport Map can be displayed in either a track-up mode (MAP) or north-up mode (PLAN). The Airport Map may be displayed at 5NM, 2NM, 1NM and 0.5NM by selecting the range on the EFIS Control Panel.

Vertical Situation Display (VSD)

The VSD presents a profile view of the airplane and its environment. Information shown within the cyan dashed lines (enroute corridor) on the ND is shown in profile on the VSD. The pilot selects the VSD display from the map information selections on the MAP mode pull-down menu.

The VSD depicts terrain and waypoint information that is within the enroute corridor on the ND. The VSD range is a function of the ND range and is depicted on the horizontal reference scale. The normal-display VSD has the same range as the ND except when the ND range is less than 5 NM. The full-display VSD has twice the range of the ND – from 10 NM to 2560 NM.

The altitude reference scale is linked to the VSD range and is not independently adjustable. This ensures that a consistent 3 degree glidepath is depicted up to an 80NM range. The selected altitude shown on the VSD is the same as the selected altitude shown on the on-side PFD.

Failure Flags and Messages

Failure flags are displayed for system failures or invalid information. Indications are removed or replaced by dashes when source system information is not available.

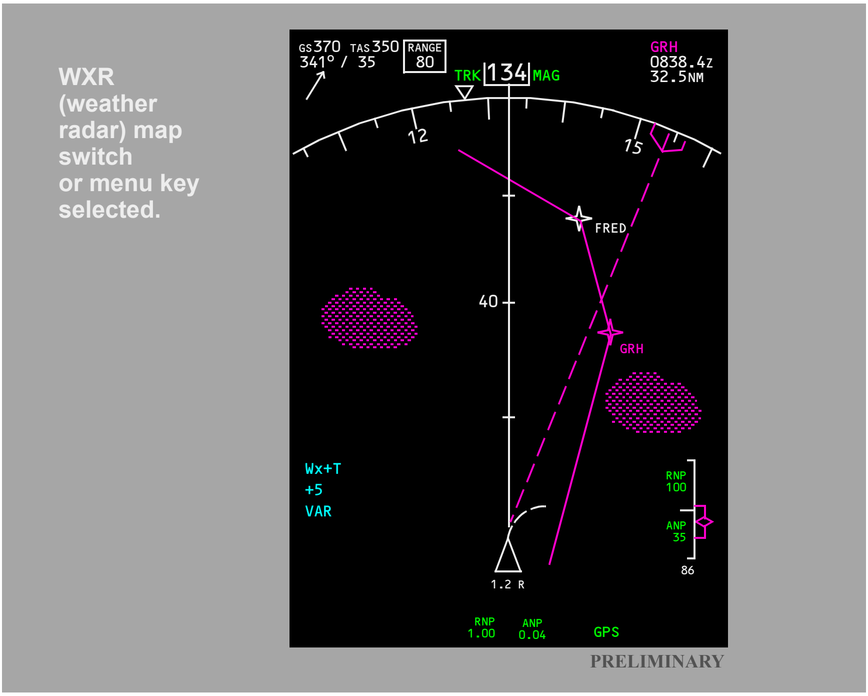
The message EXCESS DATA is displayed if the amount of information sent to the ND exceeds the display capability. When this occurs, the primary display system removes information from the center of the display outward; information near the outer selected range area is still displayed. The message can be removed by:

- reducing the amount of map information
- reducing range, or
- deselecting one or more of the map information selections (STA, WPT, APT, DATA, POS)

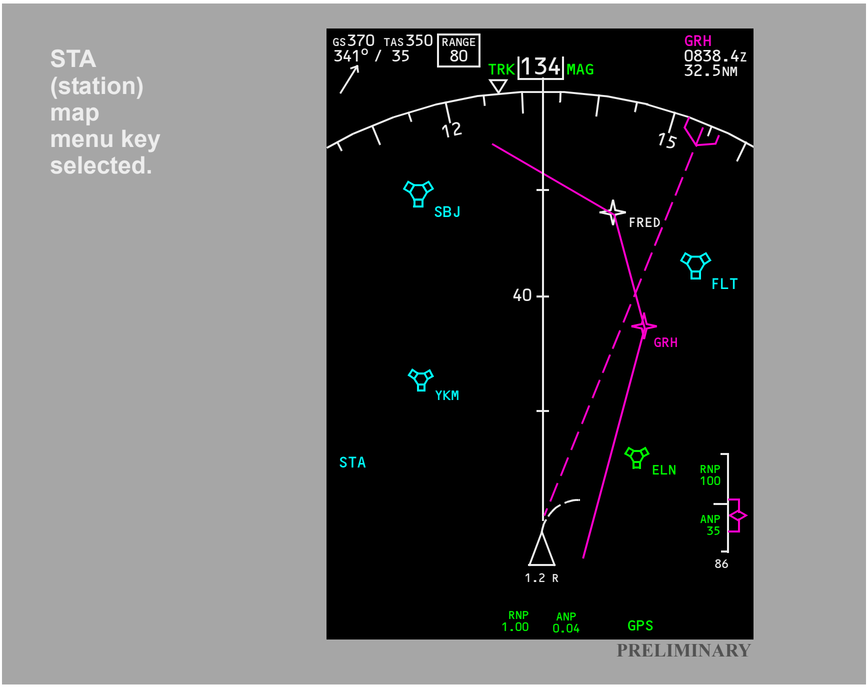
Typical ND Map Displays

ND Expanded Map Displays

[Option – Track up]

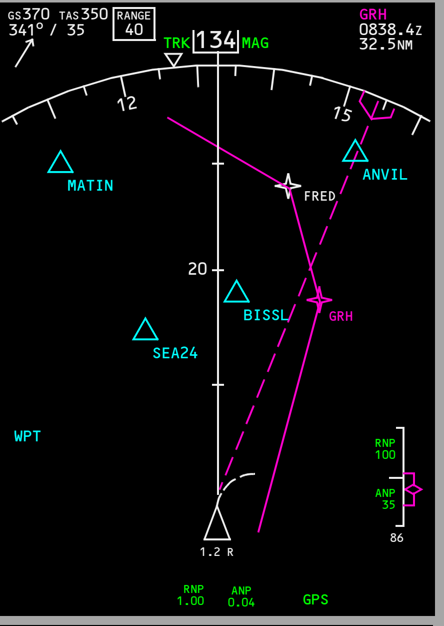


[Option – Track up]

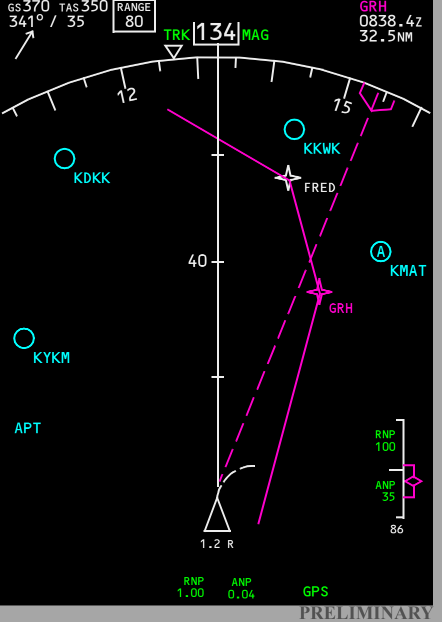


[Option – Track up]

WPT (waypoint) map menu key selected.

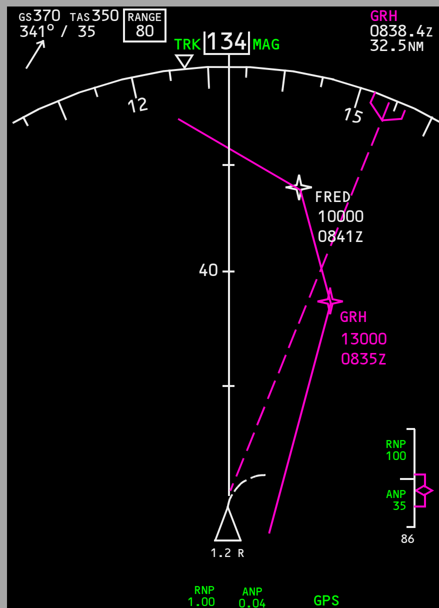


APT (airport) map menu key selected.

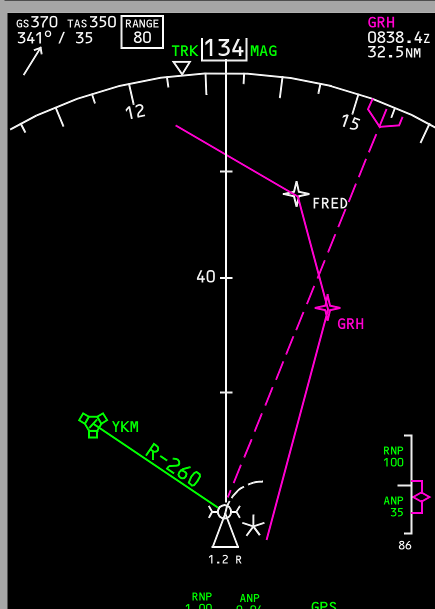


[Option – Track up]

DATA map menu key selected.



POS (position) menu key selected.



PRELIMINARY

ND Symbology

The following symbols can be displayed on each ND, depending on EFIS control panel switch selections. Colors indicate the following:

- W (white) – present status, range scales
- G (green) – dynamic conditions
- M (magenta) – command information, pointers, symbols, fly–to condition
- C (cyan) – nonactive or background information
- A (amber) – cautions, faults, flags
- R (red) – warnings

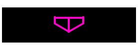
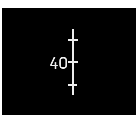
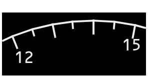
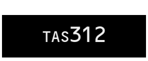
Heading, Track, and Speed

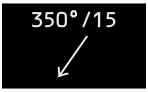
Symbol	Name	ND Mode	Remarks

[Option – Track up]

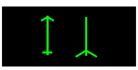
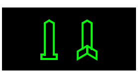
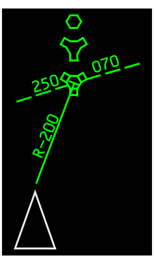
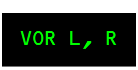
Symbol	Name	ND Mode	Remarks
TRK 062 MAG	Track orientation (G), current track (W), and track reference (G)	MAP, MAP CTR	Displays TRK as the orientation, the current track, and MAG or TRU as the reference, and points to the heading on the compass rose.

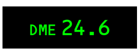
Symbol	Name	ND Mode	Remarks
SEL HDG 132 SEL TRK 132 MAG	Selected Heading/Track (M), and heading/track reference (G)	mini-map	Displays SEL HDG or SEL TRK and MAG or TRU as the reference.
GRID 155	Grid heading (W)	MAP, MAP CTR	Displays above 70 degrees latitude.
TIME TO ALIGN 05:35	Time to align (W)	All	Indicates time remaining for IRU alignment. Replaces wind direction/speed and wind arrow, on the ground, during alignment.

Symbol	Name	ND Mode	Remarks
	Selected heading bug (M)	MAP, MAP CTR, mini-map	Displays the MCP–selected heading. A dashed line (M) may extend from the marker to the airplane symbol. In the MAP mode with LNAV, LOC, or ROLLOUT engaged, the dashed line is removed 10 seconds after the selected heading bug is moved.
	Selected track bug (M)	MAP, MAP CTR, mini-map	Displays the MCP–selected track. A dashed line (M) may extend from the marker to the airplane symbol.
	Track line and range scale (W)	MAP, MAP CTR, mini-map	Indicates current track. Number indicates range.
	Heading/track reference (G) box (W) in TRU, box (A) if TRU displayed in descent	MAP, MAP CTR, mini-map	Indicates heading/track is referenced to magnetic north or true north. Switching from TRU to MAG displays a box around MAG for 10 seconds.
	Expanded compass (W)	MAP	Displays 90 degrees of compass rose.
	Current heading pointer (W)	MAP, MAP CTR, mini-map	Points to current heading on the compass rose.
	Groundspeed (W)	All	Current groundspeed.
	True airspeed (W)	All	Current true airspeed displayed above 100 knots.

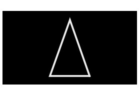
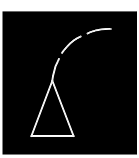
Symbol	Name	ND Mode	Remarks
	Wind direction/ speed and wind arrow (W)	All	Indicates wind bearing, speed, and direction, with respect to display orientation and heading/track reference. Arrow not displayed in the PLAN map mode.

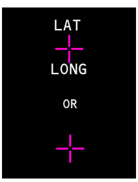
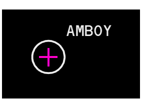
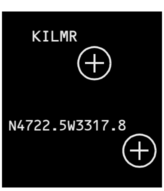
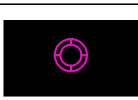
Radio Navigation

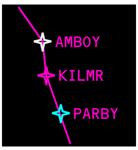
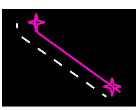
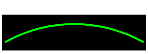
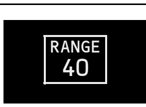
Symbol	Name	ND Mode	Remarks
	Left VOR (G) pointer head and tail	MAP, MAP CTR	Indicates bearing to (head) or from (tail) the tuned station, if selected on the respective MAP or MAP CTR pull-down menu.
	Right VOR (G) pointer head and tail		
	VOR (C, G), DME/TACAN (C, G), VORTAC (C, G)	MAP, MAP CTR, PLAN	When the STA key is selected, appropriate navaids are displayed (C). Tuned VHF navaids are displayed in green, regardless of menu key selection. When a navaid is manually tuned, the selected course and reciprocal are displayed.
	VOR/DME raw data radial and distance (G)		When the POS key is selected, the station radial extends to the airplane.
	VOR (G) selection	MAP, MAP CTR	Located lower left or right corner. Represents positions selected on the MAP or MAP CTR pull-down menu.

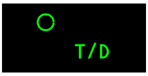
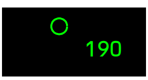
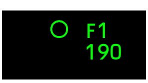
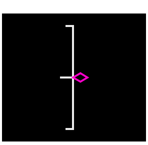
Symbol	Name	ND Mode	Remarks
	VOR frequency or identifier (G)	MAP, MAP CTR	Frequency is displayed before identifier is decoded. Decoded identifier replaces the frequency. Small size characters indicate only DME information is being received.
	DME distance (G)	MAP, MAP CTR	Indicates DME distance to the referenced navaid.

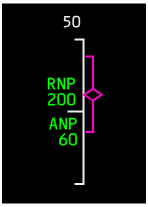
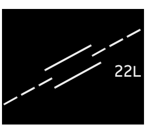
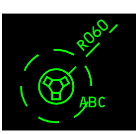
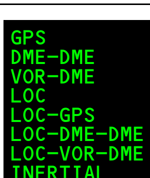
Map

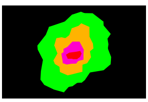
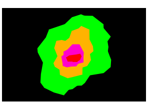
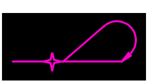
Symbol	Name	ND Mode	Remarks
	Airplane symbol (W), lateral path deviation (W), lateral ANP/RNP values (G, A)	MAP, MAP CTR	Current airplane position is at the apex of the triangle. Displays lateral path deviation distance. When ANP exceeds RNP, the ANP/RNP labels and values are displayed in amber.
	Airplane symbol (W)	mini-map	Current airplane position is at the apex of the triangle.
	Position trend vector (W) (dashed line)	MAP, MAP CTR, mini-map	Predicts position at the end of 30, 60, and 90 second intervals. Each segment represents 30 seconds. Based on bank angle and groundspeed. Selected range determines the number of segments displayed. For range: • greater than 20 NM, 3 segments • = 20 NM, 2 segments • = 10 NM, 1 segment

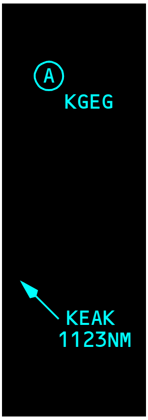
Symbol	Name	ND Mode	Remarks
	Airplane symbol (W)	PLAN	Indicates actual position and track along the flight plan route. Symbol changes to a circle north of 82N latitude and south of 82S latitude.
	Waypoint: active (M), inactive (W)	MAP, MAP CTR, PLAN, mini-map	Active – represents the waypoint the airplane is currently navigating to. Inactive – represents the waypoints on the active route.
	Pick waypoint (PICK WPT) cursor (M)	MAP, MAP CTR, PLAN	Displayed when the PICK WPT key is selected. When the cursor highlights a waypoint, airport, or navaid, the letters LAT and LONG are removed.
	Highlighted waypoint (W)	MAP, MAP CTR, PLAN	Displayed when a visible route waypoint, background waypoint, airport, or navigation aid is passed over by the cursor.
	Temporary waypoint (W)	MAP, MAP CTR, PLAN	Displayed after a waypoint is selected when PICK WPT cursor is active. Displays selected waypoint name if visible waypoint, airport, or navigation aid is selected. Displays latitude and longitude if visible waypoint, airport, or navigation aid is not selected.
	Cursor shape for Center on Cursor mode (M)	PLAN	Displayed when Center on CURSOR key is selected.

Symbol	Name	ND Mode	Remarks
	Off route waypoint (C)	MAP, MAP CTR	When the WPT key is selected, waypoints not on the selected route are displayed, in ND ranges of 10, 20, or 40.
	Flight plan route: active (M), modified (W), inactive (C)	MAP, MAP CTR, mini-map, PLAN	The active route is displayed with a continuous line (M) between waypoints. Active route modifications are displayed with short dashes (W) between waypoints. Inactive routes are displayed with long dashes (C) between waypoints.
	Offset path and identifier: active route (M), modified route (W)	MAP, MAP CTR, mini-map, PLAN	Presents a dashed line parallel to and offset from the active or modified route.
	Route data: active waypoint (M), inactive waypoint (W)	MAP, MAP CTR, mini-map	When the DATA key is selected, entered or procedural altitude and ETAs for route waypoints are displayed. Times are based on distance to go and groundspeed. They do not consider FMC performance predictions and may differ from other FMC ETAs that do.
	Altitude range arc (G)	MAP, MAP CTR, mini-map	Based on vertical speed and groundspeed, indicates the approximate map position where the MCP altitude will be reached.
	Range readout (W)	MAP, MAP CTR, PLAN	Shows the current selected range.

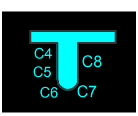
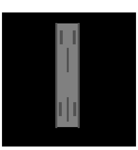
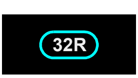
Symbol	Name	ND Mode	Remarks
	Altitude profile point and identifier (G)	MAP, MAP CTR, mini-map	Indicates the approximate map position of the FMC–calculated T/C (top–of–climb), T/D (top–of–descent), S/C (step climb), and E/D (end of descent) points. Predicted altitude/ETA points entered on the FIX page display the altitude/ETA along with the profile point. Deceleration points have no identifier.
	Speed profile point and settings (G)	MAP, MAP CTR, mini-map	Indicates the approximate map position for FMC-calculated speed settings. Position and settings are calculated to be on speed, on path and on time at the final approach fix.
	Flap speed profile point and settings (G)	MAP, MAP CTR, mini-map	Indicates the approximate map position for FMC-calculated flap and speed settings. Flap setting is indicated only for flaps 1, 5, and 20. Position and settings are calculated to be on speed, on path and on time at the final approach fix.
	VNAV path pointer (M) and deviation scale (W)	MAP, MAP CTR	Displays vertical deviation from selected VNAV PATH during descent only. Scale indicates ± 400 feet deviation. Digital display is provided when the pointer indicates more than ± 400 feet.

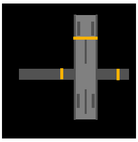
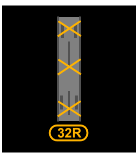
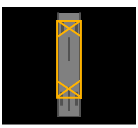
Symbol	Name	ND Mode	Remarks
	Path deviation band (M), vertical path deviation (W), vertical ANP/RNP values (G)	MAP, MAP CTR	Path deviation band is symmetric about the pointer and represents vertical RNP. Whenever ANP exceeds RNP, the ANP/RNP labels and values are displayed in amber.
	Airport and runway (W)	MAP, MAP CTR, PLAN	Displayed when selected as the origin or destination and ND range is 80, 160, 320, or 640 NM.
	Airport (C)	MAP, MAP CTR, PLAN	Displayed when the APT key is selected. Origin and destination airports are always displayed, regardless of map switch selection.
	Airport and runway (W)	MAP, MAP CTR, PLAN	Displayed when selected as the origin or destination and ND range is 10, 20, or 40 NM. Dashed runway centerlines extend 14.2 NM.
	Energy management circles (C, W)	MAP, MAP CTR	Indicates clean (C) and speedbrake (W) energy management circles as defined on the CDU OFFPATH DES page.
	Selected reference point and bearing distance information (G)	MAP, MAP CTR, PLAN	Displays the reference point selected on the CDU FIX page. Bearing and/or distance from the fix are displayed with dashes (G).
	FMC position update status (G)	MAP, MAP CTR, mini-map	Indicates the system providing FMC position update.

Symbol	Name	ND Mode	Remarks
	GPS position (W)	MAP, MAP CTR	When the POS key is selected, indicates GPS position relative to FMC position.
	IRU position (W)	MAP, MAP CTR	When the POS key is selected, the star indicates IRU position relative to FMC position.
	Weather radar returns (R, A, G, M)	MAP, MAP CTR, VOR, APP	The most intense areas are displayed in red, lesser intensity in amber, and lowest intensity green. Turbulence is displayed in magenta.
	Weather radar returns (R, A, G, M)	MAP, MAP CTR, mini-map	The most intense areas are displayed in red, lesser intensity in amber, and lowest intensity green. Turbulence is displayed in magenta.
STA WPT ARPT	Selected map options (C)	MAP, MAP CTR, mini-map	Displays MAP menu selected map options.
N↑	North up arrow (G)	PLAN	Indicates map background is oriented and referenced to true north.
	Holding pattern: active route (M), modified route (W), inactive route (C)	MAP, MAP CTR, PLAN	A holding pattern appears when in the flight plan. Depicts entry path until entry completed.
	Procedure turn: active route (M), modified route (W), inactive route (C)	MAP, MAP CTR, PLAN	A procedure turn appears when in the flight plan. It increases in size upon entering the procedure turn. Also used for procedure hold course reversal.

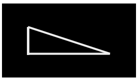
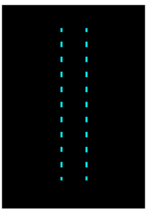
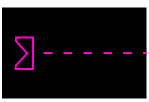
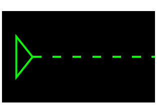
Symbol	Name	ND Mode	Remarks
	Alternate airports (C)	MAP, MAP CTR, PLAN	PLAN: displays up to four alternate airports at all times. MAP, MAP CTR: displays the FMC or pilot selected primary alternate airport. Displays up to four alternate airports when the APT key is selected. Offscale airports (only with 1280NM scale selected), directional arrow relative to airplane position or PLAN center point and distance.

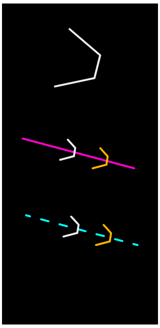
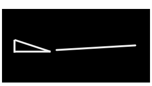
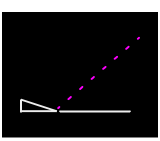
Airport Map

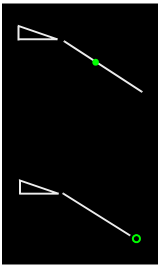
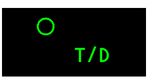
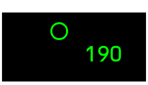
Symbol	Name	ND Mode	Remarks
	Airport beacon (W)	MAP, MAP CTR, PLAN	Displayed at ranges 2, 1, and 0.5 NM.
	Airport identifier (W)	MAP, MAP CTR, PLAN	Displayed at ranges 2, 1, and 0.5 NM.
	Concourse and gates (C)	MAP, MAP CTR, PLAN	Concourse is displayed at ranges 2, 1, and 0.5 NM. Gates are displayed at ranges 1, and 0.5 NM.
	Runway	MAP, MAP CTR, PLAN	Displayed at ranges 5, 2, 1, and 0.5 NM.
	Runway identifier (W, C)	MAP, MAP CTR, PLAN	Displayed at ranges 2, 1, and 0.5 NM.

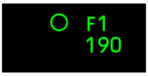
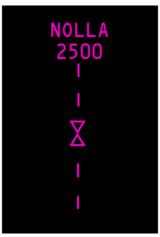
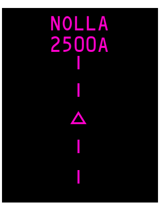
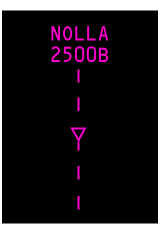
Symbol	Name	ND Mode	Remarks
	Taxiway holding position, land and hold short line (A)	MAP, MAP CTR, PLAN	Taxiway holding position displayed at ranges 1 and 0.5 NM. Land and hold short line displayed at ranges 2, 1, and 0.5 NM.
	Closed runway indications (A)	MAP, MAP CTR, PLAN	Displayed at ranges 5, 2, 1, and 0.5 NM.
	Partially closed runway indications (A)	MAP, MAP CTR, PLAN	Displayed at ranges 5, 2, 1, and 0.5 NM.
	Stopway / blast pad, stopway chevrons	MAP, MAP CTR, PLAN	Stopway / blast pad displayed at ranges 5, 2, 1, 0.5 NM. Chevrons displayed at ranges 2, 1, 0.5 NM.
	Taxiway and taxiway identifier	MAP, MAP CTR, PLAN	Taxiway is displayed at ranges 5, 2, 1, 0.5 NM. Taxiway identifier is displayed at ranges 2, 1, and 0.5 NM.
	Closed taxiway indications (A)	MAP, MAP CTR, PLAN	Displayed at ranges 2, 1, and 0.5 NM.
	De-icing area (W, C)	MAP, MAP CTR, PLAN	Displayed at ranges 1 and 0.5 NM.
	Helicopter landing area (W, C)	MAP, MAP CTR, PLAN	Displayed at ranges 1 and 0.5 NM.

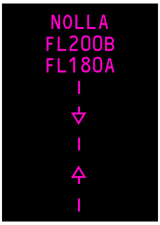
Vertical Situation Display (VSD)

Symbol	Name	ND Mode	Remarks
	Airplane symbol (W)	MAP, MAP CTR	Current airplane altitude is the bottom of the triangle. Current airplane lateral position relative to terrain is the point of the triangle.
	Enroute swath (C) (dashed line)	MAP, MAP CTR	Indicates area of the map that is shown on the VSD. Displayed full time when VSD is selected. During turns, the swath edge leading the turn opens in the direction of the turn.
	Selected altitude bug and line (M)	MAP, MAP CTR	Bug indicates the altitude set in the MCP altitude window. When the selected altitude is off scale, the bug is parked at the top or bottom, with only one half the bug visible. Dashed line extends from bug to background display boundary. Line does not park.
	BARO minimums pointer and line (G)	MAP, MAP CTR	Pointer indicates the barometric minimums selected on the EFIS control panel. Dashed line extends from pointer to background display boundary. Pointer and line turn amber when airplane descends below selected minimum altitude. Reset with the RST switch on the EFIS control panel.

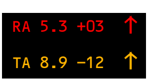
Symbol	Name	ND Mode	Remarks
	Decision gates (W, A)	MAP, MAP CTR	Indicates suggested points where airplane should be path and speed stable on approach. Gates are placed on the 3 Degree Reference Line or FMC Approach Glidepath Angle Line: • at 1000 feet above field elevation (W) • at 500 feet above field elevation (A) Decision gates that are below the missed approach waypoint altitude are not displayed.
	Flight path vector (W)	MAP, MAP CTR	Fixed length line indicates current flight path angle and rotates about the point of the triangle. Angle of the line is dependent on the vertical speed and groundspeed of the airplane.
	MCP selected vertical speed vector (M)	MAP, MAP CTR	Dashed line indicates the selected vertical speed as a target angle when the MCP V/S mode is selected. Extends to the edge of the background display and rotates about the point of the triangle.

Symbol	Name	ND Mode	Remarks
	Range to target speed dot (G)	MAP, MAP CTR	Indicates where the airplane will achieve the FMC or MCP target speed. If the airplane is within 5 knots of target speed, the dot blanks. If the airplane increases 10 knots or more faster than target speed, the dot reappears. Displayed at the end of the Flight Path Vector as an unfilled dot if target speed will not be achieved within the vector length.
	Altitude profile point and identifier (G)	MAP, MAP CTR	Indicates the approximate map position of the FMC–calculated T/C (top–of–climb), T/D (top–of–descent), S/C (step climb), and E/D (end of descent) points. Predicted altitude/ETA points entered on the FIX page display the altitude/ETA along with the profile point. Deceleration points have no identifier.
	Speed profile point and settings (G)	MAP, MAP CTR	Indicates the approximate map position for FMC-calculated speed settings. Position and settings are calculated to be on speed, on path and on time at the final approach fix.

	Flap speed profile point and settings (G)	MAP, MAP CTR	Indicates the approximate map position for FMC-calculated flap and speed settings. Flap setting is indicated only for flaps 1, 5, and 20. Position and settings are calculated to be on speed, on path and on time at the final approach fix.
	Waypoint altitude constraint: active (M), inactive (W)	MAP, MAP CTR	At Altitude example.
	Waypoint altitude constraint: active (M), inactive (W)	MAP, MAP CTR	At or Above Altitude example.
	Waypoint altitude constraint: active (M), inactive (W)	MAP, MAP CTR	At or Below Altitude example.

Symbol	Name	ND Mode	Remarks
	Waypoint altitude constraint: active (M), inactive (W)	MAP, MAP CTR	Block Altitude example.

TCAS

Symbol	Name	ND Mode	Remarks
	TCAS resolution advisory (RA), relative altitude (R)	MAP, MAP CTR, mini-map	Refer to Chapter 15, Warning Systems for display criteria. The arrow indicates traffic climbing or descending at a rate greater than or equal to 500 fpm. At rates less than 500 fpm, the arrow is not displayed. The number and associated signs indicate altitude of traffic in hundreds of feet relative to the airplane. The number is below the traffic symbol when the traffic is below, and above the traffic symbol when the traffic is above the airplane. Absence of the number implies altitude unknown.
	TCAS traffic advisory (TA), relative altitude (A)		
	TCAS proximate traffic, relative altitude (W)		
	TCAS other traffic, relative altitude (W)		
	TCAS no bearing message (RA–R, TA–A)	MAP, MAP CTR, mini-map	Message provides traffic type, range in NM, altitude and vertical direction.
	TCAS traffic alert message (RA–R, TA–A)	All	Displayed whenever a TCAS RA or TA is active. EFIS control panel TFC switch does not have to be selected on.

Symbol	Name	ND Mode	Remarks
OFFSCALE	TCAS off scale message (RA–R, TA–A)	MAP, MAP CTR, mini-map	Displayed whenever RA or TA traffic is outside the traffic area covered by the ND range. Refer to Chapter 15, Warning Systems for display criteria.
TFC	TCAS mode (C)	MAP, MAP CTR, mini-map	Indicates the ND TCAS display is active.
TA ONLY	TCAS mode (C)	All	Indicates TCAS computer is not computing RAs. Displayed whether the EFIS control panel TFC switch is selected on or off.
TCAS TEST	TCAS mode (C)	All	Indicates TCAS is operating in the test mode. Displayed whether EFIS control panel TFC switch is selected on or off.
TCAS OFF	TCAS mode (A)	MAP, MAP CTR, mini-map	Displayed when the TCAS/ATC mode switch is not in TA ONLY or TA/RA, if traffic is selected. Not displayed if TCAS is failed.
TCAS FAIL	TCAS mode (A)	MAP, MAP CTR, mini-map	Indicates TCAS failure, if traffic is selected.

Radar

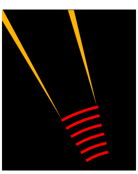
Symbol	Name	ND Mode	Remarks
TEST	Weather radar (WXR) test mode (C) (A)	MAP, MAP CTR, mini-map	Weather radar system is selected on the EFIS control panel or MAP mode pull-down menu (refer to Chapter 11, Flight Management, Navigation).
WXR	WXR precipitation only mode (C)		
WX+T	WXR and turbulence mode (C)		
VAR	WXR receiver gain (C)		
MAP	Mode used with down–tilt when ground mapping (C)		
+15.0 to −15.0	WXR antenna tilt (C)		
WXR FAIL	WXR system failure (A)		
RT	WXR receiver transmitter failure (A)		
ANT	WXR antenna failure (A)		
CONT	WXR control panel failure (A)		
ATT	WXR loss of attitude data (A)		
WEAK	WXR calibration fault (A)		

Look-Ahead Terrain

Symbol	Name	ND Mode	Remarks
TERR	Terrain mode annunciation (C)	MAP, MAP CTR, mini-map	Terrain display enabled (manual or automatic display).
TERR TEST	Terrain test mode annunciation (C)	All	GPWS operating in self-test mode.

Symbol	Name	ND Mode	Remarks
TERRAIN	Terrain annunciation (R, A)	All	Look-ahead terrain caution alert active (A), look-ahead terrain warning alert active (R).
TERR FAIL	Terrain status annunciations (A)	MAP, MAP CTR, mini-map	Look-ahead terrain alerting and display have failed.
TERR POS		MAP, MAP CTR, mini-map	Look-ahead terrain alerting and display unavailable due to position uncertainty.
TERR OVRD		MAP, MAP CTR, mini-map	GPWS terrain inhibit switch in TERR INHIBIT position.

Predictive Windshear

Symbol	Name	ND Mode	Remarks
	Predictive windshear symbol (R, C, A)	MAP, MAP CTR, mini-map	Displays windshear location and approximate geometric size (width and depth). Amber radials extend from predictive windshear symbol to help identify location of windshear event.
WINDSHEAR	Windshear annunciation (R, A)	All	Predictive windshear caution active (A). Predictive windshear warning active (R).

Flight Instruments, Displays — Chapter 10
Electronic Checklist Displays — Section 50

Normal Checklist

1 Cursor Selection Box

Highlights cursor selection area.

2 Open Loop Indicator

Indicates line item is an open loop action item. Requires crew confirmation to become complete.

3 Complete Indicator

Indicates line item is complete.

4 Normal Checklist (NORMAL) Key

Select –

- displays next incomplete normal checklist
- displays normal checklists menu page when all normal checklists are complete

5 Line Item Override (ITEM OVRD) Key

Select – overrides line item in current line item box. Item is displayed cyan.

6 Checklist Line Item

Displayed (white) –

- when action is required, line item is incomplete
- when action is not required, line item remains white and is complete

Displayed (green) – line item is complete.

Displayed (cyan) – line item is inactive or overridden.

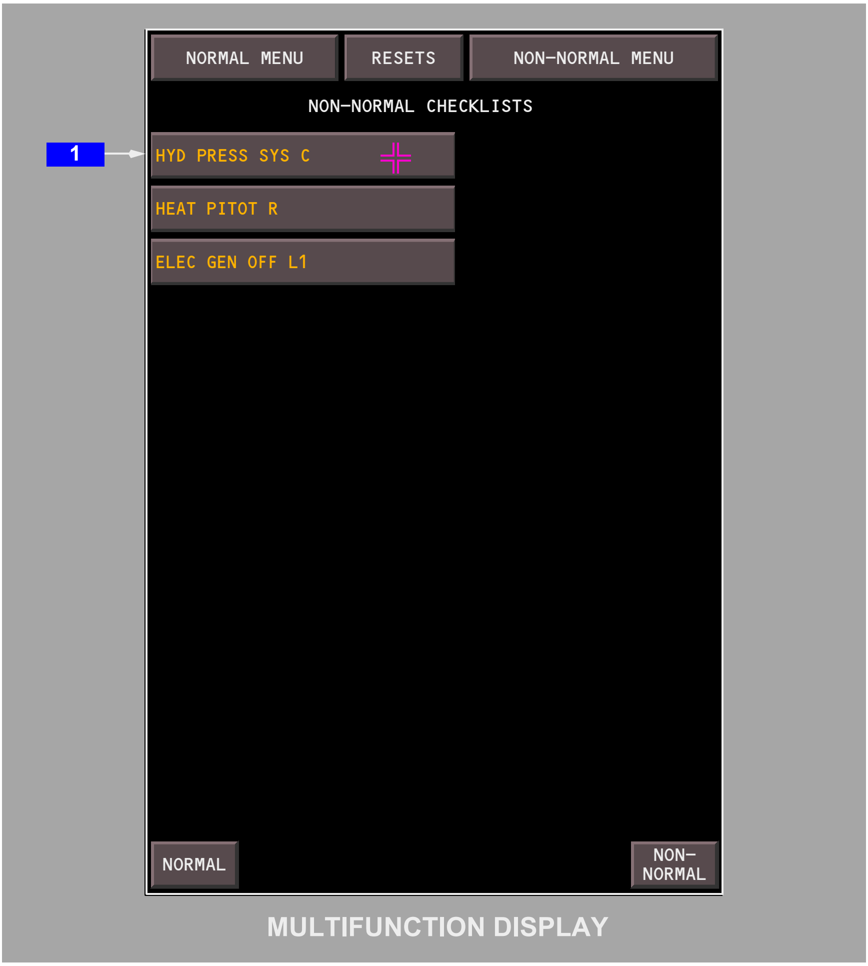
7 Current Line Item Box

Highlights current incomplete line item.

8 Checklist Reset (CHKL RESET) Key

Select – resets displayed checklist. All open loop line items become incomplete and current line item box, cursor selection box, and cursor move to first incomplete line item.

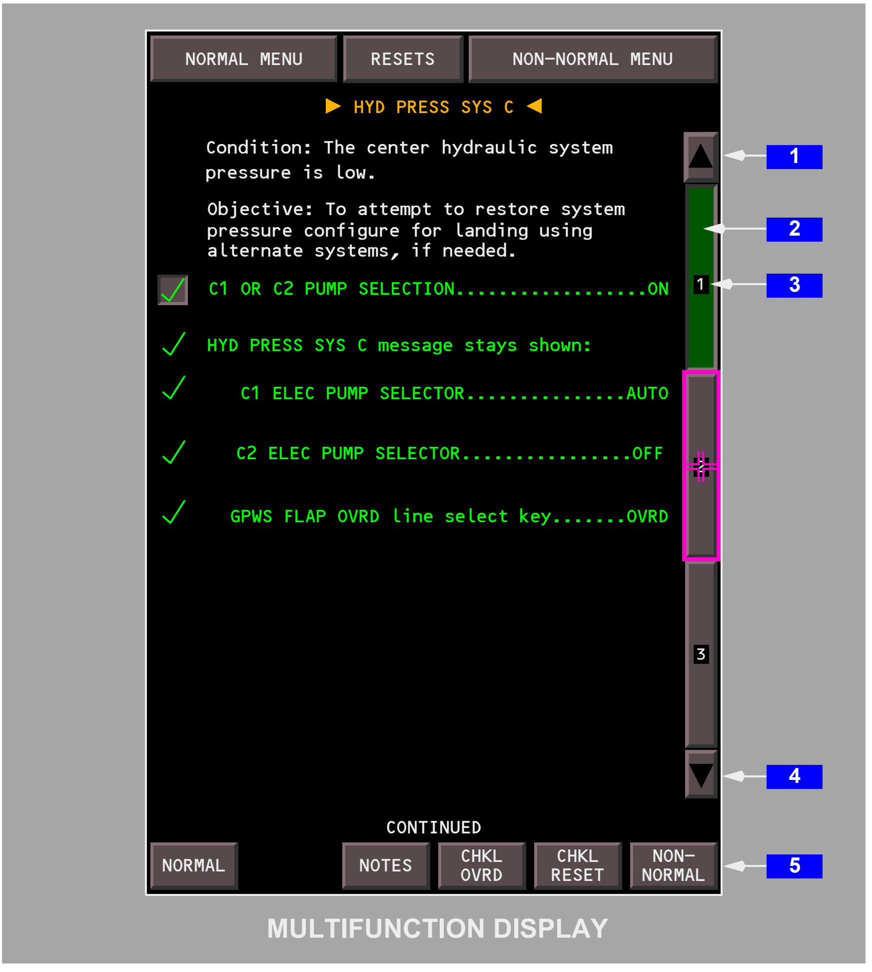
Non–Normal Checklist Queue



1 **Checklist Key**

Select – displays checklist corresponding to title on key.

Non–Normal Checklist



1 **Previous Page Key**

Select – displays previous checklist page.

Displayed (gray) – previous page is available.

Displayed (cyan) – key is inactive. First page of checklist is displayed.

2 **Checklist Page Key**

Select – displays checklist page corresponding to page number on key.

Displayed (white) – checklist page corresponding to page number on key is currently displayed.

Displayed (gray) – checklist page corresponding to page number on key is not currently displayed.

3 Checklist Page Number

Displayed (white) – checklist page is incomplete.

Displayed (green) – checklist page is complete.

4 Next Page Key

Select – displays next checklist page.

Displayed (gray) – next page is available.

Displayed (cyan) – key is inactive. Last page of checklist is displayed.

5 Non–Normal Checklist (NON–NORMAL) Key

Displayed when additional incomplete non–normal checklists exist.

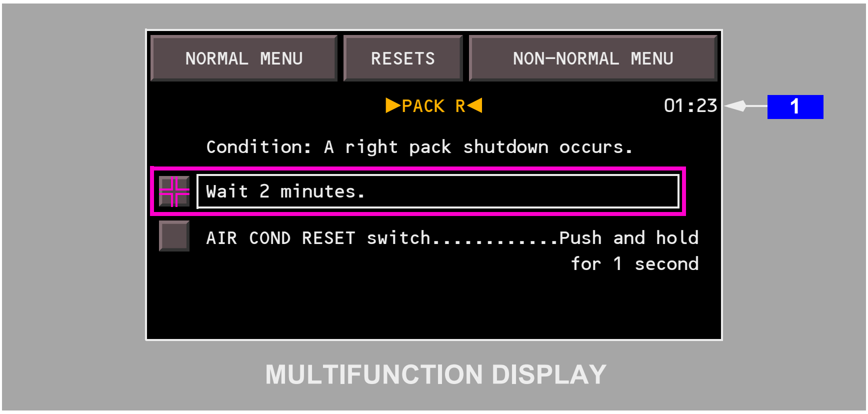
Select –

- displays next incomplete non–normal checklist when one incomplete non–normal checklist exists
- displays non–normal checklist queue when more than one incomplete non–normal checklist exists

Displayed (white) – incomplete non–normal checklist has not been displayed.

Displayed (amber) – incomplete non–normal checklist has been displayed but is not currently displayed.

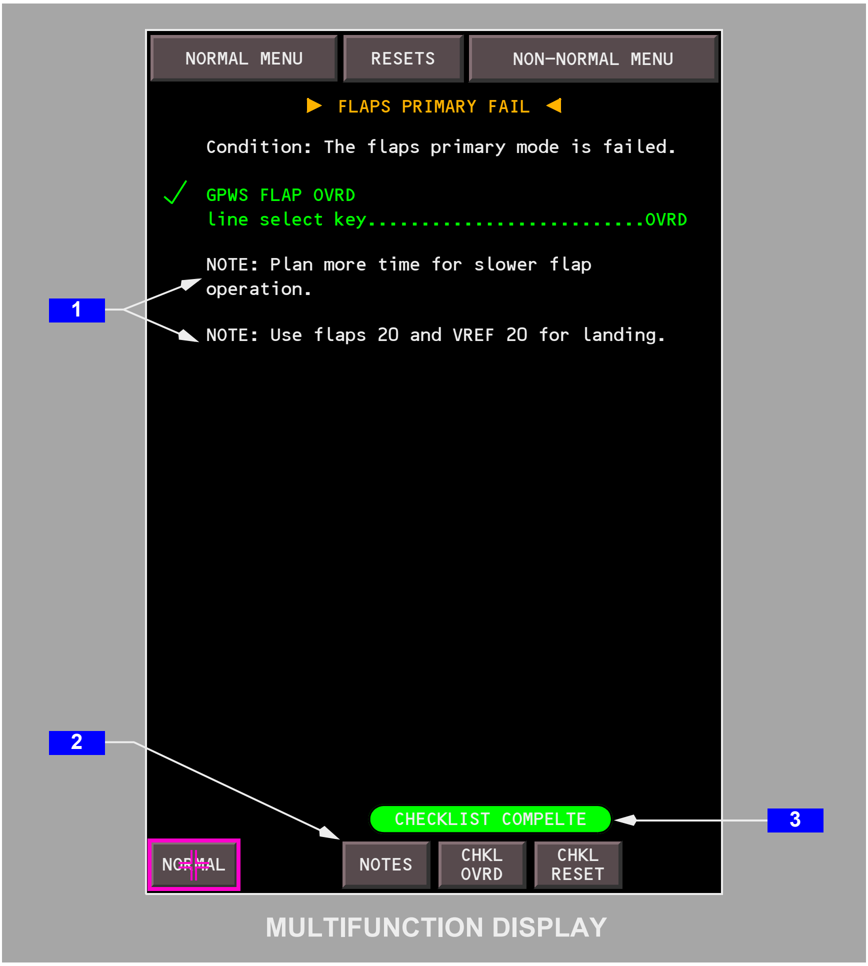
Checklist Timer



1 Timer

Displays time remaining of time delay associated with line item in current line item box. If line item is complete, current line item box remains until timer expires.

Operational Note



1 Operational Notes

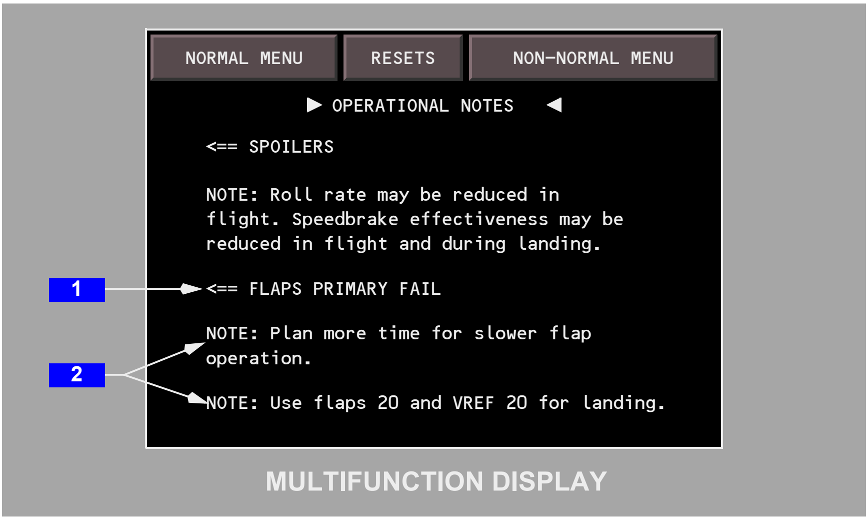
Shown in non–normal checklist.

2 Operational Notes (NOTES) Key

Select – displays operational notes page.

3 CHECKLIST COMPLETE Indicator

Displayed when all line items are either complete, inactive, or overridden, and all pages have been displayed.



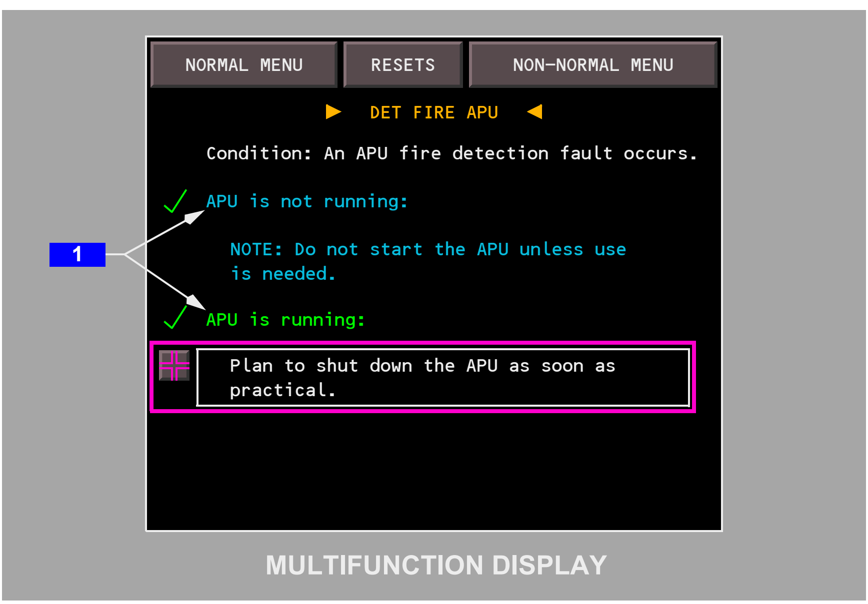
1 **Checklist Reference**

References non–normal checklist from which operational notes originated.

2 **Operational Notes**

Shown on operational notes page.

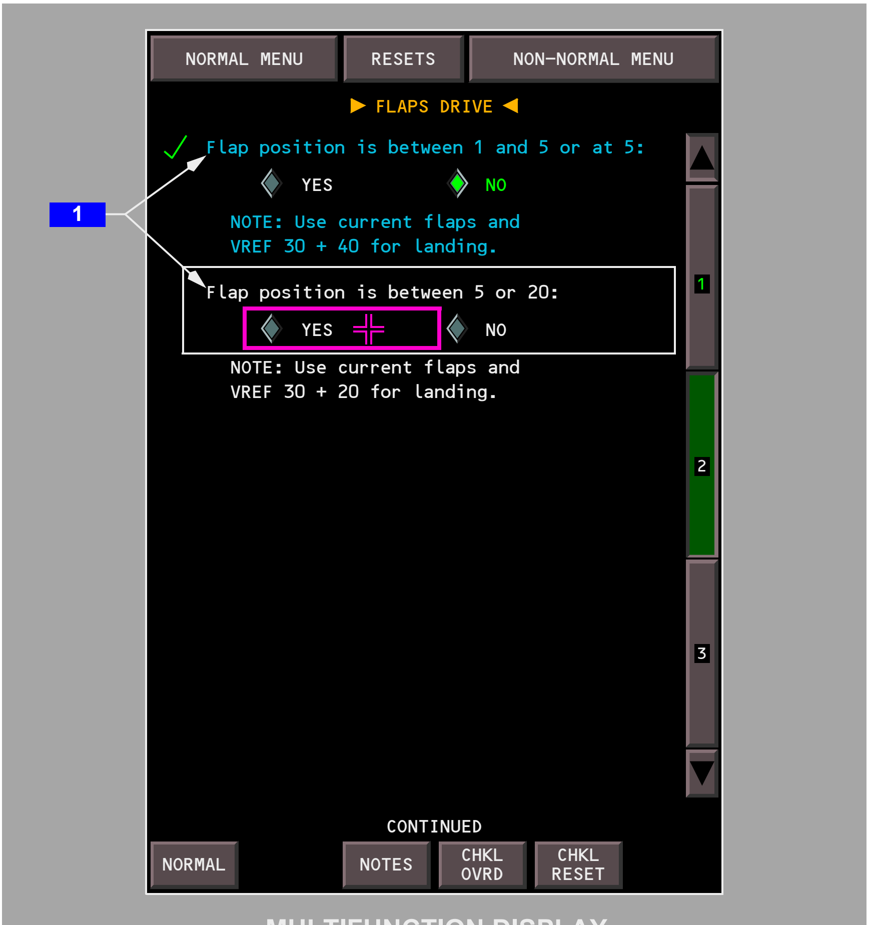
Conditional Line Item



1 Closed Loop Conditional Line Items

Displayed (cyan) – conditional line item is sensed false. All subsequent line items associated with the conditional line item become inactive and are displayed cyan. Current line item box, cursor selection box, and cursor skip inactive items and move to next incomplete line item.

Displayed (green) – conditional line item is sensed true. Current line item box, cursor selection box, and cursor move to next incomplete line item.



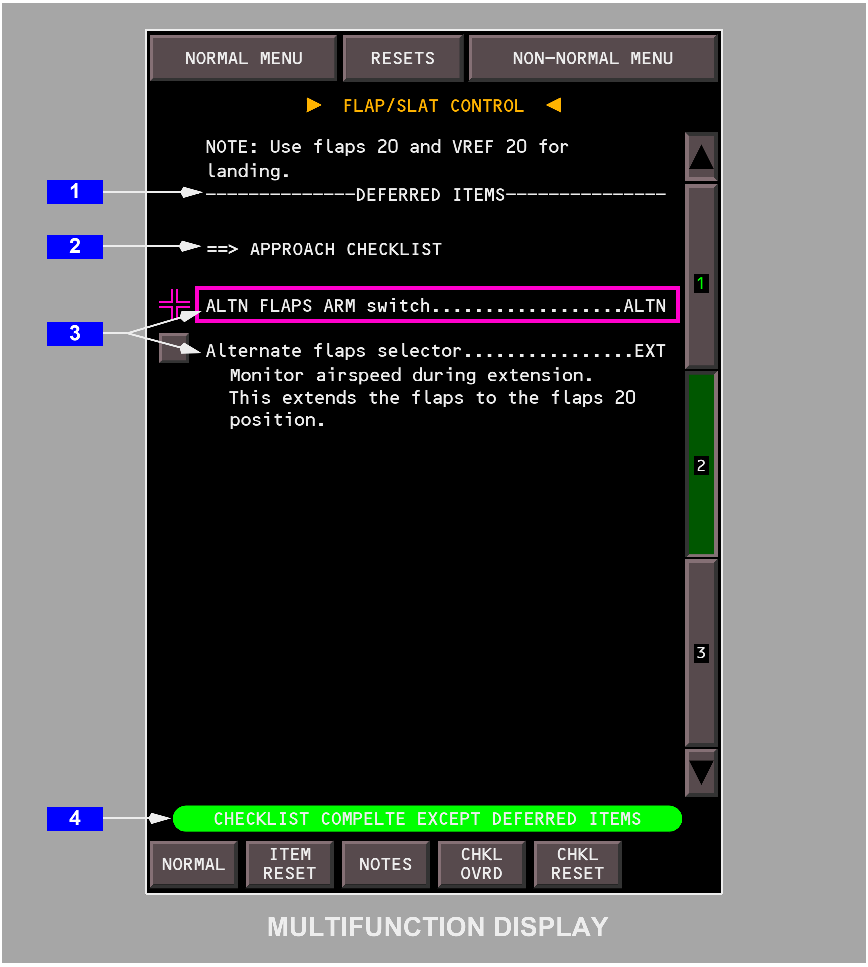
MULTIFUNCTION DISPLAY

1 Open Loop Conditional Line Items

Displayed (cyan) – conditional line item is selected NO. All subsequent line items associated with the conditional line item become inactive and are displayed cyan. Current line item box, cursor selection box, and cursor skip inactive items and move to next incomplete line item.

Displayed (green) – conditional line item is selected YES. Current line item box, cursor selection box, and cursor move to next incomplete line item.

Deferred Line Item



1 **Deferred Line Items Separator**

Separates deferred line items from non–normal checklist line items. All line items below separator are deferred.

2 **Checklist Reference**

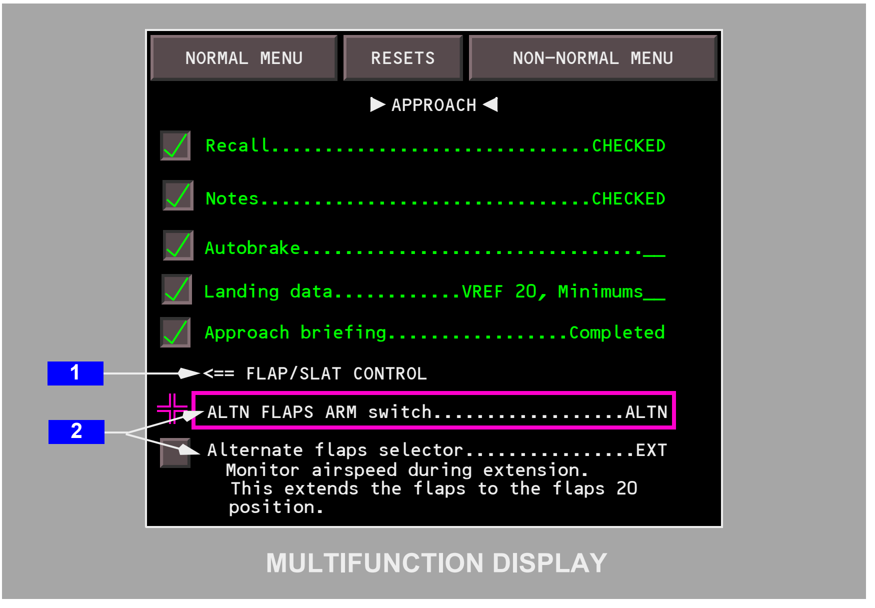
References normal checklist to which deferred line items are targeted.

3 **Deferred Line Items**

Shown in non–normal checklist.

4 **CHECKLIST COMPLETE EXCEPT DEFERRED ITEMS Indicator**

Displayed when all line items except deferred line items are either complete, inactive, or overridden, and all pages before the deferred line items separator have been displayed.



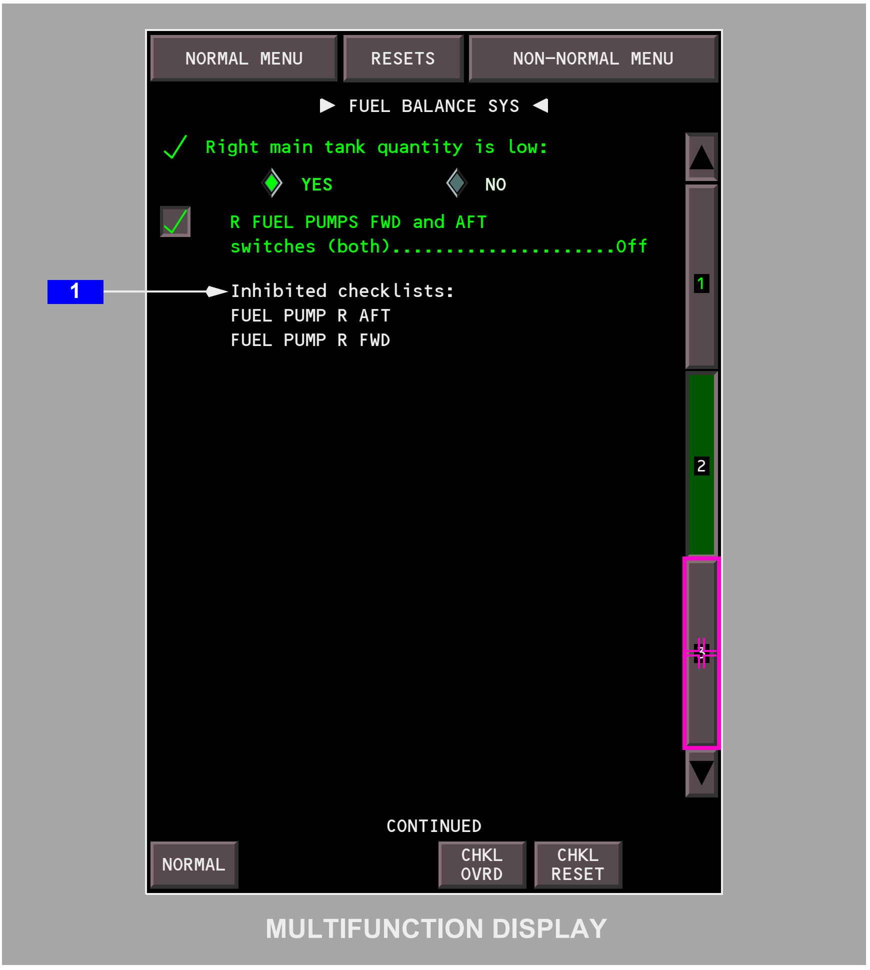
1 **Checklist Reference**

References non–normal checklist from which deferred line items originated.

2 **Deferred Line Items**

Shown in normal checklist.

Inhibit Checklist Line Item



1 Inhibit Checklist Line Item

Lists consequential checklists which are inhibited or removed from the checklist queue and whose corresponding checklist icons are inhibited or removed from display.

Checklist Override

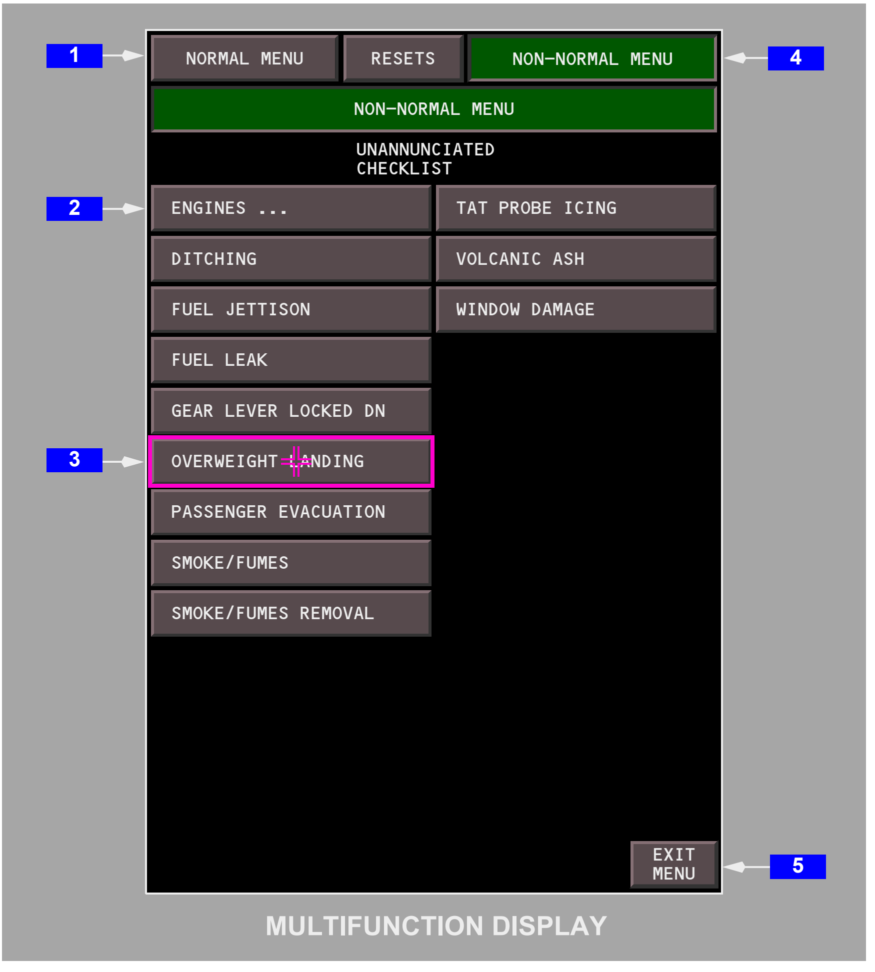
1 **Checklist Override (CHKL OVRD) Key**

Select – overrides displayed checklist.

1 CHECKLIST OVERRIDDEN Indicator

Displays when checklist is overridden. All line items are displayed cyan.

Checklists Menu Page



1 NORMAL MENU Key

Select – displays normal checklists menu page. Page contains checklist keys corresponding to the normal checklists.

2 Menu Key

Indicated by three dots following menu title.

Select – displays checklists menu page corresponding to title on key.

3 Checklist Key

Select – displays checklist corresponding to title on key.

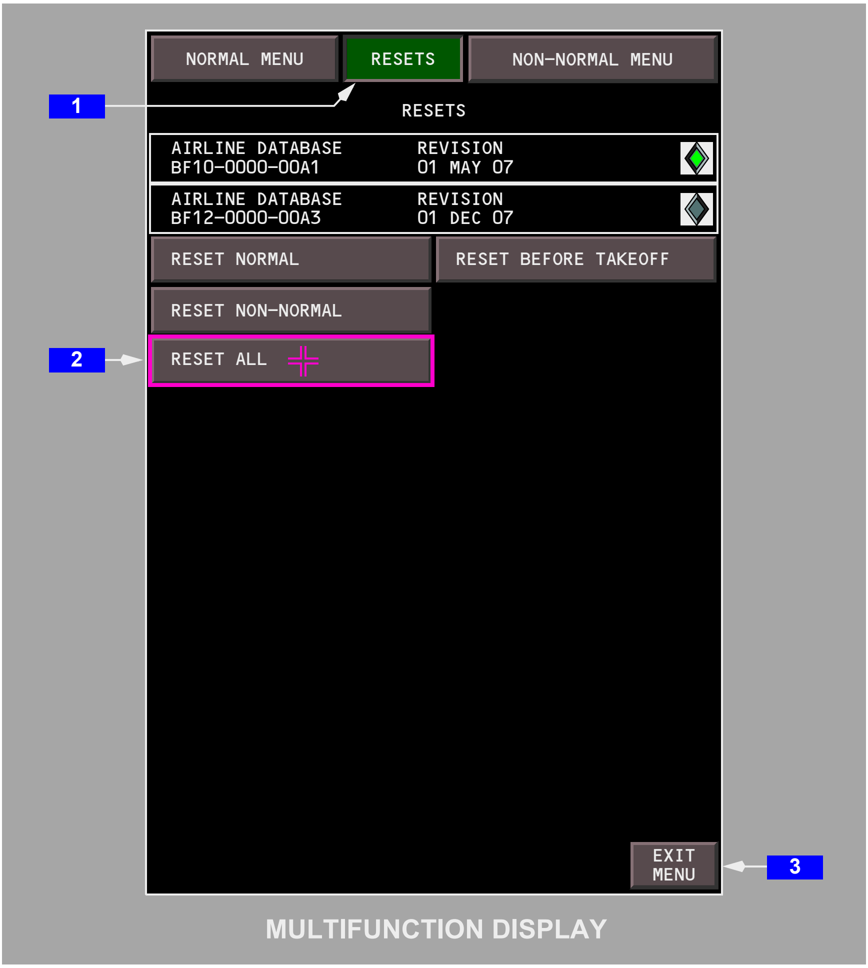
4 **NON–NORMAL MENU Key**

Select – displays non–normal checklists menu page. Page contains menu keys corresponding to airplane systems.

5 **EXIT MENU Key**

Select – exits page for access to the normal and non–normal checklist keys.

Resets Menu Page



1 **Resets Menu (RESETS) Key**

Select – displays checklist resets page.

2 **Reset Key**

Select – resets checklists corresponding to title on key. All affected checklists become incomplete.

3 **EXIT MENU Key**

Select – exits page for access to the normal and non–normal checklist keys.

Flight Instruments, Displays — Chapter 10
Electronic Checklist Description — Section 60

Introduction

Normal and non–normal electronic checklists can be displayed on any selected multifunction display (MFD). The electronic checklist system is not required for dispatch, and a paper checklist must be available on the flight deck.

Electronic checklists can be displayed on any MFD by pushing the checklist display switch on the display select panel. The checklists are controlled using either one of the two cursor control devices (CCDs). Cursor control devices and MFD selection are described in the System Description section of this chapter.

Electronic Checklist Operation

Pushing the checklist display switch on the display select panel displays the proper checklist (see Checklist Access, this section, for the checklist display priority order). Only one checklist is displayed at a time.

Three types of checklists can be displayed:

- normal
- non–normal associated with EICAS messages (annunciated)
- non–normal not associated with EICAS messages (unannunciated)

As each normal checklist is completed, pushing the checklist display switch displays the next sequential normal checklist.

Some checklist steps must be checked–off by the pilot to be completed. Other checklist steps are automatically checked–off from sensed flight deck control positions, airplane system status, and/or EICAS messages.

Checklist Status

The CHECKLIST COMPLETE indicator is displayed at the bottom of all pages of the checklist when all of the line items are either complete, inactive, or overridden, and every page has been displayed. If the flight crew chooses not to perform a particular line item, the line item can be overridden by selecting the ITEM OVRD key at the bottom of the page. When a line item is overridden, the text changes color from white to cyan and the current line item box moves down to the next incomplete line item. If the flight crew chooses to not perform an entire checklist, the checklist can be overridden by selecting the CHKL OVRD key at the bottom of the page. When a checklist is overridden, the text of the entire checklist changes color from white to cyan, and the CHECKLIST OVERRIDDEN indicator is displayed at the bottom of all pages.

Checklist Pages

The checklist is displayed on one or more pages. Page keys are located on the right side of each checklist containing more than one page. Page keys are not shown on checklists containing only one page.

When a checklist is complete and there are no additional checklists in the non-normal checklist queue, the cursor automatically moves to the normal checklist key in the lower left corner of the display. Pressing the cursor select switch displays the next sequential normal checklist. If there is one or more checklists in the non-normal queue, the cursor automatically moves to the non–normal checklist key in the lower right corner of the display. Pressing the cursor select switch displays the next appropriate non-normal checklist (if only one is in the queue) or the non-normal checklist queue.

When a checklist has more than one page, and the checklist steps on the current page are complete, the cursor automatically moves to the checklist page key corresponding to the next page. CONTINUED is displayed on the bottom of the page. Pressing the cursor select switch advances to the next checklist page. When the last page is complete, the cursor moves to the normal or non–normal checklist key as described above.

Checklist Line Items

Each step in a checklist is referred to as a line item. After selecting a checklist, the current line item box automatically encloses the text of the first incomplete line item. When the cursor is on that line item, the cursor selection box encloses the current line item box. When the line item becomes complete, the cursor, cursor selection box, and current line item box move to the next incomplete line item.

Incomplete checklist line items appear as white text. Complete line items appear as green text with a complete indicator (green check mark) to the left. Overridden and inactive line items are displayed in cyan.

Closed Loop Line Items

Closed loop line items are steps in the checklist that involve the continuous and automatic monitoring of switch, lever, or selector position. In a limited number of cases, actual system state, such as flap or landing gear position, is monitored. When the control is in the required position, the line item text color changes from white to green. In addition, a complete indicator is displayed left of the line item. The current line item box then moves to the next line item to be completed.

Open Loop Line Items

Open loop line items are steps in the checklist that require the flight crew to manually confirm completion by using the CCD cursor select switch. Open loop line items do not provide any monitoring of control position or system state. Open loop line items rely on the flight crew to confirm that the required action has been completed, or that a specific condition exists. Open loop line items can be distinguished from closed loop line items by display of the open loop indicator, a gray box located to the left of the line item. When the cursor is positioned within the current line item box or open loop indicator, and the CCD cursor select switch is pressed, the checklist line item text color changes from white to green and a complete indicator is displayed on the open loop indicator. The current line item box then moves to the next line item to be completed.

Operational Notes

Checklist operational notes are used for ongoing consequences of the non-normal condition, such as:

- inoperative equipment lists
- operational limitations

Operational notes are selectable through the operational notes key at the bottom of the page. After display of a non–normal checklist that includes operational notes, the notes are accessible during all subsequent phases of flight. Each operational note includes a checklist reference for the checklist that generated the note.

If there are multiple pages of operational notes, page keys are displayed. Once all pages of operational notes have been accessed, the cursor is placed on the non–normal checklist key, if it is displayed, or moves to the normal checklist key.

Operational notes are dependent upon the status of the non–normal condition causing the note. If the condition goes away, the checklist reference and associated notes are removed from the operational notes display.

Deferred Line Items

Deferred line items are items that are part of a non-normal checklist, but must be accomplished later in the flight, usually during approach.

If a non–normal checklist containing deferred items is displayed, the items are automatically attached to the appropriate normal checklist. Each set of deferred items is referenced to the checklist that generated the deferred item. Any type of line item can be a deferred item.

A non–normal checklist containing deferred items is considered complete when all applicable steps prior to the deferred items have been accomplished. The CHECKLIST COMPLETE EXCEPT DEFERRED ITEMS indicator is displayed at the bottom of the page.

If a non–normal condition occurs after completion of the approach or landing checklist, the originating non–normal checklist is considered incomplete until all steps including the deferred items are accomplished.

Conditional Line Items

There are two types of conditional line items within checklists:

- closed loop (airplane system state sensed)
- open loop (airplane system state not sensed)

Open loop conditional line items are followed by selections labeled YES and NO. The cursor is placed adjacent to the YES – NO line, requiring the pilot to use the cursor to select the appropriate answer.

If the pilot selects YES, the steps associated with the conditional line item become active. If the pilot selects NO, the steps associated with the conditional line item become inactive and change color to cyan indicating the steps are not applicable. The current line item box skips past the cyan items. Cyan steps are not selectable. Any associated operational notes are removed from the notes page and deferred line items are removed from the target normal checklist when they are displayed in cyan. YES-NO selections remain active even after a selection is made. The pilot can change selections at any time.

Sometimes a group of two or more open-loop conditional line items are designated as a mutually exclusive set. When the pilot answers YES to any one of the items in the exclusive set, all other items are automatically answered NO. However, the opposite is not true. If all of the items but one are answered NO, the last item is not automatically answered YES. The pilot must manually select YES to one of the conditional line items in the exclusive set.

The closed loop conditional line item function is identical to open loop except the decision is made automatically by using airplane system state sensing. When the conditional line item is sensed true, it changes color to green and the current line item box moves to the first incomplete step associated with it. If the condition is sensed false, the conditional line item and its associated steps are no longer applicable and change color to cyan. The current line item box skips past the cyan items.

Inhibit Checklist Line Items

When a single airplane system failure results in the display of multiple EICAS alert messages (a primary message and one or more consequential messages), inhibit checklist line items allow unnecessary non-normal checklists (consequential checklists) to be inhibited from display in the checklist queue.

Consequential EICAS alert messages may be displayed as a result of a primary failure condition. For example, an AUTO SPEEDBRAKE message is displayed as a result of a HYD PRESS SYS C condition. Consequential EICAS alert messages also may result from a non-normal checklist crew action. For example, a PACK L message is displayed when the crew selects the pack off during accomplishment of the SMOKE AIR CONDITIONING checklist. Corresponding consequential checklists are inhibited by inhibit checklist line items in the primary checklist. The inhibit checklist line item lists the consequential checklists which are inhibited. The inhibit has the following effects on a consequential checklist:

- checklist icon is removed from corresponding EICAS message
- checklist is removed from checklist queue
- notes are not collected on operational notes page
- deferred items are not collected in normal checklists

If consequential checklist steps, notes, and information are applicable to the primary failure condition, then these are included in the primary checklist.

Additional Information

Additional information is provided for some checklists. It is located at the very end of the associated non-normal checklist. Viewing the information is not required to complete the checklist.

Precautionary Text

Precautionary text is critical information which should be read before completing certain non-normal checklist actions. Precautionary text is displayed directly above the associated line item.

Timers

Where required, an automatic timer is displayed in the upper right hand corner of the checklist page. Timers help the flight crew keep track of time delays that are part of checklists. All timers are countdown timers. Timers can be associated with open loop, closed loop, or conditional line items.

Timers are activated by completing the step just prior to the line item associated with the timer. Timers run in the background. This allows the flight crew to leave the checklist to accomplish other tasks and then return to the checklist. An accurate countdown time is displayed. Timers initially appear in white. When the time elapses, the timer displays 00:00 and the color changes to amber. When the current line item box moves to the next incomplete item, the expired timer is removed from display.

Checklist Menu Operation

An alternate means of operating the checklist is through the use of menus. The normal, resets, and non–normal menus can be selected by the keys at the top of the checklist page, using the cursor control device.

An EXIT MENU key is located in the lower right corner of all menu displays. This exits the menu page to allow access to the normal and non–normal checklist keys.

Normal Menu

Normal checklists are arranged in the menu in sequence. Selecting the NORMAL menu key or the checklist display switch results in the display of the next incomplete normal checklist in sequence.

Non–Normal Menu

Non–normal menu selections are arranged by airplane system. Submenus are used to select the appropriate checklist.

Resets Menu

Selecting the RESETS menu key displays miscellaneous information (such as checklist database part number and revision information) and the following selectable resets:

- RESET NORMAL
- RESET NON–NORMAL
- RESET ALL

This provides a way to reset multiple checklists. See Checklist Resets, this section.

Dual Database

The dual database feature provides the flight crew the capability of activating either of two different ECL databases, each having a different database part number and revision identification. Revision identification usually corresponds to the Operations Manual revision or an effective date for the new database. Selection of a different ECL database is accomplished on the RESET menu using the CCD. Database selection keys are used to activate the desired database. A green diamond displayed in the active database indicator shows the active database. The flight crew can select either ECL database as often as desired while on the ground. The database selection keys are inhibited in flight. Changing the active ECL database also results in RESET ALL action.

Checklist Access

Air/ground logic, fuel control switch position, and EICAS message level determine the checklist retrieval priority when the checklist display switch is pushed.

Checklist call–up priority order is shown below.

On the ground with both fuel control switches in the CUTOFF position and both engine start selectors in NORM:

- checklists associated with any EICAS warning messages
- NORMAL checklists (incomplete or not yet displayed)
- checklists associated with any EICAS caution messages
- checklists associated with any EICAS advisory messages
- unannunciated (no EICAS message) checklists

On the ground with either fuel control switch in the RUN position, or either engine start selector not in NORM, or in the air:

- checklists associated with any EICAS warning messages
- checklists associated with any EICAS caution messages
- checklists associated with any EICAS advisory messages
- unannunciated checklists
- NORMAL checklists

Normal Checklists

Normal electronic checklist use follows the same philosophy as used with paper checklists. The normal procedures are done from memory, then the checklist is read to confirm the actions.

Normal Checklist Access

The checklist sequence is:

- PREFLIGHT
- BEFORE START
- AFTER START
- BEFORE TAKEOFF
- AFTER TAKEOFF
- APPROACH
- LANDING
- SHUTDOWN
- SECURE

As each normal checklist is completed, the next incomplete normal checklist is displayed.

Any normal checklist can be accessed using the NORMAL menu.

Normal Checklist Completion

At the completion of each checklist (all steps are complete or overridden), the appropriate message appears at the bottom of the page:

- CHECKLIST COMPLETE (white text on green background)
- CHECKLIST OVERRIDDEN (white text on cyan background)

The CHKL INCOMPLETE NORM message is displayed if critical items in a normal checklist are not completed before the associated phase of flight transition. In addition, the normal checklist key in the lower left corner of the display changes color to amber indicating that one or more normal checklists is incomplete. The normal checklists associated with the alert are:

- BEFORE TAXI
- BEFORE TAKEOFF
- APPROACH
- LANDING

Non–Normal Checklists

Non–normal electronic checklist use is designed to follow the same philosophy as used with paper checklists. Non–normal checklists are done by read–and–do. If a checklist has memory steps, those steps are accomplished before accessing the checklist.

Non–Normal Checklist Access and Checklist Icon

Annunciated non–normal checklists are accessed by pushing the checklist display switch. Any non–normal checklist can be accessed using the NON–NORMAL menu.

EICAS messages determine which non–normal checklist is automatically displayed. EICAS alert messages with associated incomplete or unaccessed checklist procedures are displayed with an icon (a white, empty box) to the left of the message. The icon indicates checklist status. The presence or absence of the icon indicates:

- icon displayed – the checklist for the displayed message has not been accessed, or the checklist has incomplete steps
- icon not displayed – all checklist steps are complete, there is no checklist procedure for the displayed message, or another message is displayed whose corresponding checklist inhibits display of the icon

When pushing the checklist display switch and a single EICAS message exists, the non–normal checklist for that condition is displayed. If multiple active EICAS messages exist, pushing the checklist display switch displays a list showing the non–normal checklists ready for display. This list represents the non-normal checklist queue. If the number of checklists in the queue exceeds 10, a page indicator is displayed to the right of the list.

The checklist queue order is similar to EICAS message priority:

- EICAS WARNING
- EICAS CAUTION
- EICAS ADVISORY
- UNANNUNCIATED

When a message becomes active, the corresponding checklist is automatically placed in the queue. After checklist completion, the message may still be active, but the checklist is removed from the queue. A checklist is also removed from the queue when another message is displayed whose corresponding checklist inhibits placement of the checklist in the queue.

Selection of the desired checklist in the queue is accomplished using the cursor, which is initially placed on the first checklist. Once a checklist is selected and completed, pressing the NON–NORMAL key returns the display to the queue, if additional non–normal checklists exist.

Non–Normal Checklist Completion

At the completion of each checklist (all steps are either complete, inactive, or overridden), the appropriate indicator is displayed at the bottom of the page:

- CHECKLIST COMPLETE (white text on green background)
- CHECKLIST OVERRIDDEN (white text on cyan background)
- CHECKLIST COMPLETE EXCEPT DEFERRED ITEMS (white text on green background)

If the checklist was left unfinished, the text in the non–normal checklist key in the lower right corner of the display changes color to amber to indicate that one or more non–normal checklists is incomplete.

In addition, the CHKL NON-NORMAL message is displayed if one or more non-normal checklist is incomplete and is not displayed on EICAS.

Non–Normal Unannunciated Checklists

Non–normal checklists not associated with EICAS messages are called unannunciated checklists. Unannunciated checklists are accessed only through menu selection. UNANNUNCIATED CHECKLISTS is the first submenu item when the NON–NORMAL menu is accessed. This menu selection provides quick menu access to all unannunciated checklists.

Dual Database

The dual database feature provides the flight crew the capability of activating either of two different ECL databases, each having a different database part number and revision identification. Revision identification usually corresponds to the Operations Manual revision or an effective date for the new database. Selection of a different ECL database is accomplished on the RESET menu using the CCD. Database selection keys are used to activate the desired database. A green diamond displayed in the active database indicator shows the active database. The flight crew can select either ECL database as often as desired while on the ground. The database selection keys are inhibited in flight. Changing the active ECL database also results in RESET ALL action.

Checklist Resets

If a checklist is partially complete or complete and the pilot wishes to begin the checklist again, the checklist must be reset. Selecting the checklist reset key at the bottom of the page while the checklist is displayed resets the checklist and allows the checklist to be accomplished again.

For certain conditions, such as go-around, resets are used to set the normal checklist back to a previous phase of flight. There are automatic resets and manual resets.

Normal Checklist Automatic Reset Conditions

Automatic checklist resets occur for the following conditions:

- GO–AROUND – if the airplane is in the air, the landing gear is not up, and TO/GA is selected, then all normal checklists beginning with the AFTER TAKEOFF checklist automatically reset
- TOUCH–AND–GO – if the airplane has transitioned from air to ground, takeoff thrust is reached with groundspeed greater than 80 KIAS, and the thrust reversers not deployed, then all normal checklists beginning with the AFTER TAKEOFF checklist automatically reset
- NORMAL MENU CHOICE – if a previously completed checklist is selected from the menu, it automatically resets when it is displayed

Normal Checklist Manual Resets

Manual checklist resets are required for the following conditions:

- RESET NORMAL – selecting the resets menu key and then the reset key labeled RESET NORMAL resets all normal checklists. The flight sequence begins again
- INDIVIDUAL CHECKLIST RESET – selecting the checklist reset key resets any displayed checklist. The checklist is then ready to accomplish again

Non–Normal Checklist Manual Resets

Manual reset of non-normal checklists is accomplished as follows:

- RESET NON-NORMAL – selecting the resets menu and then the reset key labeled RESET NON–NORMAL resets all non-normal checklists. The flight crew is prompted to reaccomplish all annunciated non-normal checklists that were previously completed. Use of the RESET NON-NORMAL function in flight is not recommended
- INDIVIDUAL CHECKLIST RESET – selecting the checklist reset key resets any displayed checklist. The checklist is then ready to accomplish again

Manual Reset All

Manual reset of all normal and non-normal checklists is accomplished as follows:

- RESET ALL – selecting the resets menu and then the reset key labeled RESET ALL resets all normal and non-normal checklists. The flight crew is prompted to re-accomplish all annunciated non-normal checklists that were previously completed. Use of the RESET ALL function in flight is not recommended

Overrides

There are two types of override functions: item override and checklist override.

Item Override

Item override is used by the flight crew when an item in a checklist will not be accomplished or an item has been accomplished but the closed-loop sensing is not functioning correctly. Overriding an item when required allows the checklist to be completed.

The line item override key is available on all checklists. Selection of the line item override key changes the color of the highlighted step to cyan, indicating the step is not applicable and is overridden. Both closed loop and open loop steps can be overridden.

Conditional line items (both closed and open loop) cannot be overridden. Individual steps associated with conditional line items can be overridden.

Checklist Override

Checklist override is used by the flight crew when a checklist in the non-normal queue will not be accomplished or after the crew browses a checklist but does not intend to complete it.

By pressing the checklist override key, the displayed checklist changes color to cyan, indicating that it is overridden. The CHECKLIST OVERRIDDEN indicator is displayed at the bottom of the page. For non-normal checklists, all associated operational notes are removed from the operational notes page, and deferred line items are removed from the target normal checklist.

Electronic Checklist System Inoperative

If the checklist display switch is pushed and the electronic checklist system is inoperative, the message CHECKLIST NOT AVAILABLE is displayed on the MFD. If the electronic checklist system has been disabled by maintenance, the message CHECKLIST DISABLED is displayed on the MFD.

When the electronic checklist system is inoperative or disabled, checklist icons are not displayed on the EICAS display for any messages.

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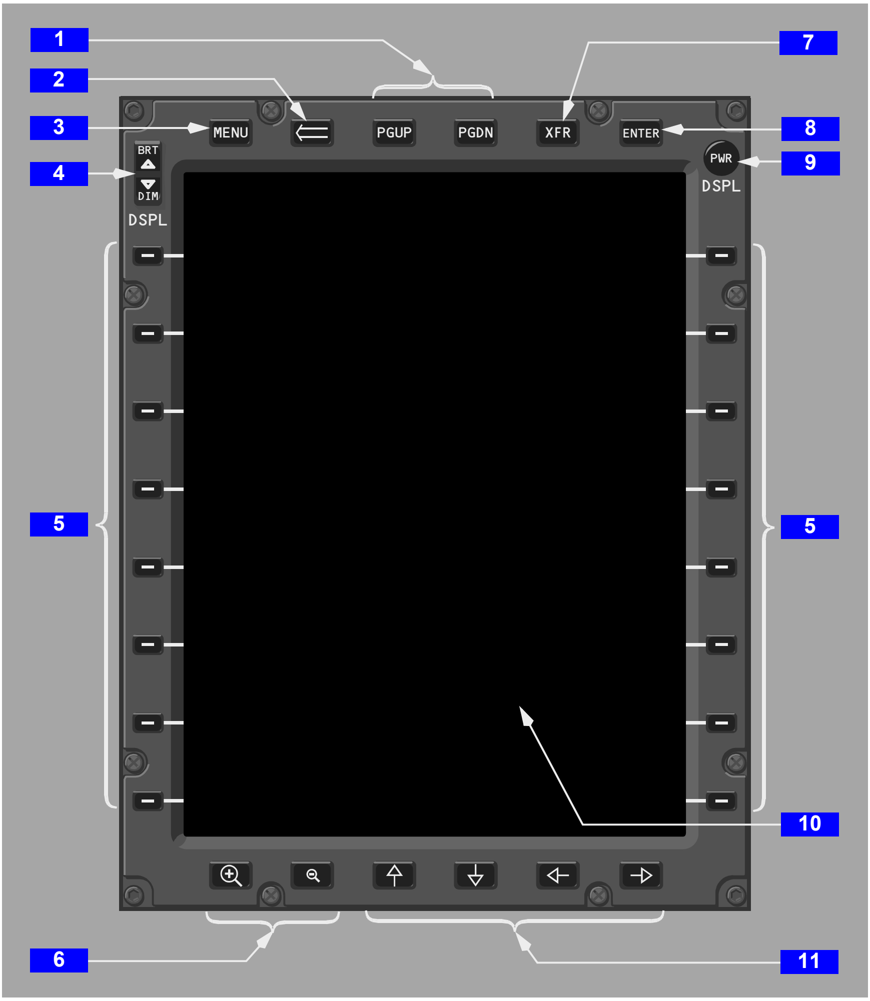
Electronic Flight Bag - Controls and Displays — Section 70

Display Unit



1 Page Up (PGUP) and Page Down (PGDN) Keys

Selection moves the displayed information up or down when the material exceeds one display screen in length.

2 Back Key

Selection returns the display to the previous screen.

3 MENU Key

Selection displays the Main Menu page. Also, selecting MENU while in transfer (XFR) mode cancels XFR mode.

4 Bright (BRT) DIM Control Switch

Rocker switch changes the display brightness; upper portion brighter, lower portion dimmer.

5 Line Select Keys

When applicable, selection activates the item adjacent to the line select key.

6 Zoom Keys

Selection increases or decreases the zoom level. Left + key to zoom in, right - key to zoom out. Repeated selection brings zoom level to the maximum or minimum.

7 Transfer (XFR) Key

Selection displays a view of the off-side EFB screen onto the on-side display and:

- XFR displays in green text in upper right corner of the screen
- selections being made off-side are seen on the on-side display in real time
- XFR key (second push) exits transfer mode and returns display to the last screen viewed prior to selecting XFR

Note: Selecting the MENU bezel key also exits the transfer mode and displays the Main Menu page.

8 ENTER Key

When applicable, selection activates the high-lighted item on the page.

9 Power (PWR) Switch

Selection turns the display backlight on or off.

Note: This switch does not power on or off the EFB hardware, only the display unit backlight.

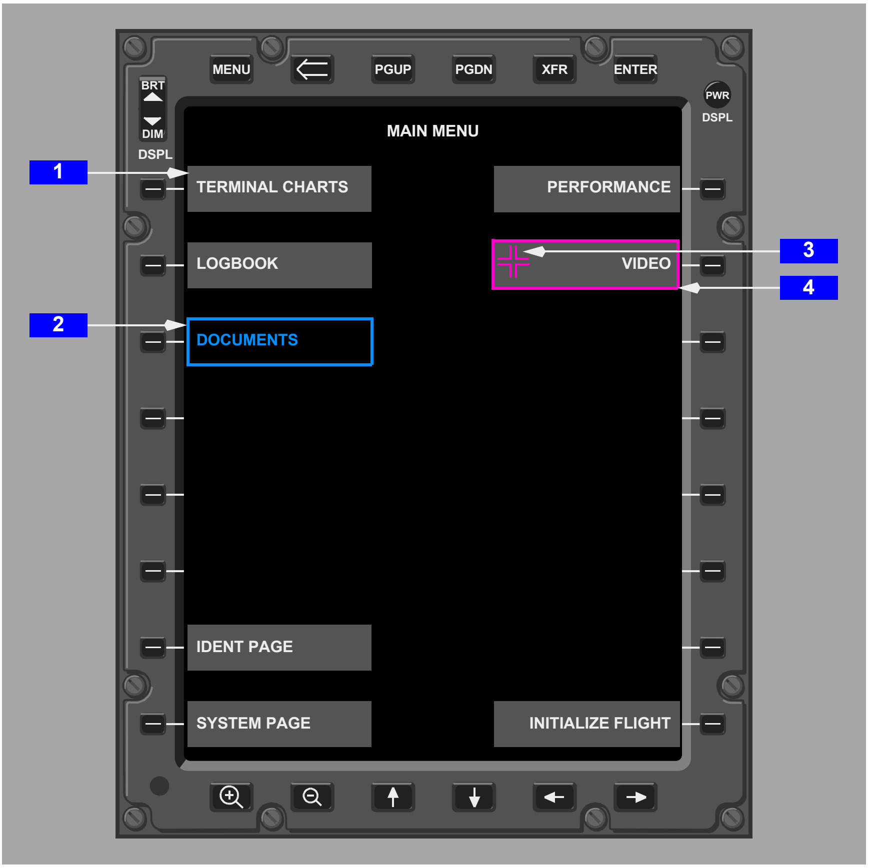
10 Touch Sensitive Screen

Enables direct selection of soft keys and fields on the display screen, and in some applications allows panning and scrolling.

11 Arrow Keys

Moves the viewing window over the display in the direction of the selected arrow.

Display Description



1 Available Applications

Soft keys for available applications display in white text with a gray background.

2 Unavailable Applications

Soft keys for applications that are installed but are unavailable, display in cyan text in a cyan box. The application may be initializing and become available later.

3 Cursor

A magenta cursor appears on the display when the EFB key is selected on a CCD.

4 Highlight Box

A magenta highlight box displays around an available application soft key when:

- the cursor is moved over the application's soft key, or
- the soft key is touched on the screen, or
- the application's line select key is pushed

An available application is selected when:

- the soft key is highlighted with the cursor and the cursor select switch is pushed, or
- the soft key is touched on the screen and released, or
- the application's line select key is pushed

The soft key momentarily displays a green background when selected, then the application displays.

EFB Main Menu Page

1 FAULT Message

Displayed (amber) -

- a fault has occurred within an application
- displays in the header regardless of the application displayed
- displays next to the affected application soft key on the Main Menu page
- removed from display upon selection of SYSTEM PAGE

Only one message at a time can be displayed next to an application soft key. FAULT takes priority over MSG and MEMO. MSG takes priority over MEMO. MSG or MEMO displays, as applicable, after the fault has been cleared.

2 **MEMO Message**

Displayed (white) –

- one or more applications need attention
- displays in the header regardless of the application displayed
- displays next to the affected application soft key on the Main Menu page
- removed from display upon selection of appropriate application

Only one message at a time can be displayed next to an application soft key. FAULT and MSG take priority over MEMO. MEMO displays, as applicable, after the fault has been cleared and the message has been addressed.

3 **TERMINAL CHARTS Application Soft Key**

Selection starts the terminal charts application.

After flight initialization, displays the Terminal Charts page.

Subsequent selections of the application display the page that was in view when the application was last exited.

4 **LOGBOOK Application Soft Key**

Selection starts the logbook application.

After flight initialization, displays the Logbook Home page.

Subsequent selections of the application display the page that was in view when the application was last exited.

5 **DOCUMENTS Application Soft Key**

Selection starts the documents application.

After flight initialization, displays the Document Library page.

Subsequent selections of the application display the page that was in view when the application was last exited.

6 **IDENT PAGE Soft Key**

Selection displays the Ident page.

7 **SYSTEM PAGE Soft Key**

Selection displays the System page.

8 **Message (MSG)**

Displayed (white) –

- one or more applications has an uplink available
- displays in the header regardless of the application displayed
- displays next to the affected application soft key on the Main Menu page
- removed from display upon selection of appropriate application

Only one message at a time can be displayed next to an application soft key. FAULT takes priority over MSG. MSG displays, as applicable, after the fault has been cleared.

9 **XFR**

Displayed (green) –

- the display is in transfer mode and the current view of the other EFB is being displayed
- only MENU and XFR key selections are enabled while in transfer mode

10 **PERFORMANCE Application Soft Key**

Selection starts the performance application.

After flight initialization, displays the Takeoff performance page.

Subsequent selections of the application display the page that was in view when the application was last exited.

11 **VIDEO Application Soft Key**

Selection starts the video application.

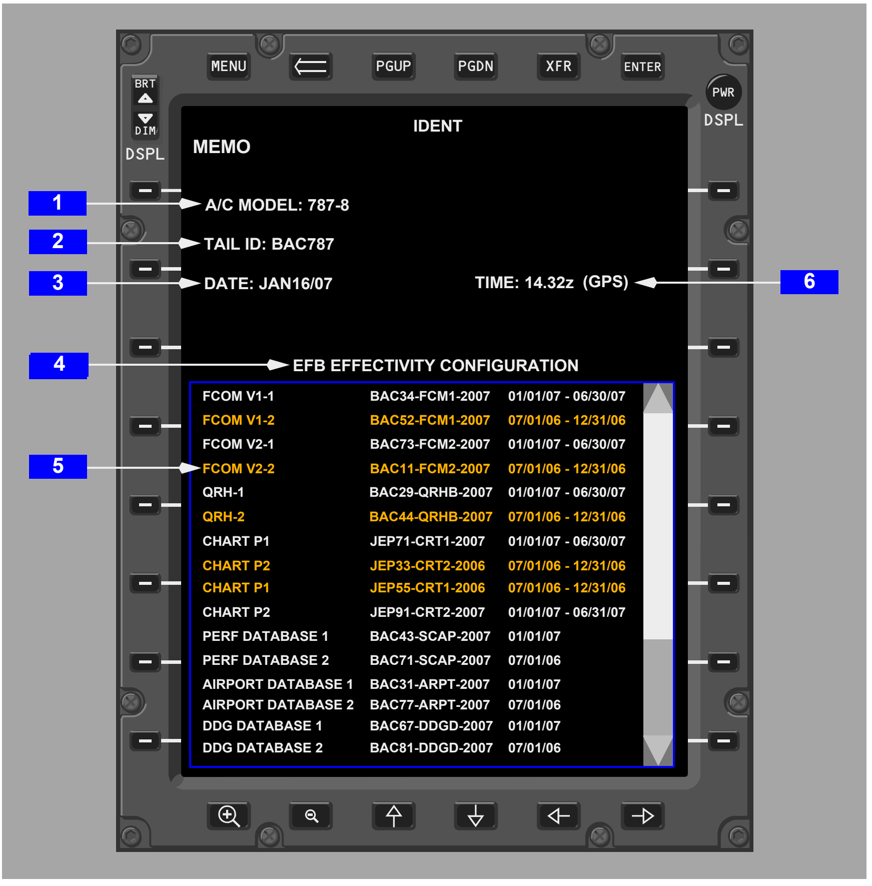
12 **INITIALIZE FLIGHT Soft Key**

Selection initializes the installed applications for flight. The following functions are preformed:

- clears all previous search results from each of the installed applications
- restores default settings in all of installed applications and functions
- uploads certain data entered in the FMC to specific EFB applications

After selection, soft key changes to CLOSE FLIGHT for later use.

EFB IDENT Page



1 A/C MODEL

Displays the airplane model number.

2 TAIL ID

Displays the airplane registration number.

3 DATE

Displays the current date based on Zulu time.

4 EFB EFFECTIVITY CONFIGURATION

Displays the list of loaded databases including; name, part number, and effectivity dates.

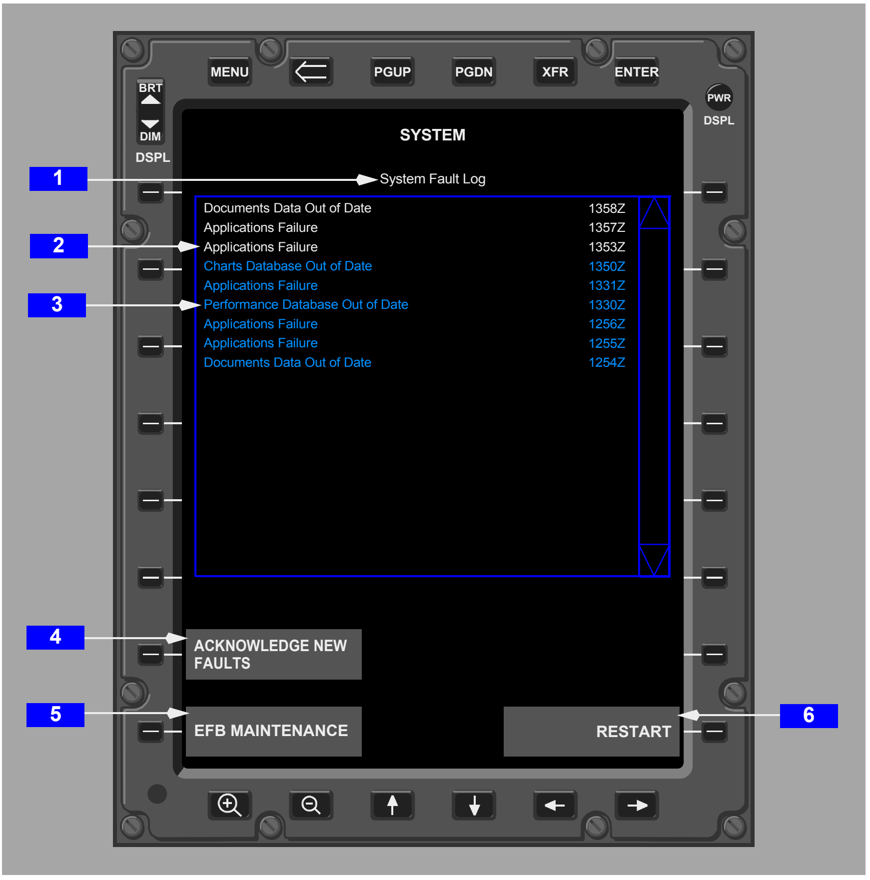
5 Out of Date Database (amber)

An out of date database displays in amber. MEMO displays in the header on all pages and next to any affected applications on the Main Menu page.

6 TIME

Displays the current Zulu time and its source.

EFB SYSTEM Page



1 SYSTEM FAULT LOG

Displays a list of hardware, software, and application faults that have occurred within the system, and the time they occurred, since the last power-up cycle.

2 Unacknowledged Fault

Unacknowledged fault information is displayed in white.

3 Acknowledged Fault

Acknowledged fault information is displayed in cyan.

4 ACKNOWLEDGE NEW FAULTS Soft Key

Selection acknowledges all new faults.

Unacknowledged faults change to cyan and the FAULT message displayed on the Main Menu page adjacent to the SYSTEM PAGE soft key is removed.

Becomes selectable only when there are unacknowledged faults in the list.

5 EFB MAINTENANCE Soft Key

Selection displays the EFB maintenance menu page. This menu and its applications are for maintenance use only.

6 RESTART Soft Key

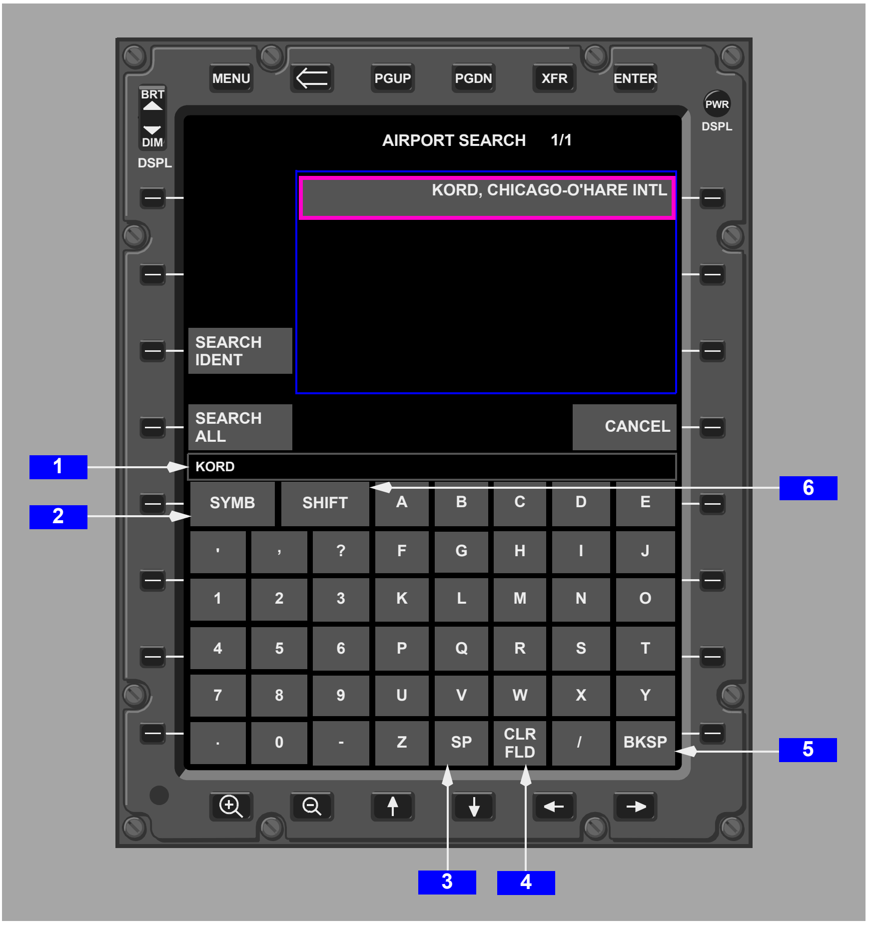
Selection shuts down all Windows applications and initiates a restart.

Available while Windows is running.

After selection, IN PROGESS displays above the RESTART soft key.

After restart, COMPLETE momentarily displays above the RESTART soft key.

EFB Virtual Keyboard Display



1 Text Entry Field

Displays the text entered using the virtual keyboard.

2 Symbol (SYMB)/Number (NUM) Key

Selection toggles between symbols and numbers on the numeric keypad.

Displays cyan when not required for the current data entry field.

3 Space (SP) Key

Inserts a blank space into the currently active field.

4 Clear Field (CLR FLD) Key

Deletes everything in the currently active field.

5 **Backspace (BKSP) Key**

Deletes the previous character in the currently active field.

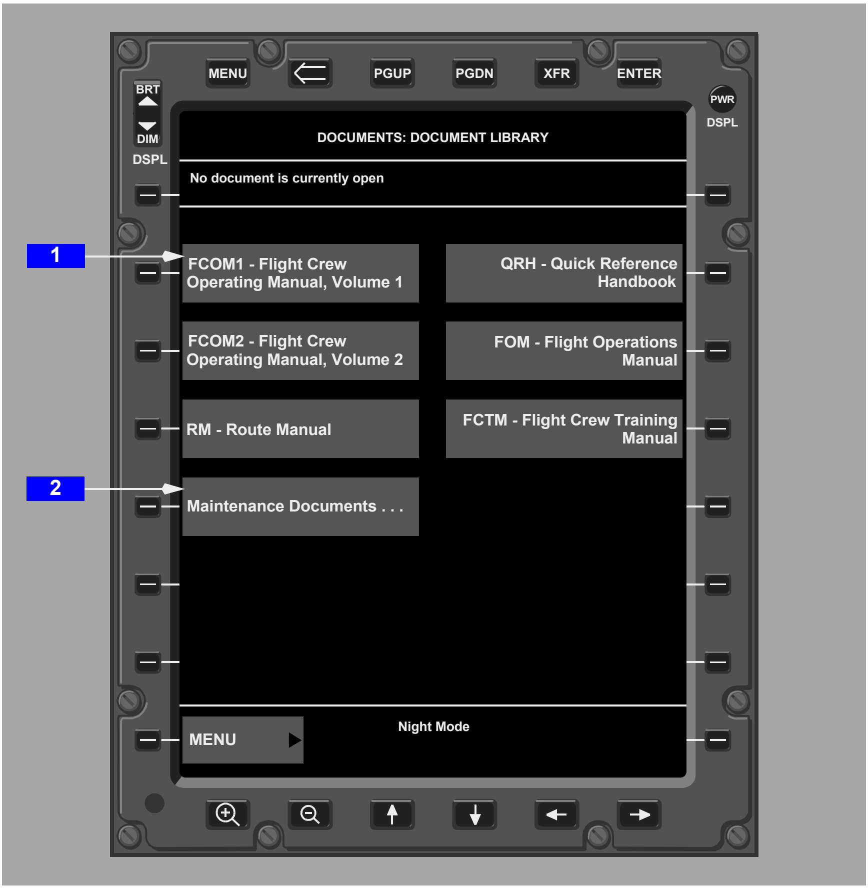
6 **SHIFT Key**

Selection toggles between upper case and lower case on the ALPHA keypad.

Displays cyan when not required for the current data entry field.

Electronic Document Browser (Typical)

Document Library Page



1 Document Soft Key

Selection opens the corresponding document.

After flight initialization, displays the document table of contents.

Subsequent selections of the document display the page that was in view when the document was last exited.

2 Document Group Soft Key

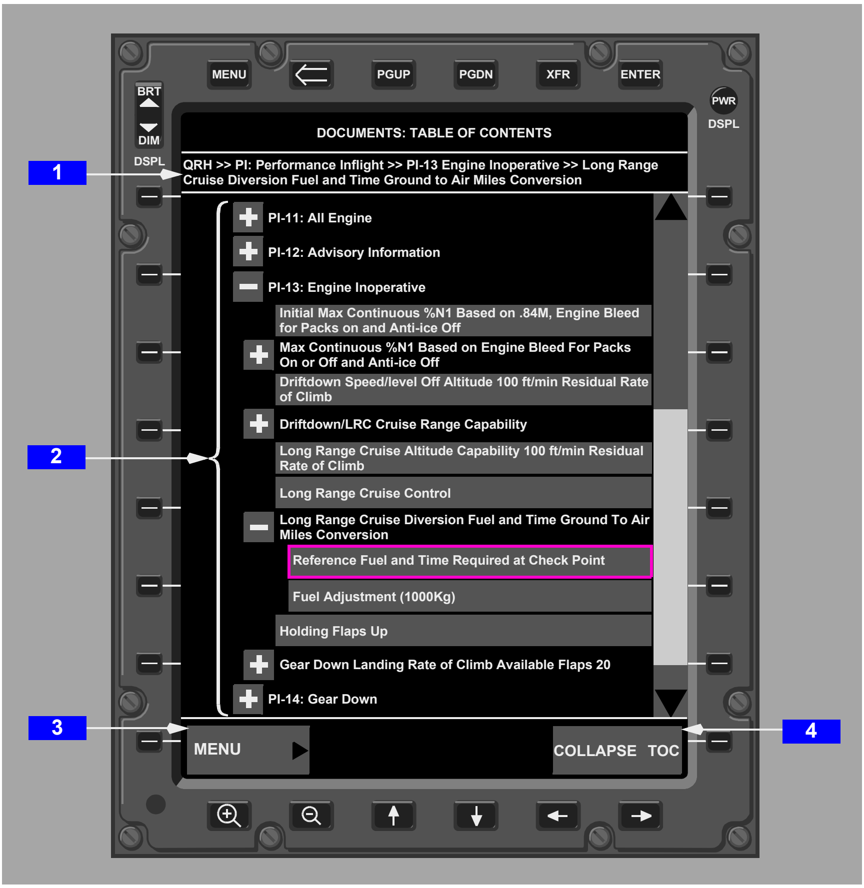
Document groups display the group title followed by an ellipsis (...). Selection displays a second level of the Document Library listing all documents in the group. Selection of a document at this level opens the corresponding document.

After flight initialization, displays the document table of contents.

Subsequent selections of the document display the page that was in view when the document was last exited.

Select the BACK bezel key or the RETURN soft key to access the previous level.

DOCUMENTS - TABLE OF CONTENTS Display



1 Hierarchy Chain

Displays the hierarchy of the table of contents.

Begins with the document name and lists the chapter and section, each separated by (>>), as the table of contents is expanded.

The last entry is the current position and is in bold font.

Remains displayed while viewing the document on the View Content page and continues to update as the document is browsed.

2 **Table of Contents**

Displays the table of contents for the document.

Can be expanded by selecting the + symbol, or collapsed by selecting the – symbol.

Scrolling is controlled using the scroll bar at the far right of the screen.

Content can be displayed on the View Content page by selecting the chapter/section soft keys.

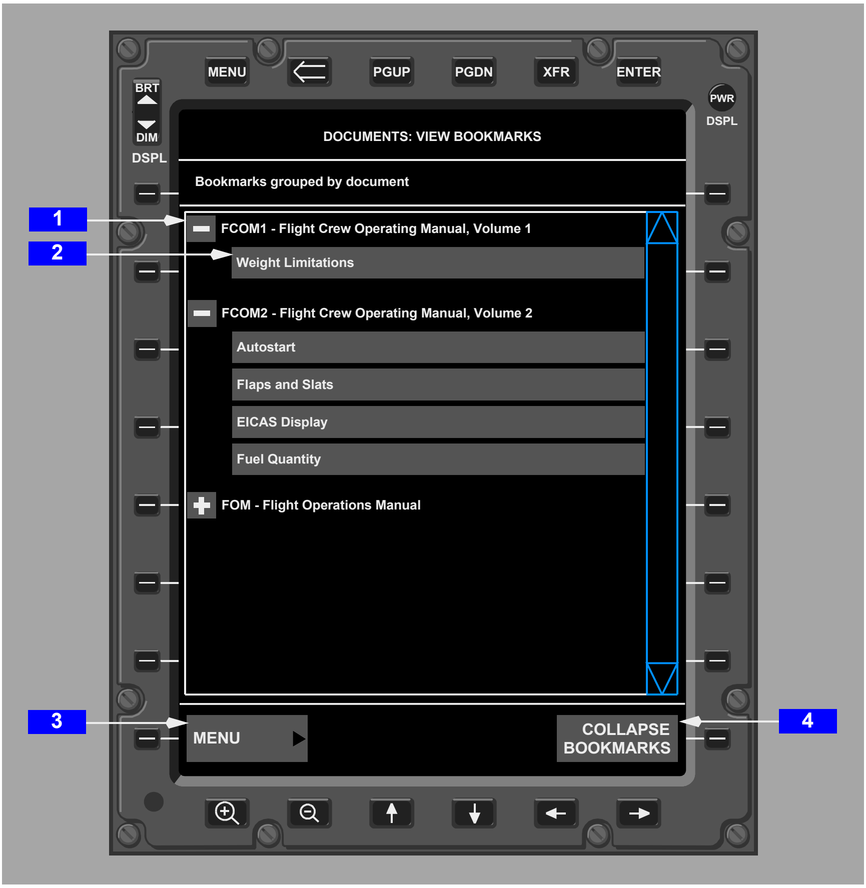
3 **MENU Soft Key**

Selection opens a cascading menu of application or screen specific tasks. Menu items not available for the current application or screen are displayed in cyan.

4 **COLLAPSE Table of Contents (TOC) Soft Key**

Selection returns the entire table of contents to the collapsed view.

DOCUMENTS: VIEW BOOKMARKS Page



1 Document Title

Displays the document title where the bookmark is located.

2 Document Chapter/Section

Displays the document chapter/section where the bookmark is located.

Selection displays the View Content page at the beginning of the bookmarked chapter/section.

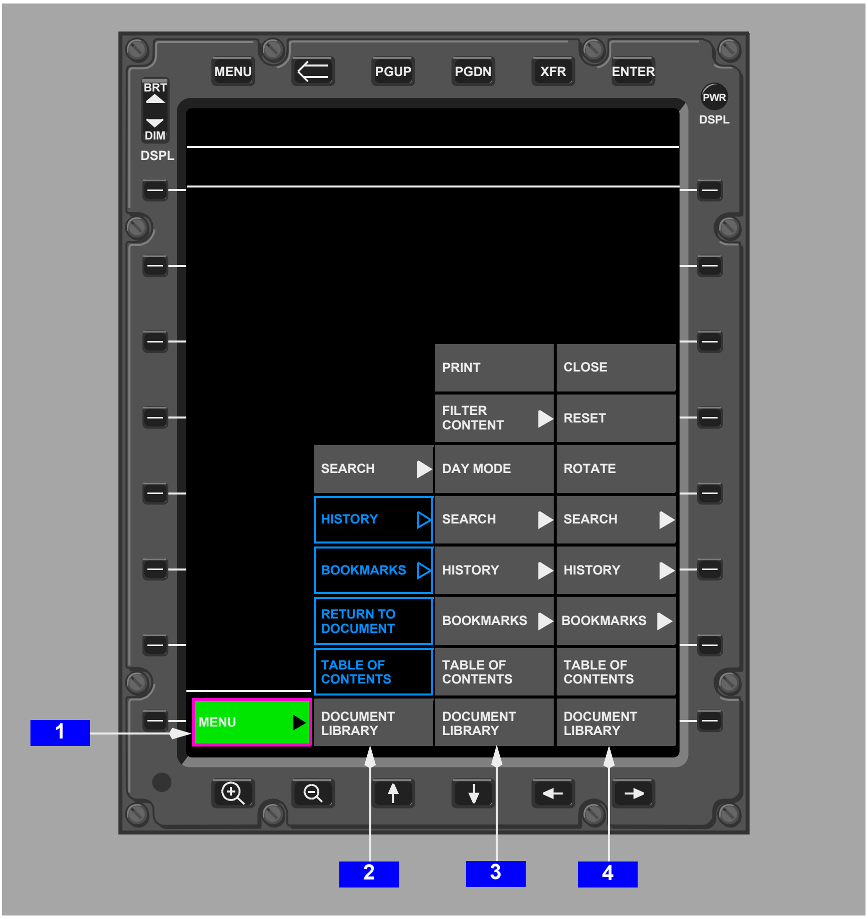
3 MENU Soft Key

Selection opens a cascading menu of application or screen specific tasks. Menu items not available for the current application or screen are displayed in cyan.

4 COLLAPSE BOOKMARKS Soft Key

Selection returns the bookmarks to the collapsed view.

Menus Display (Typical)



1 MENU Soft Key

Selection opens a cascading menu of application or screen specific tasks. Items in cyan are unavailable in the present application or screen. Arrowheads indicate the soft key has further cascading menu options.

2 Application Menu List

Applications have the following menu items:

- SEARCH - selection opens a further menu
- HISTORY - selection opens a further menu
- BOOKMARKS - selection opens a further menu
- RETURN TO DOCUMENT - selection returns view to the document

- TABLE OF CONTENTS - selection returns view to the table of contents
- DOCUMENT LIBRARY - selection returns to the Document Library page

3 VIEW CONTENT Menu List

The View Content page has the following menu items in addition to some of the application menu items:

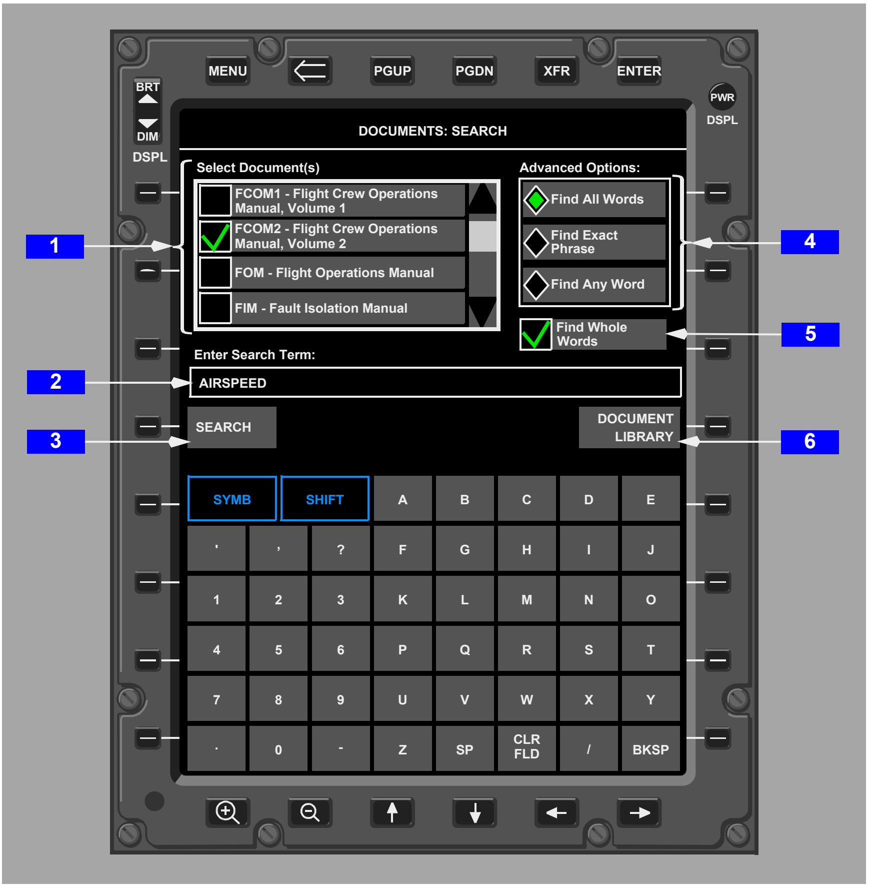
- PRINT - selection starts the printing feature
- FILTER CONTENT - selection opens a further menu
- DAY/NIGHT MODE - selection toggles between day and night modes

4 VIEW FIGURE Menu List

The View Figure page has the following menu items in addition to some of the View Content menu items:

- CLOSE - selection closes the View Figure page and returns to the View Content page where the figure was selected
- RESET - selection resets the figure to the original view (removes any rotation or zoom)
- ROTATE - selection rotates the figure 90 degrees clockwise. Further selection rotates the figure 90 degrees counter-clockwise

DOCUMENTS - SEARCH Page



1 Documents to Search

Displays a list of available documents in which a term can be searched. Search all documents or individual document titles by placing a green check mark in the box next to the appropriate title. The check mark is removed by selecting the box again.

2 Search Term Field

Enter the search term. Valid entries are alphanumeric strings, separated by a space if more than one term is required.

3 SEARCH Soft Key

Selection begins a search. Soft key turns green and "In Progress..." is displayed while the search is being performed.

4 **Advanced Options**

Displays a list of advanced search options which can be individually selected. Only one option can be selected from the list.

Selection places a green diamond marker in the area left of the appropriate option.

The diamond marker is moved to another option by further selection.

5 **Find Whole Words**

Displays the option to search on whole words only. For example, when this option is active searching for "speed" finds only the whole word "speed" and does not return results for the words "airspeed" or "groundspeed".

Selection places a green check mark in the box left of the option.

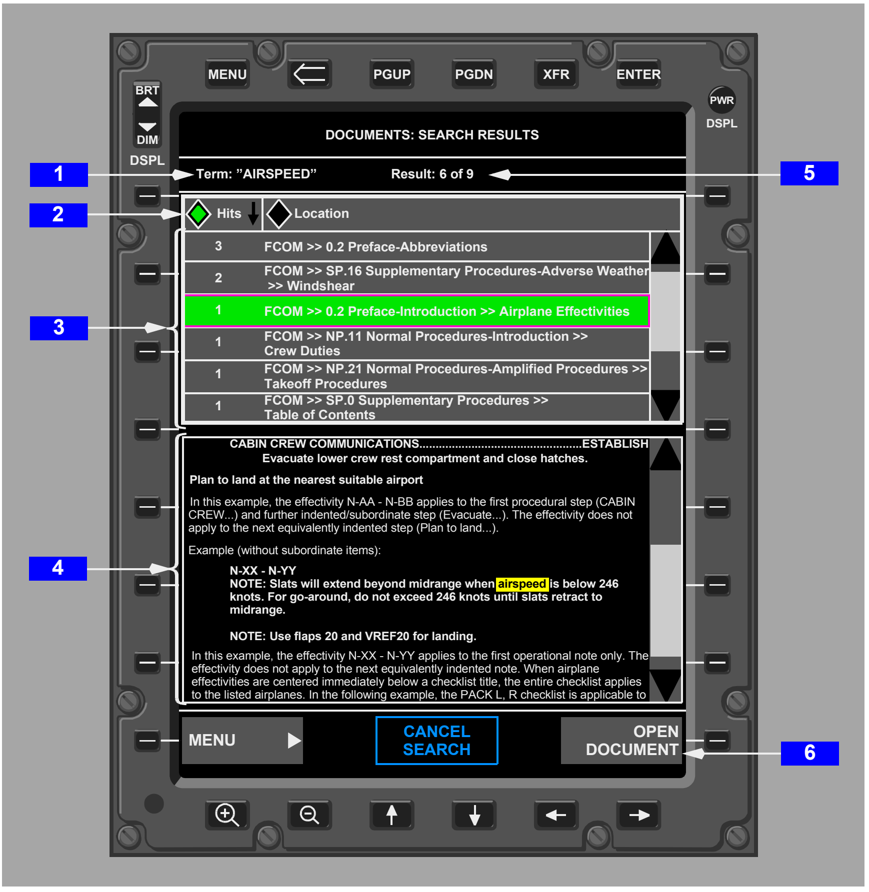
The check mark is removed by selecting the box again.

6 **DOCUMENT LIBRARY/CANCEL SEARCH Toggle Soft Key**

DOCUMENT LIBRARY displays when a search is not in progress. Selection returns to the Document Library page.

CANCEL SEARCH displays when a search is in progress. Selection cancels the search being performed.

DOCUMENTS - SEARCH RESULTS Page



1 Search Term

Displays the term that was used in the search for the results listed.

2 Search Results Filter

The search results can be displayed by the number of hits or where they occur in the document in ascending or descending order.

3 Search Results Soft Key(s)

Displays the search results for the term entered. Each soft key displays the number of hits and the search result hierarchy. The hierarchy could contain the following; document title >> chapter number and name >> section number and name.

Selection of the results soft key highlights it in green and displays the relevant document, at the lowest level displayed in the hierarchy, in the preview window.

4 **Search Results Preview Window**

The highlighted search results from the soft key selected document are displayed in the preview window.

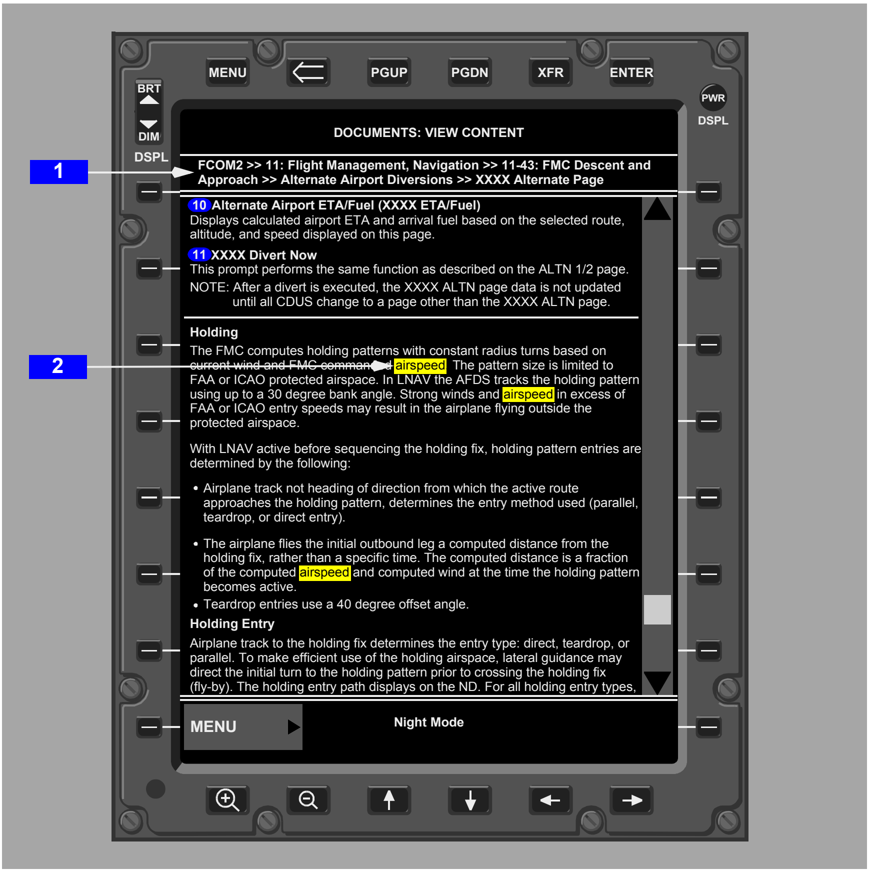
5 **Results**

Displays the current search result being displayed in the preview window, and the amount of hits the search provided.

6 **OPEN DOCUMENT**

Selection displays the document being displayed in the preview window with the highlighted search results.

Search Results VIEW CONTENT Page



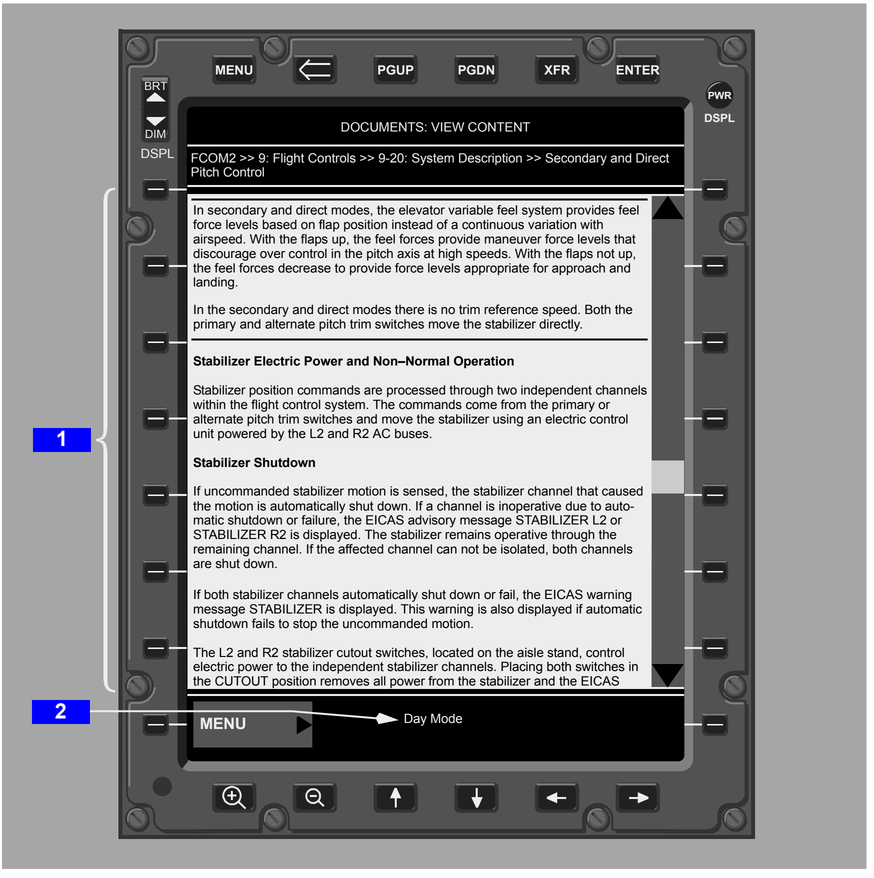
1 **Hierarchy Chain**

Displays the hierarchy of the displayed page.

2 Highlighted Search Results

The highlighted search results are displayed where they occur in the document.

VIEW CONTENT Page - Day Mode



1 Displayed day mode text

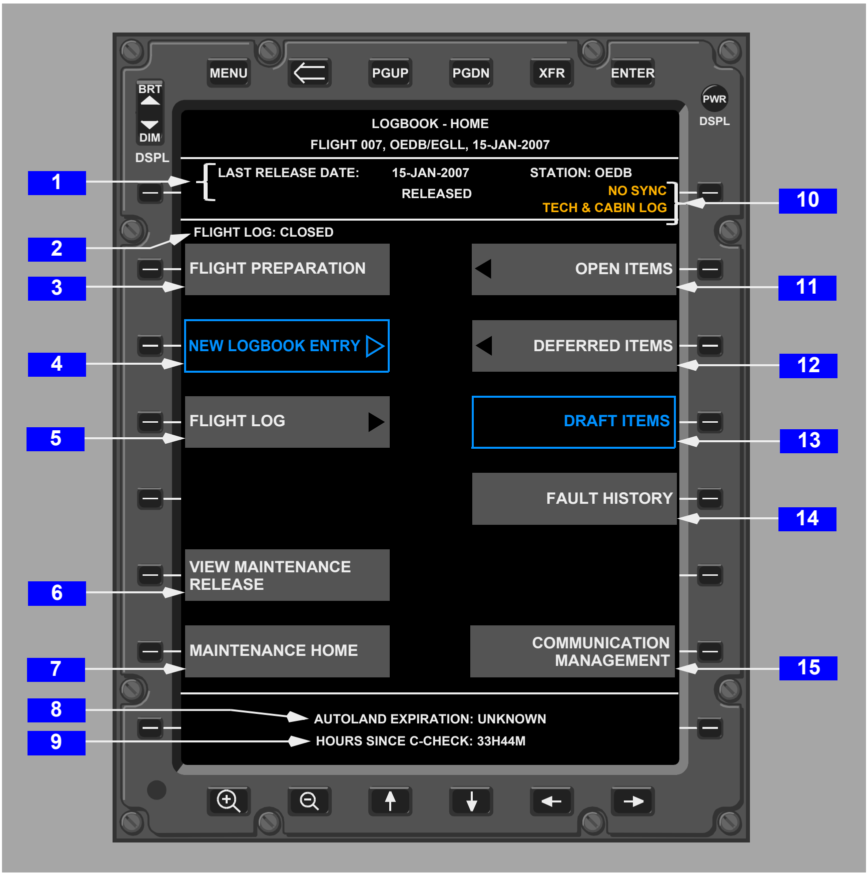
Displays the content in black text on a white background.

2 Day Mode indication

Displays the current display mode. Toggles between Day Mode and Night Mode.

Electronic Logbook (Typical)

LOGBOOK - HOME Page



1 Release Information

Contains the following release information:

- date and time of the last release for flight
- station where the last release occurred
- current release state of the airplane
  - RELEASED - displayed in white text
  - RELEASE REQUIRED - displayed in amber text

2 FLIGHT LOG status

Displays flight log status as either ACTIVE or CLOSED.

3 **FLIGHT PREPARATION Soft Key**

Selection starts a guided process that prepares a flight log to document the upcoming flight. This function is intended to be used prior to flight.

4 **NEW LOGBOOK ENTRY Soft Key**

Selection starts a guided process that prepares a new FAULT REPORT or INFORMATION ENTRY.

5 **FLIGHT LOG Soft Key**

Selection displays the flight log for the current flight.

6 **VIEW MAINTENANCE RELEASE Soft Key**

Selection displays the Maintenance Release page.

7 **MAINTENANCE HOME Soft Key**

Selection displays the Maintenance Home page. This page provides maintenance crews a summary of airplane status (release status, open & deferred item counts) and quick access to maintenance functions. This page is accessible only on the ground and is for maintenance operations use.

8 **AUTOLAND EXPIRATION**

Displays the date and time the autoland currency expires.

9 **HOURS SINCE C-CHECK**

Displays the hours and minutes since the last C-check was accomplished.

10 **NO SYNC caution message**

Displays when the flight log is not in sync with the tech or cabin logs:

- NO SYNC displays in amber text with:
  - amber TECH LOG, or
  - amber CABIN LOG, or
  - amber TECH & CABIN LOG

11 **OPEN ITEMS Soft Key**

Selection displays a list of all open faults that have been documented for this airplane. It could also include any expired deferrals.

12 **DEFERRED ITEMS Soft Key**

Selection displays a list of all deferred faults reported for the airplane and also provides a brief description, the expiration of the deferral, and an indication if any Maintenance (M) or Operational (O) procedures related to this deferral exist.

13 **DRAFT ITEMS Soft Key**

Selection displays a list of all fault reports that have been created but not signed for official entry into the logbook. If a record has not been signed the user must choose either signing, modifying, or deleting the draft report.

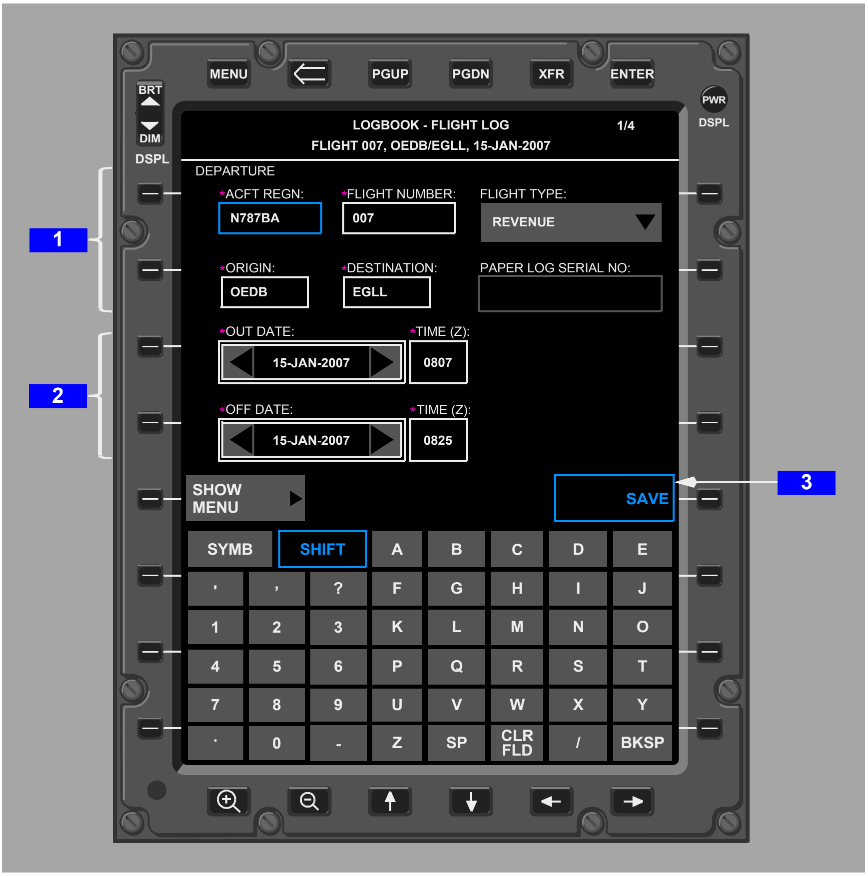
14 **FAULT HISTORY Soft Key**

Selection displays a list of all fault reports for the airplane including a description of the fault, plus the time it was reported and the current report status. The list is organized by the DATE/TIME field.

15 **COMMUNICATION MANAGEMENT Soft Key**

Selection displays the Communication Management page. This page allows maintenance messages to be sent and received to/from ground station databases. This page is for maintenance operations use.

LOGBOOK - FLIGHT LOG Departure Page



1 **Flight Information Fields**

Input fields for creating the flight log. Fields with a magenta asterisk are required.

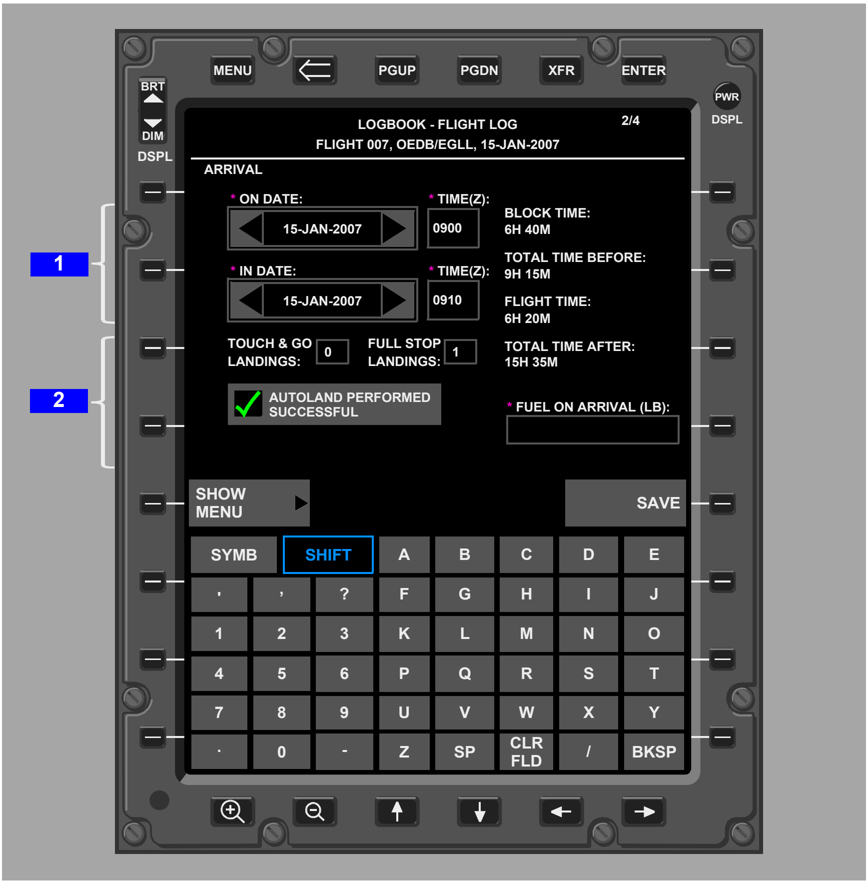
2 OUT and OFF Fields

These fields are filled automatically when the event occurs, or can be manually entered. Fields with a magenta asterisk are required.

3 SAVE Soft Key

Becomes available when all necessary information is entered. Selection saves the information entered for use with other logbook applications.

LOGBOOK - FLIGHT LOG Page



1 ON and IN Fields

These fields are filled automatically when the event occurs. If necessary, these fields can be manually entered.

2 Flight Information

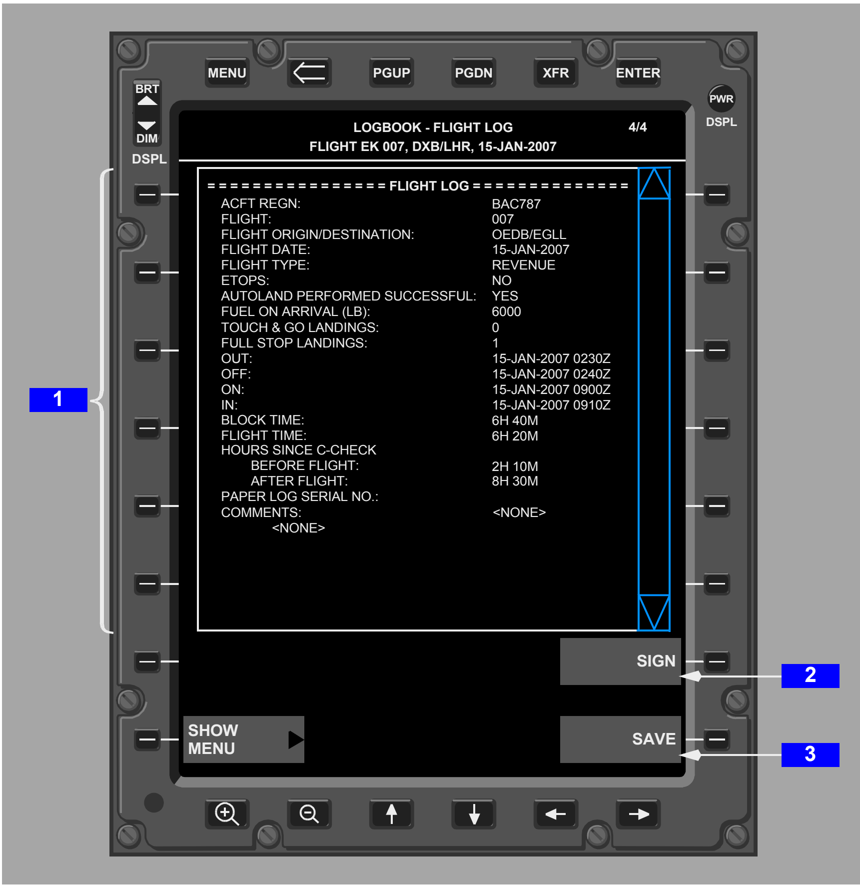
Input the required information for creating the flight log.

LOGBOOK - COMMENTS Page

1 COMMENTS Field

Flight comments are typed here if necessary.

LOGBOOK - FLIGHT LOG Summary/Signature Page



1 **Flight Log Summary**

Displays the log summary information. Use scroll bar if necessary.

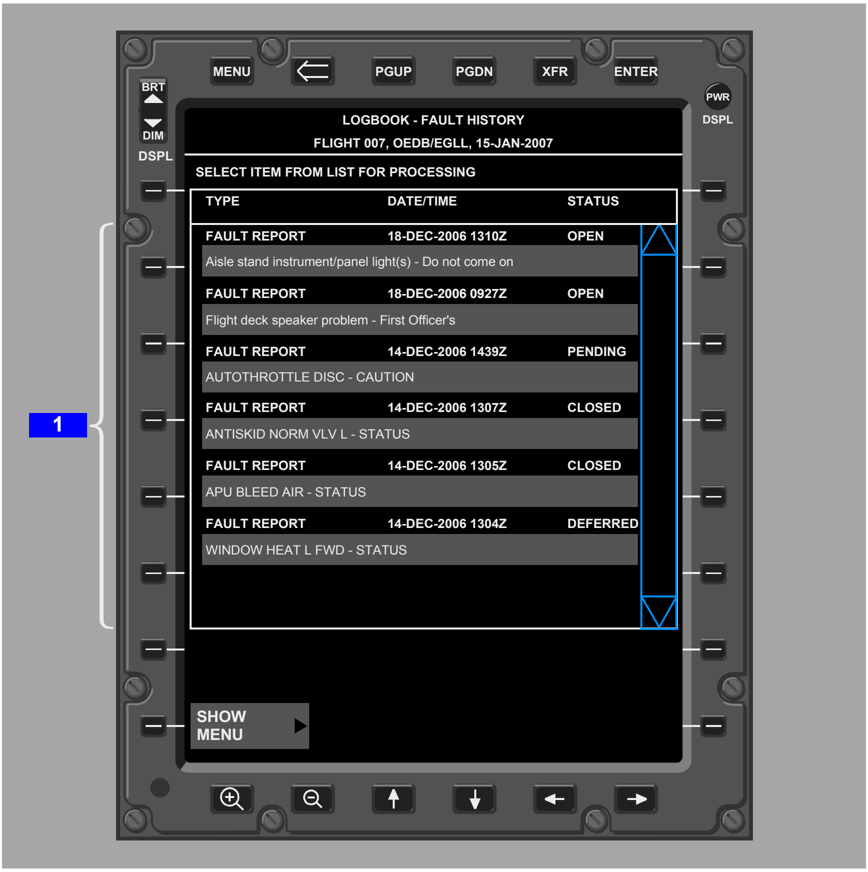
2 **SIGN Soft Key**

Selection displays the Sign Flight Log page for completion of the flight log.

3 **SAVE Soft Key**

Selection saves the information entered without signature for completion later.

LOGBOOK - FAULT HISTORY Page



1 Fault history items

Displays a historical list of fault items by date and time the item was reported. Selection of an item displays item details.

LOGBOOK - MAINTENANCE RELEASE Page

1 Release Details and Restrictions

Displays flight release information.

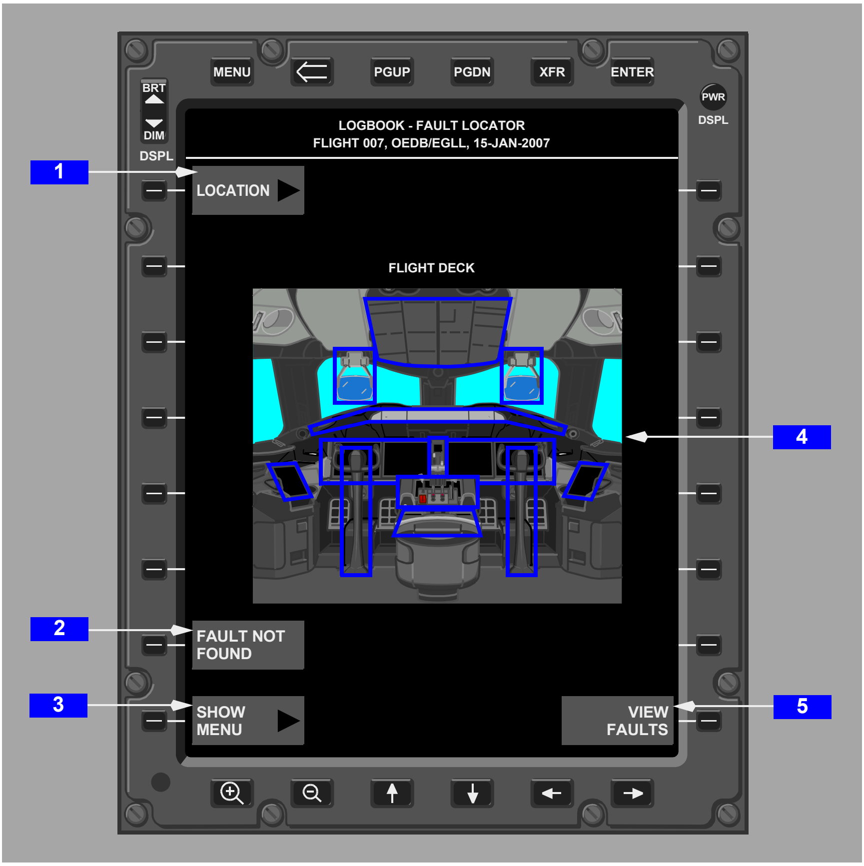
2 Airplane Service Information

Displays maintenance service information. Depending on the length of the previous information, service information may appear on subsequent pages. Use the scroll bars to access these pages.

3 Fault Information

Displays airplane fault information. Depending on the length of the previous information, fault information may appear on subsequent pages. Use the scroll bars to access these pages.

LOGBOOK - FAULT LOCATOR Graphic Locator Page



1 LOCATION Soft Key

Selection opens a list of airplane areas (Flight Deck, Engine, Exterior, etc.) for use in locating an area where a fault has occurred.

2 FAULT NOT FOUND Soft Key

Selection opens a blank fault report form for the user to complete. This is required when a fault can not be found in the selected area.

3 SHOW/HIDE MENU Soft Key

Selection toggles between showing or hiding the extended menu selections.

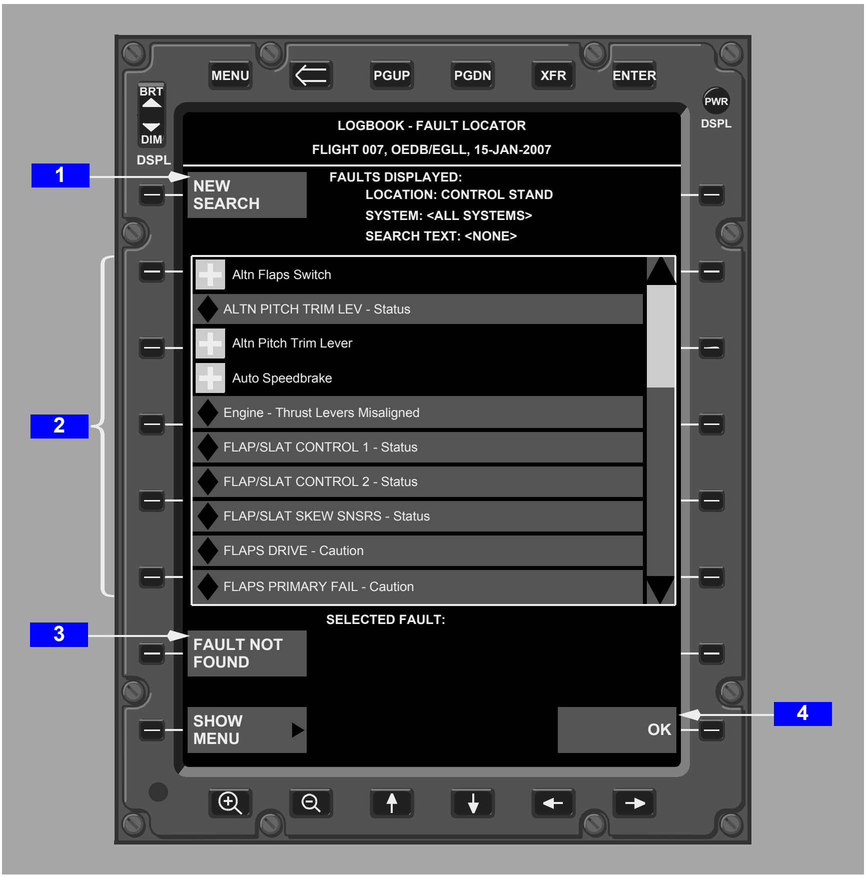
4 Panel Selection Area

Selection of a boxed area navigates through a series of images to help identify a fault. The purpose is to narrow the search area to find the appropriate fault code.

5 VIEW FAULTS Soft Key

Selection displays a list of all faults associated with the region displayed in the graphic. The more the region is narrowed by selecting specific areas, the fewer faults that are returned.

LOGBOOK - FAULT LOCATOR Display Page



1 NEW SEARCH Soft Key

Selection opens the data entry field for use in locating a fault using text search.

2 Fault List

Displays a list of faults for the specific area selected. Use the scroll bar if needed.

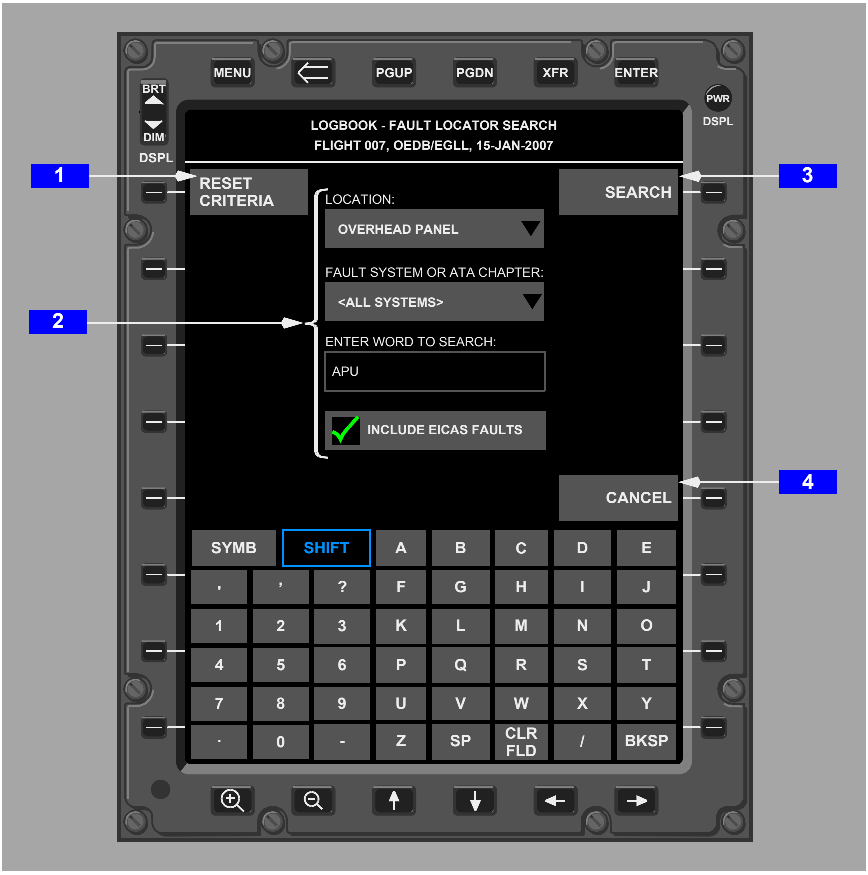
3 FAULT NOT FOUND Soft Key

Selection returns to the Record Fault Report page.

4 OK Soft Key

Available after selecting a fault from the list. Selection returns to the Record Fault Report page.

LOGBOOK - FAULT LOCATOR Search Page



1 RESET CRITERIA Soft Key

Selection returns the search criteria fields to the default settings.

2 Search Criteria Fields

Input fields for further limiting the text search.

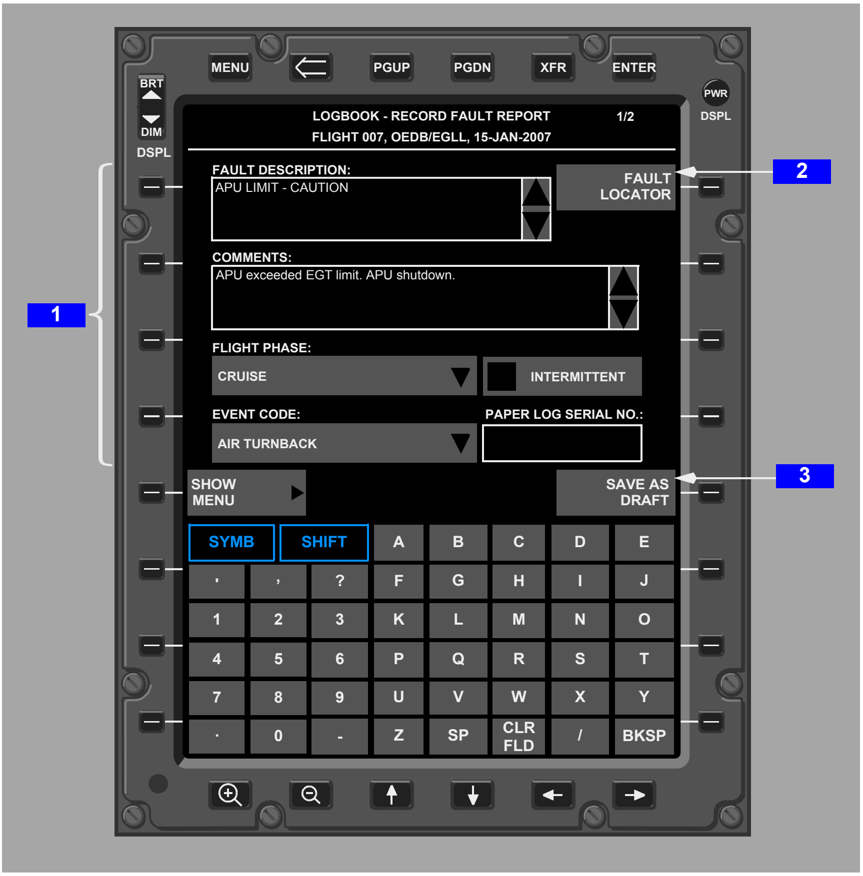
3 SEARCH Soft Key

Selection starts the search function. Results are displayed upon search completion.

4 CANCEL Soft Key

Selection cancels the text search and returns to the Fault Locator page.

LOGBOOK - RECORD FAULT REPORT Page 1/2



1 **Data Entry Fields**

Data entry fields required to complete the fault report.

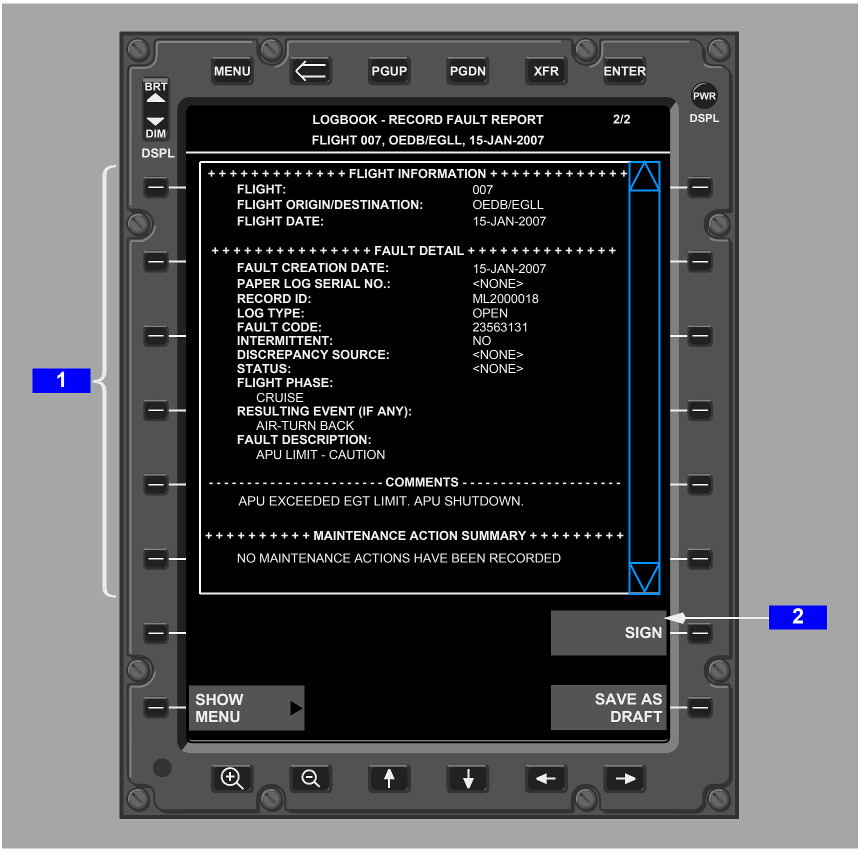
2 **FAULT LOCATOR Soft Key**

Selection displays the Fault Locator page.

3 **SAVE AS DRAFT Soft Key**

Selection saves the fault report in draft form for future access.

LOGBOOK - RECORD FAULT REPORT Page 2/2
Summary/Signature Page



1 **Fault Report Summary Information**

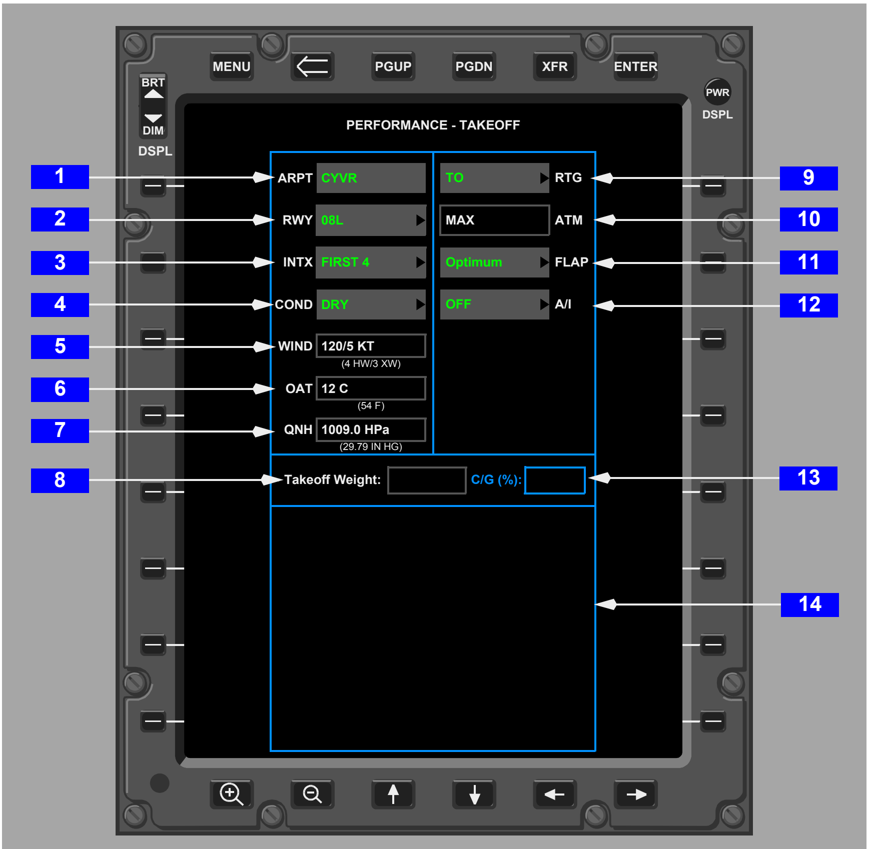
Displays the report summary information. Use scroll bar if necessary.

2 **SIGN Soft Key**

Selection displays the Sign Fault Report page.

Performance (Typical)

PERFORMANCE - TAKEOFF Inputs Page



Note: Some soft keys were removed from this display for simplicity.

1 Airport (ARPT)

Displays the airport identifier from the airport search function or transferred from the FMC route (RTE) page in the ORIGIN field. Manual entry of an airport on this page is not allowed.

2 Runway (RWY)

Displays the runway selected by the flight crew or transferred from the FMC route (RTE) page in the RUNWAY field.

Selection opens the drop-down list. Selecting a runway or EXIT closes the list.

Runways closed by NOTAM display amber. If selected an error message is displayed but the program still performs the requested calculation.

3 Runway Intersection (INTX)

Displays –

- NO INTX boxed in cyan when no runway intersection data exists
- INTX LIST in standard grey box when runway intersection data exists
- after selection, displays the runway intersection option selected

Selection opens the drop-down list. Selecting from the list or EXIT closes the list.

If there are more than three intersections, the full-length runway and the first three intersections are grouped under the FIRST FOUR menu item. Selecting FIRST FOUR provides performance results for the full length runway and the first three intersections listed.

If there are fewer than three intersections, these are grouped with the full length runway under the ALL menu item. Selecting ALL provides performance results for the full length runway and every intersection listed.

4 Runway Condition (COND)

Displays the runway condition selected by the flight crew.

Selection opens the drop-down list. Selecting from the list or EXIT closes the list.

5 WIND

Displays the wind direction and speed (ddd/ss K) entered by the flight crew.

The wind direction can be replaced with a headwind or tailwind component by entering a numeric value. Headwind components are positive values (i.e. 10) and tailwind components are negative values (i.e. -10).

A tailwind component can also be entered using a leading or trailing T entered with the wind velocity (i.e. T10 or 10T).

6 Outside Air Temperature (OAT)

Displays the temperature entered by the flight crew or transferred from the FMC TAKEOFF REF page 2 in the REF OAT field.

Temperature is displayed in the unit (Celsius or Fahrenheit) set by company policy. The default can be over-ridden by typing a C or F after the value entered.

7 Barometric Pressure (QNH)

Displays the barometric pressure entered by the flight crew or transferred from the data displayed on the primary flight display (PFD). If the entry is made from the Captain's EFB, then the QNH value transferred is from the Captain's PFD. Likewise, the First Officer's EFB uses the QNH value transferred from his PFD.

Entry can be either hectopascals or inches of mercury. The value is automatically recognized as hectopascals or inches of mercury and is labeled accordingly.

8 **Takeoff Weight**

Displays the takeoff weight entered by the flight crew, transferred from the weight and balance function, or transferred from the FMC performance initialization (PERF INIT) page in the gross weight (GR WT) field. The last occurrence of these entries is the takeoff weight displayed.

Calculation with the actual takeoff weight entered is used to determine the assumed temperature data for takeoff.

Calculation with the takeoff weight field blank is used to determine the maximum takeoff weight data.

9 **Takeoff Thrust Rating (RTG)**

Displays the selected takeoff thrust rating.

Selection opens the drop-down list. Selecting from the list or EXIT closes the list.

10 **Assumed Temperature Method (ATM)**

Displays the assumed temperature value/modifier. The field becomes active after an entry in the Takeoff Weight field.

Valid entries are:

- 0 or MAX - either uses the maximum assumed temperature available
- positive values - use the number entered (i.e. entering 40 uses 40C) for the assumed temperature
- negative values - use a decrement equal to the value entered (i.e. entry of -10 is used as a 10 degree decrement) from the maximum assumed temperature available

If the entry in this field is outside the operating parameters for the conditions, an error message displays after selecting calculate (CALC).

11 **FLAPS**

Displays the selected takeoff flap setting.

Selection opens the drop-down list. Selecting from the list or EXIT closes the list.

12 **Anti-Ice (A/I)**

Displays the selected anti-ice setting.

Selection opens the drop-down list. Selecting from the list or EXIT closes the list.

13 **Percent Center of Gravity [CG (%)]**

Displays the percent center of gravity (CG%) entered by the flight crew or transferred from the weight and balance function. The value is not used in any performance calculation, but is transferred with other data to the FMC.

The field becomes active only after an entry in the Takeoff Weight field.

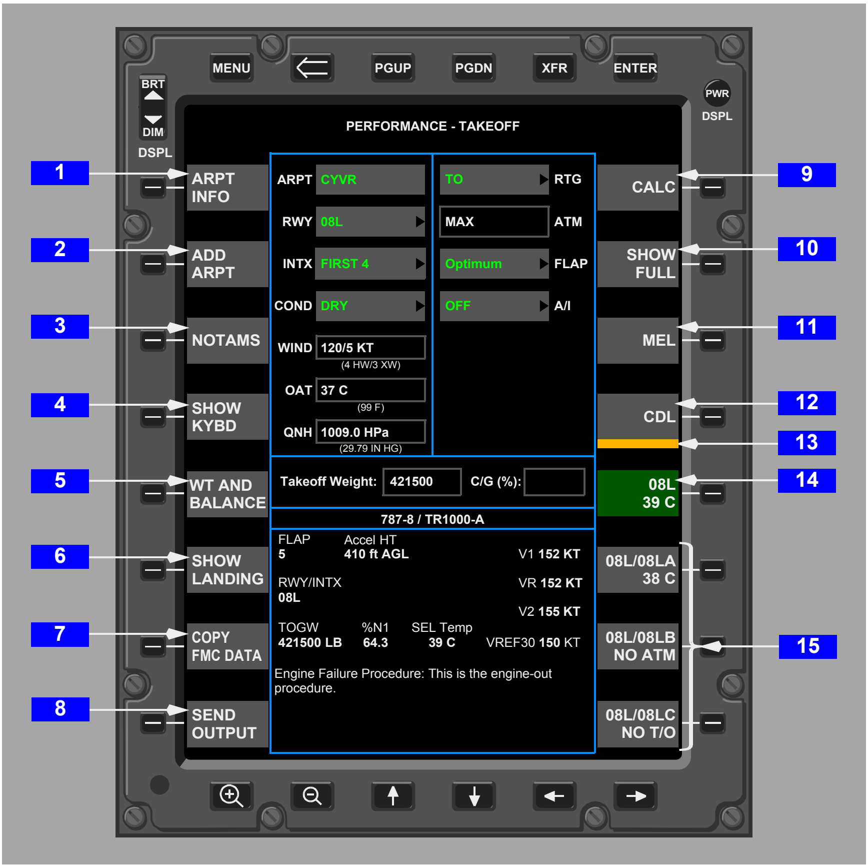
14 **Performance Data Display Area**

Displays the airplane performance information for the corresponding conditions selected.

Information displayed includes:

- flap setting
- acceleration height
- runway and intersection if applicable
- takeoff gross weight
- engine power setting
- selected temperature
- V-speeds (V1, VR, V2)
- landing reference speed (VREF)
- runway information such as engine failure procedure

PERFORMANCE - TAKEOFF Page



1 **Airport (ARPT) Information (INFO) Soft Key**

Selection displays the Airport Data page.

Active only after an airport and runway are selected in the ARPT and RWY fields.

2 **ADD Airport (ARPT) Soft Key**

Selection displays the Add Airport page.

3 **Notice to Airmen (NOTAMS) Soft Key**

Selection displays the NOTAMs page.

4 **SHOW KYBD (Keyboard) Soft Key**

Displays a touch sensitive keypad at the bottom of the page that is used for data entry.

5 **WT (Weight) AND BALANCE Soft Key**

Selection displays the Weight and Balance page.

6 **SHOW LANDING Soft Key**

Selection displays the Landing page.

7 **COPY FMC DATA Soft Key**

Selection copies data from the FMC to the takeoff page.

8 **SEND OUTPUT Soft Key**

Selection displays the Send Output page.

9 **CALC (Calculate) Soft Key**

Selection initiates the calculation of takeoff data.

Becomes active only after all the required data has been entered.

10 **SHOW FULL/SHOW ATM Soft Key**

Selection toggles between the display of full thrust data and assumed temperature data for the airport/runway entered.

11 **Minimum Equipment List (MEL) Soft Key**

Selection displays the MEL page.

12 **Configuration Deviations List (CDL) Soft Key**

Selection displays the CDL page.

13 **Amber bar**

Indicates an active NOTAM, MEL, or CDL item exists. This item is considered in the performance calculations.

14 **Full Length Runway Soft Key**

Displays the runway and temperature data upon which the calculations are based.

Selection turns the soft key green and displays the full length runway data in the performance display area.

If the Takeoff Weight field is left blank, the soft key displays the runway and the calculated maximum gross weight.

If an assumed temperature calculation is not possible, NO ATM displays in the soft key data field.

If no takeoff performance is available, NO T/O displays in the soft key data field.

15 **Intersection Runway Soft Key(s)**

Displays the runway/intersection and temperature data upon which the calculations are based.

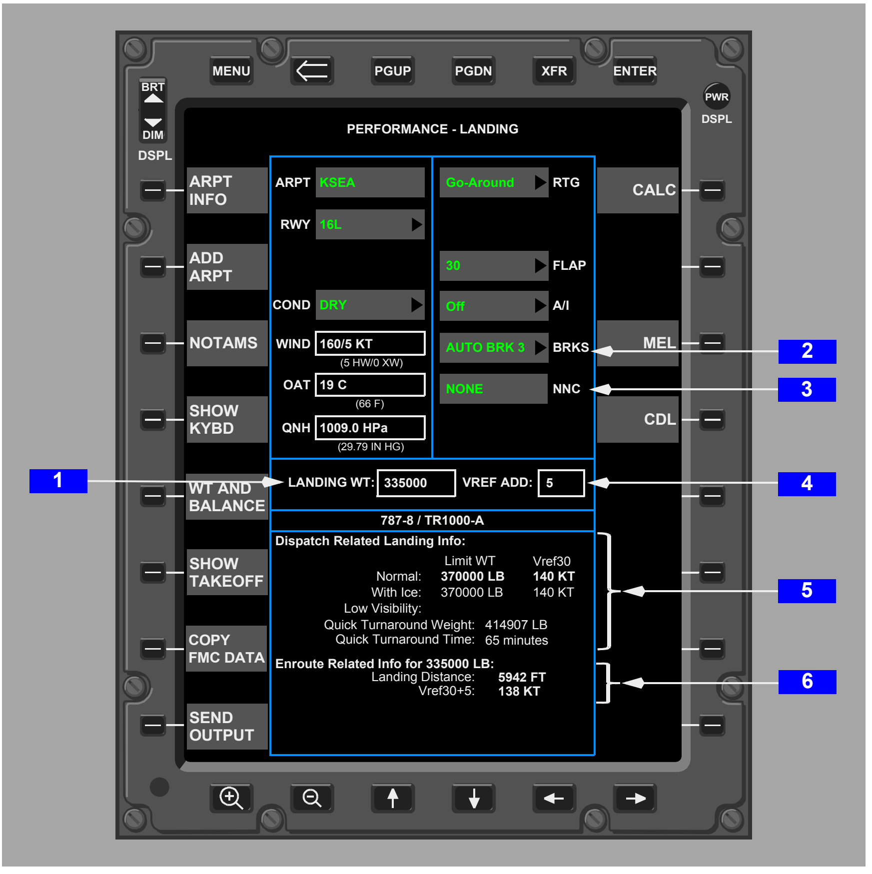
Selection turns the soft key green and displays the runway intersection data in the performance display area.

If the Takeoff Weight field is left blank, the soft key displays the runway/intersection and the calculated maximum gross weight.

If an assumed temperature calculation is not possible, NO ATM displays in the soft key data field.

If no takeoff performance is available, NO T/O displays in the soft key data field.

PERFORMANCE - LANDING Page



1 **Landing Weight Entry Field**

Displays the landing weight that was either manually entered, or calculated and transferred by the weight and balance application.

Leaving the Landing Weight field blank calculates only dispatch limit weights.

2 **Brakes (BRKS)**

Becomes active when a value is entered in the LANDING WT field.

Selection opens the drop-down list. Selecting from the list or EXIT closes the list.

Displays the brake setting information. Selecting a brake setting is only required for enroute landing performance calculations.

3 **Non-Normal Configuration (NNC)**

Becomes active when a value is entered in the LANDING WT field.

Selection displays an alphabetical list of non-normal aircraft landing configurations. This is a required field for all enroute calculations. If a non-normal configuration does not exist, select NONE from the list. After making a selection select COMPLETE to return to the Landing page.

4 Reference Speed (VREF) Additive (ADD) Field

Displays the default or manually entered approach speed increment used for tailwind or gust conditions.

5 Dispatch Related Information

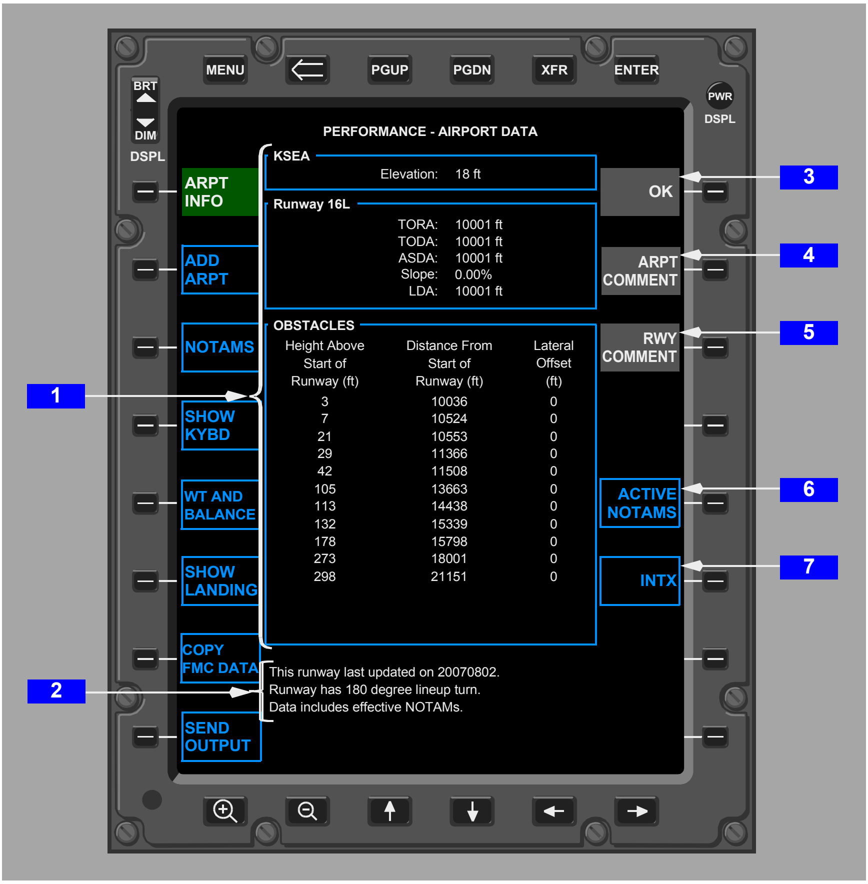
Displays dispatch related landing information.

6 Enroute Related Information

Displays enroute related landing information.

Displayed only when a value is entered in the LANDING WT field.

PERFORMANCE - AIRPORT DATA Page



1 Airport Information

Displays the active airport information.

2 File Information

Displays information regarding the displayed airport file.

3 OK Soft Key

Selection returns to the previous Takeoff or Landing page.

4 Airport (ARPT) COMMENT Soft Key

Selection displays the Airport Comments page.

This soft key is active when airport comments are available in the database. When finished viewing the information, select OK to return.

5 Runway (RWY) COMMENT Soft Key

Selection displays the Runway Comments page.

This soft key is active when runway comments are available in the database. When finished viewing the information, select OK to return.

6 ACTIVE NOTAMS Soft Key

Selection displays the Active NOTAMs page for the selected runway.

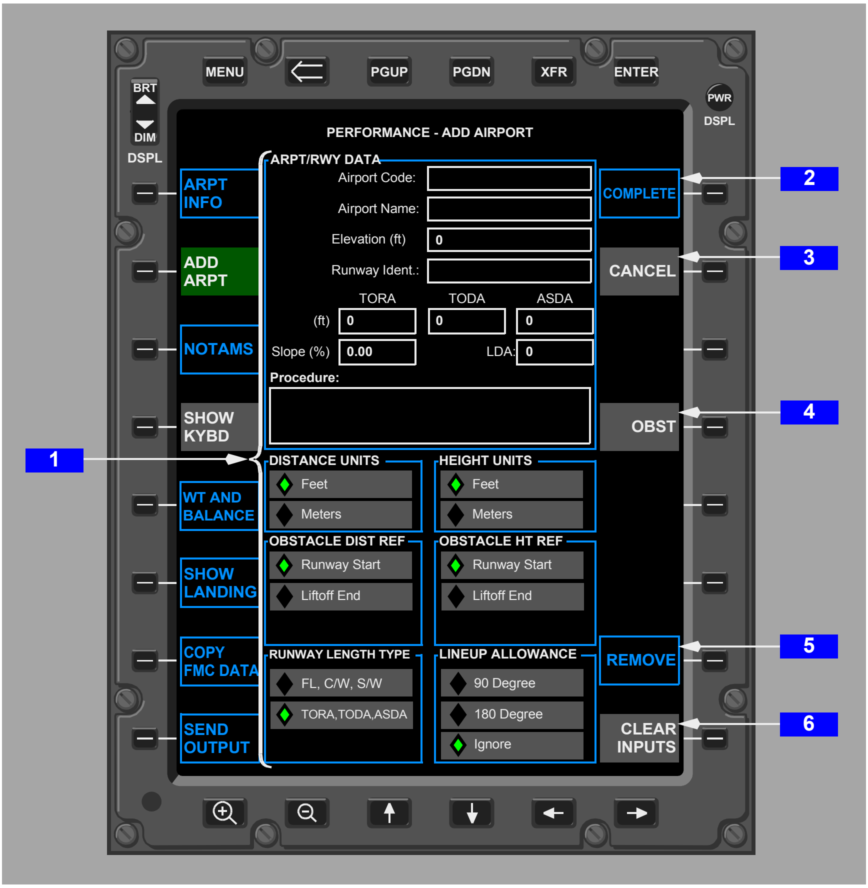
This soft key is active when NOTAMs are available in the database. When finished viewing the information, select OK to return.

7 Intersections (INTX) Soft Key

Selection displays the Intersection page for the selected runway.

This soft key is active when intersection information is available in the database. When finished viewing the information, select OK to return.

PERFORMANCE - ADD AIRPORT Page



1 Airport Information Input Fields

Entry fields required to add an airport.

2 COMPLETE Soft Key

Selection adds the airport to the database and returns to the previous Takeoff/Landing page. Becomes active only after all required fields are complete.

3 CANCEL Soft Key

Selection cancels the airport addition and returns to the previous Takeoff/Landing page.

4 Obstacle (OBST) Soft Key

Selection displays the obstacle entry page.

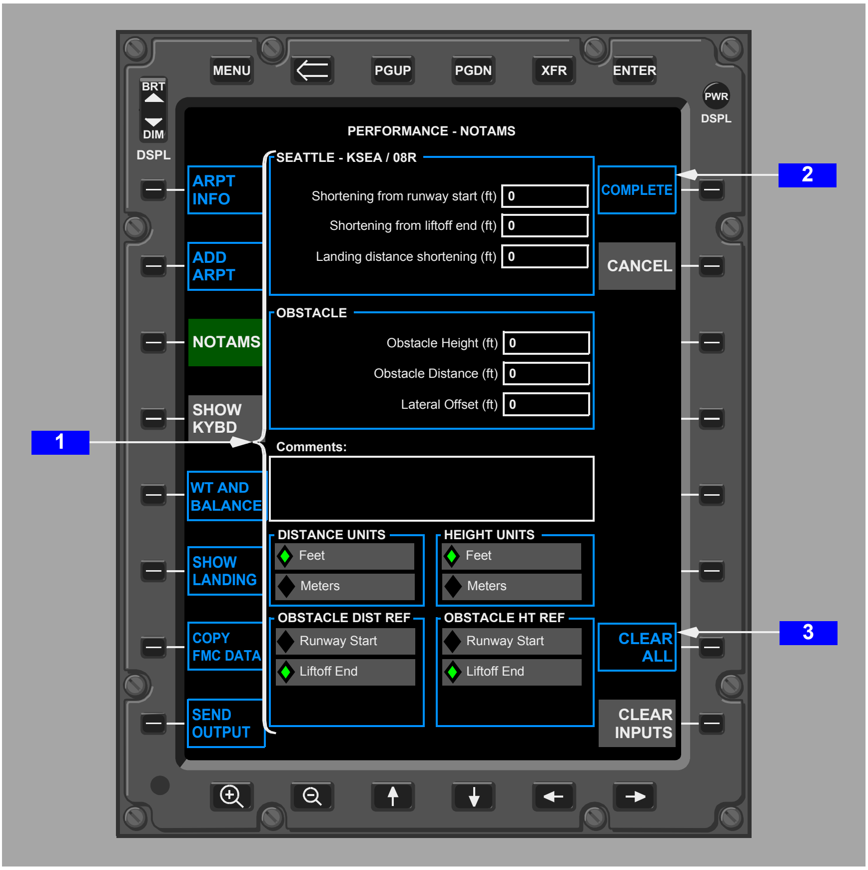
5 **REMOVE Soft Key**

Selection removes the airport from the database and returns to the previous Takeoff/Landing page.

6 **CLEAR INPUTS Soft Key**

Selection removes all inputs made in all entry fields.

PERFORMANCE - NOTAMS/Add NOTAMS Page



1 **NOTAM Input Fields**

Entry fields required to add a NOTAM.

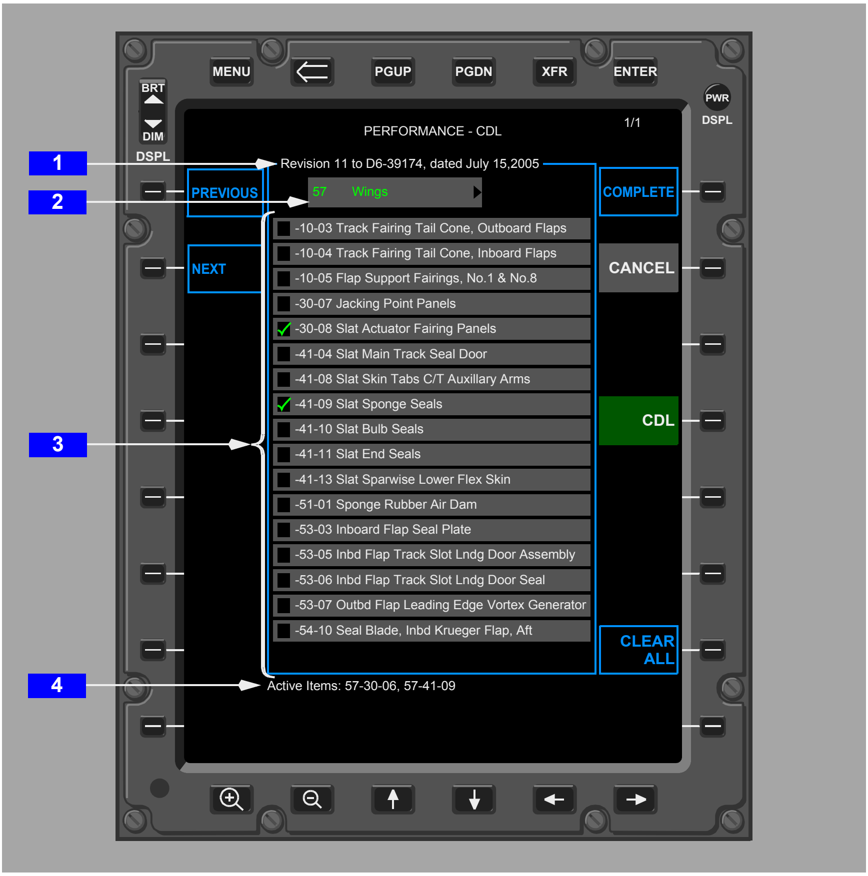
2 **COMPLETE Soft Key**

Selection adds the NOTAM to the database and returns to the previous Takeoff/Landing page. Becomes active only after all required fields are complete.

3 CLEAR ALL Soft Key

Selection clears all NOTAMs added and returns to the previous Takeoff/Landing page.

PERFORMANCE - MEL/CDL Input Page



1 MEL/CDL Revision Information

Displays the revision, document name/number, and date of current revision.

2 ATA Chapter Listing

Displays current ATA chapter title.

Selection opens a drop-down list of all the ATA chapters.

3 MEL/CDL Items

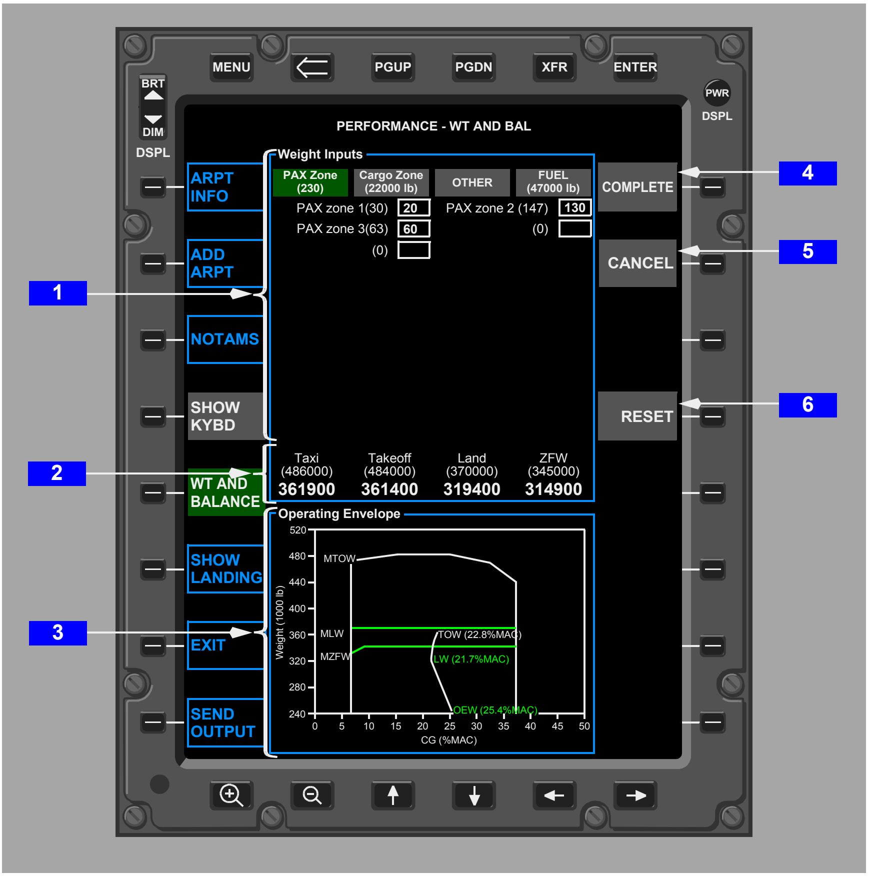
Line selectable MEL/CDL items. Chapter number is omitted in the item reference but listed in the drop-down box title.

Selection places a green check mark in the appropriate box. Selecting the item again removes the check mark.

4 **Active Items**

Lists all selected MEL/CDL items. This list would include any items selected in other chapters as well. The list is limited to either MEL or CDL specific items.

PERFORMANCE - WT AND BAL (Weight and Balance) Page



1 **Weight Inputs**

Selection displays either the Passenger, Cargo, Other, or Fuel input page.

2 **Aircraft Weights**

Initially displays airplane operating empty weight. Values are updated as data fields are completed.

Weight fields turn amber when the weight limit (the figure in parenthesis) is exceeded, or if the corresponding CG position is outside the envelope.

3 **Operating Envelope**

Graphic depiction that includes; OEW (%CG), TOW (%CG), and LW (%CG) plotted within the CG limit envelope. The airplane maximum weight limit lines; MZFW, MTOW, MLW are displayed as well.

4 **COMPLETE**

Becomes active when all required fields are complete.

Selection uploads the calculated takeoff gross weight and CG to the Takeoff page, and the landing weight to the Landing page, then returns to the previous Takeoff/Landing page.

5 **CANCEL**

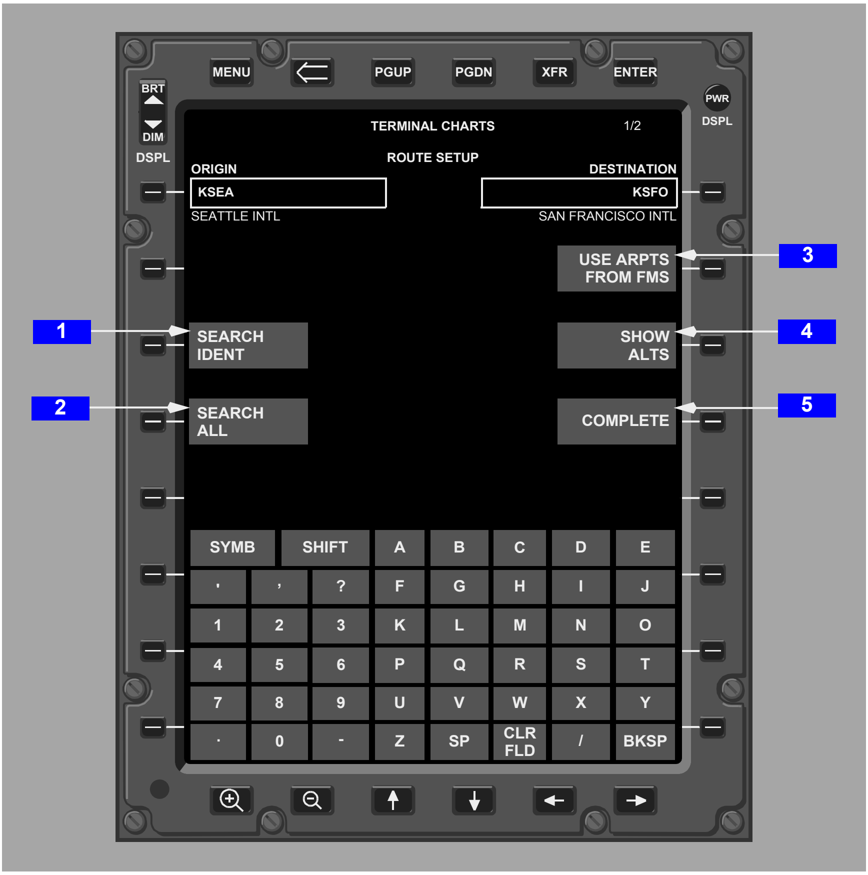
Clears all entries and returns to the previous Takeoff/Landing page.

6 **RESET**

Selection resets the weight and balance page and clears all previous entries.

Terminal Charts

TERMINAL CHARTS - ROUTE SETUP Page



1 **SEARCH IDENT Soft Key**

Selection displays search results in the Airport Search page. If needed, select the PGDN bezel key to view additional results.

2 **SEARCH ALL Soft Key**

Selection displays search results in the Airport Search page. If needed, select the PGDN bezel key to view additional results.

3 **USE Airports (ARPTS) FROM FMS Soft Key**

Selection loads the ORIGIN and DESTINATION fields with those entered on the FMC Route page.

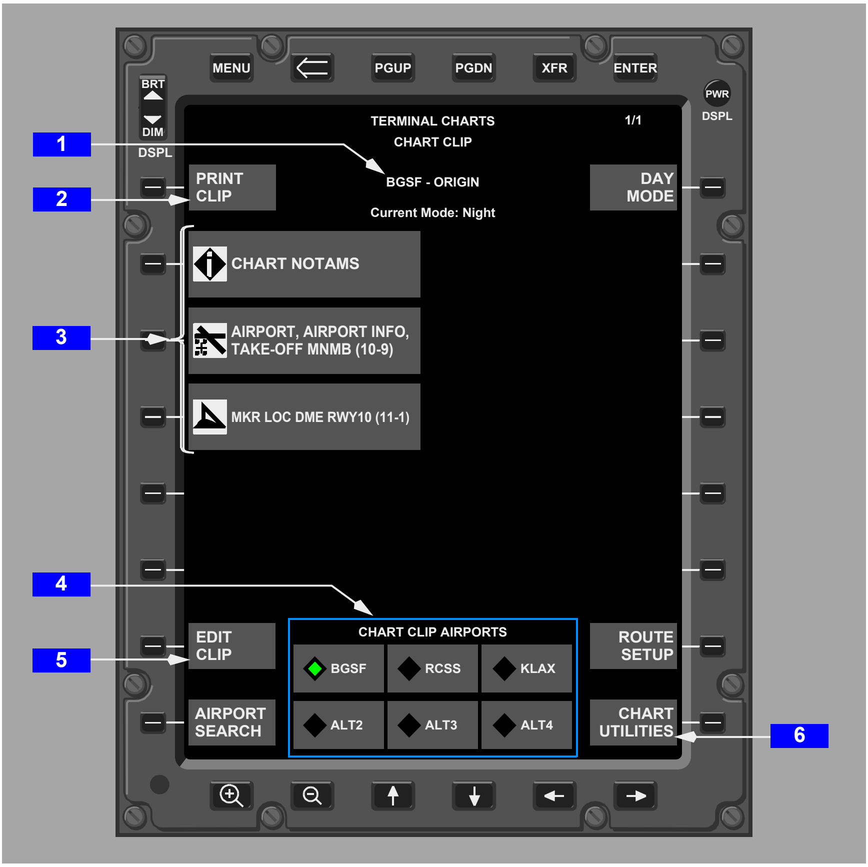
4 **SHOW Alternates (ALTS) Soft Key**

Selection displays a list of the alternate airports.

5 **COMPLETE Soft Key**

Selection saves any changes and displays the Chart Clip page.

TERMINAL CHARTS - CHART CLIP Page



1 **Airport Identifier**

Displays the current chart clip airport identifier.

2 **PRINT CLIP Soft Key**

Selection displays the Print page.

3 **Charts Soft Keys**

Selection displays the relevant chart.

4 CHART CLIP AIRPORTS Field

Displays the available airports in the chart clip. Selection of an airport (green diamond) displays the Terminal Charts page for that airport.

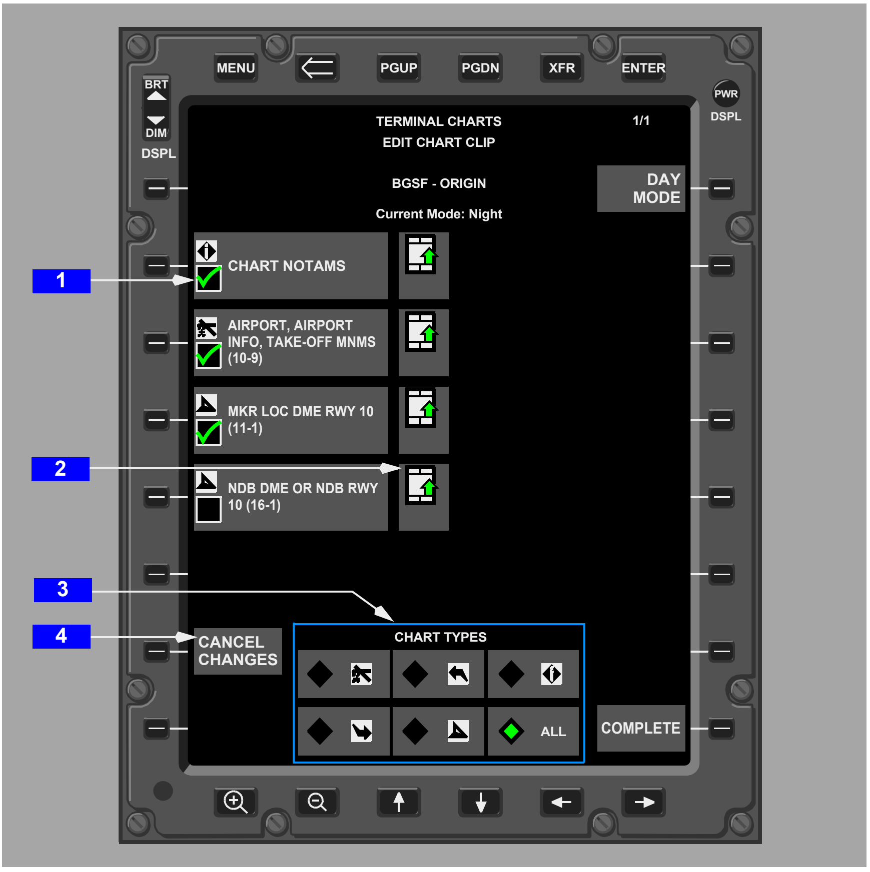
5 EDIT CLIP Soft Key

Selection displays the Edit Clip page.

6 CHART UTILITIES Soft Key

Selection displays the Chart Utilities page.

TERMINAL CHARTS - EDIT CHART CLIP Page



1 Selection Box

Selection –

- Box (empty) - chart is not displayed in the chart clip
- Box (green check mark) - chart is included in the chart clip

2 **Preview Chart Soft Key**

Selection opens the chart for viewing on the Preview Chart page.

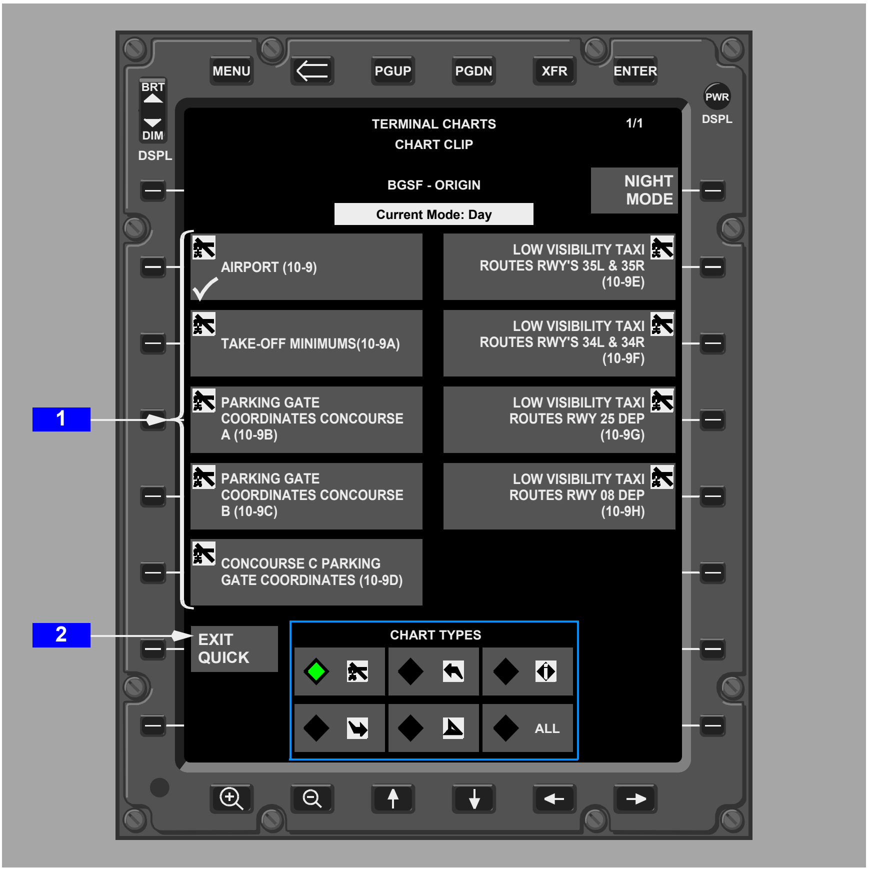
3 **CHART TYPES Field**

Displays the available charts for the selected airport. Selection of a chart (green diamond) displays the chart on the Chart Clip page.

4 **CANCEL CHANGES Soft Key**

Selection cancels any changes made and returns to the Chart Clip page.

QUICK USE CHART LIST Page



1 **Charts Available for Selection**

Displays the charts that are available for selection to the Chart Clip. The soft keys displayed are in direct reference to the CHART TYPES previously selected. Changing the CHART TYPES selection changes the quick use displayed charts.

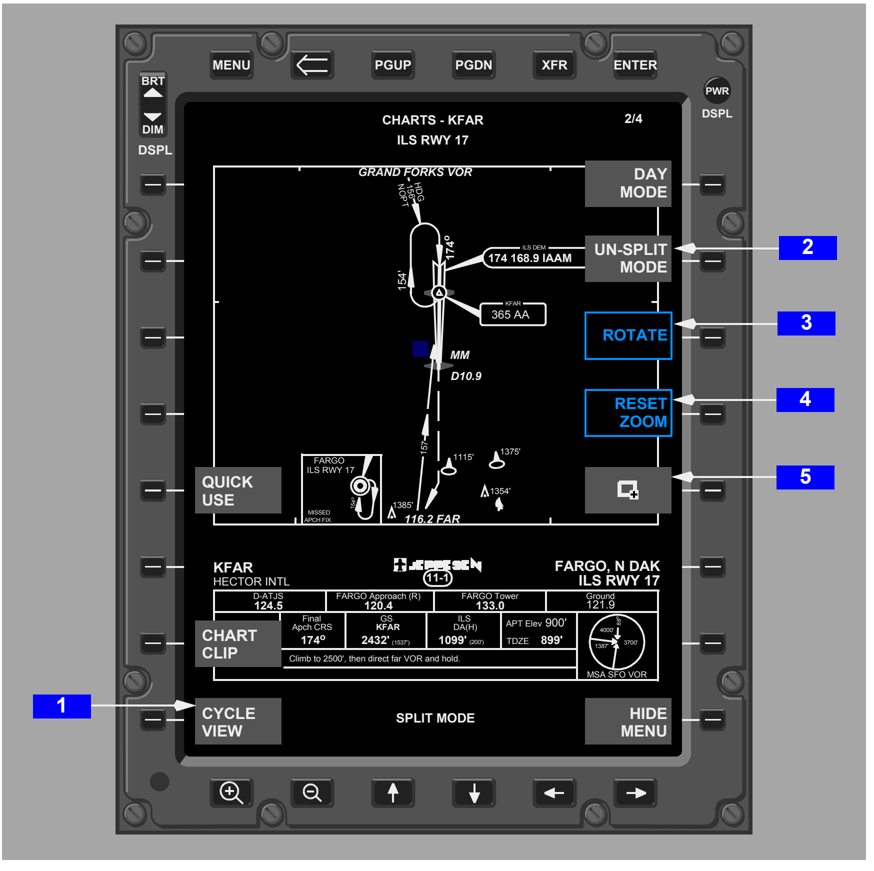
Selection of a chart for display on the Chart Clip page displays a white check mark on the soft key.

Use the back arrow bezel key to return to the Chart Clip page.

2 EXIT QUICK Soft Key

Selections exits the Quick Use page and returns to the Chart Clip page.

CHARTS View Page



1 CYCLE VIEW Soft Key

Selection cycles the bottom display through the chart's frames:

- Briefing Strip™, or
- Profile, or
- Minimums

After all three frames display individually, the next CYCLE VIEW displays the three views all together without the chart. The next selection of CYCLE VIEW returns to the beginning of the cycle.

2 SPLIT/UN-SPLIT MODE Soft Key

Selection toggles between the split modes.

SPLIT MODE view is split so the plan view is displayed on top of the screen and the Briefing Strip™, Profile View, or Minimums displays at the bottom.

UN-SPLIT MODE displays the entire chart (identical to a paper chart).

A specific mode is set as the default according to company set preferences.

This functionality is not available on the Preview Chart page.

3 ROTATE Soft Key

Selection rotates the chart clockwise 90 degrees. Select ROTATE again to return the orientation to the original position.

This soft key is unavailable when the chart is being viewed in Split Mode.

4 RESET ZOOM Soft Key

Selection returns the chart to its original magnification after using the Rectangle Zoom, Zoom In, or Zoom Out functions.

5 Rectangle Zoom (horizontal rectangle with magnifying glass) Soft Key

Selection initiates drawing a diagonal line across a specific area of the chart to magnify. When the diagonal line expands, it creates a rectangle around the area. The specified area of the chart is centered and zoomed to the maximum extent possible proportional to the screen. Use RESET ZOOM to cancel the view.

TERMINAL CHARTS - NEAREST AIRPORTS Page

1 Nearest Airports List

Displays up to ten of the closest airports from current GPS position. Five airports are displayed per page. Select the PGDN bezel key to view any additional airports.

Note: Only airports contained in the company database are displayed.

2 Current Airport Criteria Field

Airport search criteria used when retrieving the closest airports. This criteria is set by the operator.

3 DISABLE CRITERIA Soft Key

Selection overrides the airport search criteria. The nearest airports list displays the closest airports from current GPS position regardless of airport criteria.

Note: Only airports contained in the company database are displayed.

[Option]

Video Surveillance (Typical)

VIDEO SURVEILLANCE Main Page

1 Primary Display Area

Displays the selected thumbnail image inside a green border.

Border changes to cyan when FREEZE is selected.

Border turns amber and NO VIDEO SIGNAL displays when the selected image is not available.

2 Primary Display Title Bar

Displays the name of the thumbnail image being displayed in the primary area.

3 **FREEZE/UNFREEZE Soft Key**

Selection toggles between FREEZE and UNFREEZE.

Selection either freezes or unfreezes the image in the primary display.

4 **Thumbnails**

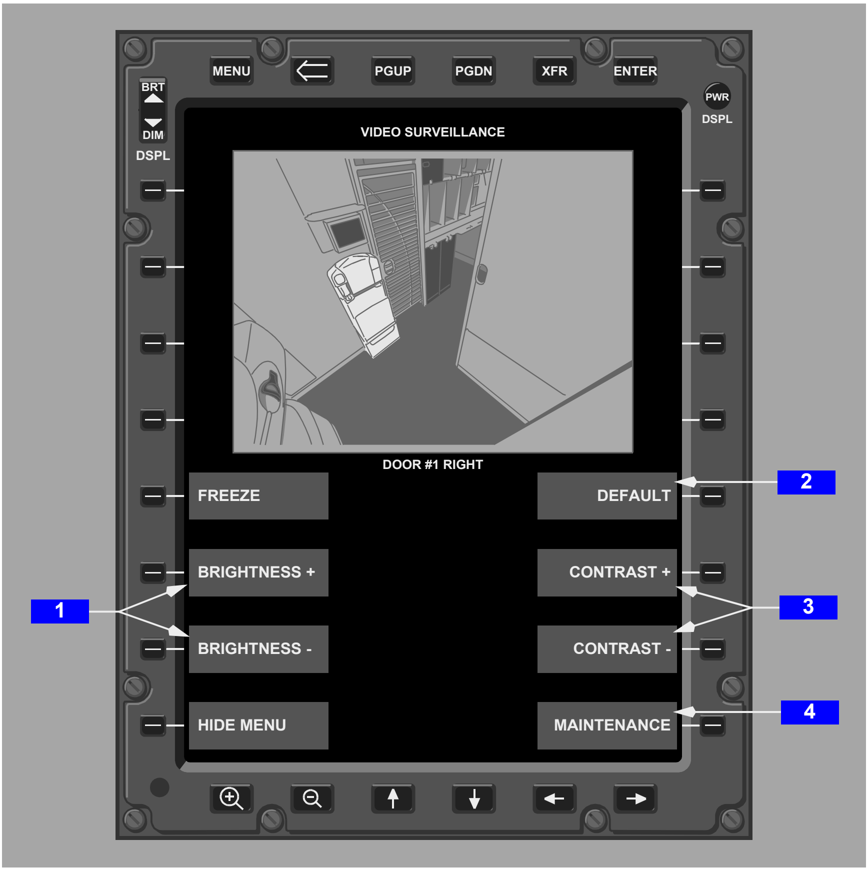
Any of the three thumbnail images:

- borders are gray when they can be selected for display in the primary area
- borders become white when the cursor is moved over the image
- borders become green when being displayed in the primary area
- borders turn amber and NO VIDEO SIGNAL displays when the image is not available

5 **SHOW/HIDE MENU Soft Key**

Selection toggles between displaying and hiding the additional BRIGHT, CONTRAST, DEFAULT, and MAINTENANCE soft keys.

VIDEO SURVEILLANCE Show Menu Page



1 BRIGHTNESS +/- Soft Keys

Changes the brightness of the image in the primary display as indicated by the + and - selections.

2 DEFAULT Soft Key

Returns the brightness and contrast to the default settings.

3 CONTRAST +/- Soft Keys

Changes the contrast of the image in the primary display as indicated by the + and - selections.

4 MAINTENANCE Soft Key

Displays the Maintenance page for maintenance personnel use.

Intentionally
Blank

Electronic Flight Bag

The material presented in this section, combined with the information in section 10.70 - EFB Controls and Displays, should provide the operator with enough knowledge to make use of the Electronic Flight Bag (EFB) and its applications. There are many simple, intuitive operations that are not covered in these sections. These basic operations are assumed to be understood by the user. The information presented here is not intended to be an analogy of every step within an application, nor is it provided as a complete narrative of each function within the EFB. Customizing by the airline makes the EFB and its applications appear differently and therefore does not allow for an in depth narrative of system operation in this section.

The electronic flight bag is an operating system with a suite of applications designed to assist the flight crew with routine tasks, enhance security, and reduce the reliance on paper documents. The flight crew interact with the EFB using display units located in the left and right side panels. The display units operate independently of each other, but can also display information from the offside unit, exchange data with the FMS, and send information directly to the flight deck printer, or company personnel (via ACARS).

Under typical flight conditions, the majority of pilot interaction consists of manipulating bezel keys or using the touch screen on the display unit to move back and forth among applications, or within applications, and to display, send or print data. In addition, the flight crew can interact with the EFB using the cursor control device (CCD) or an optional full size QWERTY keyboard.

The suite of applications available to the flight crew is selected by the airline. The presentation can be customized by assigning applications to certain soft keys, revising application names, or defining the order in which applications appear on the screen. Airline modifiable portions of each application may be further customized by choosing different display colors, fonts, icons and cursors. Third party applications may also be installed on the EFB. Applications, descriptions, and illustrations provided in this section are examples of a typical EFB installation and may not reflect the user installed configuration.

Display Unit

The display unit is the main interface between the flight crew and the EFB and its applications. The display unit incorporates a touch screen and 30 keys located on the bezel around the screen itself. These bezel keys allow the user to perform the following functions:

- control screen power and brightness
- access the Main Menu page or exit the transfer mode
- return to the previous level or view
- page up or page down
- activate the highlighted soft key
- line select a soft key on the display
- zoom in and zoom out
- move the displayed item left, right, up, or down

The touch screen allows the user to activate various applications, functions, or menus by touching the area defined as a soft key. Soft keys are explained later in this chapter.

Display Description

The top of the display is reserved for the header which displays the title and fault information. The title may use two lines with the top line providing the name of the application, and the second line listing the name of the page being viewed.

The main body of the display area is everything below the header. There is no footer or bottom display area.

Certain EFB screen areas are reserved for system messages. For example, messages displayed in the top left corner of the screen indicate that a fault occurred or an application needs attention. For most system messages the appropriate response is to contact maintenance personnel. Messages and their descriptions are listed in the EFB Messages Table found later in this chapter.

Although each application has a unique function on the EFB, they all conform to standard interface display guidelines. These standards include:

- gray soft keys indicating that a function is available for use
- gray soft keys highlighted with a magenta box indicating that a function can be selected for use
- cyan outlined soft keys with cyan text indicating that an application or function is currently unavailable
- green soft keys identifying a selected function or currently active application
- amber horizontal stripe beneath soft keys when the associated function has an annunciation

For details about a certain application's display interface, refer to the specific application description in this chapter.

EFB Main Menu

The EFB Main Menu page contains access to all the hosted applications via soft keys displayed on the page. The Main Menu page also contains the IDENT PAGE and SYSTEM PAGE soft keys, as well as the INITIALIZE FLIGHT soft key. All of these items are described later in this chapter. The EFB Main Menu page also displays the FAULT, MEMO, and/or MSG label adjacent to the appropriate application or system soft key.

IDENT page

The IDENT page, which is accessible through the main menu page, displays airplane information, date and time, and software and database part numbers with associated effective dates. Part numbers with expired effective dates display in amber font. This page allows quick access to the operational readiness of the system, data, and documents required for flight.

Note: If the IDENT page is unavailable, all part numbers, regardless of effective dates, display on the SYSTEM page.

SYSTEM page

If a system FAULT, MEMO, and/or MSG indicator appears on the EFB screen, more information regarding the indication can be found on the System page. All existing EFB faults are displayed on the system page. New faults display at the top of the list. Unacknowledged faults display in white font; acknowledged faults display in cyan font. If needed, use the scroll bar to view additional faults. When all faults are acknowledged, the FAULT, MEMO, and/or MSG indicators are removed.

On the System page are two selections that should be reserved for use by maintenance personnel. The RESTART soft key is used to restart the Windows operating system, and the EFB MAINTENANCE soft key provides access to the EFB Maintenance page.

EFB Messages Table

Message	Description
FAULT	Indicates that a fault has occurred. Navigate to the System page for more information.
MEMO	Indicates that an application requires attention. When this message displays, navigate to the corresponding application for more information.
MSG (Message)	Indicates that one of the applications has a message. When this message displays, navigate to the corresponding application to view the message.
XFR (Transfer)	Indicates that the system is in transfer mode and the contents of the offside EFB are being displayed. While in this mode, the display cannot be manipulated. Select the XFR soft key or MAIN bezel key to cancel the transfer mode.

Virtual Keypad

The virtual keypad can be used to type information, such as airport identifiers or performance data, into the EFB applications. The keypad is automatically activated for certain functions such as airport searches and performance data entry. The typed selection displays in the active field and can either be in an application, or the field in the keypad itself. The typed data, when complete, is then entered into the appropriate field in the application, or searched for with the returned results listed above the keypad. Refer to each individual application description in this chapter for more information on using the keypad.

Initializing a Flight

The flight should only be initialized after verifying the effective dates of the software and databases, actioning all appropriate messages, and completing the CDU Pre-Flight procedure.

Note: It is recommended to have completed the CDU Pre-Flight from the Normal Procedures before initializing the flight as the EFB retrieves as much information as possible from other aircraft systems for use when initializing the various other EFB applications.

After initializing the flight the following information is collected from the airplane systems and made available to the EFB applications:

- flight deck date and time
- GPS latitude, longitude, date, and time
- true and magnetic heading

- origin and destination airports
- flight number
- airplane tail number
- several performance data points

For specific information gathered by each application during flight initialization, refer to the individual application descriptions found in this chapter.

During flight initialization, all applications are reset to the start-up default settings, thus clearing any information loaded or viewed by the previous flight crew.

To initialize the flight select INITIALIZE FLIGHT from the Main Menu page.

Note: During the initialization process certain application soft keys turn cyan to indicate unavailability. This is normal and the applications becomes available after the initialization is complete.

If the INITIALIZE FLIGHT soft key is not available, a flight has already been initialized. Before initializing a new flight, the current flight must be closed. Refer to Closing a Flight in this chapter for more information about closing a flight.

Electronic Document Browser

Overview

The Electronic Document Browser (EDB) application provides the ability to view and search electronic information on the flight deck. The documents included in the library can be customized and loaded by the user. Therefore the descriptions and illustrations provided in this section are examples of a typical EDB installation and may not exactly reflect the currently installed configuration.

Using the EDB, the pilot can quickly and easily navigate throughout the document to find critical information. Key features include eliminating paper documents from the flight deck, ease of navigation within documents, support for XML and native PDF document formats, support for printing with flight deck printer, key word searches, zooming capabilities, and night use via white text on black background (XML only).

Although there are limitations to the included PDF functions, the EDB can easily display these types of documents and does provide limited search capabilities.

Note: For consistency, "document" is used throughout this section to describe a book, guide, handbook, or other entire document; "chapter" refers to a section, part, or other division of a document.

Selecting Content to View

Select and load content to view in any of the following ways:

- select a document from the Document Library page, or
- select a chapter from the Table of Contents page, or
- select a chapter from the History list, or
- select a chapter from the View Bookmarks page (if chapter was viewed since initializing the flight), or
- search for words in a document by using the Search function

After navigating away from viewing the document, select MENU and then RETURN TO OPEN CONTENT to go back to the currently open content.

Only one document can be viewed at a time. A document selected for viewing remains in the browser until another document is selected, even after exiting the EDB application and returning at a later time.

Note: Initializing a flight clears all previous references (searches, bookmarks, etc.) to any document.

Selecting a Document from the Document Library

The Document Library page displays all of the documents that are available for viewing which may include both single documents and groups of documents. For example, the Document Library might include a Maintenance Documents group; when that group is selected, the titles of the documents defined for that group are displayed in a sub-library page.

To select a document from the Document Library; select DOCUMENTS from the EFB Main Menu page. If the EDB application was previously accessed, the system displays the last page being viewed before exiting the application. In this case, select the MENU soft key and then DOCUMENT LIBRARY.

Use the PGUP and PGDN bezel keys to page through the document list and locate the document to view. Documents are listed individually or grouped into categories. Grouped documents display in the top-level page only and are identified by use of an ellipsis (...) in the title.

Select the name of the document to view. If the selected document is divided into chapters, the Table of Contents page displays with the document title or abbreviation at the top of the page. If the selected document does not have a Table of Contents, the document's content displays in the View Content page.

Expand (+) or collapse (-) the Table of Contents as needed to locate the chapter to view. Select COLLAPSE TOC to collapse all the entries in the Table of Contents. Select a chapter to display its contents in the View Content page.

Note: For XML documents, the default setting is to display the content associated with a specific tail number. If necessary select MENU, FILTER CONTENT, and then ALL TAIL NUMBERS to display document content regardless of tail number.

Selecting a Document from the History List

Because the EDB application tracks the order in which the documents and chapters were viewed, the History menu option allows the easy return to a previously viewed document or chapter.

To view the content of a document or chapter from the History list:

- select MENU, HISTORY, and then PREVIOUS HISTORY ITEM to view the content of the previous document or chapter in the history list
- select MENU, HISTORY, and then NEXT HISTORY ITEM to view the content of the next document or chapter in the history list

Note: Initializing a flight clears the History list.

Using Bookmarks

Using the Bookmarks menu function marks content within a chapter for easy retrieval. All bookmarks are stored in a list that displays on the View Bookmarks page. The bookmarks function is only available in documents with a table of contents, and only one bookmark in each chapter is permitted.

To create a bookmark for the content being viewed select MENU, BOOKMARKS, and then CREATE BOOKMARK. To view a bookmark select MENU, BOOKMARKS, and then VIEW BOOKMARKS to display the View Bookmarks page. Select the document name and then the chapter from the expanded list. The beginning of the chapter's content displays in the View Content page.

Note: Initializing a flight deletes all saved bookmarks.

Navigating Through a Document

While viewing document content, moving within the document is accomplished in several ways:

- select the PGUP or PGDN bezel key to scroll through chapters that are too long to fit on one screen
- use the scroll bar and arrow bezel keys to move through the displayed content
- select a hyperlink in XML or HTML documents to display the graphics in the View Figure page

In the View Figure page:

- use the zoom bezel keys to magnify the image
- use the ROTATE menu function to rotate the image to the right or left
- use the RESET menu function to return the rotated figure to its original orientation
- use the CLOSE menu function to return to the View Content page

Changing the Display of a Document

Use any of the options described below to change the display of a document.

For all types of documents; select the zoom bezel keys to change the magnification of the content. A zoom scale displays for three seconds in the bottom center of the View Content and View Figure pages when the display increases or decreases in size.

For XML documents; select MENU and DAY MODE or NIGHT MODE to toggle between day and night mode viewing if both modes are available.

For PDF documents; select MENU and FIT TO WIDTH to expand the document display to the full width of the display area. Select MENU and FIT TO SCREEN to view the entire page of the document in the display area. Select MENU, ROTATE, and then RIGHT or LEFT to rotate the document display 90 degrees to the left or right while maintaining the same view factors.

Searching For Information Within Documents

Text string searches within documents can be performed using the EDB search function. The search results can be limited so that one or all text strings can be included in the search results. Searches can be performed across one, several, or all documents in the Document Library.

To search for one or more text strings select MENU, SEARCH, and then NEW SEARCH.

Indicate which documents to search in by selecting the check boxes in the Select Documents to Search area. To search all of the documents in the Document Library, select the Search ALL Documents check box. Select a checked box to un-check the selection.

Select how a search for multiple text strings is conducted by selecting one of the following options in the Advanced Options area:

- Find All Words – searches for every text string typed in the Enter Search Term field. For example, while the word “or” should not be used in a search, use Find All Words to search for the entry "flaps or slats"
- Find Exact Phrase – searches for the phrase exactly as typed in the Enter Search Term field

- Find Any Words – searches for any of the text strings typed in the Enter Search Term field. For example, the entry "flaps or slats" search for every occurrence of "flaps", every occurrence of "or", and every occurrence of "slats"
- Find Whole Words – searches for a complete word instead of a partial word inside a larger word

In the Enter Search Term field, type the text string(s) to search on. Do not type “and” or “or” in this field. Use a space to separate multiple text strings.

Selecting SEARCH transitions to the Search Results page. A Progess monitor displays in the upper right area of the screen. This page lists each location that contains the search term specified. The list can be sorted by number of hits, or location in both ascending and descending order.

Note: If the search is too large and retrieves many results, selecting CANCEL SEARCH stops the search and returns to the Search page so the original search terms can be refined as necessary.

Select a document or chapter from the list to view its content in the preview window. Search results display in yellow highlighted text.

Select OPEN DOCUMENT to view the document in the preview pane. Search results display in yellow highlighted text.

Select MENU, SEARCH, and then any of the following choices:

- SEARCH RESULTS to return to the Search Results page, view the search results list, and select another result
- PREVIOUS RESULT to view the content of the previous search result without displaying the Search Results page
- NEXT RESULT to view the content of the next search result without displaying the Search Results page
- HIGHLIGHT RESULTS to maintain highlighted search results. Active as long as the check box is marked

Viewing Large Tables

Tables containing text and images that do not fit in the display area may display in a "table viewer" on the View Content page of XML documents.

In the table viewer, table headers are automatically frozen in place so that scrolling down the table does not lose the context of the header. Columns on the left and right side of the table can also be frozen while scrolling the table horizontally. Table rows and columns resize based on their content to avoid wrapping of any word.

The table viewer allows selection of an individual table cell to highlight its location. It also allows selection of a column header or row header to highlight and select the entire row or column. Clicking on a cell again removes the highlighting.

Printing a Document on the Flight Deck Printer

Both text and graphics can be printed depending on the type of printer connected to the flight deck. Text is available from an XML document when using a text printer. Both text and graphics are available from a PDF, XML, or HTML document when using a graphics printer.

Printing Text

When printing text in an XML document, the system prints all content contained within the scroll bars on the View Content page. A text printer prints only text in the document, not graphics, links, or tables.

Another print job can not be started until the PRINT soft key becomes active.

Printing Graphics

When printing a PDF document, position the top of the page at the top of the View Content page to ensure that the correct material prints.

When printing an XML or HTML document (including graphics), the system prints all content contained within the scroll bars on the View Content page.

Another print job can not be started until the PRINT soft key becomes active.

Understanding Document Conventions

Documents that conform to the Boeing schema and use related style sheets adhere to the following conventions:

- WARNING text is displayed in red font, CAUTION text is displayed in amber font, and NOTE text is displayed in bold font
- revised text is denoted by a white revision bar in the left margin
- linked text is denoted by a dark gray box around the specific text, similar to a soft key on the EFB interface
- graphics are linked so that they can display in a separate page that allows zooming
- a document can display in Day mode, which is suitable for bright light conditions, or Night mode, which is suitable for dark conditions

Troubleshooting

The EFB Document Browser application might display the following memos upon flight initialization or application startup:

- DOCUMENT EFFECTIVITY OVERLAP – two or more of the same documents have a date overlap. Select the proper document for the flight
- DOCUMENTS HAVE PASSED EXPIRATION DATE – one or more documents with effective dates have expired. Select CONTINUE to use a document, regardless of effectivity

- DOCUMENTS HAVE NOT REACHED EFFECTIVE DATE – one or more documents have not reached their effectivity ranges. Select CONTINUE to use a document, regardless of effectivity
- DOCUMENT FAILED TO PRINT – an error occurred preventing the document from printing. Select CONTINUE to acknowledge the error and return to the View Content page
- TAIL NUMBER CANNOT BE FOUND – a tail number included as part of the effectivity is not available. Select CONTINUE to acknowledge the error and go to the DOCUMENT LIBRARY page

Electronic Logbook (Typical)

Overview

The Electronic Logbook (ELB) is a software application that replaces paper maintenance/technical logbooks by allowing the pilot to record observed faults on the airplane for the maintenance crew to review and take appropriate action. The ELB provides the following functions:

- review open, deferred, and draft items
- review the previous fault history, flight log, and maintenance release
- record flight information such as Out, Off, On and In times
- record faults that occur during the flight
- review and sign the flight log

Launching the ELB

To start the ELB, select LOGBOOK on the EFB Main Menu page to display the Logbook Home page.

The Logbook Home page displays the following at the top of the page:

- the flight number, origin and destination airports, and scheduled departure date (this is the previous flight's data until after a new flight log is created)
- the last maintenance release date, station where the release was signed, and the release status of the airplane
- the status of the flight log (Closed, Inactive, or Active) is displayed above the FLIGHT PREPARATION soft key

The Logbook Home page displays the autoland expiration date and the number of hours since the last C-Check at the bottom of the page.

Note: Black arrows on soft keys indicate there is a sub-menu under that item.

Operation of the ELB

The ELB is very similar to other EFB applications, with most of the basic operations being identical. The ELB application uses a diamond next to an item to indicate that the item can be selected, and the VIEW MAINTENANCE RELEASE and MAINTENANCE HOME soft keys are disabled when the airplane is in flight.

The SHOW/HIDE MENU toggle soft key provides options to:

- PRINT a summary page (if a flight deck printer is configured)
- VOID (delete) a draft item
- AMEND (modify) a draft item
- return to the current (FLIGHT or MAINTENANCE) home page

Preparing for a Flight

Prior to flight, the flight crew must prepare a flight log to document the upcoming flight. The ELB flight preparation function offers an electronic version of a pre-flight process to assess the technical status of an airplane. This is an ELB guided process intended to be used prior to flight. The sequence of tasks includes:

- reviewing all open items
- reviewing all deferred items
- reviewing the fault history
- creating a new flight log
- reviewing the maintenance release (if available)

Completing the flight preparation process creates an inactive flight log. Only when a flight log is active can a fault be recorded. The flight log is activated automatically when the groundspeed exceeds 3 knots, or when the weight on wheels indicator becomes false. The flight log can also be manually activated by selecting ACTIVATE from the FLIGHT LOG menu.

Reviewing Open Items

To begin the flight preparation process, select FLIGHT PREPARATION from the Logbook Home page to display the Open Items page. The system performs a search of the onboard database and looks for fault reports with the status of Open. The list also includes any expired deferrals. If the maintenance release has already been signed, no open items are displayed on this page. If the maintenance release has not been signed, faults that have not yet been deferred or closed by the maintenance crew are displayed.

If the Open Items page lists any faults, they must be closed or deferred by the maintenance crew before the flight can begin. However, even if there are open faults, continue with flight preparation by selecting DEFERRED ITEMS at the bottom right of the page.

Note: The maintenance release for the aircraft is not visible if there are open items. These must be closed by maintenance prior to flight.

Note: The ELB flight preparation function is designed so that the next step in the process can be selected using the soft key at the bottom right of each page.

Reviewing Deferred Items

The Deferred Items page allows for review of the airplane’s deferred items (sometimes called "open deferrals" or "active deferrals"). The user can select the item from the list to review the item further. Information for each fault includes the description and the date on which the deferral expires. Select DEFERRED ITEMS to go back to the Deferred Items page. After reviewing the deferred items, select FAULT HISTORY.

Reviewing Fault History

The Fault History page displays a list of the past faults on the airplane. The administrator defines how many days of fault history display. Select an item from the list to review its details.

Note: Selecting RECURRING ITEMS filters the fault list to display items that have occurred more than once.

To return to the Fault History page, select FAULT HISTORY. After reviewing the fault history, select FLIGHT LOG to continue the flight preparation process.

Creating the Flight Log

The flight log captures information for the upcoming flight such as flight times and origin and destination airports. Some of the fields may be pre-populated with data from the FMC. The flight crew can modify the FMC data or manually enter data where required. To create the flight log verify, select or enter the appropriate values for the following fields:

- ACFT REGN* – aircraft registration number
- FLIGHT NUMBER*
- FLIGHT TYPE – for example revenue, non-revenue, ferry, etc.
- ORIGIN* – departure airport
- DESTINATION* – arrival airport
- FLIGHT DATE*
- OUT DATE/TIME
- OFF DATE/TIME

Note: The fields with an asterisk (*) may be populated by the FMC. The OUT and OFF fields are automatically populated when the event occurs.

Select SAVE to complete the flight log entries. The flight number, origin and destination airports, and date for the current flight now display at the top of the Logbook Home page.

Note: The maintenance release must be complete (signed by the maintainer) before a flight log can be created.

Selecting SAVE above automatically displays the Maintenance Release page for review. Alternately it can be displayed by selecting the VIEW MAINTENANCE RELEASE soft key from the Logbook Home page.

Viewing the Maintenance Release

The presence of a maintenance release indicates that the maintenance crew has signed the logbook and approved the flight for departure. The maintenance release displays any operational restrictions, active deferrals, faults that were closed, servicing information, and all maintenance work that has been performed on the airplane. Use the scroll bar as necessary to review all of the information.

Note: The maintenance release form has various sections. The first part includes information such as details, restrictions, comments and a release date. The next part allows the maintenance crew to document any deferred and closed items associated with the release. Before a release can be signed, the user is required to review the contents of the maintenance release.

Recording a Fault

The ELB application allows flight crews to document observed faults in the logbook. The purpose of fault reporting is to find the appropriate fault description and have it associated with the respective Fault Reporting Manual (FRM) fault code. This helps with accurate and consistent reporting of faults.

The process for recording faults includes locating the fault and filling out the fault report form. After the form is complete, signing the fault report creates an official logbook entry in the database for maintenance personnel to review on the ground.

Note: The flight log must be active to enter faults. The flight log is normally automatically activated, but can be manually activated from the Logbook Home page by selecting FLIGHT LOG and then ACTIVATE.

There are two ways to locate the fault; using a graphical fault locator or a text search engine.

Locating a Fault Using the Graphical Fault Locator

One method for locating an observed fault in the database is by using the graphical fault locator. This feature uses a graphical fault finder tool that navigates through pages with images showing sections of the airplane to narrow the search area of a fault. Selecting an image brings up a list of the faults associated with the section of the airplane being viewed. This allows selection of the actual fault and records it in the logbook.

To use the graphical fault locator start on the Logbook Home page and select NEW LOGBOOK ENTRY, and then FAULT REPORT. On the Fault Locator page select LOCATION and then select the appropriate option from the drop-down list. Alternately, on the Fault Locator page select the link to the appropriate region.

Note: Selecting FAULT NOT FOUND returns to the first Record Fault Report page. Selecting VIEW FAULTS displays a list of faults associated with the current location.

Continue making the appropriate selections until ELB displays a list of faults for the section of the airplane being viewed. Locate the fault, and then select OK. If necessary, use the scroll bar to find the fault.

Fill out the Fault Report form described in the section “Entering Fault Information”.

Locating a Fault Using Text Search

The other method for locating a fault in the database is by entering text search criteria. All items that match the search criteria are displayed to enable selection of the appropriate fault.

To use a text search start from the Logbook Home page, select NEW LOGBOOK ENTRY, and then FAULT REPORT. On the Fault Locator page select VIEW FAULTS, a list of faults is displayed. Select NEW SEARCH to display the Fault Locator Search page and type or select the appropriate values in the search fields:

- LOCATION - where the fault was observed on the airplane
- FAULT SYSTEM OR ATA CHAPTER
- ENTER WORD TO SEARCH - enter text to search for. Use the virtual keypad to enter search text. If a partial word is entered the system retrieves all records that begin with the text string

When the entries are complete select SEARCH. The system retrieves and displays fault records that match the search criteria. The search criteria appear at the top of the page. Select the appropriate fault and then select OK.

Note: Selecting RESET CRITERIA redisplays the Fault Locator Search Criteria page with the LOCATION and FAULT SYSTEM OR ATA CHAPTER fields set to ALL, and the ENTER WORD TO SEARCH field is left blank.

Fill out the Fault Report form described in the section “Entering Fault Information.”

Entering Fault Information

When fault information is entered it can either be saved as a draft fault item; the system does not create an official logbook entry, or sign as a fault report; the system creates an official logbook entry and sends the fault report information to the ground database for the maintenance crew to initiate action.

To enter fault information on the first Record Fault Report page, type or select the appropriate values in all the fields. These fields include:

- FAULT DESCRIPTION – contains the description in the Fault Reporting Manual that automatically populates from the ELB database
- COMMENTS – enables details to be entered regarding the fault

Note: If the FAULT NOT FOUND soft key was selected to navigate to this page, the FAULT DESCRIPTION field is blank and the COMMENTS field must be completed.

- FLIGHT PHASE – flight phase when the fault was observed
- RESULTING EVENT (IF ANY) – reason for the fault defined by ATA
- INTERMITTENT – indicates that the fault starts and stops periodically
- PAPER LOG SERIAL NO. – document number of the paper technical log to associate with the electronic version. This field is only used during trial periods or failure scenario situations where paper versions are required

Note: Selecting FAULT LOCATOR returns to the first FAULT LOCATOR page.

After completing the selections select the PGDN bezel key to view the fault report and sign it if appropriate as described in the section “Signing the Fault Report” in this chapter. Signing the fault report creates an official logbook entry that is sent to the ground database so that the maintenance crew can take action.

If the fault report is not complete, select SAVE AS DRAFT to save it in draft format. This action saves the fault record onboard, but the system does not create an official logbook entry and the fault report is not sent to the ground database. The saved fault report can be retrieved later by selecting DRAFT ITEMS from the Logbook Home page.

Signing the Fault Report

Signing the Fault Report form officially records the fault in the logbook, and sends the fault report to the ground system database. Sign the fault report by selecting SIGN on page 2/2 of the Record Fault Report page. Enter or select the appropriate values in the NAME, PERSONNEL ID, and PASSWORD fields. Select CONFIRM to sign the report.

Note: All fields are required in order to CONFIRM and sign the report.

Viewing Item Information

In addition to access of flight preparation and logbook entries, the Logbook Home page has soft keys for viewing the following:

- OPEN ITEMS
- DEFERRED ITEMS
- DRAFT ITEMS
- FAULT HISTORY

- FLIGHT LOG
- COMMUNICATION MANAGEMENT
- VIEW MAINTENANCE RELEASE

Accessing these pages is covered in the sections that follow.

Viewing Open Items

To view items with a status of open select the OPEN ITEMS soft key on the Logbook home page and then select the log to view from the list. From the Open Items page select the appropriate item to view the fault information. This information also includes any expired deferrals. To return to the Open Items page select the OPEN ITEMS soft key.

Viewing Deferred Items

To view items with a status of deferred select the DEFERRED ITEMS soft key on the Logbook home page and then select the log to view from the list. From the Deferred Items page select the appropriate item to view the fault information.The information includes a brief description, the expiration of the deferral and an indication if any maintenance (M) or operational (O) procedures related to this deferral. To return to the Deferred Items page select the DEFERRED ITEMS soft key.

Viewing Draft Items

To view items with a status of draft select the DRAFT ITEMS soft key on the Logbook home page and then select the log to view from the list. The Draft Records page provides a list of all fault reports that have been created but not signed for official entry into the logbook. These draft items can be modified, deleted, or signed. Fault reports saved in draft form must be deleted or signed before closing the flight.

To delete an item from the Draft Records list select the item, select the SHOW MENU soft key, and then select the VOID option.

Note: There is no prompt to confirm draft record deletion. Ensure the correct draft item is selected prior to selecting VOID.

To modify an item from the Draft Records list select the item, select the SHOW MENU soft key, and then select the AMEND option. On the Fault Report page make the appropriate changes and then select SAVE AS DRAFT.

To sign an item from the Draft Records list select the item, select the SHOW MENU soft key, and then select the AMEND option. Page down to page 2/2 on the Fault Report page and then sign the report.

Viewing Fault History

The Fault History page displays a list of all faults that have been stored in the onboard database. The length of time which faults are stored onboard is an airline configurable parameter. From this page users can review a list of faults, as well as review the corresponding details of individual faults including when the fault was recorded and the fault status.

To view the fault history for the airplane select FAULT HISTORY on the Logbook home page then select the item to view from the list. Use the scroll bar if necessary to locate an item. To return to the Fault History page select FAULT HISTORY.

Viewing Communication Management Information

Selecting COMMUNICATION MANAGEMENT displays information regarding the communication link between air and ground. The top portion of the Communication Management page displays the status of the communication link, the number of messages in progress, and the last time synchronization was successful.

Selecting SYNCHRONIZE NOW manually forces the synchronization of the ground and air databases if necessary. The ELB checks for a synchronized system on application startup, flight log close, and maintenance release. Typically, the system automatically stays synchronized with the ground databases. However, if a significant amount of time has passed since the last synchronization, or if the airplane has been out of communication for some time, manual synchronization may be required.

Select VIEW MESSAGE LOG to access the message log menu. The TO GROUND option displays the messages sent between the air and ground. A status of SUCCESS indicates that the message reached the ground successfully. IN PROGRESS indicates the message is in the process of being sent to the ground. The TO EFB selection enables viewing on one EFB the messages sent from the other EFB. The TO CSM (Core Server Module) displays the messages sent between the three logbooks; Flight, Maintenance, and Cabin.

Select the LOGBOOK HOME soft key when finished viewing the information to return to the Logbook Home page.

Viewing the Flight Log

The Flight Log function provides four pages of information that can be modified and reviewed before signing. The Flight Log can be viewed any time after it has been created during the flight preparation process.

Navigate to the first flight log page by selecting FLIGHT LOG on the Logbook Home page and then DEPARTURE. Once in the Flight Log, use the PGUP/PGDN bezel keys to move from one page to the next.

DEPARTURE –

This page displays the departure information for the flight entered during flight preparation. The OUT/OFF DATE/TIME fields are configured by the administrator (local, GMT, ZULU). Typically, the OUT fields represent airplane pushback (brakes off) from the gate and the OFF fields represent takeoff. The fields are automatically populated when the event occurs, but manual entry of the date can be accomplished using the arrows on either side of the box. If the TIME fields are blank or incorrect, the appropriate values can be manually entered. These fields must be complete in order to close the flight.

ARRIVAL –

This page displays the arrival information for the flight entered during flight preparation. The ON/IN DATE/TIME fields are configured by the administrator (local, GMT, ZULU). Typically, the ON fields represent landing and the IN fields represent arrival at the gate (wheel chocks in place). The fields are automatically populated when the event occurs, but manual entry of the date can be accomplished using the arrows on either side of the box. If the TIME fields are blank or incorrect, the appropriate values can be manually entered. These fields must be complete in order to close the flight.

The BLOCK TIME, TOTAL TIME BEFORE, FLIGHT TIME, and TOTAL TIME AFTER fields are calculated automatically. The BLOCK TIME is OUT minus IN time. TOTAL TIME BEFORE is the number of flight hours before this flight started. The FLIGHT TIME is OFF minus ON time. TOTAL TIME AFTER is the TOTAL TIME BEFORE plus the FLIGHT TIME.

Other information on this page includes the number of Touch & Go and Full Stop landings, whether autoland was performed successfully, and the paper log serial number if it exists.

COMMENTS –

This page allows pilot comments to be recorded in the flight log.

SUMMARY –

This page provides a summary of the flight log that can be printed using the SHOW MENU > PRINT option. This page also provides access to the signature page (SIGN) to close the flight log.

Closing the Flight Log

The close function verifies the flight times and dates, writes any comments in the log record, and checks for any draft fault records that must be resolved.

To close the flight select FLIGHT LOG on the Logbook Home page, then the SUMMARY page. On the Flight Log Summary page select the SIGN soft key and complete the required NAME, PERSONNEL ID, and PASSWORD fields. Select CONFIRM to close the flight.

The signed flight log closes the flight so that a new flight log can be created.

Onboard Performance Tool

Overview

The Onboard Performance Tool (OPT) application calculates takeoff and landing performance using a combination of pre-loaded and manually-entered data for a specific aircraft configuration under current conditions. The Weight and Balance tool within OPT may also be available to aid in completing performance calculations.

The EFB administrator can activate or deactivate certain performance functions (such as Weight and Balance) and set preferences (such as pounds or kilograms, flap configuration and brake settings) according to company policy and fleet management specifications.

CAUTION: The OPT application interface is configurable (keys, labels, colors, etc.). The information presented in this section represents a typical application and individual airline implementation may be different.

Pre-loaded Data and Pilot Inputs

Pre-loaded data are configured, maintained and updated by the EFB administrator. This data can include information about the following items:

- the airport; such as airport elevation, runway information, takeoff intersections, obstacle information, etc.
- the aircraft; such as tail number, engine type and rating, flap configurations, MEL, CDL, loading capacity, CG envelope, etc.
- NOTAM data that might affect performance; such as temporary runway construction, runway modifications, or obstacles
- company policies; such as V1 basis, the use of lineup allowances, contaminated runway selections

After selecting INITIALIZE FLIGHT on the EFB Main Menu page, the following information is retrieved from the FMC by the OPT application:

- origin airport
- departure runway
- destination airport
- outside air temperature

- altimeter setting
- aircraft gross weight

Note: The altimeter value transferred to OPT is the value displayed on the on-side PDF. In other words, if the INITIALIZE FLIGHT is selected from the captain's EFB, the altimeter value displayed on the captain's PFD is transferred to the OPT.

Any required data or selections not pre-loaded by the transfer function requires manual entry or selection prior to any performance calculation.

Calculating Takeoff Performance

Unless otherwise specified, all of the information in this section is referenced to the Takeoff page in the OPT application.

To complete a takeoff calculation, entries in the following fields are required:

- ARPT – origin airport
- RWY – planned departure runway
- COND – departure runway condition
- WIND – airport surface wind
- OAT – outside air temperature
- QNH – altimeter setting
- RTG – thrust rating
- FLAP – takeoff flap position
- A/I – anti-ice setting

These required entries may be made by transferring the data from the FMC, by manual entry, or by a combination of both.

The CALC soft key does not become available until all the required entries are complete. If an invalid value was entered in a field (for example, 299.2 in the QNH field or 430/15 in the WIND field), a system error displays either after the entry is made, or after CALC is selected.

The following fields are also available for use when required:

- INTX – takeoff runway intersection
- ATM – assumed temperature method value/modifier
- ADD ARPT – temporary creation of an airport runway that is not in the OPT application database
- NOTAMS – temporary creation of a runway NOTAM that effects runway length or obstacles and may affect performance calculations
- WT AND BALANCE – entry of weight and balance values for passenger, cargo, fuel, and other fixed-weight items for use with takeoff calculations
- MEL – items that may affect performance calculations
- CDL – items that may affect performance calculations

After completing the takeoff data entries and selecting CALC, the following values are displayed in the performance results area:

- FLAP – flap setting
- ACCEL HT – acceleration height
- V1, VR, V2 and VREF speeds
- RWY/INTX – runway and intersection
- TOGW – takeoff gross weight
- TPR or %N1 – takeoff thrust setting
- SEL TEMP – selected/assumed temperature if available
- Engine Failure Procedure (if applicable)

For each takeoff calculation, OPT generates two types of performance if available; an assumed temperature method (ATM) and a full rated thrust. Both can be alternately displayed using the SHOW FULL/ATM soft key.

To calculate the takeoff weight complete all the required fields and enter the actual TOGW in the TAKEOFF WEIGHT field. Enter any required modifier in the ATM field and select CALC. The calculated performance figures for the assumed temperature are displayed in the results area.

Note: If the OPT takeoff weight does not closely match the FMS takeoff weight, a message regarding verifying the input weight against the FMS weight is displayed. Performance results are generated, but the message cautions that the two figures are in disagreement and should be verified.

If needed, select SHOW FULL to display the full thrust data for the TOGW entered. Select SHOW ATM to redisplay the assumed temperature results.

To calculate the maximum takeoff weight (MTOW) allowed for the entered conditions, complete all the required fields; but leave the TAKEOFF WEIGHT field blank. Select CALC to display the MTOW performance data in the results area (no speeds are calculated). This is sometimes helpful when planning takeoff performance for the flight.

If speeds are then required, enter the actual takeoff weight in the TAKEOFF WEIGHT field and select CALC again. An information message regarding the availability of assumed temperature may be displayed. Select OK to clear the message and then select the SHOW FULL soft key to display the full thrust takeoff data including speeds.

Calculating Landing Performance

Unless otherwise specified, all of the information in this section is referenced to the Landing page in the OPT application.

To complete a landing calculation, entries in the following fields are required:

- ARPT – destination airport
- RWY – planned landing runway
- COND – landing runway condition
- WIND – airport surface wind
- OAT – outside air temperature
- QNH – altimeter setting
- FLAP – landing flap position
- A/I – anti-ice setting

These required entries may be made by transferring the data from the FMC, by manual entry, or by a combination of both.

The CALC soft key does not become available until all the required entries are complete. If an invalid value was entered in a field (for example, 299.2 in the QNH field or 430/15 in the WIND field), a system error is displayed either after entry, or after CALC is selected.

The following fields are also available for use when required:

- BRKS – braking method
- NNC – non-normal landing configurations that effect performance
- ADD ARPT – temporary creation of an airport runway that is not in the OPT application database
- NOTAMS – temporary creation of a runway NOTAM that effects runway length or obstacles and may affect performance calculations
- WT AND BALANCE – entry of weight and balance values for passenger, cargo, fuel, and other fixed-weight items for use with landing calculations
- MEL – items that may affect performance calculations
- CDL – items that may affect performance calculations

After completing the landing data entries and selecting CALC, the following values are displayed in the performance results area:

- Limit Wt – landing limit weight for Normal, With Ice, and Low Visibility conditions if applicable
- VREFXX – landing flaps reference speed for Normal, With Ice, and Low Visibility conditions if applicable
- Quick Turnaround Weight
- Quick Turnaround Time
- Landing Distance – the enroute advisory landing distance if applicable
- VREFXX+Y– the enroute advisory landing flaps reference speed with additive if applicable

There are two types of landing calculations OPT can perform, dispatch and enroute advisory.

To calculate a dispatch landing weight complete all the required fields; but leave the LANDING WT field blank. Select CALC to display the dispatch landing performance data in the results area.

To calculate the enroute advisory landing data complete all the required fields and enter the predicted landing weight in the LANDING WT field. Enter any existing non-normal condition in the NNC field (or select NONE if none exist) and then select the required braking method in the BRKS field. Select CALC to display the enroute advisory Landing Distance and landing flap VREF speed below the dispatch information in the results area.

Sending Performance Data

Certain performance information can be sent to various locations. To send the calculated results select SEND OUTPUT, then select the required destination (printer, storage, or FMC), and then select COMPLETE to send or CANCEL to return to the performance page.

If the SEND OUTPUT soft key is not active then either performance results do not exist, or the EFB is not configured for printing, saving and sending.

Updating Takeoff or Landing Information

Should any of the required OPT entry conditions change after the performance has been calculated, new performance data can be immediately calculated using either of two methods; updating on the FMC, or updating on the OPT.

To update performance calculations using the first method, change the necessary data by entering the new values in the appropriate field(s) in the FMC. Then on the OPT performance page select COPY FMC DATA, this brings the FMC updated conditions into the OPT fields. Verify the entries are correct and select CALC to recalculate the aircraft’s performance using the updated conditions. Select SEND OUTPUT and then SEND TO FMC to transfer the new data to the FMC. With the performance uplink from the OPT pending on the FMC, review and verify the new data and then select ACCEPT or REJECT as required.

To update performance calculations using the second method, change the necessary data by entering the new values in the appropriate field(s) in the OPT application. Select CALC to recalculate the aircraft’s performance using the updated conditions. Select SEND OUTPUT and then SEND TO FMC to transfer the new data to the FMC. With the performance uplink from the OPT pending on the FMC, review and verify the new data and then select ACCEPT or REJECT as required.

Reviewing Airport Data

The airport and runway data that are used to calculate takeoff and landing performance come from a database that is stored, maintained, annotated, and verified by the administrator. This information, such as airport elevation, runway and obstacle data, can be viewed at any time within the OPT application.

While on the Takeoff or Landing page select ARPT INFO (this soft key is only active when the ARPT and RWY fields are complete). The Airport Data page displays the information upon which takeoff and landing performance calculations are based. This data displays in the units determined by company policy. The Airport Data page displays the following information, if available, from the airport database:

- Airport data –
  - Elevation (height above sea level)
- Runway data –
  - Runway Length
  - Clearway
  - Stopway
  - Slope
  - LDA - Landing Distance Available
- Obstacle data –
  - Height Above either Start of Runway or End of Runway
  - Distance From either Start of Runway or End of Runway
  - Lateral Offset (distance from the runway centerline)
- Airport or Runway notes at the bottom of the page may include –
  - date of last update
  - lineup allowance per the administrator's setting
  - NOTAM details effecting airport or runway

Note: The data included on the ARPT INFO page is provided as advisory information only. This data should not be used to modify any takeoff or landing procedure and technique, nor should it be used to make decisions regarding runway usage.

Also on the Takeoff or Landing page, more information regarding the airport and runway can be found using the soft keys; ARPT COMMENT, RWY COMMENT and INTX.

Select OK to return to the previous Takeoff or Landing page.

Adding/Deleting a Temporary Airport

The OPT application can accommodate data for an airport and a runway that is not included in the database. The Add Airport page allows the user to enter temporary airport data and to calculate takeoff or landing performance based on that entry. Only one airport and one runway can be added at a time.

Note: The OPT removes all of the data for the added airport when either the FLIGHT INITIALIZE or FLIGHT CLOSE soft key is selected. The OPT also deletes the temporary airport data should the EFB be completely powered down. Permanent airport data must be added by the administrator.

Add a temporary airport from the Takeoff or Landing page by selecting the ADD ARPT soft key and then set the preferred measurement units for entering the airport data (green diamond indicates current selection). Enter the airport and runway data in the required fields. If an obstacle exists select the OBST soft key to add distance and height information (the OBST soft key toggles to ARPT/RWY to allow return to the Add Airport page). After all of the airport and runway data has been entered select COMPLETE to add the temporary information. The COMPLETE soft key becomes available only after all of the required fields have data. After selecting COMPLETE the Takeoff or Landing page is displayed with the added airport selected for use.

Delete the temporary airport from the Takeoff or Landing page by selecting the ADD ARPT soft key. On the Add Airport page select REMOVE (this soft key is active only after an airport was added) to delete the temporary airport information being displayed and return to the Takeoff or Landing page.

Entering NOTAM Information

The OPT application allows the entry of NOTAM corrections that alter available runway or obstacle data (for example runway construction or temporary obstacles).

Note: The administrator can set the OPT to remove the added NOTAM when either the FLIGHT INITIALIZE or FLIGHT CLOSE soft key is selected. The OPT deletes the temporary NOTAM should the EFB be completely powered down. The administrator can enter NOTAM data that uses effective dates to activate certain NOTAM changes.

Add temporary NOTAM information from the Takeoff or Landing page by selecting the NOTAMS soft key and then set the preferred measurement units for entering the NOTAM data (green diamond indicates current selection). Enter any shortened runway figures and/or any obstacle information in the appropriate fields. Comments can be added in the comment field as required. After the required data has been entered select COMPLETE to add the temporary information. The Takeoff or Landing page displays with a horizontal amber line under the NOTAMS soft key to indicate that the NOTAM data is considered in the performance calculations.

Accommodating MEL or CDL Issues

The OPT application can account for minimum equipment list (MEL) or configuration deviation list (CDL) performance penalties in takeoff and landing performance calculations.

Note: The administrator can set the OPT to remove the added MEL/CDL items when either the FLIGHT INITIALIZE or FLIGHT CLOSE soft key is selected. The OPT can be configured to delete the MEL/CDL items when the EFB is completely powered down.

CAUTION: Added MEL/CDL items are not automatically applied to enroute landing performance selections. For example, if the autobrakes are selected as inoperative on the MEL page, the autobrakes can still be selected for use in the BRKS field on the Landing page.

Add MEL/CDL performance penalties on the Takeoff or Landing page by selecting the MEL or CDL soft key. The MEL/CDL page displays a Chapter List which contains chapter titles conforming to the IATA standard for airplane components. Select CANCEL to exit the list without selecting any item. From the Chapter List select the appropriate chapter to display a list of individual items. Selecting the appropriate item is indicated by a green check mark. Additionally, the item's number displays in the Active Items list at the bottom of the page. When finished, select COMPLETE to accept the selections. The Takeoff or Landing page displays with a horizontal amber line under the MEL/CDL soft key to indicate that MEL/CDL data is considered in the performance calculations.

Individual items can be removed from the MEL/CDL page by de-selecting the item and then selecting COMPLETE. All selected items can be removed at once by selecting CLEAR ALL and then selecting COMPLETE.

Note: The Takeoff or Landing page displays without the amber MEL/CDL annunciation only when all MEL/CDL items have been cleared.

Calculating Weight and Balance Information

The OPT Weight and Balance page provides the ability to perform basic weight and balance calculations for takeoff and landing derived from passenger, cargo, and fuel weights, as well as other fixed-weight and last-minute items. Calculations are based on the aircraft's configuration and loading options that are set by company policy.

Note: Weight and Balance information is deleted when CLOSE FLIGHT or INITIALIZE FLIGHT is selected, or when an airport change is made. The OPT also deletes the Weight and Balance information should the EFB be completely powered down.

The weight and balance calculations can be accessed by selecting WT AND BALANCE on the Takeoff or Landing page. The Weight and Balance page displays two sections; Weight Inputs on the top of the page and Operating Envelope at the bottom.

The Weight Inputs section features individual loading tabs (tab names can vary depending on administrator preference). A green tab indicates the active loading tab. Additionally, each tab total is displayed under the tab title. The following default loading tabs are:

- PAX – displays passenger input fields for each passenger zone
- Cargo – displays cargo weight input fields for each cargo zone
- Fixed – displays fixed items and last minute changes input fields
- Fuel – displays fuel input fields and the FAST FUEL soft key

Each of the loading tabs in the Weight Inputs section contain fields that are required data entries based on the aircraft configuration. The number that appears in parentheses next to each field indicates the maximum amount that can be accommodated in that field (for example- "PAX 0A (30)" indicates that a maximum of 30 passengers may be entered in passenger zone 0A).

In the FUEL tab, selecting FAST FUEL displays the Fast Fuel page. The fast fuel function eliminates the need to type fuel weight values for individual tanks by automatically determining the weight distribution of each fuel tank.

At the bottom of the Weight Inputs display area are the calculated Taxi, Takeoff, Landing, and Zero Fuel Weights, which are based on the entered data. The figure inside the parentheses is the maximum weight limit. When any of these weights are greater than the limit, all the figures display in amber.

The Operating Envelope section of the Weight and Balance page displays the position of each operating weight (except the Taxi weight), the calculated %MAC for each weight, and the maximum weight limit line for each. These are all graphically displayed within the operating envelope itself.

After all the required information is entered select COMPLETE to save the values. Selecting COMPLETE on any Weight and Balance section or page transfers the weight and balance values into takeoff or landing calculations. For instance, on the Takeoff page the calculated takeoff weight and CG are transferred. On the Landing page the landing weight is transferred. Selecting CANCEL displays the Takeoff or Landing page without transferring the calculated data.

Note: If an airplane mis-loading conditions occurs, or a data entry error results in a weight limit being exceeded, the weight in error is shown in amber and the COMPLETE soft key is not active. The error must be corrected to complete the weight and balance function, or select CANCEL to exit the page and abandon the weight and balance calculation.

Electronic Terminal Charts

Overview

The Electronic Terminal Charts (ETC) application provides the ability to find and display any Jeppesen terminal chart in the operator's EFB terminal chart database subscription. The main features of the application are a decrease in paper management tasks on the flight deck and the ability to quickly find, sort, and page through terminal charts. When the EFB is initialized the ETC creates an origin and destination chart clip that pre-loads the charts anticipated for use during the flight. These chart clips can be transferred from one EFB to another as required.

The standard chart library may include the following chart types:

- Airport
- Departure
- Arrival
- Approach
- Notice to Airmen (NOTAMs)

Starting the Application

To start the ETC application, select TERMINAL CHARTS from the EFB Main Menu page. The Route Setup page displays when the application is first started. If the ETC application was previously started, the last page in view is re-displayed.

Note: If the ETC application has not finished loading, selecting the TERMINAL CHARTS soft key causes the "Loading Charts Database" page to briefly display.

CAUTION: Expired data has a six-day grace period before the ETC application requires updating. The message; "Database Issue Date: [Day] [Month] [Year] Terminal Charts may contain outdated information. Obtain a new database as soon as possible." appears to inform the user of this condition. Selecting OK acknowledges this message and allows continued use of the ETC application.

Defining Airports for Use

The origin and destination airports, as well as four alternate airports, can be entered on the Route Setup page for use with the ETC application. The origin and destination airports can be entered by copying them from the FMS, either automatically when the flight is initialized, or by selecting the USE ARPTS FROM FMS soft key. Any airport can be entered by typing an airport identifier or an airport or city name directly in the airport field and then selecting SEARCH IDENT or SEARCH ALL as appropriate.

Selecting and Grouping Charts for an Airport

Once the origin, destination, and alternate airports are defined, the charts expected for use during the flight can be added to the ETC created chart clip for each defined airport. The Airport chart and chart NOTAMs are automatically added to each chart clip by the ETC application.

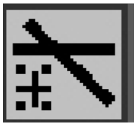
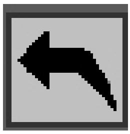
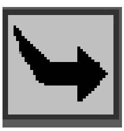
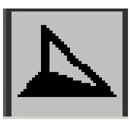
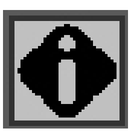
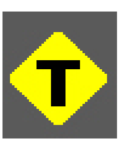
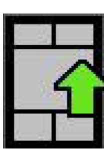
To group charts for a defined airport, select the ICAO identifier of the airport in the Chart Clip Airports area at the bottom of the Chart Clip page (a green diamond indicates selected airport). Select the EDIT CLIP soft key. If more procedure names exist than can be displayed on one page (page counter is greater than 1/1); select a specific chart type in the Chart Types area to limit the charts that are displayed (refer to “Chart Symbols” for details) or use the PGUP and PGDN bezel keys to page through the chart list. Select the desired charts so a green check mark appears in the chart field.

To view the chart prior to adding it to the Chart Clip, select the Preview Chart soft key (a vertical rectangle with a green arrow pointing up). The chart displays on the Preview Chart page. Select ADD TO CLIP if the chart is desired or REMOVE FROM CLIP if the chart is selected but not wanted. To view another chart for this airport select PGUP or PGDN bezel key (page counter is greater than 1/1). When done viewing select SHOW MENU and then EXIT PREVIEW or select the BACK bezel key to return to the Edit Chart Clip page.

When finished adding or deleting charts from the clip, verify that only the required charts have a green check mark next to them and select COMPLETE. The Chart Clip page now displays soft keys with the names of the selected charts.

Chart Symbols

Within the ETC application symbols are used to identify certain chart characteristics, including the type of chart, selected charts, and temporary charts. The following table shows the symbol and lists a brief description.

Symbol	Description
	Airport charts (for example 10-6, 10-8, and 10-9)
	Departure charts (for example 10-3, 10-3A, 10-3B, etc.)
	Arrival charts (for example 10-2, 10-2A, 10-2B, etc.)
	Approach charts (for example 11-1, 12-1, 19-1)
	NOTAMs and other text pages (for example 10-1, 10-4)
	Temporary charts. Also denoted on the chart itself as yellow outlines and text.
	Selection Preview chart. Appears on the Edit Chart Clip and View Chart List pages.

Transferring a Chart Clip from the other EFB

To transfer a chart clip from the off-side EFB to the on-side EFB select CHART UTILITIES from the Chart Clip page and then select USE CHART CLIP FROM OTHER EFB (this soft key is not active if the other EFB is unavailable). This transfer replaces all charts currently in the on-side airport chart clip. To confirm the transfer select YES. To cancel select NO and then CHART CLIP.

Note: The new chart clip overwrites all previous chart clip selections on the on-side EFB. Only the chart clip is transferred. Pilot-defined viewing options (map rotation, panning, and zooming) do not transfer.

Displaying and Manipulating a Chart

Once the chart clip for each airport is populated, the individual airport charts can be quickly accessed. Select the airport's ICAO identifier from the Chart Clip Airports area on the Chart Clip page. Use the PGUP and PGDN bezel keys to scroll through the chart list if necessary. Select a chart soft key to view the Charts page. Use the Menu to navigate the chart view.

Quick Use feature

The Quick Use feature allows the user to quickly preview and add charts to the chart clip. This function is not available for NOTAMs. To quickly view and add a chart to the chart clip select SHOW MENU then QUICK USE from the Charts page. The Quick Use Chart List page displays additional charts of the same type that were previously being viewed for the current airport. Select the chart soft key to view and add to the chart clip. To return to the Chart Clip page select SHOW MENU and CHART CLIP or use the BACK bezel key.

Changing the display of a chart

Terminal charts on the EFB can be viewed in several ways. The options listed below are available when using the bezel keys:

- Zoom In/Zoom Out – use the zoom in and zoom out bezel keys to change the magnification of the chart for better text readability
- Arrow Keys – use the bezel arrow keys to pan across the chart horizontally and vertically so that the necessary information is displayed

The options listed below are available after selecting SHOW MENU:

- DAY/NIGHT MODE – select to change the color scheme of the displayed chart between Day mode (black text on a white background), and Night mode (white text on a black background)
- SPLIT MODE – select to split the view of an approach chart so that the plan view displays at the top of the screen and the Briefing Strip™, Profile View, or Minimums display at the bottom of the screen
  - CYCLE VIEW – select while in SPLIT MODE to change the bottom frame from the chart's Briefing Strip™, Profile, and Minimums views. After all three frames display individually with the Plan View, they display together without the chart
- UN-SPLIT MODE – select to display the entire chart (this mode is identical to a paper chart). A specific mode is set as the default according to company preference. This functionality is not available in the Preview Chart screen
- ROTATE – select to rotate a chart 90 degrees. Select ROTATE again to return the orientation to the original position. This soft key is unavailable when the chart is being viewed in split mode
- RESET ZOOM – select to return the chart to its original magnification after using the Rectangle Zoom, Zoom In or Zoom Out functions
- RECTANGLE ZOOM (soft key displayed as a rectangle with magnifying glass in lower right corner) – select to create a rectangle around the area to magnify by clicking-holding-dragging the cursor. The specified area of the chart is then centered and zoomed to the maximum extent possible, proportional to the screen

Select HIDE MENU to remove the additional menu items. The menu is automatically removed after making a selection.

Locating a Terminal Chart Not in the Current Route

Charts can be viewed for an airport that is not defined in the current route (origin, destination or alternate) by independently searching for the airport in the database.

To search for an airport not in the route select AIRPORT SEARCH from the Chart Clip page. In the Search field, type the whole or partial ICAO or IATA airport identifier and select SEARCH IDENT. Alternately, in the Search field type the whole or partial airport or city name and select SEARCH ALL.

Search results are listed in the upper portion of the page. If necessary, additional search results pages can be viewed by selecting the PGDN and PGUP bezel keys. If the required airport is not displayed, select CLR FLD from the virtual keypad to clear the search field and start another search.

Select the required airport from the list to display the View Chart List page containing the charts that are available for the airport. Select a chart from the list of charts to display it on the View Chart page. To view another chart from the list for this airport, select the PGUP or PGDN bezel key. Alternately, select SHOW MENU and then VIEW LIST to select another chart form the original list.

Select CHART CLIP from the View Chart List page when finished viewing the charts for the airport.

Selecting the SET AS ALTERNATE soft key adds the airport as an alternate if space is available in the four alternate positions.

Locating the Nearest Airports from Current Location

The ETC application can search for the closest airports that meet predefined, specific criteria (runway length, jet fuel, etc.) set by the administrator. These criteria can be disabled to view all of the closest airports.

When searching for the nearest airports, the ETC application uses the current Global Positioning System (GPS) position to provide a list of the ten nearest airports that meet the search criteria (if enabled). Direction and distance from the current position are also provided. If less than ten airports meet all the criteria, only those airports are listed.

Note: Only airports for which charts are available in the company subscription database display in the Nearest Airports list.

To search for the nearest airports from the Chart Clip page, select AIRPORT SEARCH and then NEAREST AIRPORTS. The Nearest Airports page displays up to ten airports that meet the specific criteria. Only five airports display at a time. If necessary, select the PGDN bezel key to view the additional airports.

Note: The airports are sorted by distance from the aircraft. The closest airport is listed first. The Nearest Airports list does not automatically update as the flight progresses. Perform a new search to update the list.

To override the airport search criteria, select DISABLE CRITERIA. The Nearest Airports page displays up to ten airports in the subscription database, regardless of size and services available, that are closest to the current airplane location.

The Nearest Airports page can also be accessed by selecting CHART UTILITIES and then NEAREST AIRPORTS. The search is conducted in the same fashion.

Printing a Chart

The ETC application supports chart printing when a configured graphical printer is installed and operating.

Individual charts being viewed can be printed from the Chart Display or Preview Chart pages by selecting SHOW MENU and then PRINT.

All the charts in a chart clip can be printed by selecting PRINT CLIP from the Chart Clip page.

All the charts for an airport can be printed from the Edit Chart Clip page by selecting the PRINT ALL XXXX CHARTS soft key.

Note: Only one print job can be in the queue at a time. The print soft keys are unavailable until the current print job is completed.

Troubleshooting

If there is no date information available from the FMS, the TERMINAL CHARTS application soft key on the EFB Main Menu is unavailable.

The following system messages relate to search errors on the Airport Search or Route Setup pages:

- INVALID ENTRY – indicates a search was attempted with an invalid character such as a comma (,) or dash (-)
- NOT IN DATABASE – indicates that no match was found for the entered text string

Note: These error messages display in the Search Results area of the Airport Search page until another search is executed or CANCEL is selected.

[Option]

Video Surveillance

The video surveillance application on the EFB provides immediate real-time video surveillance of the area outside the flight deck entrance. If installed, expanded video surveillance is available for other parts of the aircraft. To start the application, select VIDEO from the EFB Main Menu page. The Video Surveillance page displays the default view set by the administrator when the application is started.

Selecting an Image

The Video Surveillance page displays four video images; the largest is the primary image and the three smaller are the thumbnail images. Each thumbnail view is from a different area of the aircraft. The primary image is an enlarged duplicate view of the currently selected thumbnail image. Both the current thumbnail and the primary image are bordered in green when selected and operating.

To select a different thumbnail to display in the primary image area, touch the thumbnail view on the screen. The cursor device may also be used to highlight and select the thumbnail view.

Manipulating the Display

To freeze the current primary image select the FREEZE soft key. Selecting FREEZE does the following:

- stops the video and displays a still image
- image border changes from green to cyan to help indicate a frozen image
- toggles the soft key to UNFREEZE

Select UNFREEZE to return to live video.

To manipulate the display further, select the SHOW MENU soft key on the Video Surveillance page. Several more soft key options become available for changing the display. These additional options are:

- BRIGHT + – increases the brightness of the image
- BRIGHT - – decreases the brightness of the image
- HIDE MENU – returns to the thumbnail Video Surveillance page
- DEFAULT – returns all settings to their defaults
- CONTRAST + – increases the contrast of the image
- CONTRAST - – decreases the contrast of the image
- MAINTENANCE – displays the Maintenance page for maintenance use

Troubleshooting

The message NO VIDEO SIGNAL may be displayed while using the Video Surveillance application. This message is displayed inside a video display box and is accompanied by an amber box where the video image was displayed. The message indicates a system failure and the video image is not available for display.

Closing a Flight

At the end of the flight, the EFB and its applications should be properly closed. To close the flight select CLOSE FLIGHT from the EFB main menu page. This "cleans up" the EFB application data, effectively deleting all flight-specific information from memory. A complete power down of the EFB accomplishes a similar function, but only for the non-persistent application data, such as Chart Clips and performance entries.

Note: The CLOSE FLIGHT soft key toggles to INITIALIZE FLIGHT after selection. If INITIALIZE FLIGHT is displayed on the soft key, the flight has already been closed.

Flight Instruments, Displays EICAS Messages

Note: The OVERSPEED warning and the ALTITUDE ALERT caution messages are covered in Chapter 15, Warning Systems.

The following EICAS messages can be displayed.

Message	Level	Aural	Condition
ALTN ATTITUDE CAPT, F/O	Advisory		The AIR DATA/ATT source selector is in the ALTN position.
BARO SET DISAGREE	Advisory		The captain's and first officer's barometric settings disagree.
CHKL INCOMPLETE NORM	Caution		A normal checklist from a previous phase of flight is not complete.
CHKL NON-NORMAL	Advisory		Both of these occur: • A non-normal checklist is not complete • The related EICAS message is not shown
EFIS/DSP PANEL L, R	Advisory		One of these occurs: • Both the EFIS control panel and display select panel are failed • MFD backup control of both the EFIS control panel and display select panel is used
HUD SNGL OPERATION	Advisory		Only one heads up display functions.
HUD SYS CAPT, F/O	Advisory		The heads up display is failed.

[Option – Low visibility T/O]

Message	Level	Aural	Condition
HUD TAKEOFF	Caution		Heads up display takeoff guidance is not available.

Message	Level	Aural	Condition
SGL SOURCE ATTITUDE	Advisory		Both primary flight displays use the same attitude source.

Message	Level	Aural	Condition
SGL SOURCE RAD ALT	Advisory		Both primary flight displays use the same radio altimeter source.
Vmo GEAR DOWN	Memo		Vmo value is set for dispatch with the landing gear extended.

Flight Management, Navigation — Chapter 11
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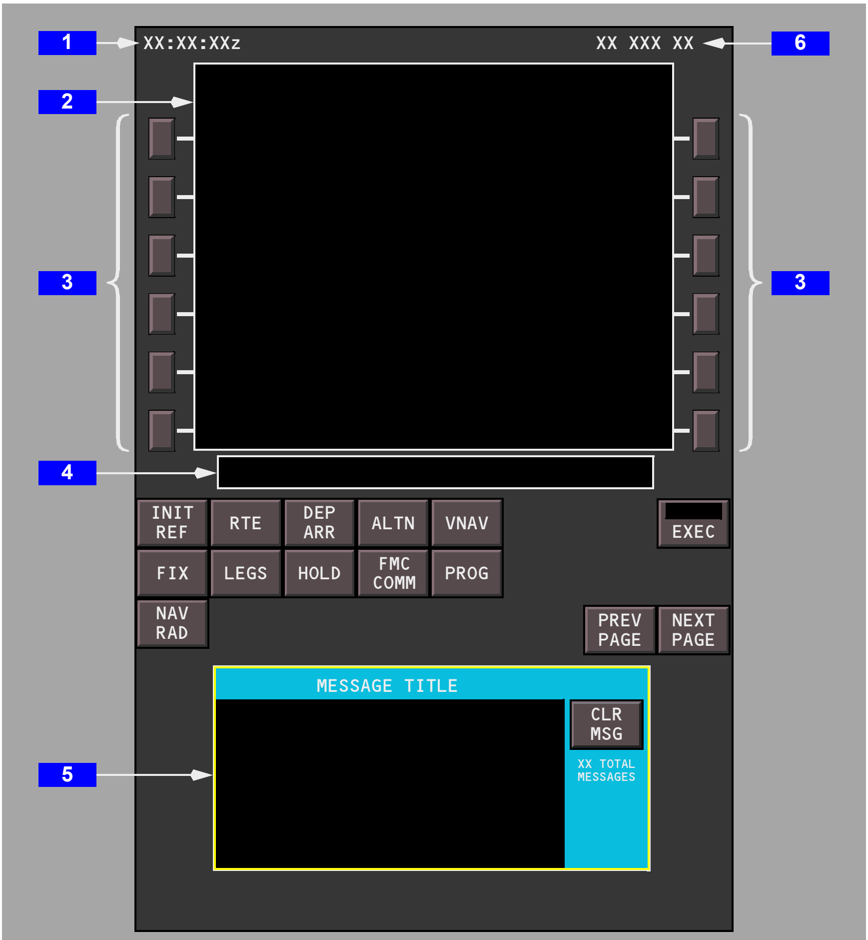
Intentionally
Blank

Flight Management System

Control Display Unit (CDU)

The CDU is an emulation which can be displayed on any of the MFDs. The display is accessed by pushing the CDU switch on the associated display select panel.



CDU DISPLAY

1 Time Display

Displays current UTC time from the GPS.

2 Control Display Unit (CDU) Display

Displays FMS data pages.

3 Line Select Keys

Push –

- moves data from scratchpad to selected line
- moves data from selected line to scratchpad
- selects page, procedure, or performance mode as applicable
- deletes data from selected line when DELETE displays in scratchpad

Conventions –

- scratchpad must be blank for line select transfer
- data can not be transferred to a blank line
- a blank scratchpad can not be transferred to a line
- not all data can be modified
- message displays if inappropriate entries are attempted

4 Scratchpad

Displays crew entered data or crew line-selected data:

- up to 34 characters may be entered in the scratchpad at one time
- data may be transferred to and from the scratchpad by pushing the cursor select switch on the cursor control device or cursor control selector or by pushing the ENTER key on the multifunction keypad.
- data may also be transferred to the scratchpad while using the PICK WPT function on the ND

5 CDU Help Window

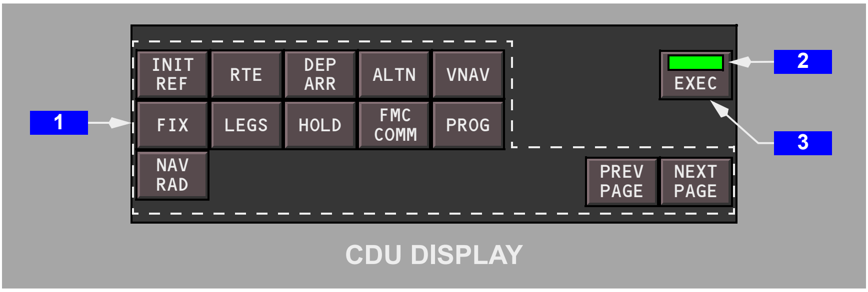
Displays error/help messages to the crew.

Refer to Help Window in Chapter 5, Section 40, for additional information.

6 Date Display

Displays current UTC date from the GPS.

Function and Execute Keys



1 CDU Function Keys

Push –

- INIT REF – displays page for data initialization or for reference data
- RTE – displays page to input or change origin, destination, route and flight number
- DEP ARR – displays page to input or change departure and arrival procedures
- ALTN – displays page to modify destination and route for alternate diversion
- VNAV – displays page to view or change vertical navigation path data
- FIX – displays page to create reference points on ND map
- LEGS –
  - displays page to evaluate or modify lateral and vertical route data
  - displays page to correlate route waypoints on the ND
- HOLD – displays page to create holding patterns and display holding pattern data, or to exit holding pattern
- FMC COMM – displays FMC datalink status page
- PROG – displays page to view dynamic flight and navigation data, including waypoint and destination ETAs, fuel remaining, and arrival estimates
- NAV RAD – displays page to view or control navigation radio tuning
- PREV PAGE – displays previous page of multiple page displays (for example, LEGS pages)
- NEXT PAGE – displays next page of multiple page displays

2 Execute Light

Illuminated (green) – active data is modified but not executed.

3 Execute (EXEC) Key

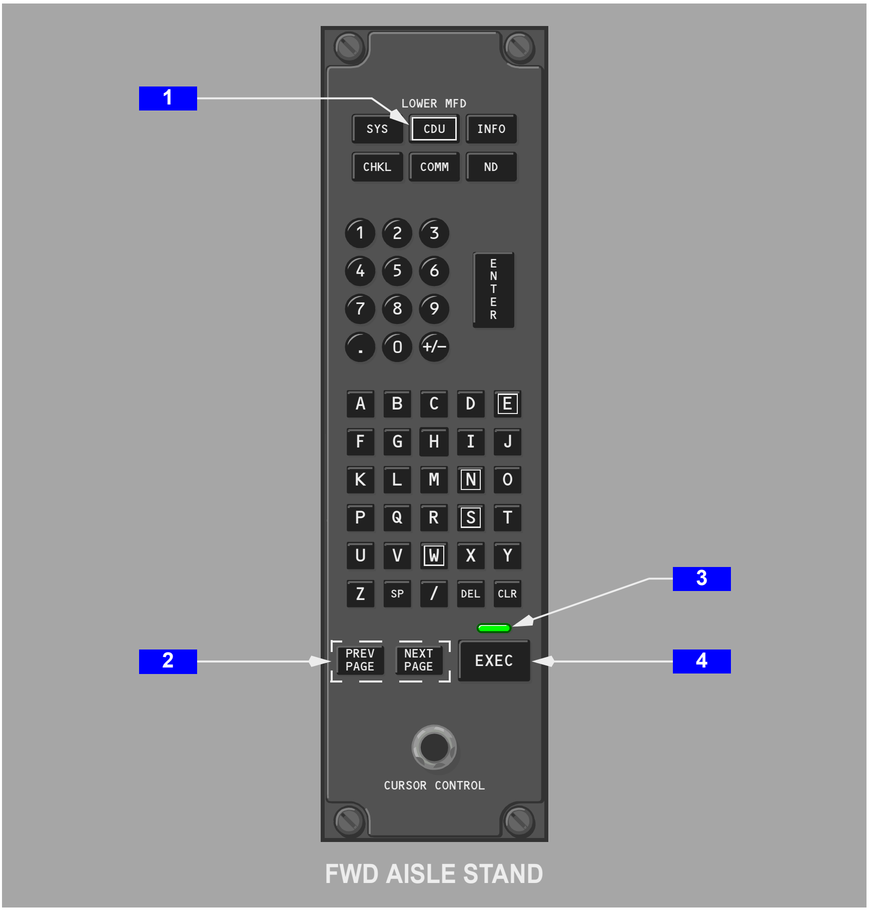
Push (while EXEC light is illuminated green) –

- activates data modification(s)
- extinguishes execute light

Multifunction Keypad

Input to the emulated CDUs is done through the multifunction keypads. Two keypads are provided, one each for the captain and first officer. The keypads are located on the forward aisle stand adjacent to the lower MFD.

Refer to Multifunction Keypad (MFK) in Chapter 10, Section 10, for additional information.



1 Control Display Unit (CDU) Switch

Push – displays the emulated CDU on the lower MFD.

2 Previous (PREV) / NEXT PAGE Key

Push –

- PREV PAGE – displays previous page of multiple page displays
- NEXT PAGE – displays next page of multiple page displays

3 Execute Light

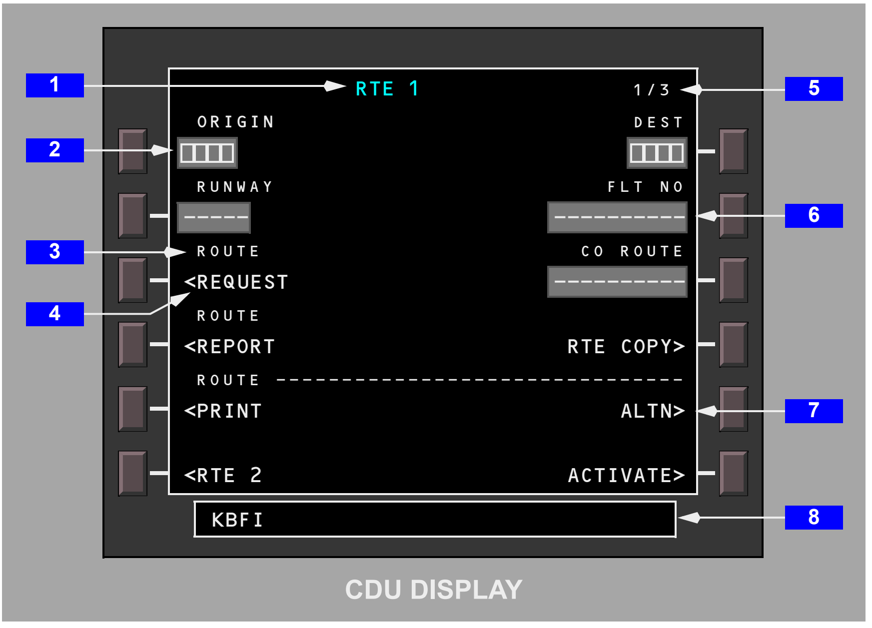
Illuminated (green) – active data is modified but not executed.

4 Execute (EXEC) Key

Push (while EXEC light is illuminated green) –

- activates data modification(s)
- extinguishes execute light

CDU Page Components



1 Page Title

Subject or name of data displayed on page.

ACT (active) or MOD (modified) indicates whether page contains active or modified data.

2 Boxes

Data input is mandatory.

3 Line Title

Title of data on line below.

4 Line

Displays –

- prompts
- selectors
- data associated with line title

Large font indicates crew entered or verified data. Small font indicates FMC computed data.

5 Page Number

Left number is page number. Right number is total number of related pages. Page number is blank when only one page exists.

6 **Dashes**

Data input is optional.

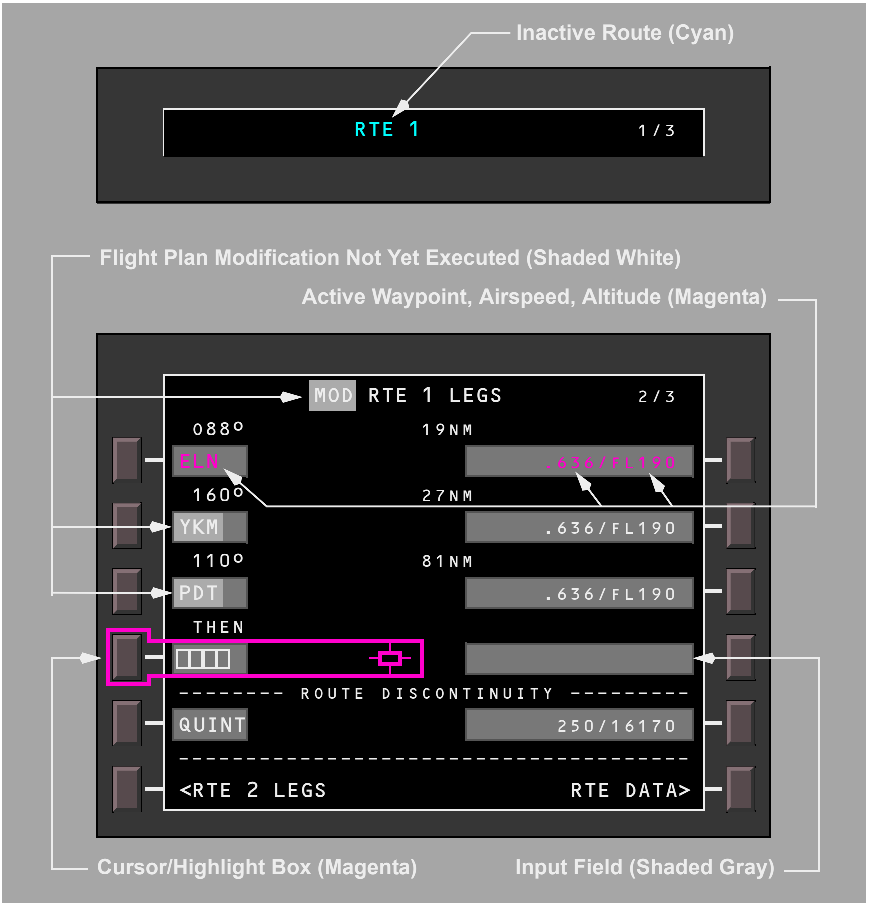
7 **Prompts**

Display pages, select modes, and control displays. Caret “<” or “>” is before or after prompt.

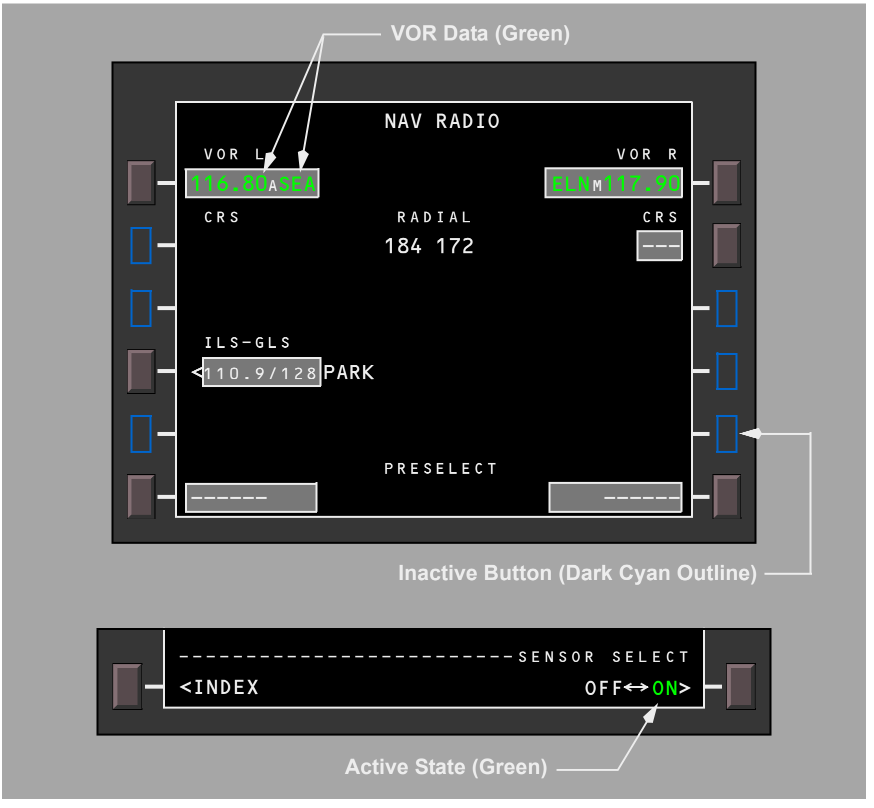
8 **Scratchpad**

Displays alphanumeric entries, or line selected data.

CDU Page Color



[Option – No ADF]



Color is used as follows:

- black – background color of page
- cyan –
  - inactive RTE page title
  - inactive button outline
- green –
  - navigation radio data
  - active state of two–position and three–position selectors
- magenta – data used by FMC for lateral and vertical flight commands
  - active waypoint
  - active airspeed
  - active altitude
  - cursor
  - highlight box
- shaded gray – input field

- shaded white –
  - modifications
  - MOD precedes page titles of modified pages
- white – most data

CDU Cursor and Highlight Box

Interaction with the CDU is accomplished by using the Cursor Control Device (CCD) or the Cursor Control Selector (CCS). When using the CCD, hovering the cursor over an active area of the CDU displays the highlight box. When using the CCS the highlight box moves down when the CCS is rotated in a clockwise direction and up when the CCS is moved in a counterclockwise direction. The highlight box does not return to the top or bottom of the display when it reaches the bottom or top respectively.

Each CDU page is composed of active and inactive areas. The highlight box only displays over an active area. When the highlight box is displayed, an action may be performed such as data entry or line key selection.

Additional manual manipulation of the highlight box is provided by the four corners on the CCD touch pad that, when touched, result in the highlighting of the corresponding 1L, 1R, 6L, or 6R line select key position.

An enter or line key selection may be performed utilizing any of the following:

- pushing the ENTER key on the onside multifunction keypad
- pushing the Cursor Select Switch on the onside multifunction keypad
- pushing the Cursor Select Switch on the onside CCD

Automatic Highlight Box Positioning

To facilitate data entry during preflight an autotabbing feature (airline configurable on or off) has been implemented to guide the pilot through the data entry process. When data is entered into a field in which autotabbing has been enabled, the cursor automatically moves to the next appropriate entry field. Autotabbing only operates when entering a page from a line select key and does not operate when a function key is used to enter a page. Autotabbing is enabled on the following FMC pages:

- ROUTE 1/X
- PERF INIT
- TAKEOFF REF 1/2

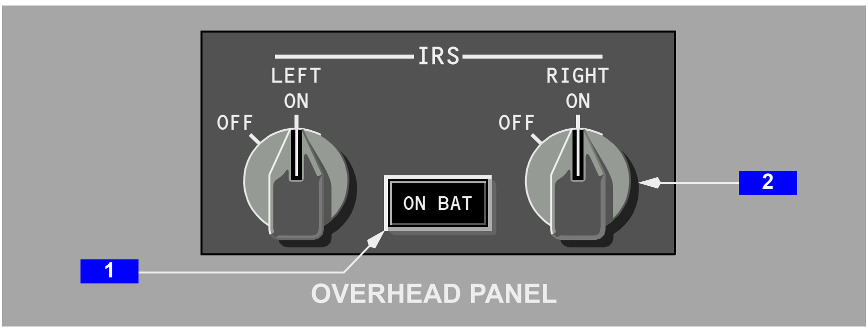
The pilot can still move the highlight box with either the CCD or the CCS to any active area within a page even if that area is not on the immediate autotabbing sequence. This action does not disable autotabbing regardless of the position of the highlight box. As long as a valid entry is made on a field that is in the autotabbing sequence, autotabbing immediately takes over the highlight box repositioning again.

If a valid entry is made in a field that is not in the autotabbing sequence, the highlight does not move and the pilot must move it manually to the next desired field. Whenever a delete is performed, the pilot must also manually move the highlight box to the next desired field.

Autotabbing only operates in the display area adjacent to the line selection keys and does not include the CDU function keys. Autotabbing is discontinued after the FMS preflight is complete.

Inertial System

Inertial Reference System (IRS)



1 On Battery (ON BAT) Light

Illuminated (white) – airplane battery powers IRS.

Note: ON BAT light illuminates only when IRS has been aligned on airplane or ground power, and primary power is subsequently removed or failed (battery power only remains).

2 IRS Selectors

ON – applies power to the associated IRS.

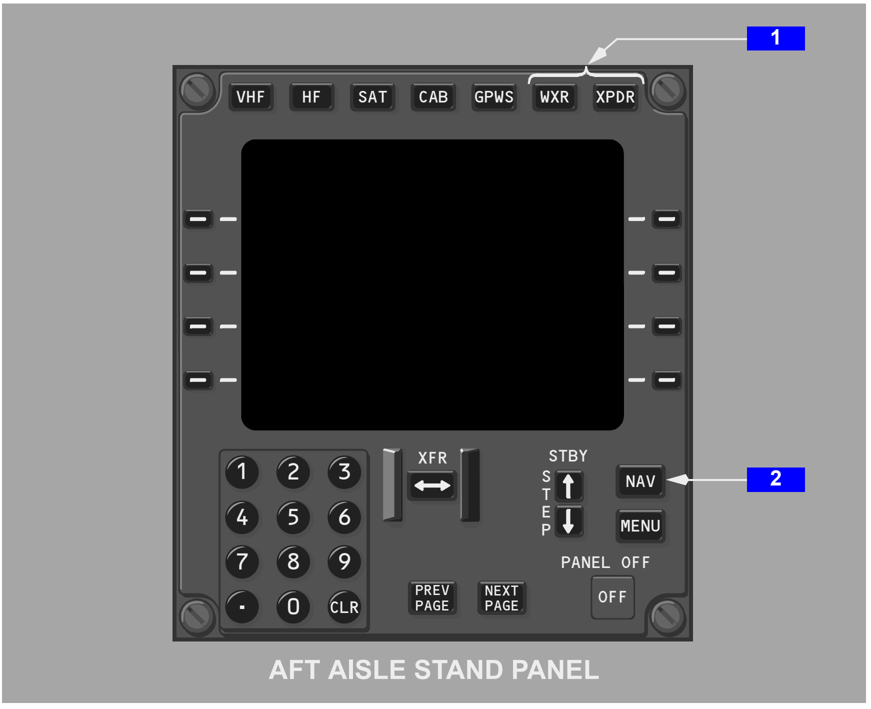
OFF – removes power from the associated IRS.

Note: IRS selectors must be pulled out before moving to the OFF position.

Tuning and Control Panel

The transponder, weather radar and alternate navigation functions may be accessed from any of the three Tuning and Control Panels (TCPs) located on the aft aisle stand. The transponder additionally uses the Alerting and Transponder Control Panel (ATP).

Refer to Tuning and Control Panel in Chapter 5, Section 10, for additional information.



1 Mode Select Keys

Push – selects desired mode page for display:

- WX – displays weather radar page
- XPDR – displays transponder page

2 Navigation (NAV) Key

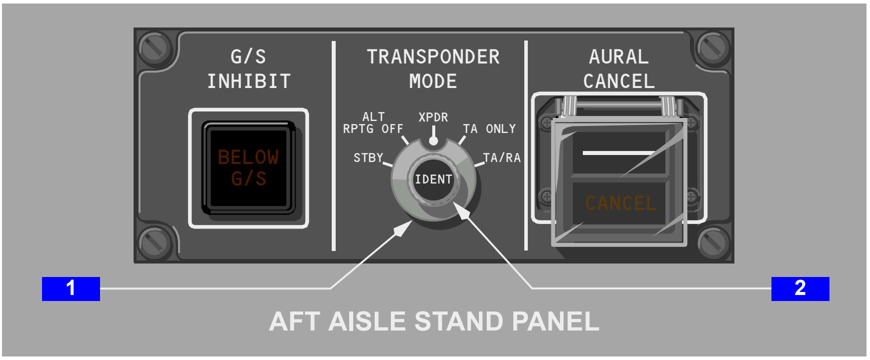
Push – selects the ALTN NAV (alternate navigation) page.

Refer to Chapter 11, Section 50, Alternate Navigation System Description, for additional information.

Transponder

Alerting and Transponder Control Panel

The Alerting and Transponder Control Panel serves as the primary means for setting transponder modes and for sending an IDENT to ATC. The ATP is used in conjunction with the transponder display on the Tuning and Control Panel.



1 **Transponder/TCAS Mode Selector**

STBY (standby) – transponder not active.

ALT RPTG (altitude reporting) OFF –

- transponder enabled
- altitude reporting disabled

XPDR (transponder) –

- transponder enabled
- in flight, altitude reporting enabled

TA (traffic advisory) ONLY and TA/RA (resolution advisory)

Refer to Traffic Alert and Collision Avoidance System (TCAS) in Chapter 15, Section 10, for additional information.

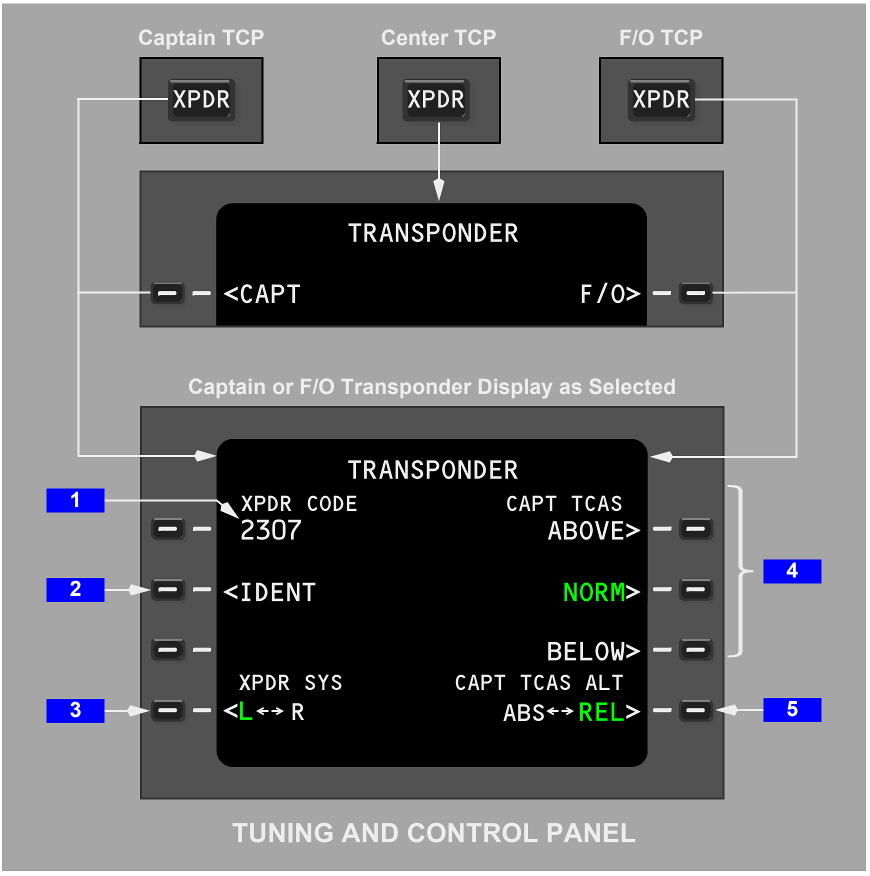
2 **Identification (IDENT) Switch**

Push – transmits an identification signal.

Tuning and Control Panel

The transponder control pages on the TCP are accessed by selecting the XPDR mode select key.

The center TCP can control both left and right side transponders. When XPDR is selected from the center TCP the flight crew is prompted to select either the CAPT (Captain) or F/O (First Officer) display.



1 Transponder (XPDR) Code

Displays the current ATC transponder squawk code.

The squawk code is also displayed in the auxiliary display area on the outboard side of each PFD.

Transponder code is typed into the scratchpad and then entered using line select key 1L.

2 Identification (IDENT)

Push –

- transmits an identification signal
- the IDENT prompt changes to large green font for 10 seconds

3 Transponder System (XPDR SYS)

Push –

- toggles the selection of the left or right ATC transponder / TCAS system
- the selected system is highlighted in large green font

The left system is the default selection.

Note: If a transponder becomes inoperative, the TCP senses the fault and automatically switch operation to the other side. The change in the XPDR SYS field (i.e. from L to R) may be the only indication the flight crew receives that an autoswitch has occurred. The flight crew is still be able to manually select an inoperative side.

4 XXXX TCAS Display

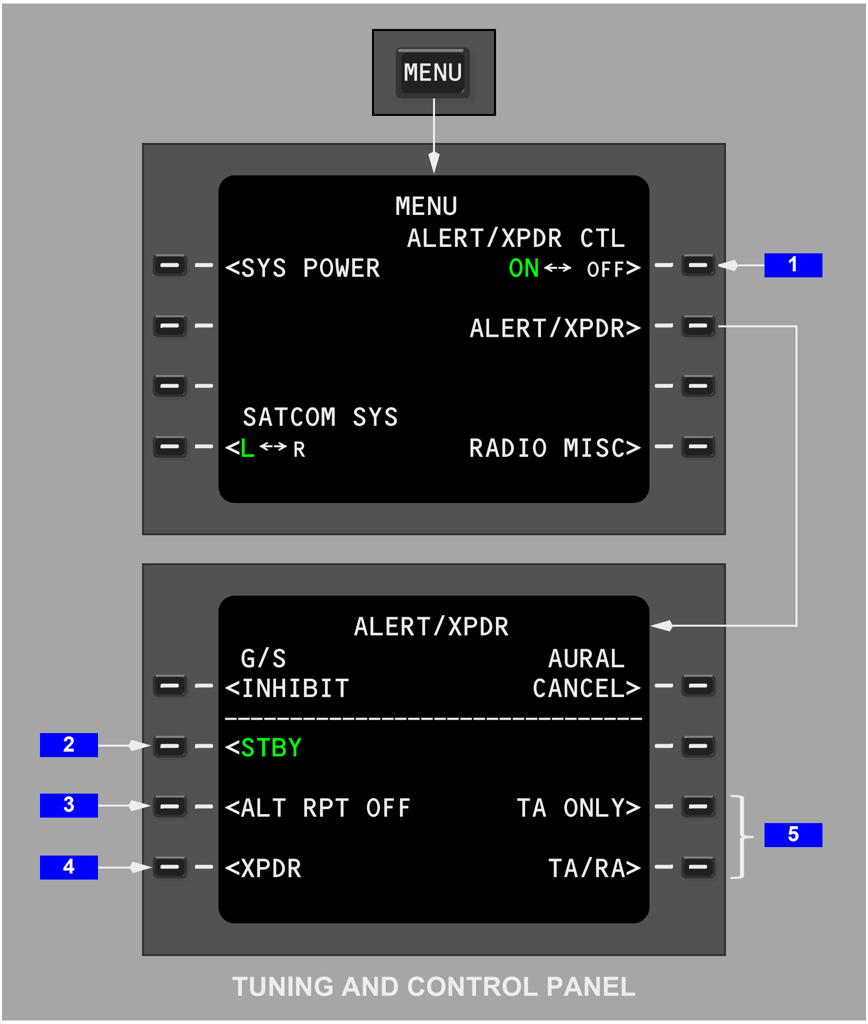
Refer to Traffic Alert and Collision Avoidance System (TCAS) in Chapter 15, Section 10, for additional information.

5 XXXX TCAS Altitude (ALT)

Refer to Traffic Alert and Collision Avoidance System (TCAS) in Chapter 15, Section 10, for additional information.

Tuning and Control Panel - ATP Inoperative

If the Alerting and Transponder Control Panel fails, the EICAS advisory message TRANSPONDER PANEL is displayed and the transponder and TCAS modes must be set using the Tuning and Control Panel.



1 **ALERT/Transponder Control (XPDR CTL)**

Push –

- toggles transponder control between ATP and the TCP
- selection appears in large green font
- when set to ON, ALERT/XPDR prompt is displayed

Note: With ALERT/XPDR CTL set to ON, even a functional ATP no longer controls the transponder/ TCAS mode, ILS glideslope inhibit, and aural cancel functions.

2 **Standby (STBY)**

Push –

- places transponder in standby mode
- STBY displayed in large green font

3 **Altitude Reporting (ALT RPT) OFF**

Push –

- transponder enabled
- altitude reporting disabled
- ALT RPT OFF displayed in large green font

4 **Transponder (XPDR)**

Push –

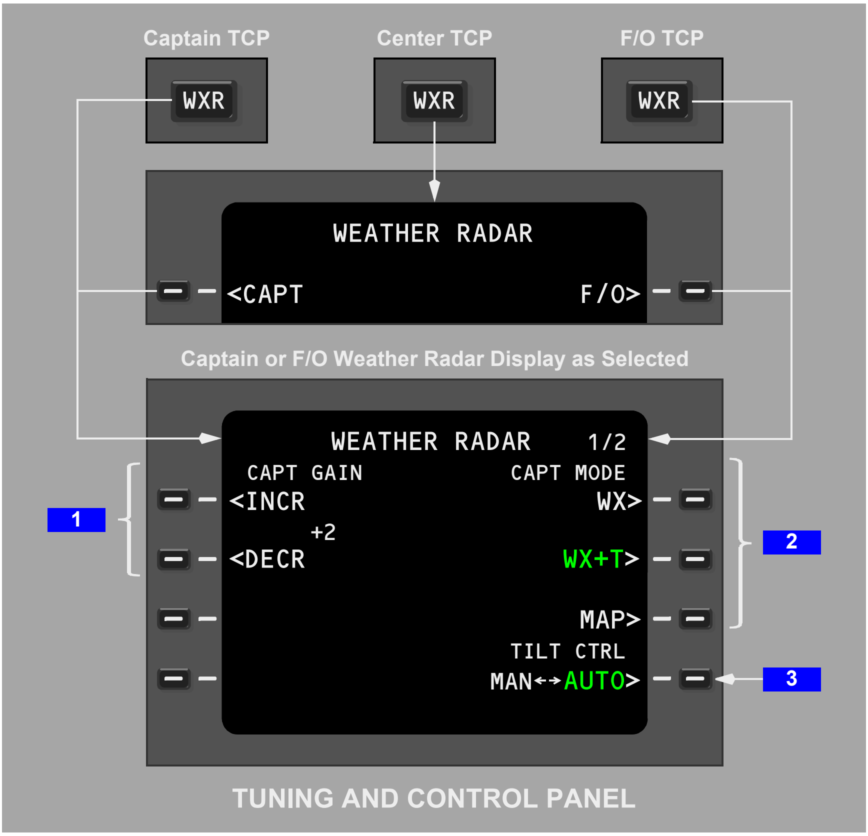
- transponder enabled
- in flight, altitude reporting enabled
- XPDR displayed in large green font

5 **Traffic Advisory (TA) ONLY and TA/Resolution Advisory (RA)**

Refer to Traffic Alert and Collision Avoidance System (TCAS), Chapter 15, Section 10, for additional information.

Weather Radar

Tuning and Control Panel



1 Gain Control

Push and hold –

- INCR – increases gain
- DECR – decreases gain
- current gain setting is displayed between line select keys 1L and 2L

2 Mode Switches

Push – selects desired mode.

WX – displays weather radar returns.

WX+T (turbulence) – displays weather returns and turbulence within precipitation at calibrated gain level. Turbulence within 40 nm is displayed at all display ranges.

Note: Turbulence detection requires presence of detectable precipitation. Clear air turbulence cannot be detected by radar.

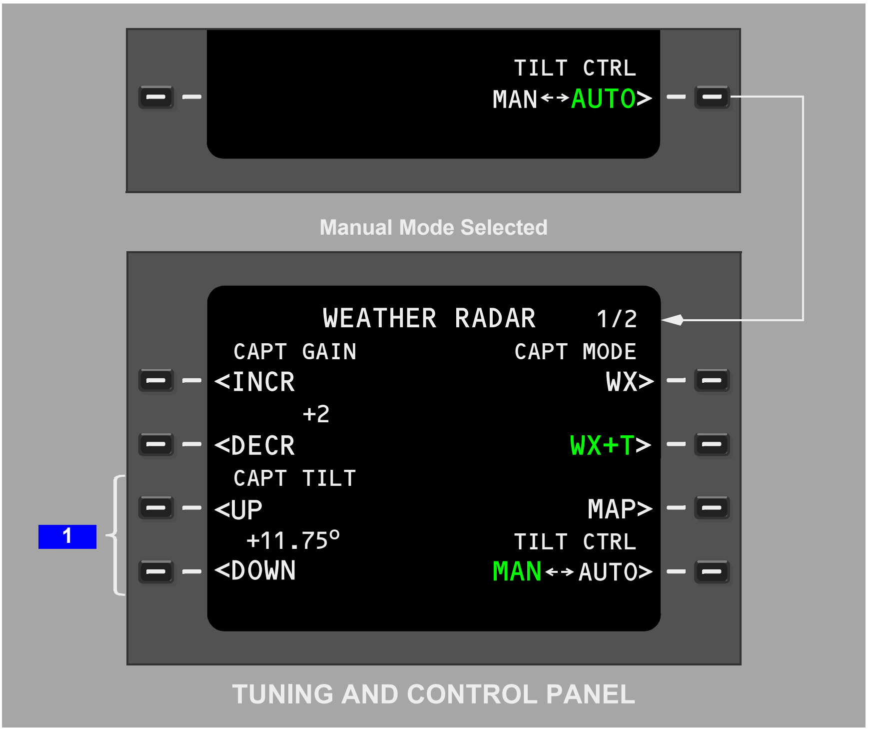
MAP – displays ground returns at selected gain level.

Selection is displayed in large green font.

3 Tilt Control

Push – selects manual (MAN) or automatic (AUTO) antenna tilt.

Selection is displayed in large green font.



1 Manual Antenna Tilt

Displayed when tilt control (TILT CTRL) is set to manual (MAN).

Push and hold –

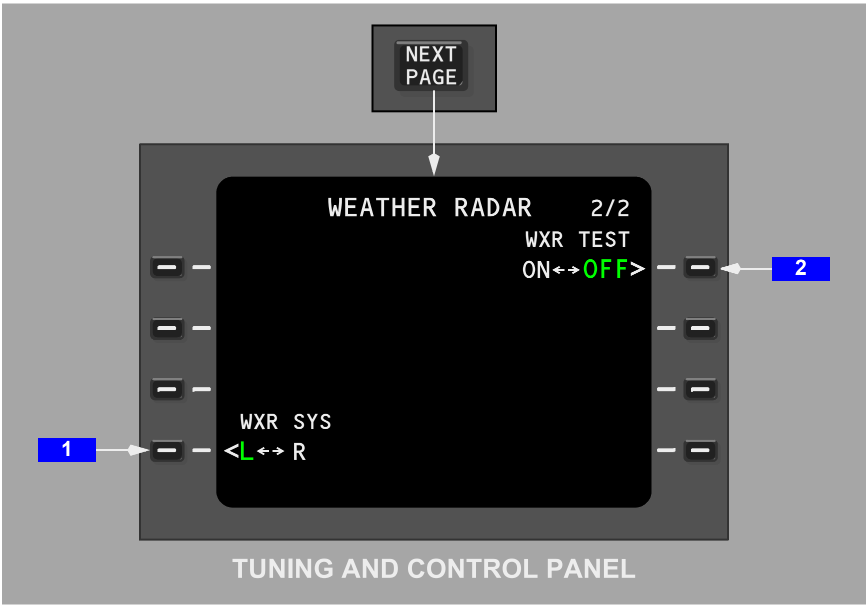
- UP – slews antenna tilt up to a maximum of +15 degrees
- DOWN – slews antenna tilt down to a maximum of -15 degrees

Push (with value entered into scratchpad) –

- UP – sets antenna up tilt to value entered in scratchpad
- DOWN – sets antenna down tilt to value entered in scratchpad

Valid scratchpad entries are 1 to 15.

Current +/- antenna tilt is displayed in degrees between line select keys 3L and 4L.



1 Weather Radar System (WXR SYS)

Push –

- toggles the weather radar system between the left and right system
- the selected system is highlighted in large font green text
- the default selection is the left system

2 Weather Radar Test (WXR TEST)

Push –

- tests weather radar system operation without transmitting
- displays test pattern and PWS symbol at the end of the test and any fault message on ND with WXR selected (except in PLAN mode)

- when on the ground, selecting WXR on the EFIS control panel and TEST on the TCP WXR page 2/2 activates a 12 second test. Initially, the amber WINDSHEAR annunciation displays and the aural MONITOR RADAR DISPLAY sounds. Next, the Master Warning Light illuminates and the EICAS alert message WINDSHEAR SYS displays. Finally, the red WINDSHEAR annunciation displays and the aural GO AROUND WINDSHEAR AHEAD, and then WINDSHEAR AHEAD, WINDSHEAR AHEAD sounds
- the test pattern and PWS symbol remain displayed until WXR is selected off on the EFIS control panel, another mode is selected on the Mode Selector, or an actual PWS alert is detected. The source of any faults displays in the weather radar tilt field on the ND

Note: Selecting the TEST mode to ON deselects the weather radar display mode (WX, WX+T, and MAP) on page 1/2.

Flight Management, Navigation — Chapter 11
Navigation Systems Description — Section 20

Introduction

Navigation systems include global positioning system (GPS), air data reference system (ADRS), inertial reference system (IRS), VOR, DME, ILS, ATC transponder, weather radar, and the flight management system (FMS). The FMS is described in the Flight Management System Description section of this chapter.

Navigation Systems Flight Instrument Displays

Refer to the following chapters and sections for additional information:

- Primary Flight Display (PFD), Ch.10, Sec.10
- Navigation Display (ND), Ch.10, Sec. 10

Global Positioning System (GPS)

Left and right GPS receivers are independent and supply very accurate position data to the IRS. The IRS in turn supplies a very accurate hybrid GPS-inertial position to the FMC. In the event that the IRS becomes inoperative, the GPS supplies position and track data directly to the FMC. All GPS tuning is automatic.

GPS Displays

POS REF page 4/4 displays the left and right GPS-IRU position. The ND annunciates GPS when the FMC uses GPS position updates.

When POS (position) is selected on the ND pull down MENU, the ND map displays raw GPS position as left and right GPS symbols. The GPS symbols are identical and display as a single symbol when the GPS receivers calculate the same position.

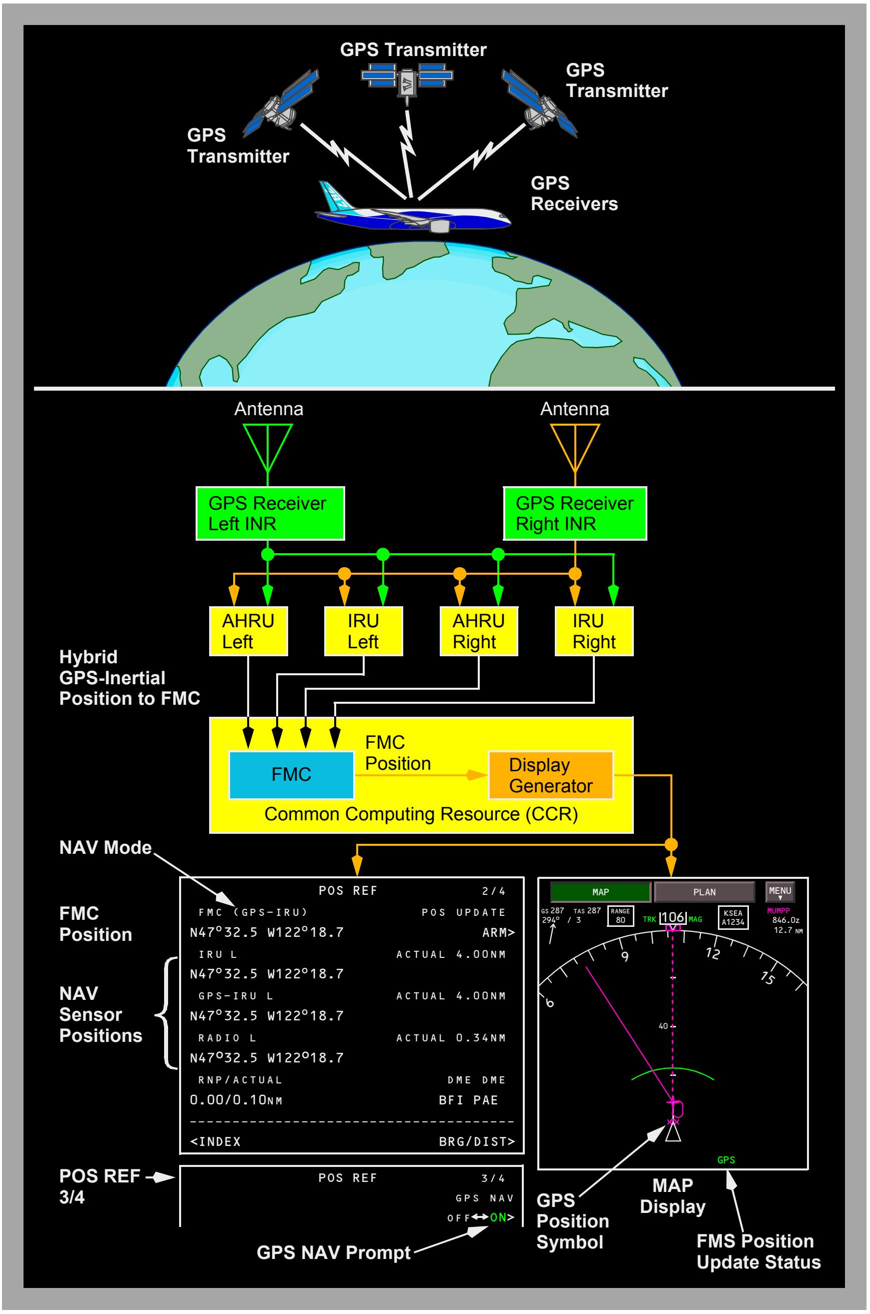
GPS Data

If the IRS becomes inoperative during flight, the FMC automatically uses GPS data to navigate. No EICAS message is displayed.

Use the GPS NAV prompt on the POS REF page 3/4 to inhibit GPS navigation data. The EICAS message GPS alerts the crew when data from both GPS systems are unavailable or when both systems have failed.

GPS position updates are allowed for all United States National Airspace approach operations. Outside of this region, GPS position updates are allowed during approaches only if the FMC database and approach charts are referenced to the WGS-84 reference datum. GPS updates should be inhibited for all other approach operations, unless other appropriate procedures are used.

GPS System Schematic



Air Data Reference System (ADRS)

The ADRS provides airplane altitude and airspeed for the displays, flight management system, flight controls, engine controls, and other systems. The major components of the ADRS are the pitot and static systems with their corresponding air data modules (ADMs), and the flight control electronics (FCE) with their corresponding flight control modules (FCMs) and air data reference functions (ADRFs).

Air Data and Attitude Sources

The ADRS receives air data from the left, center, and right pitot and static systems. The ADRS sends trusted voted air data to the PFDs. The ADRS is completely independent of the IRS.

When voted ADRS air data is invalid and the AIR DATA/ATT switch is in the AUTO position, backup airspeed (AOA SPD) and/or backup altitude (GPS ALT) are automatically provided by the IRS and GPS systems.

Refer to Instrument Source Select Panels in Chapter 10, Section 10, for additional information.

The air data modules are remote sensors that convert the sensed analog pressures to digital values for the air data functions within the ADRS. In addition, the ADRS receives data from two angle of attack vanes, an airframe mounted dual element total air temperature probe, and engine TAT sensors.

The integrated standby flight display (ISFD) receives data from the center pitot static system. Altitude, attitude, and airspeed are independent of IRU and AHRU values.

In the event of a FCE failure in which both voted and backup air data is unavailable, ISFD altitude (ISFD ALT) and ISFD airspeed (ISFD SPD) are displayed on the PFDs.

Inertial System

Inertial Reference System (IRS)

The IRS calculates airplane altitude, airspeed, attitude, heading, and position data for the displays, flight management system, flight controls, engine controls, and other systems. The major components of IRS are the inertial reference units (IRUs), and attitude and heading reference units (AHRUs).

Inertial Reference Unit (IRU)

The IRU combines inertial reference functions with GPS position information to provide hybrid GPS-inertial position outputs.

IRS Power

Initial power–up requires battery bus power and the IRS switches to be ON. If the IRSs are switched off, they must complete a full realignment cycle before the airplane can be moved.

If electrical power is subsequently removed from the airplane and the Battery switch is switched OFF, the hot battery bus continues to supply electrical power to the IRS. The ON BAT light illuminates, and the horn in the landing gear wheel well sounds to alert maintenance personnel the IRS is on battery power.

IRU Alignment

On initial power–up, the IRUs enter the align mode. The EICAS memo message IRU ALIGN MODE L+R displays. Attitude or heading/track data is removed from the PFDs. When the GPS system is operating normally there is no requirement for the flight crew to enter present position on the CDU POS INIT page. The POS INIT page displays dashes in the ENTER PRESENT POSITION line to allow the option of manually entering present position. If the GPS position is not available during the alignment, the dashes are replaced with boxes and present position must be entered to complete the alignment. Alignment time is approximately 7 to 10 minutes at mid latitudes and up to 17 minutes at high latitudes. The airplane should not move until alignment is complete.

The IRU has the additional capability to complete an alignment while in flight. This capability allows the IRU to completely recover from an in flight loss of alignment due to a power interruption or inadvertent shutdown. When power is restored to the IRU while in flight, attitude information becomes available within a few seconds and full navigation capability is restored within about 10 minutes.

If the latitude/longitude position is not close to the position of the origin airport, the EICAS advisory message FMC MESSAGE is displayed along with the CDU help window message INERTIAL/ORIGIN DISAGREE. If the crew–entered latitude/longitude position does not pass internal IRU comparison tests, the EICAS advisory message FMC MESSAGE is displayed along with the CDU help window message ENTER INERTIAL POSITION.

If a new airplane present position entry fails the internal check twice, the EICAS advisory message FMC MESSAGE is displayed along with the CDU help window message ALIGNMENT REINITIATED. The system automatically starts a new alignment cycle.

When the alignment is complete, the IRS changes to the navigate mode and the airplane can be moved. If the airplane stops for an extended period, the IRS changes to the automatic realign mode and refines the alignment until the airplane moves again.

In the automatic realign mode, IRS velocity and acceleration errors are reset to zero. The inertial position can be manually updated when the IRS is in the automatic realign mode by entering a new latitude/longitude position on the POS INIT 1/3 page.

Note: A position update is recommended if the total time in the navigation mode is expected to exceed 24 hours.

Attitude and Heading Reference Unit (AHRU)

Like the IRUs, the AHRUs supply a stable source of attitude, heading and rate information to the FCE. The FCE uses all those inputs to provide voted solutions for flight controls and output to displays and other using systems.Although the AHRUs do not have the ability to provide an independent inertial position, they do provide a hybrid GPS-inertial position that combines the accuracy of the GPS position with the stability of the AHRUs inertial sensors.

If the IRS fails, meaning both AHRUs and both IRUs fail, the GPS output from the integrated navigation radios (INRs) provides the necessary position and track data for the FMC to continue to operate without the IRS. In this mode, the FMC continues to provide flight planning, navigation, and performance information to the crew. ND map center and map expanded modes are still available. LNAV and VNAV guidance coupled to the autopilot however are not available when the IRS is inoperative.

The CDU POS INIT page displays the SET HDG prompt immediately after any IRU or AHRU failure. However, voted heading information is still being sent to the IRS from the working IRUs and AHRUs and no aircrew action is required. Should the IRS fail however, the aircrew must use the SET HDG prompt to periodically sync the display heading to the standby compass magnetic heading.

The following functions are inoperative after failure of the IRS:

AFDS Modes:

- LNAV
- VNAV
- TO/GA
- LOC
- G/S
- FPA
- TRK HOLD/SEL
- HDG HOLD/SEL*

Navigation Functions:

- FMC VNAV pages
- ND Wind Direction and Speed (wind arrow)

PFD Functions:

- PFD Heading*

Note: *These functions are operative when standby magnetic compass heading is entered on the POS INIT page.

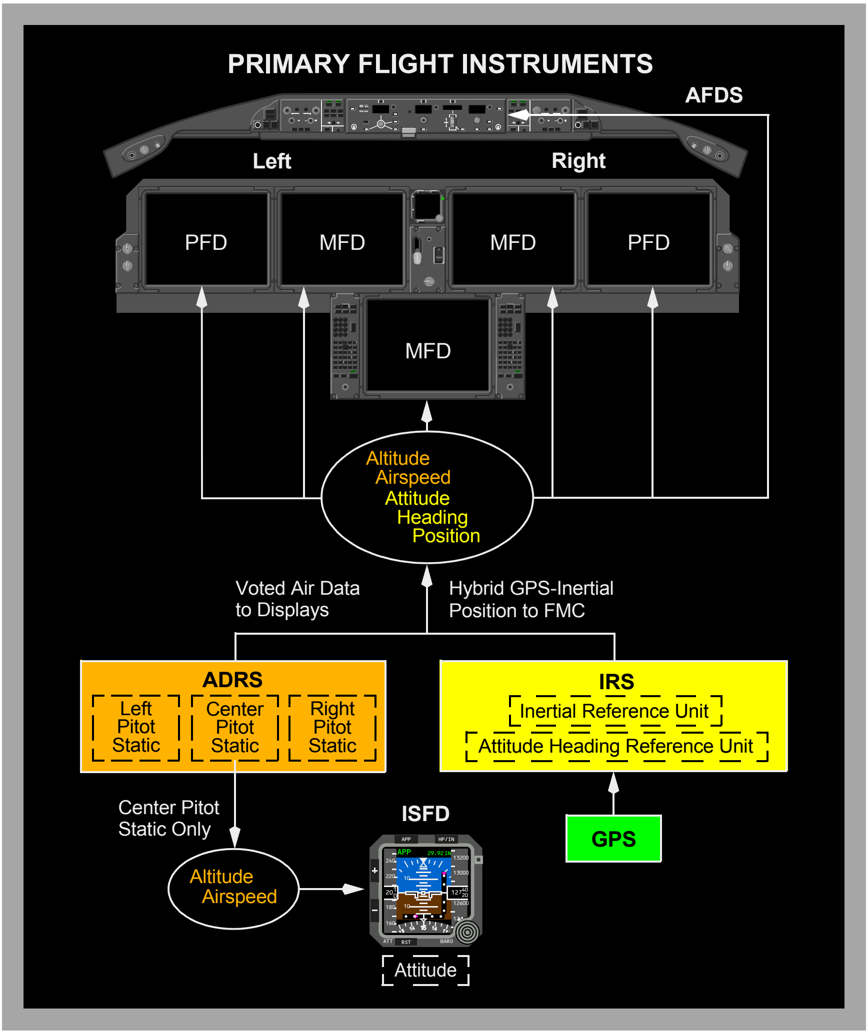
Note: ND map mode display following IRS failure references TRK.

Note: Autobrakes are also inoperative.

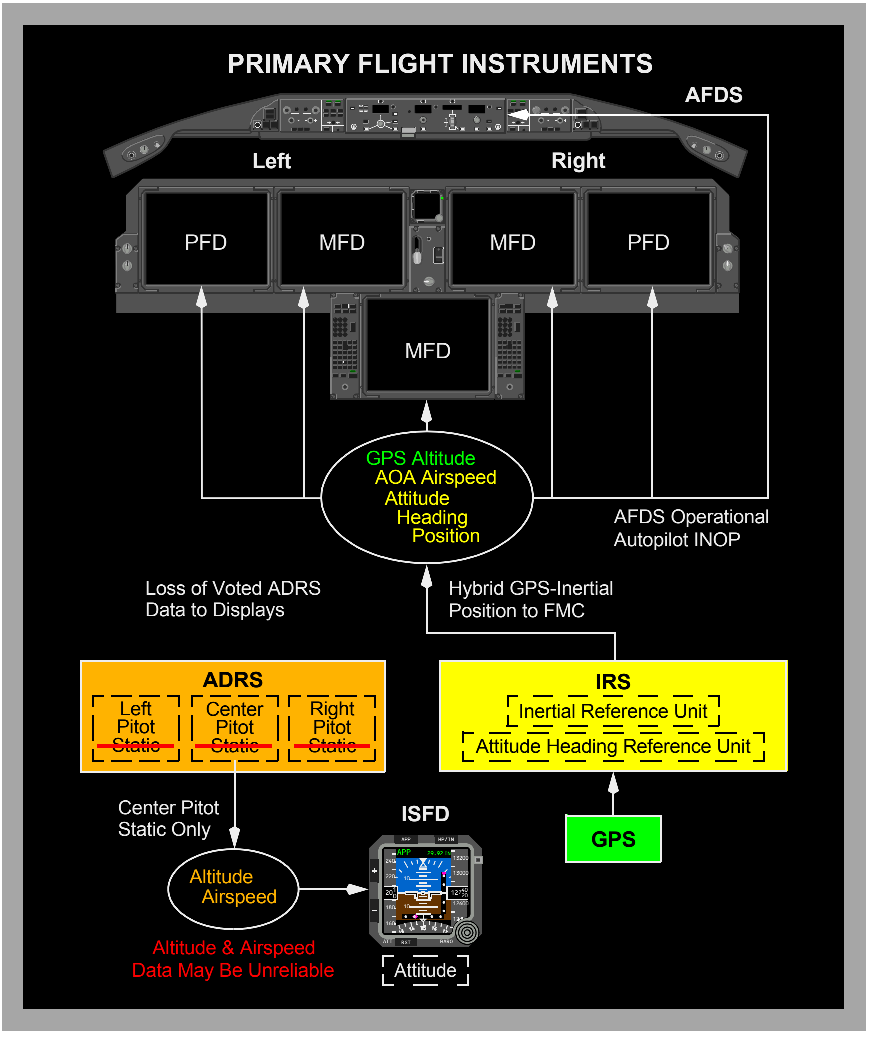
The following additional functions are inoperative after failure of both the IRS and GPS:

- ND Map (center and expanded)
- CDU active leg course and distance
- CDU direct-to a waypoint
- FMC Alternate Airport DIVERT NOW
- FMC navigation radio autotuning

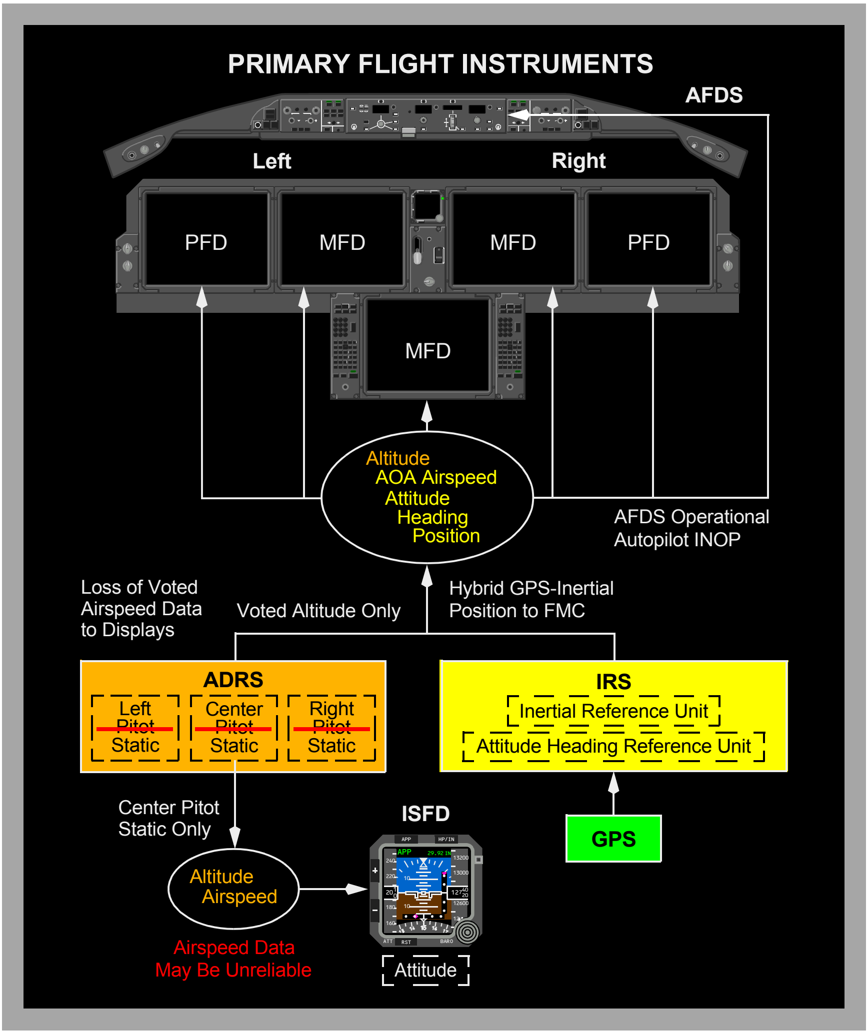
IRS Schematic, Normal Mode



IRS Schematic, With NAV AIR DATA SYS Message



IRS Schematic, With NAV AIRSPEED DATA Message



Radio Navigation Systems

Distance Measuring Equipment (DME)

Two DME systems are installed. The DMEs are usually tuned by the FMC, but may be tuned manually.

DME Tuning

DME is tuned manually when the VOR portion of a VOR/DME pair is entered on the NAV RADIO page. The FMC tunes DME as necessary for radio position updates. Manual DME tuning does not inhibit FMC DME tuning.

The FMC uses two DMEs for position updates. DME/DME position updates are usually more accurate than VOR/DME updates. The FMC cannot tune specific DMEs if the navaids are inhibited on the REF NAV DATA page.

DME Displays

DME distances are displayed on the ND map when VOR L or VOR R are selected on the ND pull down menu. DME distance also displays on the PFD when the ILS receivers are tuned to a collocated DME and localizer facility.

POS REF page 2/4 displays the identifiers of the DME stations used for FMC position updates.

Instrument Landing System (ILS)

Two ILS receivers are installed. They are usually tuned by the FMC, but can be tuned manually on the NAV RADIO page.

ILS Tuning

Two conditions must be met for FMC ILS autotuning to occur:

- an ILS, LOC, back course, LDA (localizer–type directional aid), or SDF (simplified directional facility) approach have been selected to the active route, and
- the airplane is within 50 nm from the top of descent, 150 nm of the landing runway threshold, or the FMC is in descent mode

Both ILS receivers can be manually tuned from the NAV RADIO page at anytime unless ILS approach tuning inhibit is active.

ILS approach tuning inhibit is active when:

- the autopilot is engaged and either the localizer or glideslope is captured
- only the flight director is engaged, and either the localizer or the glideslope is captured, and the airplane is below 500 feet radio altitude, or
- on the ground, the localizer is alive, airplane heading is within 45 degrees of the localizer front course, and groundspeed is greater than 40 knots

ILS tuning is again enabled when:

- either TO/GA switch is pushed
- the autopilot is disengaged and both flight director switches are switched off, or
- the MCP approach mode is deselected above 1500 feet radio altitude

The ILS frequency is automatically retuned when ILS tuning is enabled and a new approach is selected on the CDU.

In the unlikely event that all three FMCs fail, or if all of the large displays fail, the left ILS can be tuned from ALTN NAV RADIO page 2/2 on the TCP.

ILS Displays

The tuned ILS frequency displays on the PFD and on the ND in the approach mode.

When both ILS receivers are operating, deviations from the left ILS are displayed on the captain’s PFD, and deviations from the right ILS are displayed on the first officer’s PFD. If an ILS receiver fails, data from the remaining ILS is displayed on both the captain's and first officer's displays and the EICAS caution message SINGLE SOURCE APPROACH is displayed. Localizer and glideslope deviation, and selected course display on the ND when that ND is in the approach mode. Front or back course deviation is determined from airplane heading.

Navaid Identifier Decoding

The Morse code identifier of a tuned VOR, ILS, DME, or ADF can be converted to alpha characters. The decoded identifier then displays on the PFD and ND. The crew should monitor this identifier for correct navigation radio reception. The identifier name is not compared with the FMC database.

Due to the large variation in ground station identifier quality, the decode feature may incorrectly convert the intended identifier name. Examples: the Hong Kong localizer “KL” may display as “KAI”, or the Boeing Field ILS may display as “QBFI” or “TTTT” instead of “IBFI.”

Pilots should verify the identity of the tuned navigation station from the audio Morse code when the tuned frequency remains displayed or an incorrect identifier displays.

VOR

Two VOR receivers are usually tuned by the FMC but, can be tuned manually by the crew. The tuned VORs display on the ND and may be used for position updates.

VOR Tuning

The crew manually tunes VORs on the NAV RADIO page.

The FMC can tune a VOR and a collocated DME for position updates. The FMC uses VOR/DME radio position updates when more accurate sources are not available. Specific VOR/DME pairs can be inhibited on the REF NAV DATA page. If the crew enters two VOR identifiers on the NAV RADIO page, then the FMC cannot tune any other station for VOR/DME updates.

VOR Displays

The NAV RADIO page displays FMC tuned or manually tuned VOR data. POS REF page 2/4 displays the identifier of the VOR and DME pair used for position updates.

The ND displays the identifier or frequency of the VORs tuned on the NAV RADIO page. The FMC usually tunes the same VOR in the left and the right. The ND VOR L and VOR R data are usually the same.

Left and right VOR bearing pointers display on the ND map compass rose when the related VOR checkbox on the ND pull down menu is selected. The tuned frequency or identifier, and associated DME distances are also displayed in the lower corners of the ND when the VORs are selected on the ND pull down menu.

Transponder

Two ATC transponders and the traffic alert and collision avoidance system (TCAS) are controlled from the ATP and the TCP.

Alerting and Transponder Control Panel

The ATP controls the following Transponder/TCAS modes:

- STBY
- ALT RPTG OFF
- XPDR
- TA ONLY
- TA/RA

Traffic displays if the transponder mode selector is in TA ONLY or TA/RA. In flight, the selected transponder activates beacon and altitude reporting when the transponder mode selector is in XPDR, TA ONLY, or TA/RA.

If the ATP becomes inoperative the Transponder/TCAS modes can be set through the backup function of the TCP.

Tuning and Control Panel - Normal Operation

The transponder control pages on the TCP are accessed by selecting the XPDR mode select key.

The TCP controls:

- Mode A numeric code
- ATC Ident function
- TCAS envelope (Above, Normal, or Below)
- Altitude Mode (Absolute or Relative)
- Transponder select (Left or Right)

The Captain and First Officer TCPs share control of the:

- XPDR code
- IDENT function
- left or right side selection

Any changes made are also reflected on the center and cross-side TCPs. TCAS envelope and altitude settings control only the on-side TCAS display, and changes on one TCP are not reflected on the cross-side TCP.

The center TCP can control both left and right side transponders. When XPDR is selected from the center TCP the flight crew is prompted to select either Captain (left) or First Officer (right).

Should the on-side transponder fail, the TCP automatically switches to the cross-side transponder. A status message is logged and a status prompt displayed. Should both transponders fail, the EICAS advisory message TRANSPONDER is displayed. If altitude reporting fails, the transponder can be switched to the alternate altitude source.

Refer to Traffic Alert and Collision Avoidance System (TCAS) in Chapter 15, Section 10, for additional information.

Tuning and Control Panel - ATP Inoperative

If the ATP fails, the EICAS advisory message TRANSPONDER PANEL is displayed and the transponder and TCAS modes must be set using the TCP.

The ALERT/XPDR CTL page of the TCP is accessed from the MENU page by turning ALERT/XPDR CTL to ON (LSK 1R), and then selecting the ALERT/XPDR CTL page (LSK 2R).

When selected ON the transponder and TCAS modes can be set via the ALERT/XPDR CTL page.

Weather Radar

The weather radar system consists of a receiver/transmitter unit and antenna. Control is managed through the TCP. Radar returns display on the ND in MAP mode only.

The EFIS control panel weather radar (WXR) map switch controls power to the transmitter/receiver. Weather radar is displayed on the ND when the WXR checkbox is checked on the ND pull down MENU. The radar display range automatically adjusts to the ND range selected on the EFIS control panel. At ND ranges greater than 320 nm, WXR can still be displayed but only shows weather returns out to 320 nm.

The weather radar system performs various levels of self test on power up, during each sweep, and when descending through 2,300 feet AGL.

Turbulence can be sensed by the weather radar only when there is sufficient precipitation. Clear air turbulence can not be sensed by radar.

The weather radar also provides predictive windshear alerting.

Refer to Predictive Windshear (PWS) Display and Annunciations in Chapter 15, Section 10, for additional information.

Introduction

The flight management system (FMS) aids the flight crew with navigation, in–flight performance optimization, automatic fuel monitoring, and flight deck displays. Automatic flight functions manage the airplane lateral flight path (LNAV) and vertical flight path (VNAV). The displays include a map for airplane orientation and command markers on the airspeed, altitude, and thrust indicators to help in flying efficient profiles.

The flight crew enters the applicable route and flight data into the CDUs. The FMS then uses the navigation database, airplane position, and supporting systems data to calculate commands for manual and automatic flight path control.

The FMS tunes the navigation radios and sets courses. The FMS navigation database supplies the necessary data to fly routes, SIDs, STARs, holding patterns, and procedure turns. Cruise altitudes and crossing altitude restrictions are used to calculate VNAV commands. Lateral offsets from the programmed route can be calculated and commanded.

Flight Management Computer (FMC)

The basis of the flight management system is the flight management computer function. Since the term FMC is universally understood, it is used here for standardization and simplification.

There are three independent FMCs. At power up, one FMC is designated to accomplish the flight management tasks while the other FMCs monitor. The second FMC is ready to replace the first FMC if system faults occur. When the second FMC becomes active, the third FMC becomes its backup.

Refer to FMC Failure in Chapter 11, Section 32, for additional information.

The FMC uses flight crew entered flight plan data, airplane systems data, and data from the FMC navigation database to calculate airplane present position and pitch, roll, and thrust commands necessary to fly an optimum flight profile. The FMC sends these commands to the autothrottle, autopilot, and flight director. Map and route data are sent to the NDs. The ND pull down MENU is used to select the items displayed on the ND. The MCP selects the autothrottle, autopilot, and flight director operating modes.

Refer to Chapter 4, Automatic Flight, for additional information.

Refer to Chapter 10, Flight Instruments, Displays for additional information.

The FMC is certified for area navigation when used with navigation radio and/or GPS updating. The FMC and CDU are used for enroute and terminal area navigation, RNAV approaches, and to supplement primary navigation during all types of instrument approaches.

Control Display Units (CDUs)

The flight crew controls the FMC using emulated CDU displays. The CDUs may be displayed on any of the MFDs as selected by the aircrew.

Refer to Multifunction Display Management in Chapter 10, Section 20, for additional information.

Introduction

When first powered, the FMS is in the preflight phase. When completing a phase, the FMS changes to the next phase in this order:

- preflight
- takeoff
- climb
- cruise
- descent
- approach
- flight complete

Preflight

During preflight, the flight crew enters the flight plan and load sheet data into the CDU. Some data can be entered by datalink. The flight plan defines the route of flight from the origin to the destination and initializes LNAV. Flight plan and load sheet data provide performance data to initialize VNAV.

Required preflight data consists of:

- initial position (when not provided by GPS)
- route of flight
- performance data
- takeoff data

Optional preflight data includes:

- navigation database selection
- route 2
- alternate airport
- standard instrument departure (SID)
- standard terminal arrival route (STAR)
- thrust limits
- wind

Preflight starts with the IDENT page. If the IDENT page is not displayed, it can be selected with the IDENT prompt on the INIT/REF INDEX page. Visual prompts help the flight crew select CDU preflight pages. Preflight pages can be manually selected in any order.

After data on each preflight page is entered and checked, pushing the lower right line select key selects the next preflight page. After selecting ACTIVATE on the ROUTE page, the execute (EXEC) light illuminates. Pushing the EXEC key activates the route.

The departure/arrival (DEP/ARR) page can be used to select a SID. Selection of the SID may cause a route discontinuity. Resolution of the discontinuity and execution of the modification should be accomplished on the ROUTE or LEGS page.

Once the crew has entered the route and PERF INIT page information, the crew selects FLIGHT INITIALIZATION on the EFB. The EFB receives the minimum required information from the FMC (GWT, ORIGIN, OAT, QNH and takeoff runway). The crew then fills in other required or optional information in the EFB performance tool application and selects CALC. Once the EFB application has generated the appropriate takeoff data (reference speeds, runway condition, takeoff thrust and flap setting) the crew selects SEND TO FMC. A "•FMC" COMM alert is displayed with an associated aural. A TAKEOFF UPLINK CDU help window message is then displayed on the CDU. The crew selects LOAD or REJECT after reviewing the data on the THRUST LIMIT, TAKEOFF REF 1/2 and TAKEOFF REF 2/2 pages.

When all required preflight entries are complete, the PRE–FLT line title on the TAKEOFF REF page is replaced by PREFLIGHT COMPLETE. The THRUST LIM prompt displays at the next page select line location.

Takeoff

The takeoff phase starts with selection of TO/GA and terminates with thrust reduction for climb. LNAV and VNAV can be armed before takeoff to activate at the applicable altitude.

Refer to Automatic Flight Takeoff Profile in Chapter 4, Section 20, for additional information.

Climb

The climb phase starts at thrust reduction for climb and terminates at the top of climb (T/C) point. The T/C is where the airplane reaches the cruise altitude entered on the PERF INIT page.

Cruise

The cruise phase starts at the T/C point and terminates at the top of descent (T/D) point. Cruise can include step climbs and en route descents.

Descent

The descent phase starts at the T/D point or when the VNAV descent page becomes active, and terminates at the start of the approach phase.

Approach

The approach phase starts when the first waypoint of the procedure sequences or when the runway is the active waypoint and the distance to go is less than 25 nm.

Flight Complete

Thirty seconds after engine shutdown, the flight complete phase clears the active flight plan and load data. Some preflight data fields initialize to default values in preparation for the next flight.

Operational Notes

When operating in the LNAV and VNAV modes, observe system operation for unwanted pitch, roll, or thrust commands. If unwanted operation is observed, select heading select and flight level change modes.

The system must be carefully monitored for errors following:

- activation of a new database
- power interruption
- IRS failure

The FMC does not sequence the active waypoint when more than 21 nm off the active route and not on an offset route. Return to the active route can be accomplished using the DIRECT TO or INTERCEPT COURSE TO/FROM procedures.

When a waypoint is in the route more than once, certain route modifications (such as DIRECT TO and HOLD) use the first waypoint in the route.

Some SIDs or STARS contain a heading vectors leg. VECTORS waypoints display on the ND as a magenta line without an end point leading away from the airplane symbol. If LNAV is active, the DIRECT TO or INTERCEPT COURSE TO/FROM procedures can be used to start waypoint sequencing beyond the vectors leg.

When entering airways in a route page, the start and end waypoints must be in the database. A route segment must be entered as a DIRECT leg.

If the engines remain operating between flights, entering a new cruise altitude before the next flight recalculates the proper vertical profile.

If a climb to cruise altitude is necessary after completing a descent, a new cruise altitude entry must be made. Cruise altitude can be entered on the CLB page.

DIRECT TO courses are segments of a great circle route. When entering a DIRECT TO waypoint on the LEGS page, the course above the waypoint before execution is the arrival course at the waypoint. However, after execution, the course is the current course to fly to the waypoint. These courses may not be the same.

Terminology

The following paragraphs describe FMC and CDU terminology.

Active – flight plan data used to calculate LNAV or VNAV guidance commands.

Activate – changing a route from inactive to active for navigation by:

- selecting the ACTIVATE prompt
- pushing the execute (EXEC) key

Altitude constraint – a crossing restriction at a waypoint.

Delete – using the DELETE key removes FMC data and reverts to default values, dash or box prompts, or a blank entry.

Econ – a speed schedule calculated to minimize operating cost. The economy speed is based on the cost index. A low cost index causes a lower cruise speed. Maximum range cruise or the minimum fuel speed schedule may be obtained by entering a cost index of zero. This speed schedule ignores the cost of time. A minimum time speed schedule may be obtained by entering a cost index of 9999. This speed schedule calls for maximum flight envelope speeds. A low cost index may be used when fuel costs are high compared to operating costs.

Enter – putting data in the CDU scratchpad and line selecting the data to the applicable location. New characters can be typed or existing data can be line selected to the scratchpad for entry.

Erase – removing entered data, which has resulted in a modification, by selecting the ERASE prompt.

Execute – pushing the illuminated EXEC key to make modified data active.

Inactive – data not being used to calculate LNAV or VNAV commands.

Initialize – entering data required to make the system operational.

Message – FMC information displayed in the CDU help window.

Modify – changing active data. When a modification is made to the active route or performance mode, MOD displays in the page title, ERASE displays next to line select key 6 left, and the execute key illuminates.

Prompt – CDU symbols that aid the flight crew in accomplishing a task. Prompts can be boxes, dashes, or a careted (< or >) line to remind the flight crew to enter or validate data.

Purge – select the PURGE prompt to remove all airports uplinked to the ALTN LIST.

Select – pushing a key to obtain the necessary data or action, or to copy selected data to the scratchpad.

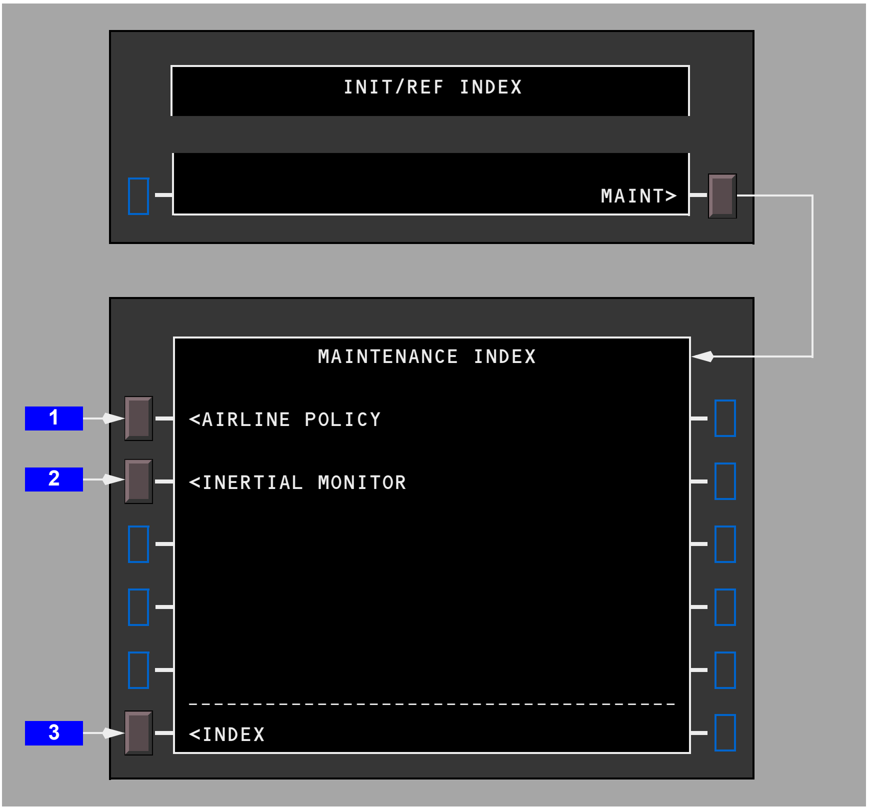
Speed restriction – an airspeed limit associated with a specified altitude entered by the flight crew.

Speed transition – an airspeed limit associated with a specified altitude entered by the FMC.

Waypoint – a point on the route or in the navigation database. It can be a fixed point such as a latitude and longitude, VOR station, or an airway intersection. A conditional waypoint is not associated with a land reference; it is based on a time or altitude requirement. An example of a conditional waypoint is “when reaching 4,000 feet”.

Maintenance Index

The MAINTENANCE INDEX page prompts are used only on the ground.



1 AIRLINE POLICY

Push – displays the AIRLINE POLICY 1/2 page.

2 INERTIAL MONITOR

This is a maintenance function.

3 INDEX

Push – displays the INIT/REF INDEX page.

Airline Policy

The airline policy pages display operating parameters kept in the airline maintained file. The FMC references this file for data before it calculates default values. These pages are not usually used by the flight crew.

Navigation Position

The FMC determines present position from these navigation systems: IRS, GPS, and navigation radios.When receiving reliable GPS data, the primary mode of navigation is from a GPS updated FMC position. If GPS data is not available, cannot be validated, or is inhibited, the FMC position is updated using navigation radios. When navigation radios are not available or not reliable, the FMC position comes from the IRUs.

FMC Position Update

FMC position may be manually updated to any of the navigation system positions. This update is accomplished on POS REF page 2.

On the ground, the FMC calculates present position based on IRS and/or GPS data.

With GPS NAV OFF, pushing a TO/GA switch updates the FMC position to the takeoff runway threshold or to the position shift position, when entered. When making an intersection takeoff, the intersection displacement distance from the runway threshold must be entered on the TAKEOFF REF page. With GPS NAV ON, the TO/GA update is inhibited.

In flight, the FMC position is continually updated from the GPS, navigation radios, and IRS. Updating priority is based on the availability of valid data from the supporting systems.

The FMC automatically tunes VOR, DME, and ILS radios for position updating and displays them on the ND and NAV RADIO page. Selection is related to the active route and any procedure (SID, STAR, etc.) in the active route. Manually selecting VOR frequencies or identifiers precludes the FMC from autotuning other VOR/DME frequencies for position updating; however, the FMC continues to tune DME-DME pairs for position updating.

FMC position updating using the IRS and navigation sensor positions occurs in the following priority order:

- LOC and GPS
- LOC and DME-DME
- LOC and collocated VOR/DME
- IRS and LOC
- IRS and GPS
- IRS and DME-DME
- IRS and a collocated VOR/DME
- IRS

The selected station identifiers of the radio navigation aids display on the POS REF page 2.

Primary FMC Position Update Source	POS REF page 2/4	ND Annunciation
LOC, GPS valid*	LOC–GPS	LOC–GPS
LOC, DME DME valid; GPS invalid*	LOC–RADIO	LOC–DME–DME
LOC, VOR DME valid; GPS invalid*	LOC–RADIO	LOC–VOR–DME
LOC valid; GPS, DME, VOR invalid*	LOC	LOC
GPS valid, LOC invalid	GPS	GPS
DME valid; GPS invalid	RADIO	DME–DME
VOR DME valid; GPS invalid	RADIO	VOR–DME
GPS, VOR, DME invalid	INERTIAL	INERTIAL
GPS valid, IRS failed	GPS	GPS
GPS invalid; IRS failed	blank	map not available

* The FMC changes to LOC updating when:

- a localizer-based approach procedure is selected
- the airplane heading is within 45° of the localizer course
- the airplane is within 20 nm of the destination airport
- the airplane is within 2.5° of the localizer center

FMC Polar Operations

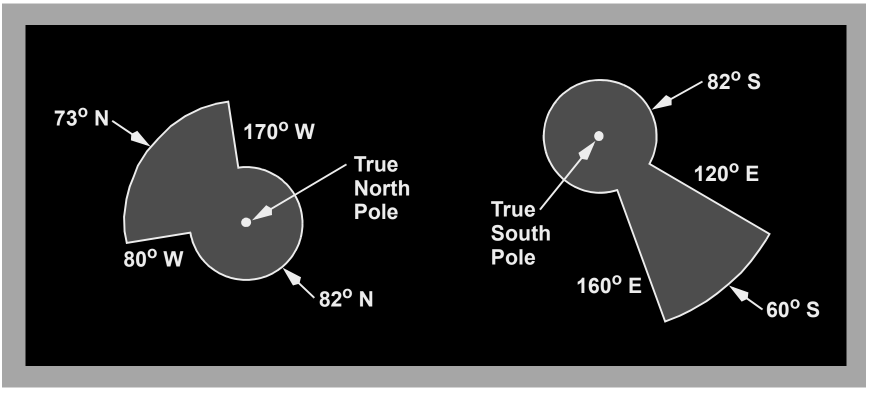
When entering the polar region, automatic switching to a true north reference is annunciated by a white box around the word TRU on both the ND and PFD. A true heading reference can be selected by placing the heading reference switch to TRUE inside or outside the polar region. The ND and PFD display a green box around the word MAG to annunciate the change back to magnetic reference when leaving the polar region. If the heading reference is TRU in the descent phase, the ND and PFD display an amber box around the word TRU.

Note: When operating the autopilot in the polar region in other than LNAV, the TRUE position on the heading reference switch must be selected.

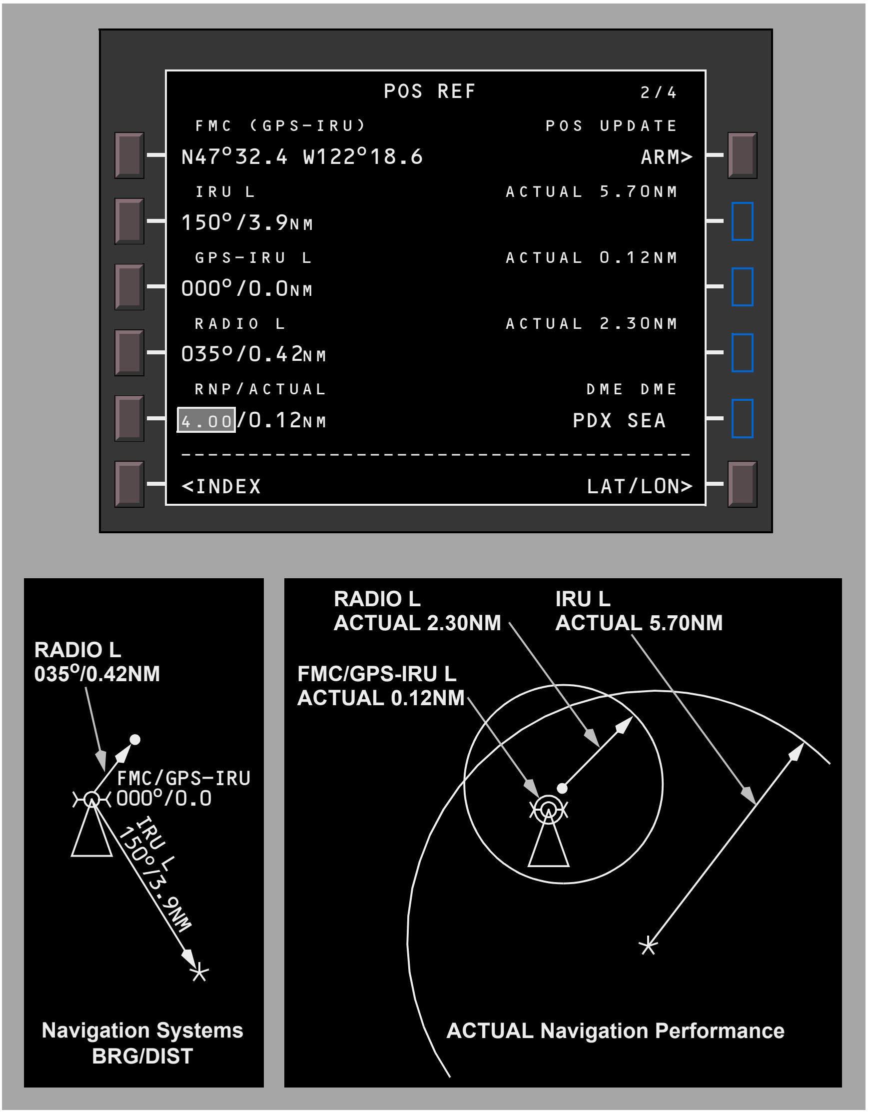
Note: When operating north of 82°N or south of 82°S using the ND PLAN mode, the airplane position symbol changes to a circle with a "X" in the middle.

Note: If the IRS fails in a polar region, the EICAS message NAV INERTIAL SYS displays and all autopilot and AFDS roll modes fail. When heading information is restored by entry of a reference heading on the POS INIT page, HDG SEL and HDG HOLD roll modes are restored. GPS continues to provide navigation data to the FMC and active route information displays on the ND. When operating in this degraded mode, heading on the POS INIT page may be referenced to magnetic, true, or grid heading. The heading display drifts significantly under these conditions. Periodic updating of the heading reference on the POS INIT page should be accomplished at least every 10 minutes.

FMC Polar Regions



Navigation Performance



The FMC uses data from the navigation systems to accurately calculate the position of the airplane. The current FMC position displays on line 1 of the POS REF page 2. The primary source of update displays in parentheses above the FMC position.

Navigation system positions display on the left side of lines 2 through 4. The bearing/distance is from the FMC position to the individual navigation system position.

The FMC position displays on the ND at the tip of the triangle. All other positions display relative to the FMC. The RADIO position is shown above as a •, but is not shown on the ND. The ACTUAL navigation performance circles shown above do not display on the ND.

Actual Navigation Performance

Actual navigation performance (ANP) is the FMC current computed position accuracy. It is titled ACTUAL and displays on the POS REF page 2 for the navigation system displayed in title line 1. ACTUAL navigation performance is a circular prediction centered at the FMC position. Airplane position is estimated to be within this ACTUAL navigation performance circle 95 percent of the time.

After a manual position update, the ACTUAL navigation performance of the FMC changes to the ACTUAL navigation performance of the selected navigation system. In the example above, a manual position update to the IRU L system would change the FMC ACTUAL navigation performance to 5.7 nm. The FMC then updates from the best available navigation system and eventually, the manual update has no effect on position calculation. Some automatic updates can be inhibited; GPS, VOR/DME and DME/DME updates on POS REF page 3 and VOR/DME updates on the REF NAV DATA page. Inertial updates can not be inhibited.

Required Navigation Performance

Required Navigation Performance (RNP) is the navigation accuracy required for operation within a defined airspace. It is expressed in nautical miles. RNP values have been published for areas of operation around the world. Operations in these areas require on–board navigation systems to alert the flight crew if ANP exceeds RNP. The FMC supplies a default RNP value for takeoff, en route, oceanic/remote, terminal, and approach phases of flight. The flight crew may enter an RNP value, if required. RNP displays on POS REF page 2.

Vertical Required Navigation Performance

Vertical RNP is the vertical navigation accuracy required for operation within a defined airspace. It is expressed in feet. The FMC supplies a default vertical RNP value for enroute, oceanic/remote, terminal, and approach phases of flight.The FMC will alert the flight crew if vertical ANP exceeds vertical RNP. When required, vertical RNP values may be manually entered or displayed on RNP PROGRESS page 4/4. Manual entry of a vertical RNP value greater than that required for a phase of flight will result in the CDU help window message VERIFY VERT RNP – PROG 4/X to display.

Lateral Navigation (LNAV)

LNAV provides steering commands to the next waypoint or the selected route intercept point. When armed on takeoff, LNAV engages at or above 50 feet, when laterally within 2.5 nautical miles of the active route leg. FMC LNAV guidance normally provides great circle courses between waypoints. However, when an arrival or approach from the FMC database is entered into the active route, the FMC commands a heading, track, or a DME arc to comply with the procedure.

Waypoints

Waypoint (navigation fix) identifiers display on the CDU and navigation display.

The CDU message NOT IN DATABASE displays if a manually entered waypoint identifier is not kept in the database. The waypoint can still be entered as a latitude/longitude, place–bearing/distance or place–bearing/place–bearing waypoint.

FMC–generated waypoints contain a maximum of five characters assigned according to the following rules:

Navaid Waypoints

VHF – waypoints located at VHF navaids (VOR/DME/LOC) are identified by one, two, three or four character facility identifier. Examples:

- Los Angeles VORTAC – LAX
- Tyndall TACAN – PAM
- Riga Engure, USSR – AN

NDB – waypoints located at NDBs are identified by use of the station identifier. Example: FORT NELSON, CAN – YE

Fix Waypoints

Waypoints located at fixes with names containing five or fewer characters are identified by the name. Examples:

- DOT
- ACRA
- ALPHA

Long Waypoints

Waypoints with more than five characters are abbreviated using the following rules sequentially until five characters remain. For double letters, one letter is deleted. Example:

- KIMMEL becomes KIMEL

Keep the first letter, first vowel and last letter. Delete other vowels starting from right to left. Example:

- BAILEY becomes BAILY

The next rule abbreviates names even further. Apply the previous rule, then delete consonants from right to left. Example:

- BRIDGEPORT becomes BRIDGPRT then BRIDT

Fixes with multi-word names use the first letter of the first word and abbreviate the last word, using the above rules sequentially until a total of five characters remain. Examples:

- CLEAR LAKE becomes CLAKE
- ROUGH ROAD becomes RROAD

Unnamed Waypoints

If an unnamed turn point, intersection, or fix is collocated with a named waypoint or navaid on a different route structure (such as low altitude routes or an approach), the name or identifier of the collocated waypoint is used. Example:

- Unnamed turn point on J2 between the Lake Charles (LCH) and New Orleans (MSY) VORTACs is coincidental with the Lafayette (LFT) low altitude VORTAC. LFT is used as the identifier for the turn point.

Identifier codes for unnamed turn points not coincidental with named waypoints are constructed from the identifier of a navaid serving the point and the distance from the navaid to the point. If the distance is 99 nautical miles or less, the navaid identifier is placed first, followed by the distance. If the distance is 100 nautical miles or more, the last two digits are used and placed ahead of the navaid identifier. Examples (NAVAID – DISTANCE – IDENT):

- INW – 18 – INW18
- CSN – 106 – 06CSN

Waypoint located at unnamed flight information region (FIR), upper flight information region (UIR), and controlled airspace reporting points are identified by the three–letter airspace type identification followed by a two–digit sequence number. Example:

- FRA01

Unnamed oceanic control area reporting points in the northern hemisphere use the letters N and E, while points in the southern hemisphere use the letters S and W. Latitude always precedes longitude. For longitude, only the last two digits of the three digit value are used.

Placement of the designator in the five character set indicates whether the first longitude digit is 0 or 1. The letter is the last character if the longitude is less than 100° and is the third character if the longitude is 100° or greater.

N is used for north latitude, west longitude. E is used for north latitude, east longitude. S is used for south latitude, east longitude. W is used for south latitude, west longitude. Examples:

- N50° W040° becomes 5040N
- N75° W170° becomes 75N70
- N50° E020° becomes 5020E
- N06° E110° becomes 06E10
- S52° W075° becomes 5275W
- S07° W120° becomes 07W20
- S50° E020° becomes 5020S
- S06° E110° becomes 06S10

Procedure Arc Fix Waypoint Names

Unnamed terminal area fixes along a DME arc procedure are identified with the first character D. Characters 2 through 4 indicate the radial on which the fix lies. The last character indicates the arc radius. The radius is expressed by a letter of the alphabet where A = 1 mile, B = 2 miles, C = 3 miles and so forth. Example:

- EPH252°/24 = D252X

An unnamed waypoint along a DME arc with a radius greater than 26 miles is identified by the station identifier and the DME radius. Example:

- CPR338°/29 = CPR29

When there are multiple unnamed waypoints along a DME arc with a radius greater than 26 miles, the station identifier is reduced to two characters, followed by the radius, and then a sequence character. Examples:

- CPR134°/29 = CP29A
- CPR190° /29 = CP29B

DME step down fixes are identified by the distance and a “D”.
Examples: 138D, 106D, 56D, 3D

Procedure Fix Waypoints

Marker beacons are identified by the marker type identifier followed by the runway number. Examples:

- Outer Marker 13R = OM13R
- Middle Marker 21 = MM21

Runway–related fixes – waypoints located at unnamed runway–related fixes are identified by adding a two–letter prefix to the runway number. The following list is used to determine the applicable prefix:

- RX – runway extension fix
- FA – VFR final approach fix
- CF – final approach course fix
- FF – final approach fix
- IF – initial approach fix
- OM – outer marker
- MM – middle marker
- IM – inner marker
- BM – back course marker
- MD – minimum descent altitude
- A – (+ an alpha) step down fix
- RW – runway threshold
- MA – missed approach point other than RW
- TD – touchdown point inboard of RW

Examples: OM25L, MM09, IM23, RW04, RW18L.

For airports with more than one approach to the same runway, the two letter prefix may change to allow different identifiers for the same waypoint. The first letter identifies the type of fix and the second letter identifies the type approach as follows:

- C( ) – final approach course fix
- F( ) – final approach fix
- P( ) – missed approach point
- I( ) – initial approach fix
- D( ) – minimum descent altitude
- T( ) – touch down point
- R( ) – runway centerline intercept.
- ( )I – ILS
- ( )L – localizer only
- ( )B –back course ILS
- ( )D – VOR/DME
- ( )V – VOR only
- ( )S – VOR with DME points
- ( )N – NDB
- ( )Q – NDB with DME points
- ( )T – Tacan
- ( )R – RNAV

Examples: CI32R, PV15, FN24L.

Unnamed turn points that are part of a procedure are identified as a latitude and longitude waypoint. These include waypoints (except conditional waypoints) defined by flying a course or track from a waypoint (except conditional waypoints) to a radial or DME distance. These waypoints are automatically entered in a route by selection of a procedure using these waypoints, from the departures or arrivals page.

Airport reference points are identified by the ICAO identifier.

Duplicate Waypoints

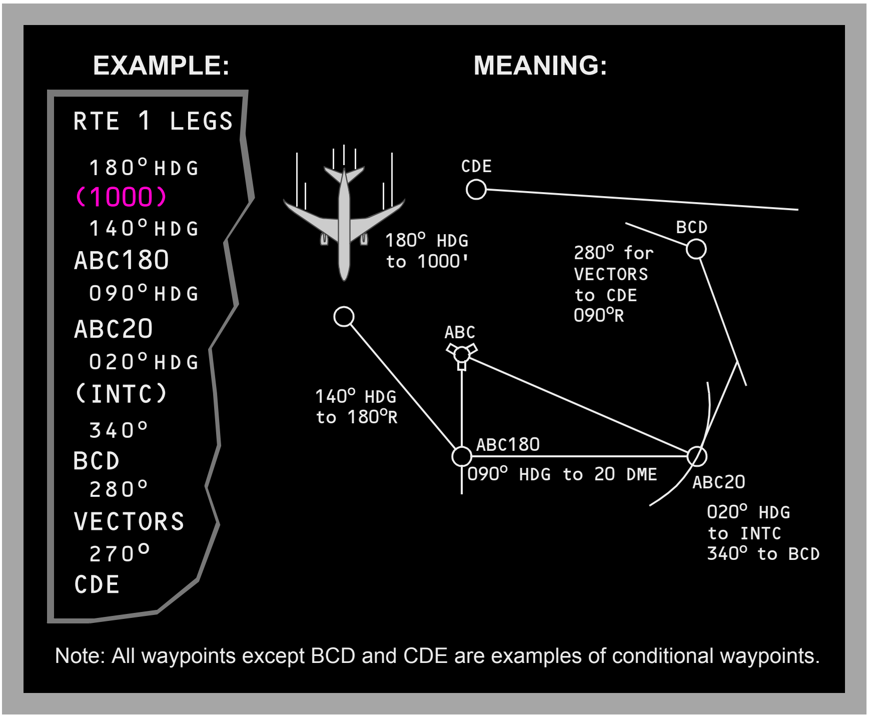
Application of the abbreviation rules may create identical identifiers for different waypoints. When a duplicate waypoint identifier is entered, the page changes to the SELECT DESIRED WPT page. The page lists the latitude and longitude of waypoints with the same identifier and the type of facility or waypoint. Select the latitude/longitude of the correct waypoint to enter the correct waypoint on the original page.

Conditional Waypoints

Conditional waypoints may display in the route when selecting a DEPARTURES or ARRIVALS page procedure. Usually, conditional waypoints cannot be manually entered on a route or legs page. These waypoints indicate when an event occurs and are not at a geographically–fixed position. The types of conditions are:

- climb/descent through an altitude
- flying a heading to a radial or DME distance
- intercepting a course
- heading vectors to a course or fix

Altitude and course intercept conditional waypoints display on the CDU inside (parenthesis) marks. The diagram below shows conditional waypoints.



Manually Entered Latitude/ Longitude Waypoints

Pilot defined waypoints entered as a latitude and longitude display in a seven–character format. Latitude and longitude waypoints are entered with no space or slash between the latitude and longitude entries. Leading zeroes must be entered. All digits and decimal points (to 1/10 minute) must be entered unless the latitude or longitude are full degrees. Examples:

- N47° W008° is entered as N47W008 and displays as N47W008
- N47° 15.4’ W008° 3.4’ is entered as N4715.4W00803.4 and displays as N47W008

Manually Entered Place Bearing/Distance or Place Bearing/Place Bearing Waypoints

Waypoints entered as a place bearing/distance or place bearing/place bearing are identified by the first three characters of the entry followed by a two–digit sequence number. Examples:

- SEA330/10 becomes SEA01
- SEA330/OLM020 becomes SEA02

The two digit sequence numbers reserved for RTE1 are 01 through 49. The two digit sequence numbers reserved for RTE2 are 51 through 99.

Manually Entered Airway Crossing Waypoints

Airway crossing fixes are entered as a five character waypoint name or by entering consecutive airways on the ROUTE page. In the latter case, the display is an X followed by the second airway name. Example: entering J70 on the VIA line of the ROUTE page causes box prompts to display opposite on the same line. Leaving the box prompts empty and entering J52 on the next VIA line, directly below J70, causes the FMC to calculate the intersection of the two airways and replace the boxes with the waypoint identifier, XJ52.

Manually Entered Latitude or Longitude Reporting Point Waypoints

Latitude or longitude reporting waypoints are entered as the full latitude or longitude followed by a dash, then the increment chosen for the following multiple waypoints. Example:

- W060–10 adds waypoints starting at W060 in ten degree increments from that point to the destination
- the entry must be made on a LEGS page on any line before the first reporting point
- usually, this entry is made on the active waypoint line and proper sequencing is performed by the FMC

Manually Entered Along–Track Waypoints

Along–track waypoints are created on the active route and do not cause route discontinuities when they are created.

Along–track waypoints are entered using the waypoint name (the place), followed by a slash and minus sign, for points before the waypoint, or no sign for points after the waypoint, followed by the mileage offset for the newly defined waypoint. The created waypoint is then inserted over the original waypoint. The distance offset must be less than the distance between the originating waypoint and next (positive value) or preceding (negative value) waypoint. Latitude and longitude waypoints cannot be used to create along–track waypoints. Examples:

- VAMPS/25 is 25 miles after VAMPS on the present route and displays as VAM01
- ELN/-30 is 30 miles before ELN on the present route and displays as ELN01

ND Map Displays

The route displays on the ND in the map, map center, mini-map and plan modes. The display color and format represent the following status:

- an inactive route displays as a cyan dashed line
- an activated, but not yet executed route, displays as an alternating cyan/white dashed line
- the active route displays in magenta
- modifications to an active route display as dashed white lines
- modified waypoints display in white
- executed route offsets display as a dashed magenta line

The ND displays the FMC position at the apex of the airplane symbol. All ND map data displays relative to this apex.

When adequate GPS or radio updating is not available, the ND map may display a shift error. This error results in the displayed position of the airplane, route, waypoints, and navigation aids being shifted from their actual position. An undetected, across track map shift may result in the airplane flying a ground track that is offset from the desired track. An undetected, along track map shift may result in the flight crew initiating altitude changes earlier or later than desired. In either case, an undetected map shift may compromise terrain or traffic separation.

Map shift errors can be detected by comparing the position of the airplane on the ND map with data from the ILS, VOR, and DME systems.

Vertical Navigation (VNAV)

VNAV provides vertical profile guidance through the climb, cruise, and descent phases of flight.

Note: The altimeter must be used to verify each crossing altitude in a VNAV procedure.

Speed/Altitude Constraints

VNAV controls the path and speed to comply with waypoint crossing constraints. Waypoint crossing constraints are entered on the LEGS page waypoint line by pushing the applicable key on the right side of the CDU. Barometric altitude constraints must be below the cruise altitude to be valid. Values entered as part of a procedure and manually entered constraints are shown in large font. FMC predicted values do not act as constraints, and display in small font.

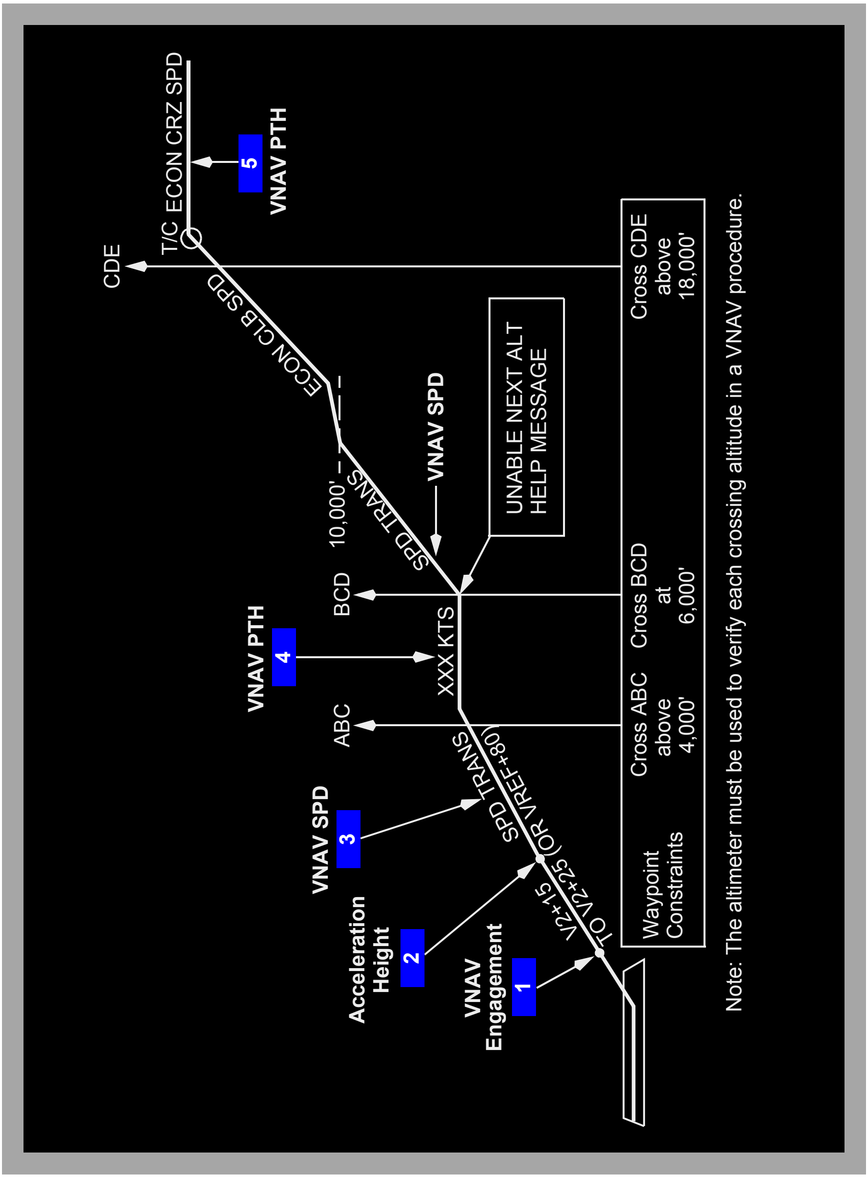
A waypoint constraint is magenta when it is active. The constraint does not have to be in line 1 to be active. Waypoints can have altitude or airspeed/altitude constraints.

Modified waypoint constraints are shaded white until they are executed. Speed constraint entries require an altitude constraint at the same waypoint. All speed constraints are considered by the FMC as at or below constraints.

At or above altitude constraints are entered with a suffix letter A (example: 220A). At or below altitude constraints are entered with a suffix letter B (example: 240B). Mandatory altitude constraints are entered without any suffix letter (example: 270).

Altitude constraints with two altitudes may be entered in either order. The lower altitude constraint, followed by a suffix letter A, and the upper altitude constraint, followed by a suffix letter B (example: 220A240B or 240B220A).

Takeoff and Climb



1 Takeoff

If armed for takeoff, VNAV activates at 400 feet RA and pitch guidance continues to maintain the target airspeed.

During takeoff, the FMC updates the target airspeed to the current airspeed until VNAV activates. The target airspeed is between V2 + 15 and V2 + 25 knots.

2 Acceleration Height

At acceleration height or flap retraction, VNAV commands an airspeed increase to a speed 5 knots below the flap placard speed for the existing flap setting. When flaps are retracted or at an AFDS capture altitude, VNAV commands the greater of VREF + 80 knots or the speed transition associated with the origin airport, limited by configuration.

The FMC changes the thrust reference mode to the selected climb thrust at the thrust reduction point.

3 VNAV Climb

The VNAV climb profile uses VNAV SPD or VNAV PTH at the default climb speed or pilot selected climb speed to remain within all airspeed and altitude constraints that are part of the SID entered into the active route. Autothrottle uses selected climb thrust limit.

If the climb speed profile cannot achieve an altitude constraint, the UNABLE NEXT ALT CDU help window message displays.

4 Climb Constraints

VNAV enters the VNAV PTH mode to remain within departure or waypoint constraints. Speed maintained during this time can be:

- procedure based speed restriction
- waypoint speed restriction
- default VNAV climb speed
- manually entered climb speed

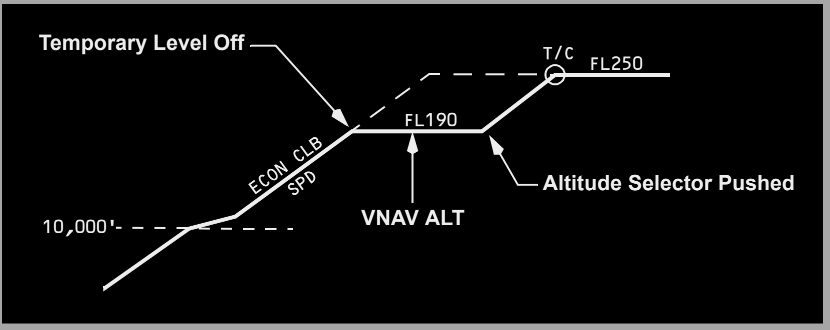
If the FMC predicts the airplane will not reach an altitude constraint, the FMS–CDU help window message UNABLE NEXT ALTITUDE displays. Speed intervention can be used by pushing the IAS/MACH selector and manually setting a lower airspeed to provide a steeper climb; or, climb derates can be deleted on the THRUST LIMIT page.

5 Top Of Climb (T/C)

The point where the climb phase meets the cruise altitude is called the top of climb. Approaching this point, the FMC changes from the climb phase to the cruise phase. The T/C displays any time the FMC calculates a change from a climb phase to a cruise phase, such as a step climb.

The T/C point displays on the map as a green open circle with the label T/C.

MCP Altitude Intervention



ALTITUDE INTERVENTION EXAMPLE

Whenever the airplane levels off at an MCP altitude not in the FMC, VNAV ALT annunciates. For example, FMC cruise altitude is FL250 and the clearance altitude, FL190, is set in the MCP. Pitch maintains altitude and thrust maintains FMC target speed. In the example, the speed after the temporary level off would be ECON CLB SPEED.

Setting the clearance altitude in the MCP window and pushing the altitude selector continues the climb. VNAV SPD activates. Pitch maintains FMC speed and thrust increases to the armed reference thrust limit. In the example, the airplane climbs to FMC CRZ ALT and then levels at FL250 in cruise.

Cruise

During cruise, the FMC commands economy cruise speed or the pilot entered speed until reaching the top–of–descent (T/D) point. Other cruise speed options are:

- long range (LRC)
- engine out (ENG OUT)
- flight crew entered speed
- flight crew entered constant Mach between two or more waypoints
- required time of arrival (RTA)

The FMC commands maximum range cruise speed with the cost index set to zero. Cost index modifications are allowed until passing the top of descent.

Step Climb

Fuel and ETA predictions assume the airplane climbs at each predicted step climb point as airplane weight decreases. FMC predicted step climb increments are based on the step size shown on the CRZ page. Entering a step size of zero causes the FMC to assume a constant altitude cruise.

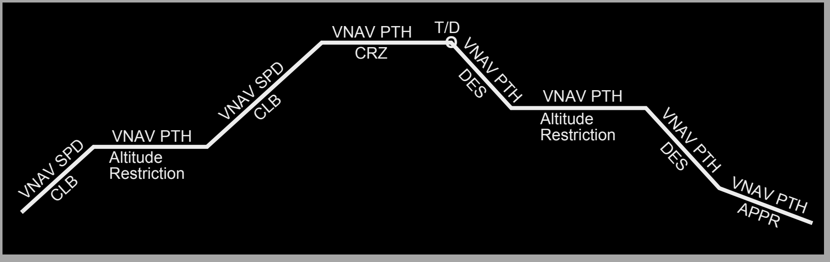
Flight crew entry of a step altitude on the CRZ or RTE LEGS page overrides the FMC step climb predictions for the next predicted step. Once a step climb to that altitude is predicted, the FMC resumes normal step altitude prediction. Entry of a planned step altitude on the RTE LEGS page overrides a “Step To” entry made on the CRZ page.

Predicted step altitudes display on the RTE LEGS page. The distance and ETA to the next step point (predicted or flight crew entered) display on the CRZ and Progress pages. They also display on the ND map display with a green circle and S/C label.

Cruise Descent

Setting an altitude below the current cruise altitude in the MCP altitude window and pushing the altitude selector (more than 50 nm from a T/D) causes the cruise altitude to be set to the MCP altitude and the airplane to descend to the new cruise altitude. The CRZ page displays ACT ECON CRZ DES. If the altitude set in the altitude window is below the speed transition (SPD TRANS) or restriction (SPD RESTR) altitude displayed on the DES page, those altitudes and speeds are deleted. Transition or speed restrictions must be maintained by flight crew action.

MCP Speed Intervention



SPEED INTERVENTION PITCH MODES

With VNAV active, pushing the IAS MACH selector enables speed intervention. Speed intervention allows the flight crew to change airplane speed with the IAS/MACH selector.

The above illustration shows the VNAV pitch flight mode annunciation for each phase of flight when using speed intervention.

In a VNAV descent after the T/D, the pitch mode does not change with speed intervention and remains in VNAV PTH throughout the descent. Pitch controls speed in VNAV SPD mode, and thrust controls speed in VNAV PTH mode.

During a VNAV, non-ILS approach while using speed intervention, the pitch mode is VNAV PTH. The vertical path is maintained regardless of IAS MACH selector changes.

If a “direct to” is executed to a waypoint in the approach, VNAV transitions to the approach phase when the airplane passes the “direct to” waypoint. If a waypoint located after the first waypoint of an FMC database approach is added and executed, VNAV does not transition to approach phase when passing the first waypoint of the approach.

Descent

The FMC calculates a descent path based on airspeed and altitude constraints and the end of descent (E/D) point. Dashes display on the LEGS page for speed and altitude descent waypoints. When an arrival or approach procedure is selected on the ARRIVALS page and incorporated into the flight plan, the FMC creates an E/D. The E/D is located 50 feet above the runway threshold (RW waypoint) for all approaches except VOR approaches. The E/D for VOR approaches is the missed approach point; which may be the VOR, runway waypoint (RWXXX), or a named waypoint. During cruise, an E/D is also created when an altitude constraint is entered on the LEGS page on a downstream waypoint.

The top of descent (T/D) is the point where the cruise phase changes to the descent phase. It displays on the ND as a green circle with the label T/D. The descent path starts at the T/D and includes waypoint altitude constraints. The path to the first constraint is based on:

- speedbrakes retracted
- FMC cruise wind
- applicable target speed
- wind entries on the DESCENT FORECAST page
- predicted use of anti-ice

The descent may be planned at economy Mach/CAS (based on Cost Index) or a manually entered Mach/CAS. VNAV does not command an economy target speed greater than (VMO/MMO minus 16 knots) or a pilot entered speed greater than (VMO/MMO minus 11 knots).

The FMC creates the descent path with a deceleration at the speed transition altitude (typically 250 knots below 10,000 feet). VNAV plans a speed target 10 knots below the transition speed to allow for unknown tailwinds.

Descent path segments after the first altitude constraint waypoint are constructed as straight line point-to-point segments. If the VNAV path segment is too shallow to be flown satisfactorily at IDLE thrust, the FMC commands speed on thrust levers (SPD). Elevators control the shallow descent path.

If flight plan modifications or unknown winds occur when above the first speed constraint, VNAV continues to maintain the path and allows the speed to vary up to the following limits:

- with greater than 15 knots below the target speed, and autothrottles not active, the CDU help window message THRUST REQUIRED displays. The airspeed may decrease to minimum maneuvering speed. Subsequently, VNAV commands the airplane to fly below the path to stop the deceleration. If VNAV can no longer maintain the airplane within 150 feet of the path without further deceleration, speed reversion occurs, the pitch mode annunciation changes from VNAV PTH to VNAV SPD, VNAV resets the target speed to 5 knots above the greater of best holding speed or minimum maneuvering speed, and the CDU help window message THRUST REQUIRED displays again. With autothrottles active, this condition should not occur as throttles are in SPD and target speed is maintained during the descent
- with greater than (VMO/MMO minus 16 knots), the CDU help window message DRAG REQUIRED displays. The airplane may accelerate up to (VMO/MMO minus 11 knots) to maintain the path. If further correction is required, VNAV may allow the airplane to rise up to 150 feet above the path. If VNAV can no longer maintain the airplane within 150 feet of the path without further acceleration, speed reversion occurs, the pitch mode annunciation changes from VNAV PTH to VNAV SPD, VNAV resets the target speed to (VMO/MMO minus 16 knots), and the CDU help window message DRAG REQUIRED displays again. The speed tape displays a VNAV PTH speed band during descent

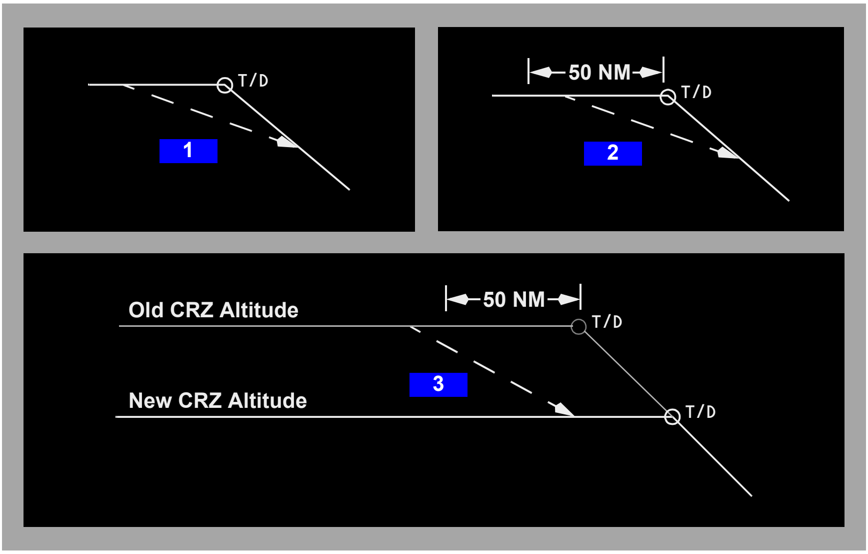
If flight plan modifications or unknown winds occur when below the first speed constraint, VNAV continues to maintain the path and allows the speed to vary up to the following limits:

- with greater than 15 knots below the target speed, and autothrottles not active, the CDU help window message THRUST REQUIRED displays. The airspeed may decrease to minimum maneuvering speed. Subsequently, VNAV commands the airplane to fly below the path to stop the deceleration. If VNAV can no longer maintain the airplane within 150 feet of the path without further deceleration, speed reversion occurs, the pitch mode annunciation changes from VNAV PTH to VNAV SPD, VNAV resets the target speed to 10 knots less than the transition speed for the destination airport (not less than minimum maneuvering speed), and the CDU help window message THRUST REQUIRED displays again.With autothrottles active, this condition should not occur as throttles are in SPD and target speed is maintained during the descent
- with greater than 10 knots above target speed, the CDU help window message DRAG REQUIRED displays. The airplane may accelerate up to 15 knots above target speed to maintain the path. The maximum speed excursion allowed is 5 knots above the transition speed after the airplane is below transition altitude for the destination airport or 5 knots below the flaps placard speed if flaps are extended. If further correction is required, VNAV may allow the airplane to rise up to 150 feet above the path to stop the acceleration. If VNAV can no longer maintain the airplane within 150 feet of the path without further acceleration, speed reversion occurs, the pitch mode annunciation changes from VNAV PTH to VNAV SPD, VNAV commands a speed 10 knots less than the transition speed for the destination airport, and the CDU help message DRAG REQUIRED displays again

Early Descent

When a descent is started before the T/D, VNAV commands a descent at a reduced descent rate until the idle descent path is intercepted.

Start an early descent by selecting the DES NOW prompt on the DES page or by pushing the MCP altitude selector. In an early descent, the autothrottle mode annunciation is initially THR, followed by HOLD, allowing the pilot to adjust the rate of descent. The pitch mode is VNAV SPD.



1 **DES NOW**

Use the DES NOW prompt on the VNAV DES page. VNAV starts an early descent and captures the idle descent path.

2 **Within 50 nm of Top of Descent Point**

Use the MCP altitude selector to start an early descent. Within 50 nm of the top of descent point, VNAV starts an early descent and captures the idle descent path.

3 **More than 50 nm from Top of Descent Point**

Use the MCP altitude selector to start a cruise descent. If the distance from the top of descent is more than 50 nm, VNAV begins a cruise descent to the new cruise altitude. VNAV may not capture the idle descent path since the target airspeed is economy cruise and the descent path is based on idle thrust and economy descent airspeed. In the example, VNAV levels at the new cruise altitude.

Approach

The FMC transitions to "on approach" under the following conditions:

- the airplane is in the descent phase and flaps are out of UP
- a VFR approach has been created and incorporated in the active flight plan and,
  - the airplane has sequenced the FAXXX or
  - the airplane is enroute to a direct-to or intercept-to the RWYYY waypoint and the airplane is within 25 nm of the runway threshold

- a published instrument approach has been selected and incorporated in the active flight plan and,
  - the airplane has sequenced the first waypoint on the published approach or
  - the airplane is enroute to a direct-to or intercept-to waypoint (DIRECT displays at 1L on RTE page) and the airplane is within 12 nm of the runway threshold

The approach condition may be delayed if the flight crew manually inserts, bypasses, or deletes an approach waypoint on the LEGS page

The FMC transitions out of "on approach" under the following conditions:

- the pilot selects TO/GA
- the airplane lands
- the airplane flies beyond the last waypoint in the approach (missed approach waypoint or runway). The VNAV page title changes from "ACT xxxxx DES" to "ACT END OF DES"

When the FMC is “on approach”, the following features are available:

- the IAS/MACH window can be opened and the command speed can be set while VNAV remains in VNAV PTH descent; VNAV commands the set speed
- the MCP altitude can be set above the airplane altitude for the missed approach. When the MCP altitude setting is at least 300 feet above the current airplane altitude, VNAV continues to command a descent
- VNAV remains in VNAV PTH and follows the descent path unless the airplane accelerates to within 5 knots of the current flap placard and the airplane rises more than 150 feet above the path. In this case, VNAV PTH changes to VNAV SPD
- when a glidepath angle is specified for one or more legs on the approach, it displays on the LEGS page and VNAV provides VNAV PTH guidance at the displayed angle. When sequencing a waypoint prior to a descent leg specified by a glidepath angle, VNAV commands level flight until the airplane intercepts the descent path

Note: Display of a specified glidepath angle is not limited to approaches. A glidepath angle may be defined for a leg in a STAR and displays on the LEGS page for the procedure.

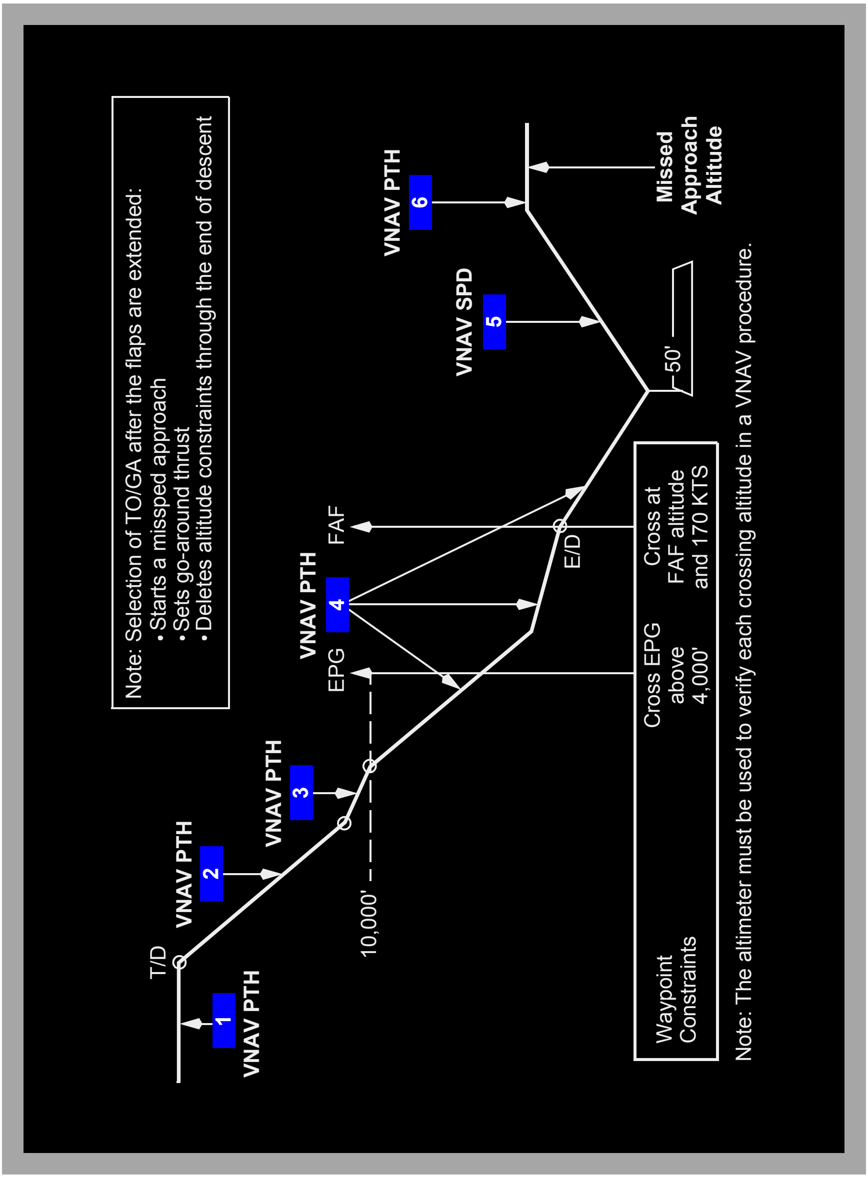
A side step to another approach can be accomplished by selection of the new approach on the ARRIVALS page. An along-course intercept to the next logical approach waypoint in the new approach can be selected on the “INTC CRS TO” line on the LEGS page or by selecting the "XXXXX INTC>" prompt on the ARRIVALS page.

Missed Approach

A missed approach is accomplished by selection of either TOGA switch. The following features are available:

- VNAV (and LNAV) can only be activated when the airplane climbs above 400 feet radio altitude
- all descent altitude constraints below the current airplane altitude are deleted; the waypoints are retained in the active flight plan
- the new cruise altitude becomes the greater of the MCP altitude or the highest altitude in the missed approach procedure
- the FMC transitions from active descent to active climb. This transition also occurs when the airplane climbs toward the MCP altitude and flaps are retracted from a landing position (25 or 30 towards 20, or 20 towards 5). For example, when a missed approach is accomplished without pushing the TO/GA switch
- AFDS guidance to fly the published missed approach procedure to the new cruise altitude is active when VNAV (and LNAV) are selected
- when cruise phase is active, the speed target is the most restrictive of speed transition, best hold speed, or ECON cruise (above speed transition altitude)

Cruise and Descent Profile
(Instrument Approach Using VNAV)



1 Cruise

Before the top of descent, FMC is in cruise mode and commands VNAV PTH and ECON cruise speed.

2 **Descent**

Nearing descent speed, VNAV commands a descent in VNAV PTH at ECON descent speed.

3 **Descent Deceleration Phase**

Before the speed restriction altitude, the FMC commands the target descent airspeed. The pitch mode remains VNAV PTH and the descent rate approximates 500 feet per minute.

4 **Descent and Approach**

When at target speed, VNAV commands a descent and starts approach in VNAV PTH at commanded speed.

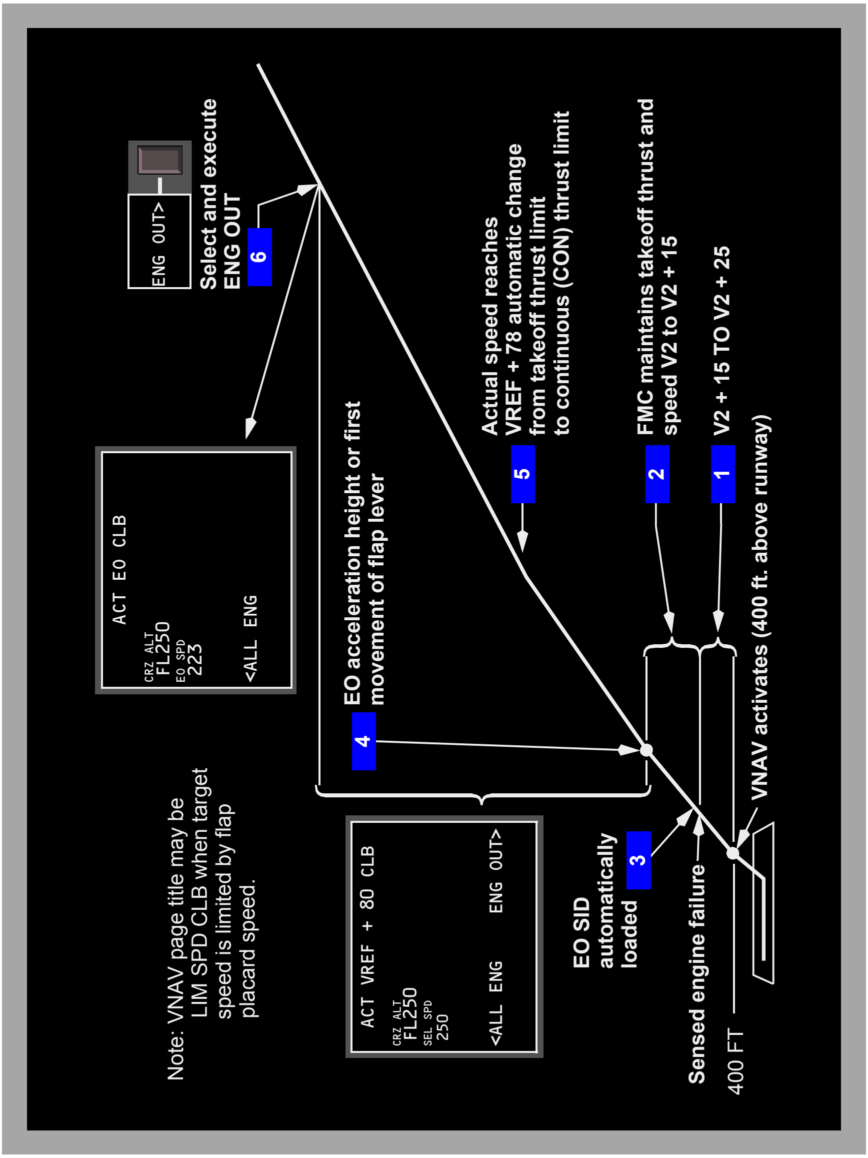
5 **Missed Approach**

When selected during missed approach, VNAV activates in VNAV SPD.

6 **Missed Approach Level Off**

At missed approach altitude, VNAV SPD changes to VNAV PTH.

Takeoff and Climb (Engine Out)



1 Takeoff

Condition: before a sensed engine failure and above VNAV activation altitude.

Result: VNAV SPD commands a climb at V2+15 to V2+25 knots. Autothrottle annunciation is THR REF and the thrust limit is takeoff.

2 **Sensed Engine Failure**

Condition: after VNAV activation, engine failure is sensed, airplane below engine out acceleration height and below the thrust reduction point entered on the TAKEOFF REF page.

Result: VNAV remains in VNAV SPD and commands a speed of V2 to V2 + 15. Autothrottle remains in THR REF and the thrust limit remains takeoff (TO).

3 **EO SID**

Condition: flaps out of UP and an engine out standard instrument departure (EO SID) is in the FMC database.

Result: the FMC loads the EO SID as a flight plan modification. The modification may be either executed or erased.

4 **Acceleration Height**

Condition: at acceleration height or flap retraction has started.

Result: VNAV commands an acceleration to VREF + 80, limited by the airplane configuration (flap placard). Pushing the VNAV function key displays the ACT VREF + 80 CLB page.

5 **Thrust Reduction**

Condition: airplane has accelerated to the commanded VREF + 78 speed.

Result: thrust is automatically reduced from TO to continuous (CON) thrust. If the engine failure occurs above the thrust reduction point, the current climb thrust is maintained.

6 **VNAV Climb (Engine Out)**

Condition: Select the ENG OUT> prompt on the VNAV CLB page to display the applicable engine out performance data. The airline company engine out company speed (CO SPD) or long range cruise (LRC) speed may be selected. Execute to make the data active.

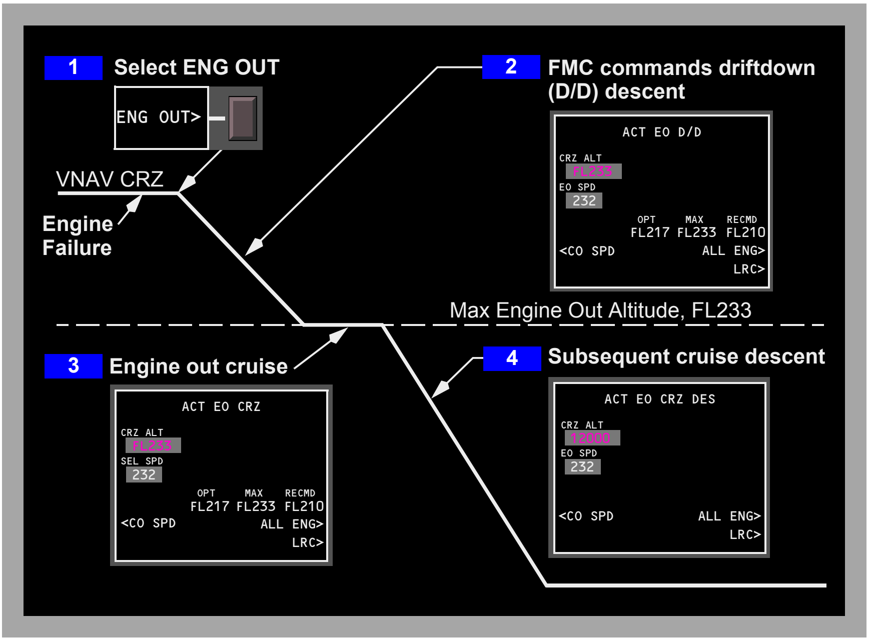
Result: the FMC engine out climb function is active, VNAV is in VNAV SPD, CON thrust is selected, if not previously selected. A different thrust limit may be selected on the THRUST LIM page.

Climb (Engine Out above EO Max Alt)

When the airplane is above the engine out maximum altitude, selection of the ENG OUT> prompt on the VNAV CLB page creates a modification and displays the applicable engine out driftdown (D/D) performance data to enable the airplane to descend to the engine out maximum altitude. Execution of the modification activates the engine out driftdown function.

Cruise (Engine Out Above EO Max Alt)

Selection of ENG OUT> may also be accomplished on the XXXX ALTN page in conjunction with a diversion modification.



1 Engine Out Modification

Condition: Select the ENG OUT> prompt on the VNAV CRZ page.

Result: The FMC creates a modification and displays the applicable engine out driftdown (D/D) performance data to enable the airplane to descend to the engine out maximum altitude.

2 Drift Down Execution

Condition 1: Set the MCP altitude at or below EO MAX altitude and execute the FMC modification. This condition assumes clearance is approved to descend slowly to a non–standard altitude; for example, FL233.

Result: The reference thrust limit becomes CON, VNAV commands a very shallow descent in VNAV SPD as the airplane decelerates to EO SPD, the EO MAX altitude becomes the cruise altitude at 1L, and the autothrottle sets CON thrust on the operative engine. Time and distance for the D/D to EO MAX altitude display at 2R.

Two other ways to activate the EO D/D (to the clearance altitude) are discussed below.

Condition 2: Execute the ENG OUT modification. Then, set the clearance altitude (lower than EO MAX) in the MCP and push the MCP altitude selector.

Result: The airplane remains at the MCP altitude until the altitude is set lower and the MCP altitude selector is pushed, the pitch mode initially changes to VNAV ALT, the reference thrust limit becomes CON, and the autothrottle adjusts thrust on the operative engine to maintain FMC-commanded EO SPD. After setting the MCP altitude window and pushing the altitude selector, the operative engine increases thrust to CON and the airplane descends in a VNAV SPD driftdown to the clearance altitude in 1L. Initial descent rate is low, depending on the gross weight and on how much the airspeed has decreased before pushing the altitude selector. If the airspeed has decreased below EO SPD, the descent rate increases to regain the airspeed.

Condition 3: Set the clearance altitude (lower than EO MAX) in the MCP, push the altitude selector; then, after the descent is established, execute the FMC modification (ENG OUT selection).

Result: After pushing the altitude selector, the airplane descends in a normal VNAV SPD cruise descent at two–engine cruise speed. The reference thrust limit is CLB/CRZ and the autothrottle maintains cruise descent airspeed. The cruise altitude is set to the MCP altitude when the altitude selector is pushed. Executing the FMC modification while above EO MAX altitude sets the driftdown descent airspeed to EO SPD. The reference thrust limit becomes CON and the autothrottle increases thrust to CON on the operative engine. The airplane initially descends at economy cruise airspeed and approximately 1,250 fpm. After executing the ENG OUT modification, the commanded airspeed is EO SPD. The rate of descent decreases to a minimum of 300 fpm.

3 Engine Out Cruise

When VNAV captures the EO MAX altitude (Condition 1 only), the VNAV cruise page title becomes EO CRZ and the pitch annunciation is VNAV PTH, regardless of the MCP altitude window setting. Predictions for EO Step Climb display at 2R. Thrust limit remains in CON.

4 Subsequent Cruise Descent

Condition: FMC in engine out mode, more than 50 nm from T/D, set a lower MCP altitude, push the altitude selector.

Result: VNAV cruise descent at approximately 1,250 fpm at EO SPD. When the EO cruise descent intersects the planned descent profile, descent mode becomes active.

Required Time of Arrival (RTA)

VNAV controls cruise speed to arrive at a specified waypoint within ± 6 seconds of a specified time. If the RTA is not achievable, the EICAS message FMC UNABLE RTA is displayed.

Data Entry Rules

Altitude Entry

Altitudes can be entered into the FMC as three digit (XXX), four digit (XXXX), five digit (XXXXX), or flight level (FLXXX) numbers. The FMC displays altitude or flight level entries in the proper form based on the transition altitude. Some data lines further restrict the valid entry forms.

Three digit entries represent altitude or flight levels in increments of 100 feet. Leading zeros are required.

Examples of three digit (XXX, FLXXX) entries with transition altitude = 10,000 feet:

- 800 feet is entered as 008 or FL008; displays as 800
- 1,500 feet is entered as 015 or FL015; displays as 1500
- 11,500 feet is entered as 115 or FL115; displays as FL115
- 25,000 feet is entered as 250 or FL250; displays as FL250

Four digit entries represent feet, rounded to the nearest ten feet. Leading zeros are required. This form is used when the altitude does not exceed 9,994 feet.

Examples of four digit (XXXX) entries with transition altitude = 18,000 feet:

- 50 feet is entered as 0050; displays as 50
- 835 feet is entered as 0835; displays as 840
- 1,500 feet is entered as 1500; displays as 1500
- 8,500 feet is entered as 8500; displays as 8500
- 9,994 feet is entered as 9994; displays as 9990

Five digit entries represent feet, rounded to the nearest ten feet. This form is used when the altitude exceeds 9,994 feet.

Examples of five (XXXXX) digit entries with transition altitude = 4,000 feet:

- 50 feet is entered as 00050; displays as 50
- 835 feet is entered as 00835; displays as 840
- 1,500 feet is entered as 01500; displays as 1500
- 8,500 feet is entered as 08500; displays as FL085
- 9,995 feet is entered as 09995; displays as FL100
- 11,500 feet is entered as 11500; displays as FL115
- 25,000 feet is entered as 25000; displays as FL250

Negative altitude entries are allowed to -1000 feet.

Airspeed Entry

Airspeeds can be entered into the FMC as calibrated airspeed, CAS, or Mach number, M. Calibrated airspeeds are entered as three digits (XXX) in knots. Mach numbers are entered as one, two, or three digits following a decimal point.

Data Pairs

Many CDU pages display data in pairs separated by a slash "/." Examples of these pairs include wind direction/speed and waypoint airspeed/altitude constraints. When entering both values in a pair, the slash is inserted between the values. When it is possible to enter only one value of the pair, the slash may not be required. When entering only the outboard value of a pair, the trailing or leading slash may be entered, but is not required before transferring to the data line. When entering the inboard value of a pair, the trailing or leading slash must be entered before transferring to the data line. Omission of the required slash normally results in an INVALID ENTRY message.

Intentionally
Blank

FMC Databases

The FMC contains three databases:

- performance
- navigation
- airline modifiable information (AMI)

The performance database supplies performance data to the flight crew. It supplies the FMC with data to calculate pitch and thrust commands. All pertinent data can be displayed on the CDU. The database includes:

- airplane drag and engine characteristics
- maximum and optimum altitudes
- maximum and minimum speeds

The navigation database includes most data found on navigation charts. This data can be displayed on the CDU or ND. The database contains:

- location of VHF navigation aids
- airports
- runways
- other airline selected data, such as SIDs, STARs, approaches, and company routes
- transition altitudes

The FMC contains two sets of navigation data, each valid for 28 days. Each set corresponds to the usual navigation chart revision cycle. The FMC uses the active data for navigation calculations. The contents of the navigation database are periodically updated and transferred to the FMC before the expiration date of the active data.

The AMI file contains airline specified data. If the FMC senses a conflict in an AMI value after a new AMI data load, the CDU help window message CHECK AIRLINE POLICY is displayed.

Thrust Management

The thrust management function operates the autothrottle in response to flight crew mode control panel inputs or to FMC commands. Reference thrust limits can be selected on the THRUST LIM page. FMC autothrottle commands are made while VNAV is engaged. Thrust management:

- calculates reference thrust limits and thrust settings, or follows FMC thrust settings
- commands thrust levers

- senses and transmits autothrottle failures
- commands thrust equalization through the engine electronic controls

[Option – RR engines]
Thrust limits are expressed as TPR limits. Thrust equalization references TPR.
[Option – GE engines]
Thrust limits are expressed as N1 limits. Thrust equalization references N1.

Thrust management calculates a reference thrust for the following thrust settings:

- TO – takeoff
- TO 1 – takeoff one
- TO 2 – takeoff two
- D–TO – assumed temperature takeoff
- D–TO 1 – derate one assumed temperature takeoff
- D–TO 2 – derate two assumed temperature takeoff
- CLB – climb
- CLB 1 – climb one
- CLB 2 – climb two
- CON – continuous
- G/A – go–around

[Option – RR engines]
With VNAV active, the reference thrust limit changes for the phase of flight. Thrust settings can be selected on the THRUST LIM page. The reference thrust limit displays above EICAS TPR indications.
[Option – GE engines]
With VNAV active, the reference thrust limit changes for the phase of flight. Thrust settings can be selected on the THRUST LIM page. The reference thrust limit displays above EICAS N1 indications.

The flight crew can specify the thrust reduction height where the change from takeoff to climb thrust takes place by making an entry on the CDU TAKEOFF REF page. This can be an altitude from 400 feet to 9,999 feet, an entry of 1 for flaps 1, or an entry of 5 for flaps 5.

Reduced Thrust Takeoff

Reduced thrust takeoffs lower EGT and extend engine life.

Derate/Variable Takeoff Rating

[Option – Takeoff thrust derate]

Two fixed derates can be selected on the THRUST LIM page. TO 1 and TO 2 reduce takeoff thrust by percentages specified by the operator on the AIRLINE POLICY page. The derate percentages can be set between maximum takeoff thrust and the maximum certified derate in one percent increments. The Airplane Flight Manual (AFM) provides performance data for these derates.

With both TO 1 and TO 2, the thrust setting parameter is considered a limitation for takeoff; therefore, thrust levers should not be advanced further except in an emergency. A further thrust increase following an engine failure could result in a loss of directional control. Use the takeoff speeds calculated by the EFB for the selected derate or variable takeoff rating condition.

Derate/variable takeoff rating can be further reduced by assumed temperature.

Assumed Temperature Thrust Reduction Takeoff

Entering an assumed temperature higher than the actual temperature reduces takeoff thrust.

The maximum thrust reduction authorized is 25 percent below any certified rating. Do not use assumed temperature reduced thrust if conditions exist that affect braking, such as slush, snow, or ice on the runway, or if potential windshear conditions exist.

The assumed temperature thrust setting is not considered a limitation. The assumed temperature reduction can be removed. If conditions are encountered where more thrust is necessary, the crew can manually apply full thrust.

Derated Thrust Climb

[Option – Thrust climb derate]

During climb, CLB 1 and CLB 2 derates are gradually removed. In cruise, the thrust reference defaults to CRZ. The reference can be manually selected on the THRUST LIM page.

Two fixed climb thrust derates (CLB 1 and CLB 2) can be selected on the THRUST LIM page. The percentage of derate is configured by each individual airline in their AMI file. The derated climb thrust is maintained until reaching a predetermined altitude where the thrust then increases linearly with altitude to achieve CLB thrust at the washout altitude. The washout altitude is configured in the AMI file.

Use of an assumed temperature reduced thrust takeoff or takeoff derate affects automatic selection of climb derate. For a thrust reduction less than 10 percent, maximum climb thrust is automatically selected by the FMC. For takeoff thrust reductions or derates from 10 percent to less than 20 percent, CLB 1 is selected. CLB 2 is selected for all takeoff thrust reductions or derates equal to or greater than 20 percent. On the ground, the pilots may override the automatic climb derate selection after the takeoff selection is complete.

Use of derated climb thrust reduces engine maintenance costs, but increases total trip fuel.

Fuel Monitoring

The FMC receives fuel data from the fuel quantity system or from manual entries. Fuel quantity values display on the PERF INIT page as calculated (CALC), MANUAL, or SENSED. They display on PROGRESS page 2/4 as TOTALIZER and CALCULATED. TOTALIZER and SENSED values are the same data with different names.

The FMC usually uses the calculated value for performance computations. Before engine start, the calculated value is set to agree with the fuel quantity indicating system value. When the FMC receives a positive fuel flow signal at engine start, the calculated value is independent of the fuel quantity system and decreases at the fuel flow rate.

When the APU is running, the APU fuel burn schedule is also used to decrement the calculated fuel value.

During fuel jettison, the calculated value is set equal to the fuel quantity system value. When fuel jettison is completed, the calculated value is independent of the fuel quantity indicating system and decreases at the fuel flow rate. This fuel quantity value displays as CALC (calculated) on the PERF INIT page and CALCULATED on PROGRESS page 2/4.

If the flight crew inputs a fuel quantity, the line title changes to MANUAL and replaces the calculated value. Like the calculated value, the manual value is updated by fuel flow rate.

The calculated value is invalid if fuel flow data is invalid. The FMC uses the fuel quantity indicating system quantity for performance computations. The line title on the PERF INIT page changes to SENSED and displays as TOTALIZER on PROGRESS page 2/4.

The fuel used by each engine is calculated with its related fuel flow signal. FUEL USED displays on PROGRESS page 2/4. FUEL USED values are retained through flight completion and are subsequently cleared at engine start or following a long-term power interrupt on the ground. If the fuel flow signal is invalid while on the ground or invalid for greater than two minutes after airborne, the display blanks.

The EICAS advisory message FUEL DISAGREE is displayed if the FMC calculates a large difference between the fuel quantity indicating system quantity and calculated value. The flight crew should select PROGRESS page 2/4, and select the fuel value for the FMC to use through landing.

The FMC continually estimates the fuel at the destination airport if the active route is flown. The CDU help window message INSUFFICIENT FUEL displays if the estimate is less than the fuel reserve value entered on the PERF INIT page and a MOD is pending. If no MOD is pending the EICAS advisory message INSUFFICIENT FUEL is displayed instead.

Note: FMC calculated fuel predictions assume a clean configuration. Flight with gear or flaps extended cause fuel prediction errors. Fuel predictions are accurate after the gear and flaps are retracted.

If the actual fuel temperature reaches the minimum value displayed on the PERF INIT page, the EICAS advisory message FUEL TEMP LOW displays.

Loss of FMC Electrical Power

The FMC must have continuous electrical power to operate. When the electrical power is interrupted and returns, the FMC restarts.

After restart, the performance data displayed on the PERF INIT page must be re–entered. The route previously in use is available but must be reactivated.

The flight crew must modify the active waypoint to activate LNAV. Selecting the applicable active waypoint and proceeding direct or intercepting a course to the waypoint allows LNAV activation.

FMC Failure

Single FMC Failure

At powerup, the three FMCs are designated as master, spare and backup. All Flight Management computing tasks are accomplished by the master (active) FMC. The spare (standby) FMC automatically becomes active and assumes all FMC functionality in the event the master FMC fails. The backup FMC then assumes the role of the spare FMC. This transition occurs automatically and is not apparent to the crew. No crew action is necessary. LNAV and VNAV, if active, remain active and all flight plan and performance data is retained.

Dual FMC Failure

If two FMCs fail in flight, the third FMC automatically takes over in a single FMC configuration. The EICAS advisory message SINGLE FMC is displayed. All data is retained, NDs continue to operate, but LNAV and VNAV is disengaged. The flight crew needs to reactivate and execute the flight plan, and reselect LNAV and VNAV.

A software reset may occur while in single FMC operation. This is a self-protection mode which prevents permanent loss of the FMC in the unlikely event the FMC is presented with an insoluble computation. Resets are accompanied by the appropriate CDU help window message. Symptoms of a reset may include the active route becoming inactive, performance data being erased, and LNAV and VNAV disengaging. To regain FMC operation, activate and execute the flight plan, enter the necessary performance data, and engage LNAV and VNAV.

Triple FMC Failure

In the unlikely event all FMCs become inoperative, the EICAS advisory message FMC is displayed. There is a loss of ND map displays, loss of the CDU page on the MFD and no LNAV or VNAV operation or guidance. The TCPs provide the capability to enter a single Latitude/Longitude position (waypoint). The TCPs then provide track, distance to go, and groundspeed to the entered waypoint. The ability to tune the left Landing System is provided through the left TCP. Information entered into the left Landing System is displayed on the ISFD.

Autothrottles should still be available and may be used in conjunction with any valid autopilot roll and/or pitch mode.

Refer to Chapter 11, Section 50, Alternate Navigation System Description, for additional information.

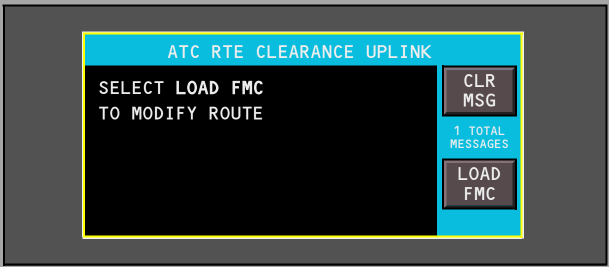
Intentionally
Blank

Air Traffic Control Datalink

Most Air Traffic Control datalink functions are accomplished on the MFD. The multifunction keypad is used as an input device for downlink message forms.

Arriving ATC uplink messages are annunciated to the crew by the appearance of the communications alert message "dot ATC" on the EICAS display, the ATC uplink information on the ATC data block, and a Hi-Lo alerting chime. Following alerting, the crew may view the message on the ATC data block and then select the COMM display on the MFD. The ATC message displayed on the ATC data block is repeated on the COMM display. A variety of clearance information may be uplinked from ATC, including tactical clearances such as headings, altitudes and speeds, as well as route clearance data.

In the ATC data block message, the words ACCEPT and REJECT are displayed to indicate that the crew must either accept or reject the clearance. The ACCEPT or REJECT switches on the glare shield or the soft keys on the COMM display can be used to complete this action. When a clearance is of a type that can be loaded into the FMC, LOAD FMC buttons appear on both the COMM display and the CDU help window. The crew may accomplish the FMC loading or accept/reject actions in either order. However, loading the FMC first provides the opportunity to view the clearance on the ND map display as a flight plan modification prior to acceptance. Selection of either LOAD FMC prompt causes the clearance to be loaded into the FMC and displayed on the CDU as a flight plan modification. The message ROUTE X UPLINK LOADING is displayed in the CDU help window and on the COMM display during loading.



CDU HELP WINDOW

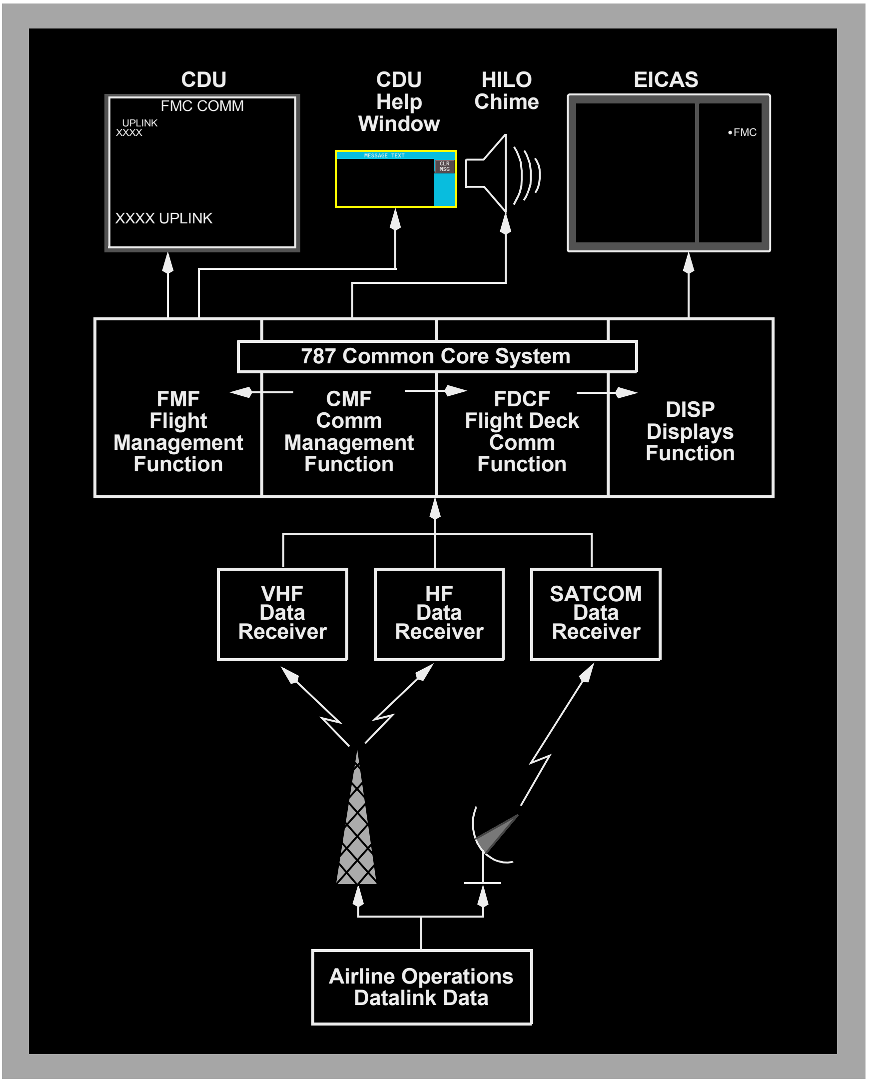
The modification may be subsequently executed or erased as with any flight plan modification. If an FMC modification was previously pending, the new ATC modification cannot be loaded into the FMC and the LOAD FMC prompts display in Cyan to indicate that they cannot be selected at the moment. Once the FMC is clear of all modifications, the LOAD FMC prompt is displayed in shaded white and completion of the FMC loading may be accomplished.

Refer to ATC Datalink in Chapter 5, Section 40, for additional information.

Company Datalink

The airplane communications system enables two–way datalink communications between the FMC and airline operations. A downlink occurs when data is transferred from the FMC and transmitted through the airplane communications system to a receiver on the ground. Data may be downlinked from the FMC either manually or automatically. An uplink is the opposite of a downlink; data is transmitted from a ground station for input to the FMC. Data may be uplinked at the discretion of the airline operations dispatcher or in response to a downlink request.

[Option – VHF / HF / SATCOM datalink]



Datalink

Downlinks are datalink messages transmitted to a ground station. Requests for data and reports of FMC data are two types of downlinks. Requests are made manually by the flight crew. Reports can be made manually or may occur automatically.

Uplinks are messages transmitted to the airplane. Most uplinks require manual selections by the flight crew. Some uplinks are input automatically.

Manual Downlinks

Select a REQUEST prompt to start the downlink request for data. REQUEST prompts (as configured by the airline) may be displayed on the PERF INIT, TAKEOFF REF 1/2, DESCENT FORECAST, RTE, ALTN, ALTN LIST or RTE DATA pages. Downlink reports of the active route may be accomplished by selection of the REPORT prompt on the RTE page and a position report may be downlinked by selection of the REPORT prompt on the POS REPORT page.

When the communications function is unable to prepare FMC downlinks, the words FAIL, NO COMM, or VOICE display on the CDU pages in place of the REQUEST and REPORT prompts. The datalink status also displays on the FMC COMM page. Radios supporting datalink operations can be reconfigured by the crew through the MFD COMM function.

Refer to Command Key Functions, Chapter 5, Section 40, for additional information.

The status messages are:

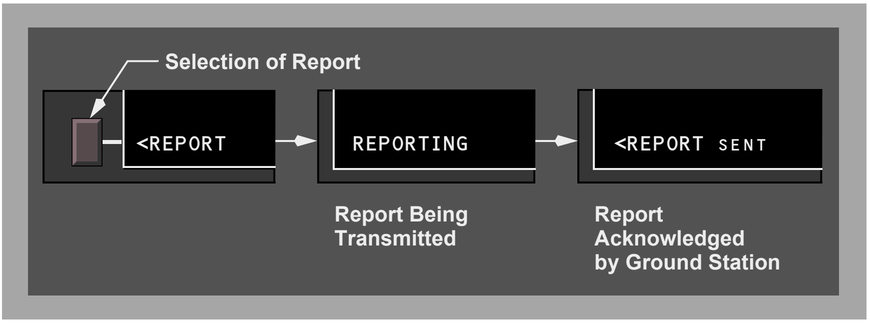
- FAIL –
  - the data communications management function is inoperative, or
  - the data radios have failed
- NO COMM –
  - the data radios are operational but, not available
- VOICE – all available radios are operating in the VOICE mode

Reports

A REPORT prompt on each page downlinks a unique report applicable to that page. The pages below contain report prompts.

Report Status

Below is a typical sequence of status in response to sending a report.



Automatic Downlinks

The FMC can be configured by the airline to automatically transmit downlinks of FMC data at predetermined points during the flight or in response to specific data requests from the airline dispatcher. The FMC response in these cases is completely automatic and no flight crew action is necessary.

Uplinks

Uplinked data may be loaded automatically or may require flight crew action. Two uplinks automatically load data into the FMC and do not require execution. Uplinked data that waits in system memory for flight crew action are considered to be pending.

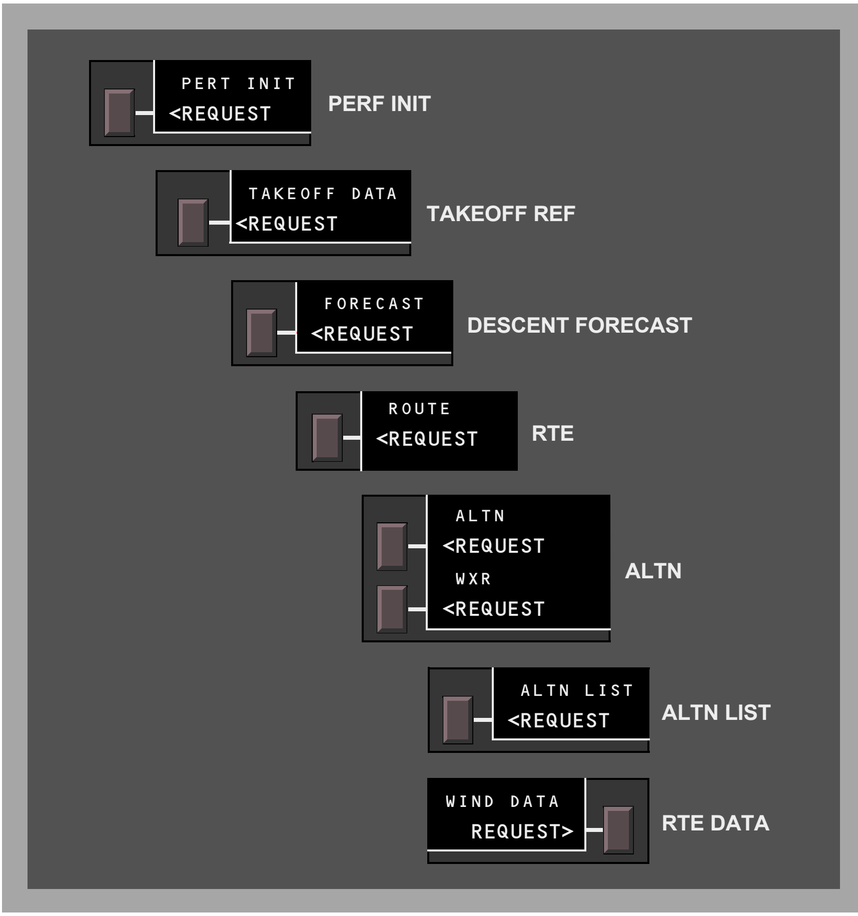
A pending uplink is included or discarded when the flight crew selects the applicable prompt. Flight crew response to an uplink depends on the type of uplink. Flight crew action is made with ACCEPT/REJECT or LOAD/PURGE prompts, FMC modification ERASE prompt or EXEC key, or when the page with the uplink is selected. Glareshield–mounted accept and reject switches operate the same as MFD ACCEPT/REJECT prompts.

Data can be uplinked from the airline dispatcher directly to the PERF INIT, TAKEOFF REF 1/2 and 2/2, DESCENT FORECAST, RTE, ALTN, ALTN LIST, and WIND pages. The uplinks are annunciated to the crew by the •FMC EICAS communications alert and a hi–lo chime. The uplink is identified by a CDU help window message and by the presence of an UPLINK label over the applicable COMM page prompt.

If there is no active route, wind uplinks are not annunciated, and the <WIND prompt on the COMM page is not shown.

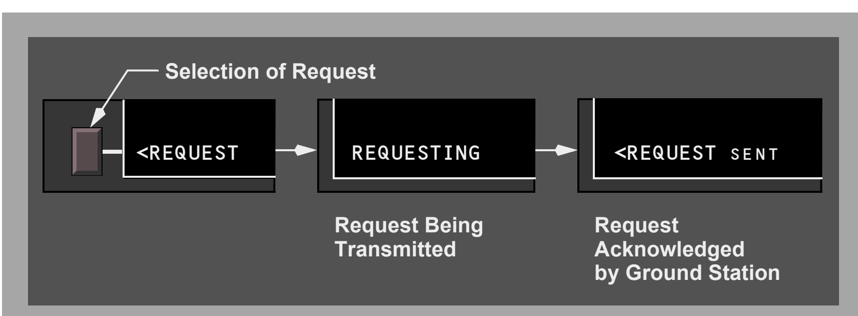
Requests

A REQUEST prompt on each page downlinks a unique request applicable to that page. The pages below (as configured by the airline) may contain request prompts.



Request Status

Below is a typical sequence of status in response to sending a request.



FMC Datalink Uplinks (Accept/Reject)

ACCEPT and REJECT display on the PERF INIT, TAKEOFF 1/2 and ALTN 1/2 pages after receipt of uplink data.

Uplink data displays initially in small font for preview.

Select ACCEPT prompt:

- displays uplinked data in large font
- replaces previous data with uplinked data
- changes page to pre–uplink format
- clears CDU help window message
- transmits a downlink accept message (if enabled)

Select REJECT prompt:

- replaces uplinked data with previous data
- changes page to pre–uplink format
- clears CDU help window message
- transmits a downlink reject message (if enabled)

FMC Datalink Uplinks (Load/Purge)

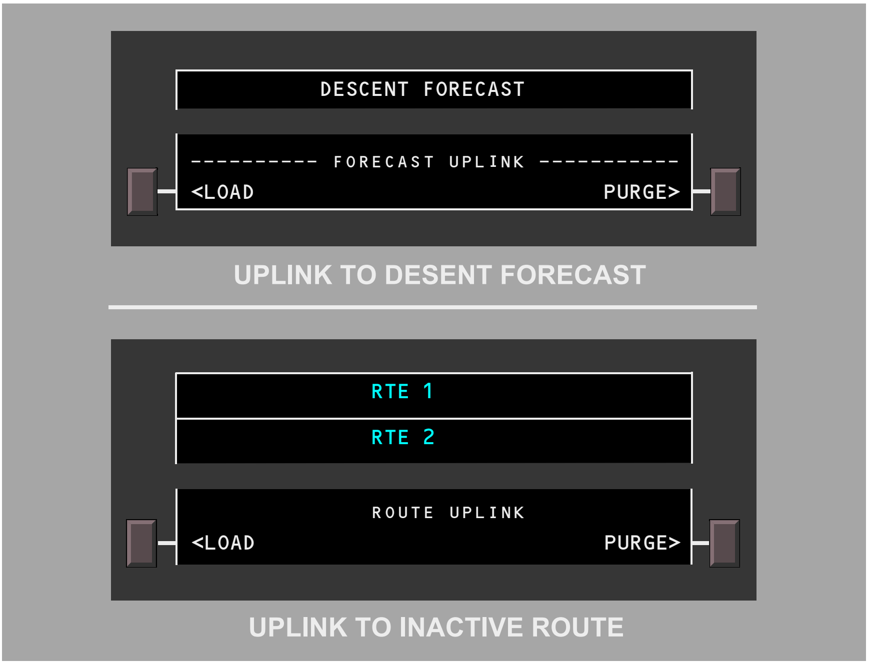
LOAD and PURGE display on the DESCENT FORECAST page after receipt of uplink data. LOAD and PURGE display on the active RTE 1 or RTE 2 page when there is an uplink to the inactive route.

Select LOAD prompt:

- loads uplinked data into FMC for viewing
- clears CDU help window message
- replaces previous data with uplinked data
- changes page to pre–uplink format
- transmits a downlink accept message (if enabled)

Select PURGE prompt:

- replaces uplinked data with previous data
- changes page to pre–uplink format
- clears CDU help window message
- transmits a downlink reject message (if enabled)



FMC Datalink Uplinks (Load/Exec–Erase)

LOAD displays on the RTE and WIND pages after receipt of uplink data.

After the uplinked data is loaded, the EXEC light illuminates and the ERASE prompt displays.

Select LOAD prompt:

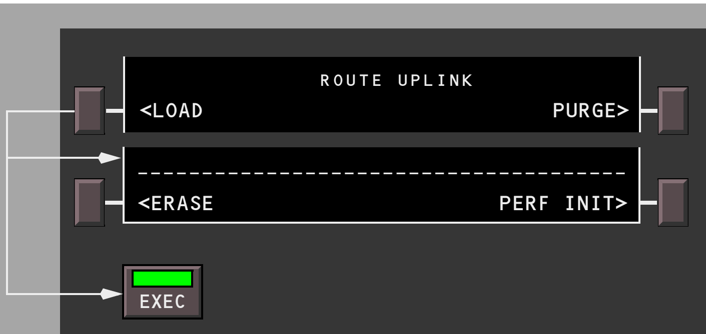
- loads uplinked data into FMC
- loaded data can be viewed
- clears CDU help window message
- replaces existing data with modified uplinked data
- changes page title to MOD
- shows ERASE prompt
- illuminates EXEC light

Push the EXEC key to:

- put modified data in active flight plan
- change page format to pre–uplink format
- transmit a downlink accept message (if enabled)

Select ERASE prompt to:

- remove modified data
- return page display to pre–uplink format
- transmit a downlink reject message (if enabled)



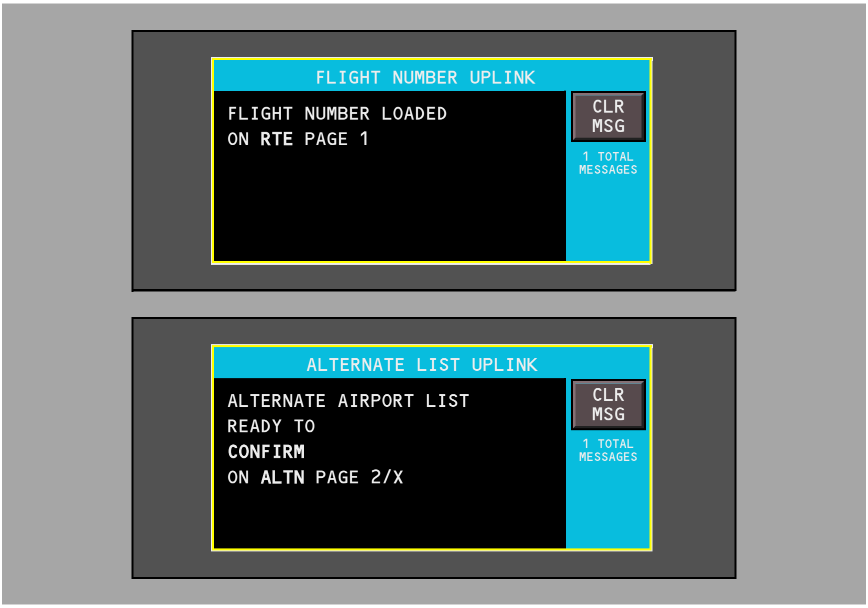
ROUTE MODIFICATION UPLINK EXAMPLE

WIND UPLINK EXAMPLE

FMC Datalink Uplinks (Automatic)

FLT NO and ALTN LIST data can be automatically uplinked and loaded. FLT NO automatically loads into the RTE 1/x page without flight crew action. The list of 20 alternates automatically loads into the ALTN LIST page without flight crew action.

The CDU help window messages FLIGHT NUMBER UPLINK or ALTERNATE LIST UPLINK stay in the CDU help window until the applicable CDU page is selected.

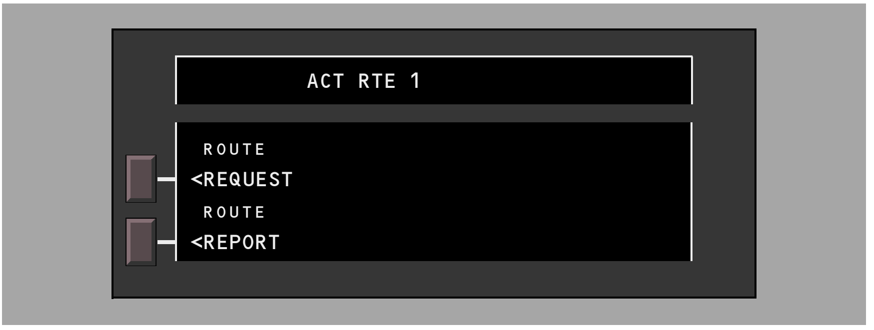


Datalink Management

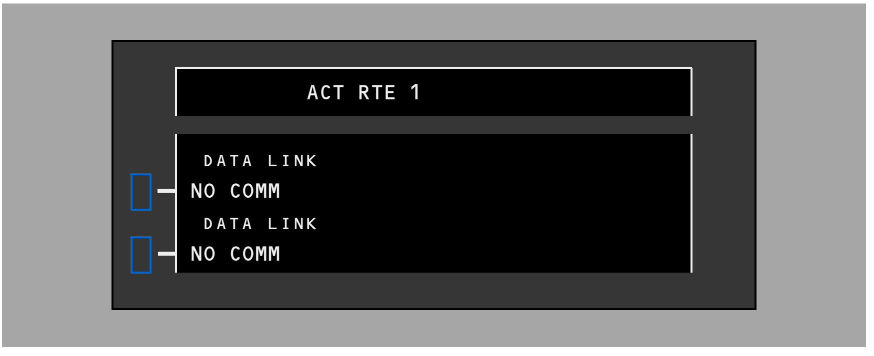
The flight crew should monitor system status of FMC datalink. This is accomplished on various CDU pages or on the FMC COMM page. Changes to datalink system operating modes are accomplished with the COMM function on the display select panel or multifunction keypad.

CDU Datalink Status Displays

Datalink operation is verified when the correct line title is above the related prompt. In the example below, the line title ROUTE is above the REQUEST and REPORT prompts on the RTE page.

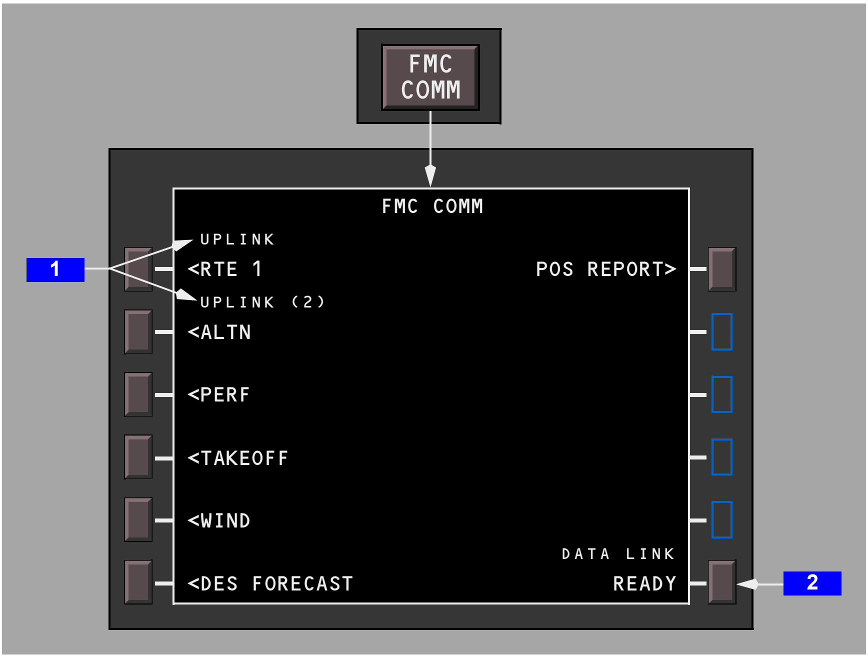


When the datalink system is not operating, CDU page prompts change to NO COMM and the line titles change to DATA LINK.



FMC Communications Page

General datalink status displays on the FMC COMM page. Page select prompts display for each FMC page with access to datalink data.



1 **Uplink Status**

The page line heading displays UPLINK when an uplink message is pending and all preprocessing is complete. Preprocessing of uplinks ensures necessary data is available for display when the uplink message is selected. Examples of preprocessing include:

- RTE ALTN, ALTN LIST, PERF, TAKEOFF and WIND uplinks are held until route activation or modifications are complete
- subsequent uplinks of the same type are held until previous uplinks are included or discarded by the flight crew

When both ALTN and ALTN LIST uplinks are pending, (2) displays to the right of UPLINK in the line heading.

The EICAS message •FMC displays whenever any UPLINK message is pending.

2 **DATA LINK**

Displays the datalink system status.

System status can be:

- READY
- NO COMM
- VOICE
- FAIL

Page Select Prompts

Selection of any of these prompts displays the related page:

- RTE X
- ALTN
- PERF
- TAKEOFF
- WIND
- DES FORECAST
- POS REPORT

Introduction

Completion of the FMC preflight requires data entry in all minimum required data locations. Entry of all required and optional preflight data optimizes FMC accuracy.

Datalink can load preflight data from airline ground stations. Using datalink reduces the number of required flight crew actions. Manual flight crew entries replace existing data.

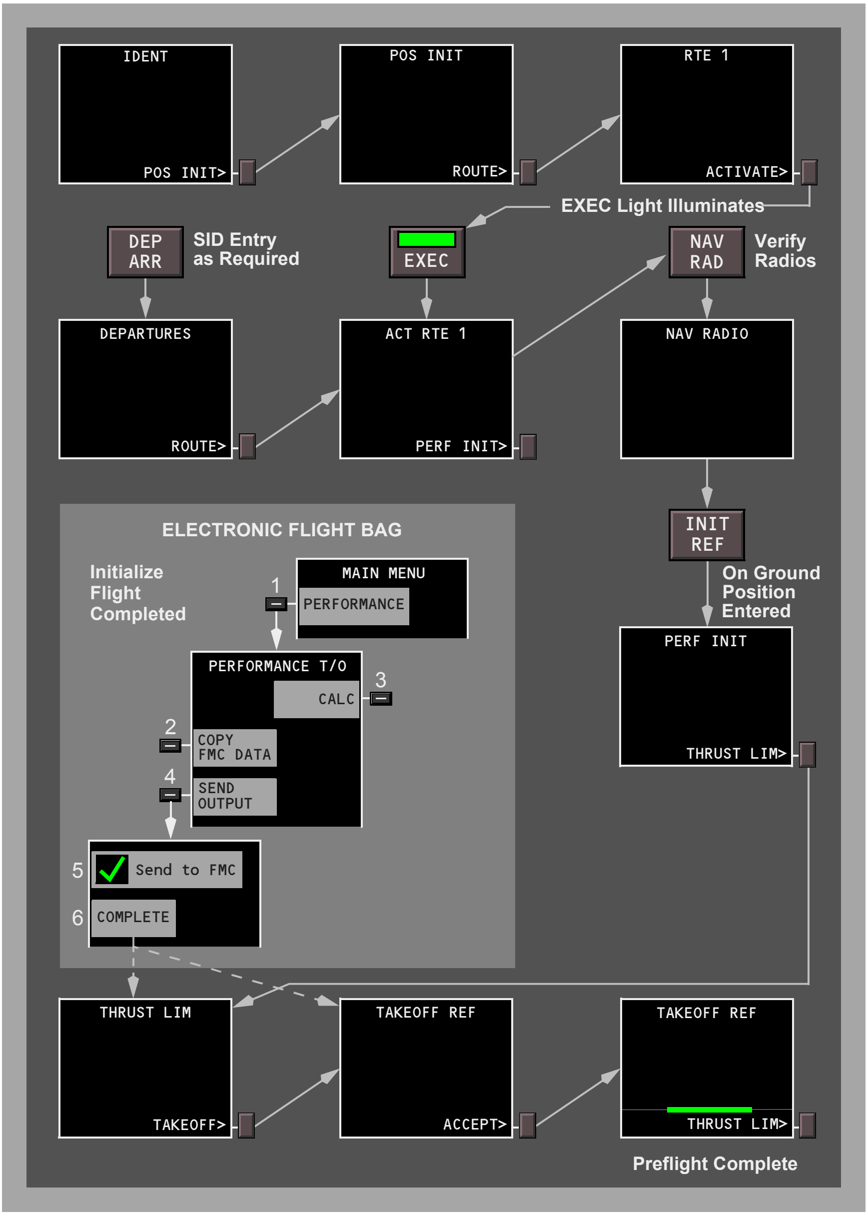
Preflight Page Sequence

The identification page usually displays when power is applied to the FMC. Preflight flow continues in this sequence:

- identification (IDENT) page
- position initialization (POS INIT) page
- route (RTE) page
- DEPARTURES page (no prompt)
- navigation radios (NAV RAD) page (no prompt)
- performance initialization (PERF INIT) page
- EFB PERFORMANCE T/O application (no prompt)
- thrust limit (THRUST LIM) page
- takeoff reference (TAKEOFF REF) page

Some of these pages are also used in flight.

Minimum Preflight Sequence



During preflight, a prompt in the lower right directs the flight crew through the minimum requirements for preflight completion. Selecting the prompt key displays the next page in the flow. If a required entry is missed, a prompt on the TAKEOFF page leads the flight crew to the preflight page missing data.

Airplane GPS position is necessary for FMC preflight and flight instrument operation. Entry of inertial position is optional as the IRS has continuous access to GPS position.

A route must be entered and activated. The minimum route data is origin and destination airports, and a route leg.

Performance data requires entry of airplane weights, fuel reserves, cost index, and cruise altitude.

Takeoff data requires a flap setting and center of gravity.

Supplementary Pages

Supplementary pages are sometimes required. These pages have no prompts and interrupt the usual sequence. Discussions of each page includes methods to display the page.

When the route includes SIDs and STARs, they can be entered using the DEPARTURES or ARRIVALS pages.

Route discontinuities are removed and the route is modified on the ROUTE and RTE LEGS pages. Speed/altitude restrictions are entered and removed on the RTE LEGS page. The RTE LEGS page is described in the FMC Cruise section of this chapter.

Alternate airports are added on the ALTN page. The ALTN page is described in the FMC Descent/Approach section of this chapter.

Waypoints, navigation, airport, and runway data is referenced on the REF NAV DATA page. The REF NAV DATA page is described in the FMC Cruise section of this chapter.

Fixed takeoff thrust derates can be changed on the AIRLINE POLICY page.

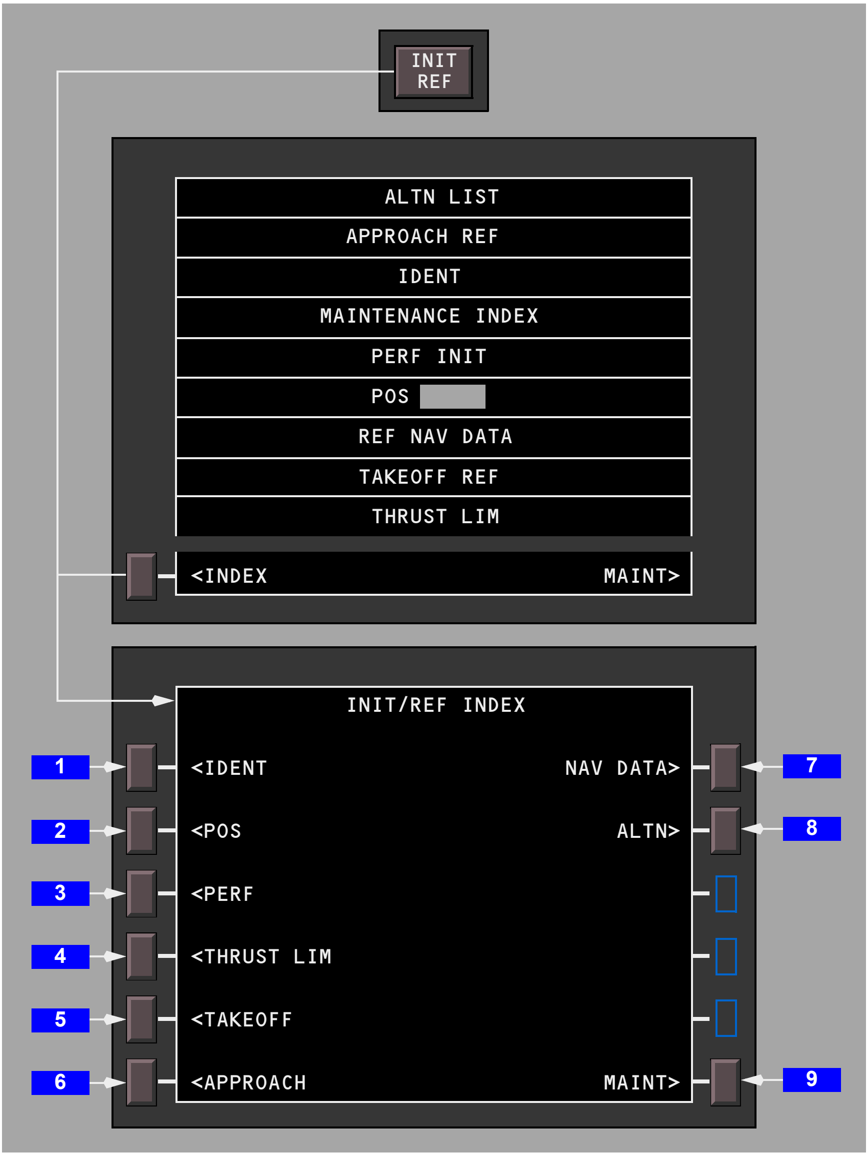
VNAV performance is improved if forecast winds and temperatures are entered during the preflight. Wind and temperature data for specific waypoints is entered on the WIND page. The WIND page is described in the FMC Cruise section of this chapter.

Preflight Pages – Part 1

The preflight pages are presented in the sequence used during a typical preflight.

Initialization/Reference Index Page

The initialization/reference index page allows manual selection of FMC pages. It gives access to pages used during preflight and not usually used in flight.



1 **Identification (IDENT)**

The IDENT page is used to verify basic airplane data and currency of the navigation database.

2 **Position (POS)**

The POS INIT page is used for IRS initialization.

The POS INIT page is also used for initialization of ADRS heading in the event the ADRS fails.

3 **Performance (PERF)**

The PERF INIT page is used for initialization of data required for VNAV operations and performance predictions.

4 **Thrust Limit (THRUST LIM)**

The THRUST LIM page is used to select thrust limits and derates.

5 **TAKEOFF**

The TAKEOFF REF page is used to enter takeoff reference data and V speeds.

6 **APPROACH**

The APPROACH REF page is used for entry of the approach VREF speed.

7 **NAV DATA**

The REF NAV DATA page is used for data on waypoints, navaids, airports, and runways. NAV DATA pages are accessible only from this page.

8 **Alternate (ALTN)**

The ALTN page is used for alternate airport planning and diversions.

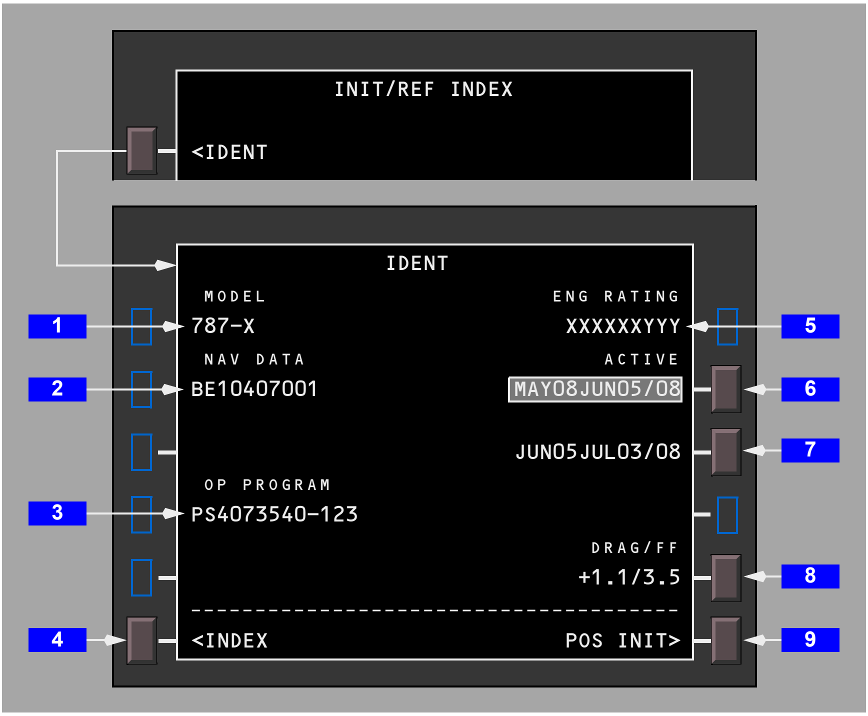
9 **Maintenance (MAINT)**

For maintenance use only; displays maintenance pages.

Identification Page

Most of the data on this page is for flight crew verification. Active date and drag/fuel flow accept manual entries.

The flight crew verifies FMC data, selects a navigation database, and checks or modifies drag and fuel flow factors on the identification page.



1 MODEL

Displays airplane model.

2 NAV DATA

Displays the navigation database identifier.

3 OP PROGRAM

Displays the Flight Management Function (FMF) Operational Program part number.

4 INDEX

Push – displays the INIT/REF INDEX page.

5 ENG RATING

Displays engine model and thrust rating. Header displays INTERMIX RATING for engine intermix installations. YY or YYY is the engine thrust rating.

6 ACTIVE

Displays the effectivity date range for the active navigation database.

If the active navigation database is out of date, it can be changed to the inactive navigation database. Pushing the date range prompt of the inactive navigation database copies that date into the scratchpad. Pushing the date range prompt of the active navigation database transfers the scratchpad date up to the ACTIVE database line. The previous active date moves to the inactive date line.

The line title ACTIVE is above the active navigation database date. No line title is above the inactive navigation database date. The navigation database date can only be changed on the ground. Changing the navigation database removes all previously entered route data.

When an active database expires in flight, the expired database is used until the active date is changed after landing. The database expires at 0900Z on the last day in the range.

7 Inactive Date Range

Displays the effectivity date range for the inactive navigation database. This database becomes active at 0901Z on the first day of the range.

8 DRAG/FF

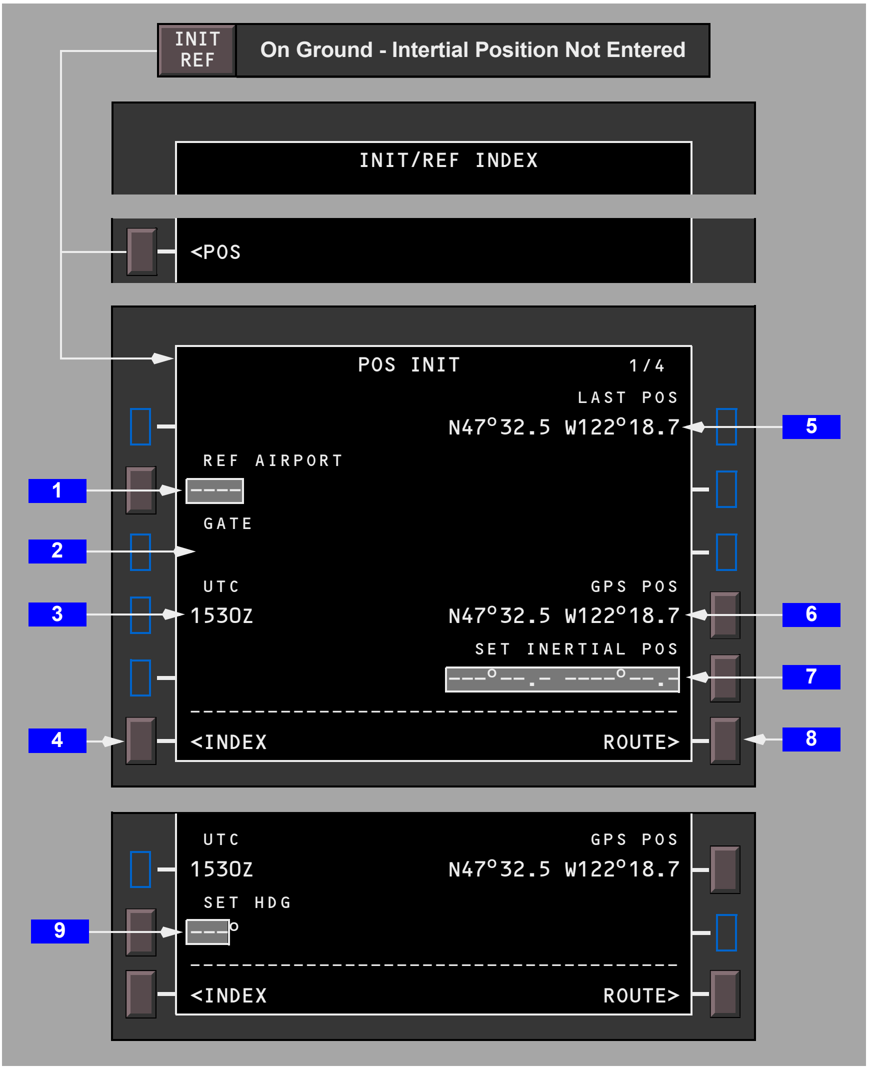
Displays the airplane drag and fuel flow correction factors.

9 Position Initialization (POS INIT)

Push – displays the POS INIT page.

Position Initialization Page 1/4

The position initialization page allows entry of airplane present position for IRS alignment in the event that automatic GPS updating is not available. The same page is used to enter the heading when the ADRS is inoperative.



1 Reference Airport (REF AIRPORT)

Entry of the reference airport displays the airport latitude/longitude.

Optional entry.

Valid entries are ICAO four letter airport identifiers.

Removes previous GATE entry.

Entry blanks at lift–off.

2 GATE

The gate entry allows further refinement of the latitude/longitude position.

Optional entry after reference airport entered.

Valid entry is a gate number at the reference airport.

Displays the latitude and longitude of the reference airport gate.

Changes to dashes when a new reference airport entered.

Entry blanks at lift–off.

3 Coordinated Universal Time (UTC)

Displays UTC time as updated from the GPS.

4 INDEX

Push – displays the INIT/REF INDEX page.

5 Last Position (LAST POS)

Displays the last FMC calculated position.

6 GPS Position (GPS POS)

Displays the GPS present position. During preflight, the GPS POS may not display due to satellite availability, performance, or unfavorable geometry.

7 Set Inertial Position (SET INERTIAL POS)

The set inertial position entry is optional because the IRS has continuous access to the GPS position. Entry may be accomplished by selecting the most accurate latitude/longitude from LAST POS, REF AIRPORT, GATE, GPS POS, or make a manual entry.

If an entered position fails the IRU internal check, the CDU help window message ENTER INERTIAL POSITION displays. If the entered position fails the IRU check after the position is entered a second time, the CDU help window message ALIGNMENT REINITIATED displays.

The entered position is compared with the FMC origin airport position. If the entered position is not within 6 nm of the FMC origin airport position, the CDU help window message INERTIAL/ORIGIN DISAGREE displays.

Dashes display when any IRU or AHRU is in the alignment mode and can receive a new position update. Enter the most accurate inertial position to remove any accumulated IRU position errors.

Enter airplane position latitude and longitude.

When box prompts are displayed, present position entry is required. Box prompts are displayed if GPS position is not available, and any IRU or AHRU is requesting position.

Blanks when both IRUs and both AHRUs have completed alignment and enter the navigation mode.

Blanks when the airplane is moving or has not been stationary for six to fifteen consecutive minutes.

New inertial position entries can be made anytime dashes are displayed. New entries display for 2 seconds. After 2 seconds, dashes display to allow entry of another position.

8 ROUTE

Push – displays the ROUTE page.

9 SET HDG

Dashes display in flight when any IRU or AHRU is in reversionary attitude mode.

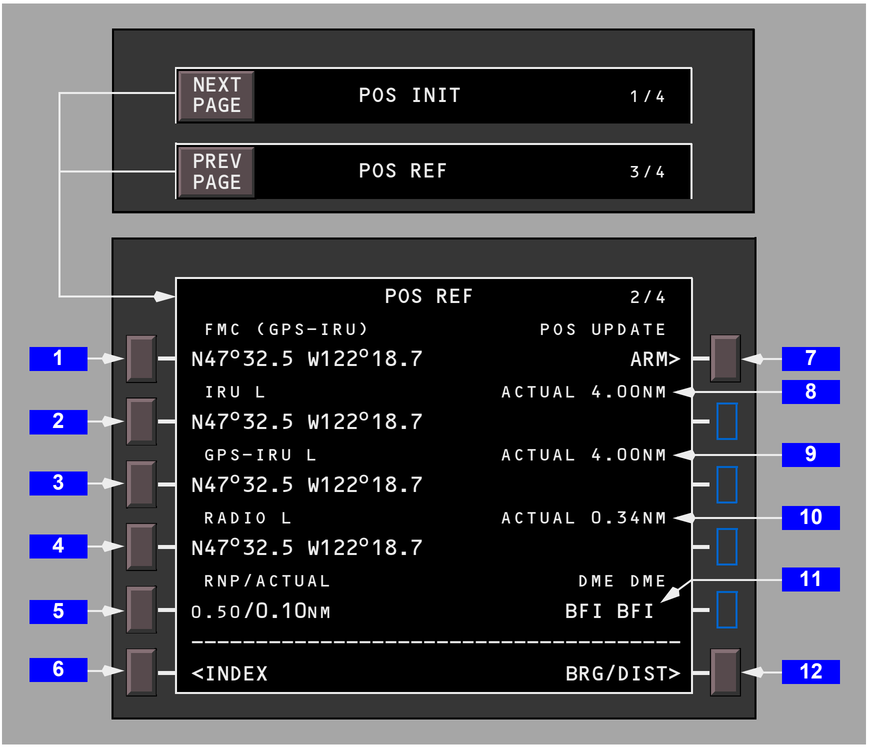
Entry of magnetic heading is displayed in the primary flight displays only after all IRUs and AHRUs have failed.

Valid entry is 0 to 360 (0 or 360 displays as 000°). Entered heading displays in large font for 2 seconds then is followed by dashes to allow entry of another heading.

Position Reference Page 2/4

Position reference page 2 displays positions calculated by the FMC, IRU, GPS, and radio navigation receivers. The FMC position can be updated to IRU, GPS, or radio position on this page.

This page displays latitude/longitude or bearing/distance. All position displays are in actual latitude and longitude, as calculated by the related system. The IRU, GPS, and radio position data can be changed to bearing/distance.



1 **FMC**

The source used by the Master FMC for position data displays next to the FMC line title. In the example, the FMC uses GPS-IRU for position data.

Displays the FMC calculated latitude/longitude.

Identifies the source for calculating the FMC position:

- GPS – position calculated from GPS position data
- GPS-IRU – position calculated from GPS and IRU position data
- GPS-AHRU – position calculated from GPS and AHRU position data
- INERTIAL – position calculated from IRU position data

- RADIO – position calculated from navigation radio position data
- LOC – position calculated from localizer and IRU position data
- LOC-GPS-IRU – position calculated from localizer, GPS and IRU position data
- LOC-GPS-AHRU – position calculated from localizer, GPS and AHRU position data
- LOC-RADIO – position calculated from localizer and navigation radio position data

2 INERTIAL

Displays latitude/longitude (or bearing/distance) position of the IRU sensor currently being used by the Master FMC.

Blank if no valid IRU position exists.

3 GPS

Displays latitude/longitude (or bearing/distance) position of the GPS sensor currently being used by the Master FMC.

Blank if no valid GPS position exists.

4 RADIO

After airborne, displays latitude/longitude (or bearing/distance) position of the navigation radios being used by the Master FMC.

Blank if no valid RADIO position exists.

5 Required Navigation Performance and Actual Navigation

Displays RNP values stored in the navigation database for departure and arrival procedures; or, if there are none, displays the default values stored within the FMC by flight phase. Also displays FMC actual navigation performance (ACTUAL).

Default RNP is in small font.

Valid RNP entries are in the range 0.01 to 99.9. ACTUAL entry not allowed.

When ACTUAL exceeds RNP, the EICAS message NAV UNABLE RNP displays.

Note: The FMC stops GPS updating if GPS data accuracy degrades due to satellite availability or unfavorable geometry, or if the flight crew inputs a small RNP value. Subsequently, the FMC receives updates from another system.

6 INDEX

Push – displays the INIT/REF INDEX page.

7 **UPDATE ARM**

Push –

- arms FMC position update function
- changes prompt to ARMED
- adds NOW prompts to right side of INERTIAL, GPS, and RADIO lines

Push a NOW prompt key to update FMC position to the selected source.

8 **ACTUAL – INERTIAL**

Displays actual navigation performance of the IRU.

9 **ACTUAL – GPS**

Displays actual navigation performance of the GPS.

10 **ACTUAL – RADIO**

Displays actual navigation performance of radio updating.

11 **Radio Update Station(s)/Mode**

Displays radio station identifiers.

Position update mode is indicated in the line title:

- DME DME
- VOR DME
- LOC

12 **Bearing/Distance (BRG/DIST) or Latitude/Longitude (LAT/LON)**

Push – alternates position data format between bearing/distance or latitude/longitude.

The page illustration is shown in the latitude/longitude display format.

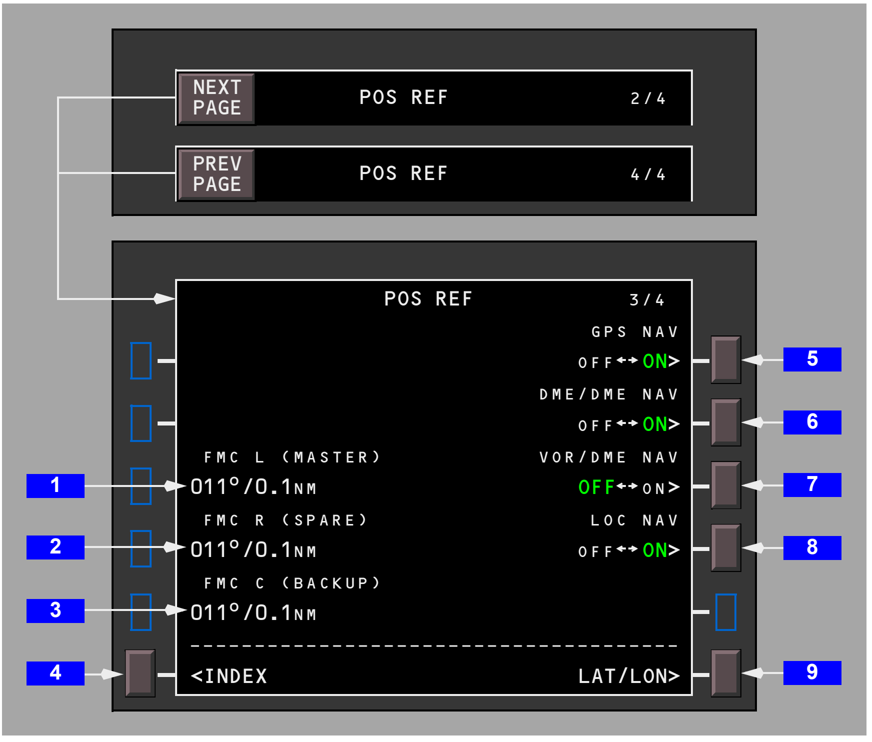
Latitude/longitude format displays are actual position.

Bearing/distance format displays the bearing and distance of other position sources relative to the Master FMC position.

Position Reference Page 3/4

On position reference page 3, the flight crew can observe the calculated positions of the left, right and center FMCs. The header line indicates which FMC is being used as MASTER, SPARE or BACKUP. This page also allows the flight crew to enable or disable position updating modes used by the FMC.

This page can display the bearing/distance or latitude/longitude format. The bearing/distance format displays bearing and distance of the position sources relative to the Master FMC position.



1 FMC L

Displays the left FMC calculated position and its current usage (MASTER).

2 FMC R

Displays the right FMC calculated position and its current usage (SPARE).

3 FMC C

Displays the center FMC calculated position and its current usage (BACKUP).

4 INDEX

Push – displays the INIT/REF INDEX page.

5 **GPS NAV**

Push – alternately selects GPS NAV ON (enabled) and OFF (disabled).

OFF – GPS position data is not available to the FMC. OFF displays in large green letters; ON displays in small white letters.

ON – GPS position data is available to the FMC. ON displays in large green letters; OFF displays in small white letters.

Note: When power is initially applied to the airplane or when engines are shut down, GPS NAV is set to ON.

6 **DME/DME NAV**

Push – alternately selects DME/DME NAV ON (enabled) and OFF (disabled).

OFF – DME/DME position data is not available to the FMC. OFF displays in large green letters; ON displays in small white letters.

ON – DME/DME position data is available to the FMC. ON displays in large green letters; OFF displays in small white letters.

7 **VOR/DME NAV**

Push – alternately selects VOR/DME NAV ON (enabled) and OFF (disabled).

OFF – VOR/DME position data is not available to the FMC. OFF displays in large green letters; ON displays in small white letters.

ON – VOR/DME position data is available to the FMC. ON displays in large green letters; OFF displays in small white letters.

8 **LOC NAV**

Push – alternately selects LOC NAV ON (enabled) and OFF (disabled).

OFF – LOC position data is not available to the FMC. OFF displays in large green letters; ON displays in small white letters.

ON – LOC position data is available to the FMC. ON displays in large green letters; OFF displays in small white letters.

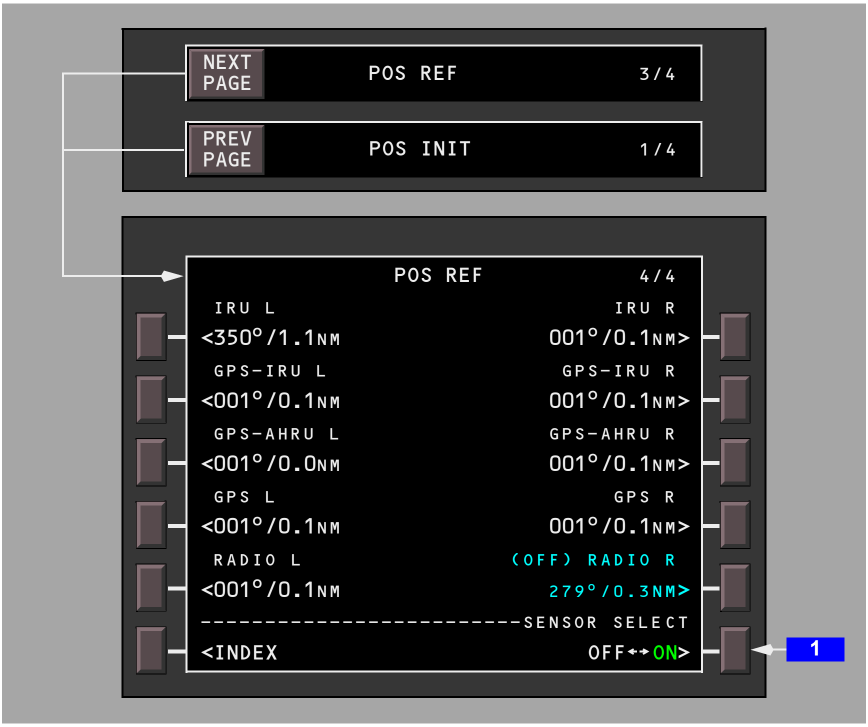
9 **Latitude/Longitude (LAT/LON) or Bearing/Distance (BRG/DIST)**

Push – alternately changes the display of position data on POS REF 3/4 and 4/4 to latitude/longitude format or bearing/distance format.

The page illustration is shown in the bearing/distance display mode.

Position Reference Page 4/4

Position reference page 4 displays the present position of individual navigation sensors in bearing/distance format from the Master FMC position. This page provides the capability to remove specific sensors from the FMC navigation solution.



1 **SENSOR SELECT**

Push – alternately selects SENSOR SELECT ON (enabled) and OFF (disabled).

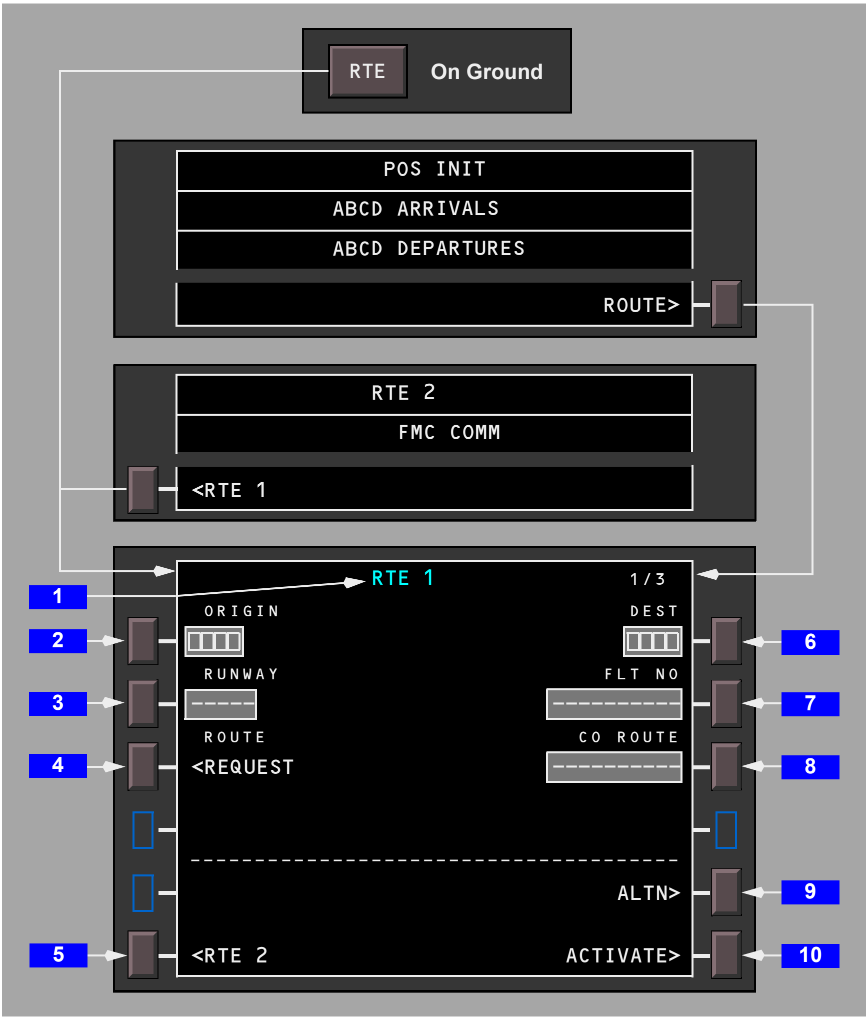
ON (large green font) – caret prompts are displayed on each sensor line that can be controlled:

- line selecting a sensor toggles it on or off
- the system prevents both of the IRU sensors or both of the GPS sensors from being selected OFF simultaneously
- when a sensor is selected OFF, the data line and header are displayed in small font cyan with (OFF) in the header
- selecting a sensor OFF does not disable or remove power from the sensor, it simply prevents the FMC from using its output for the navigation solution

OFF (large green font) – caret prompts are removed and sensor selection is disabled.

Route Page 1/X

Two routes (RTE 1 and RTE 2) can be displayed in air traffic control format. Routes can be entered by the flight crew or uplinked through datalink. All routes have two or more pages. The first route page displays origin and destination data. Subsequent route pages display route segments between waypoints or fixes. ROUTE 1 and ROUTE 2 allow management of alternate or future routes while leaving the active route unmodified. ROUTE 2 has an identical page structure as ROUTE 1. When RTE 2 is active, page display logic is the same as RTE 1.



1 **Page Title**

White when the route is active.

Cyan when the route is inactive.

The white shaded word MOD precedes the page title when the route is modified and the change is not executed.

Multiple route pages are indicated by the page sequence number to the right of the title. The minimum number of route pages is 2.

2 **ORIGIN**

Entry:

- must be a valid ICAO identifier in the navigation database
- is made automatically when a company route is entered
- enables direct selection of departure and arrival procedures
- displays MOD in page title of an active route
- entry on the ground deletes route; in flight, entries are valid on the inactive route

3 **RUNWAY**

Enter the applicable runway for the origin airport. Runway must be in the navigation database. Entry is optional.

New entries on an active route cause MOD to display in the route title.

Automatically entered when part of a company route.

Can be selected on the DEPARTURES page.

FMC deletes runway after the first waypoint is crossed.

4 **ROUTE REQUEST**

Push – transmits a datalink request for a flight plan route uplink.

Flight crew can operationally fill in origin, destination, runway, flight number, company route name, or route definition to qualify request.

5 **RTE 2**

Push – displays the RTE 2 page 1/x.

Allows access to an inactive route for creation and modification or activation.

Inactive route modifications do not alter the active route.

Prompt changes to RTE 1 when RTE 2 is displayed.

6 **Destination (DEST)**

Entry:

- must be a valid ICAO identifier in the navigation database
- is made automatically when a company route is entered
- enables selection of departure and arrival procedures

7 Flight Number (FLT NO)

Enter the company flight number.

Entry is optional for activation of the route.

Limited to 10 characters.

Flight crew entered or uplinked.

Flight number is included in the PROGRESS page title.

Flight number can be entered on multifunction COMM display ATC LOGON page.

Transponder transmits flight number to ATC when Eurocontrol-compliant transponder is installed.

8 Company Route (CO ROUTE)

A company route can be called from the navigation database by entering the route identifier. The data supplied with a company route can include origin and destination airports, departure runway, SID and STAR, and the route of flight. All company route data is automatically entered when the route identifier is entered.

An entry is optional for activation of the route.

Enter a company route identifier.

Valid entry is any flight crew entered or uplinked company route name. If the name is not contained in the NAV database, the entry is allowed and the CDU help window message NOT IN DATA BASE displays.

Entry of a new company route replaces the previous route.

In–flight entry is inhibited for the active route.

9 Alternate (ALTN)

Push – displays the ALTN page.

10 ACTIVATE

Push the ACTIVATE key to arm the route for execution as the active route. When the EXECUTE key is pushed, the route becomes the active route and the ACTIVATE prompt is replaced with the next required preflight page prompt.

Push – prepares the selected route for execution as the active route.

Activation of a route is required for completion of the preflight.

Displayed on inactive route pages.

After route activation, the ACTIVATE prompt is replaced by:

- PERF INIT, when the required performance data is incomplete, or
- TAKEOFF when the required performance data is complete

More Route Page Prompts for an Active Route

1 ROUTE REPORT

Push – transmits the active route to the company via datalink downlink.

2 ROUTE PRINT

Push – sends the active route to the flight deck printer.

3 Route Copy (RTE COPY)

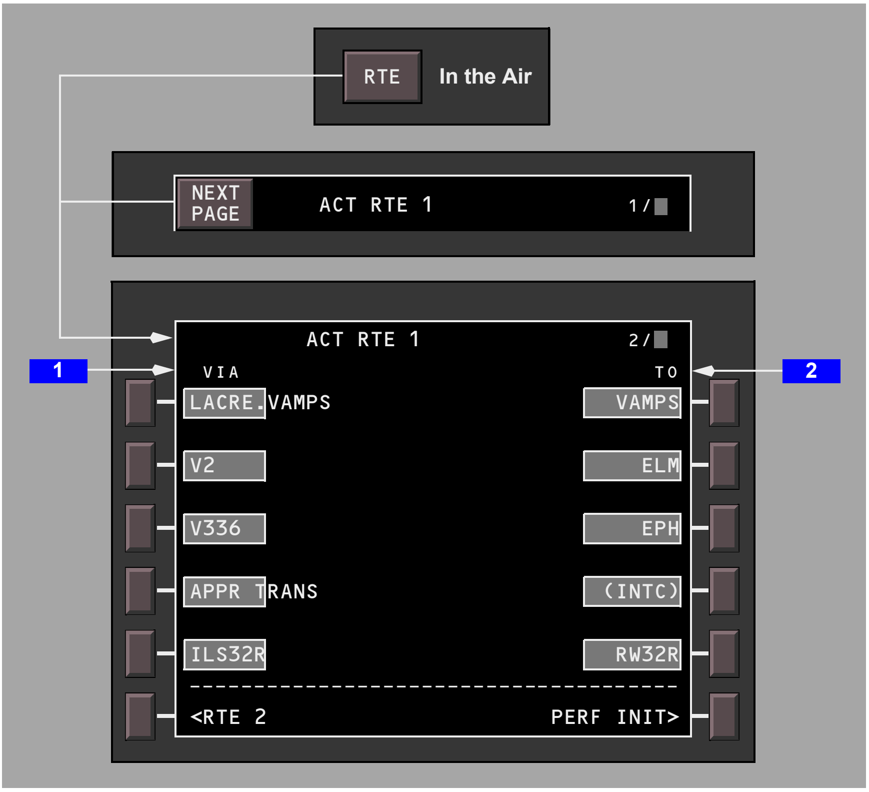
Push – copies the entire active route (RTE x) into the inactive route (RTE y).

Displayed only on the active route page.

Displays COMPLETE after the route is copied.

Route Page 2/X

The subsequent route pages 2/X through X/X, display route segments in air traffic control format. Route segments are defined as direct routing, airways, or procedures with start and end points such as waypoints, fixes, navaids, airports, or runways. More waypoints for each route segment are shown on the RTE LEGS page.



1 VIA

The VIA column displays the route segment to the waypoint or termination in the TO column. Enter the path which describes the route segment between the previous waypoint and the segment termination.

Enter an airway in the VIA column and boxes display in the TO column.

Valid entries can also include procedures or DIRECT. Procedures are usually entered through selections on DEPARTURES and ARRIVALS pages. DIRECT is usually entered as a result of entering a TO waypoint first.

Valid airways must:

- contain the fix entered in the TO waypoint, and
- contain the previous TO waypoint, or
- intersect the previous VIA route segment

Dashes change to DIRECT if the TO waypoint is entered first.

Dashes display for the first VIA beyond the end of the route.

Invalid VIA entries display the CDU help window message NOT IN DATA BASE.

Invalid VIA entries are:

- airways and company routes which do not contain the TO waypoint of the previous line
- airways that do not intersect the previous airway
- airways or company routes that are not in the navigation database

The start and end waypoints determine whether the entered airway is valid. The route segment must contain the waypoint entered in the TO position. The TO waypoint of the previous route segment must be the same as the start point of the next route segment or a route discontinuity is created between the segments.

Entry of a SID or transition enters the VIA and TO data for the route segments of the SID. A SID links to the next route segment when the final SID waypoint is part of the route segment.

When no SID is used, entering an airway on the first line of page 2 initiates an airway intercept from the runway heading and:

- replaces the airway with dashes in the first line VIA
- shows boxes in the first line TO waypoint
- moves the airway to line 2 after the TO waypoint is entered
- enters the first fix on the airway nearest to being abeam of the departure heading in the airway line TO waypoint

A route can contain segments formed by the intersection of two airways. Entering two intersecting airways in successive VIA lines without a TO waypoint causes the FMC to create an airway intersection waypoint to change from one segment to the next. The FMC created waypoint intersection (INTC) displays in the first airway segment TO waypoint.

LACRE3.VAMPS is an example of a SID selection made on the DEPARTURES page.

V2 and V336 are examples of airway entries.

APP TRANS is an example of a STAR selection made on the APPROACH page.

ILS32R is an example of an approach selection made on the APPROACH page.

2 TO

Enter the end point of the route segment specified by the VIA entry.

Entry of a waypoint in the TO column without first entering a VIA airway shows DIRECT in the VIA column.

Data input is mandatory when boxes are displayed.

Valid waypoint entries for a DIRECT route segment are any valid waypoint, fix, navaid, airport, or runway.

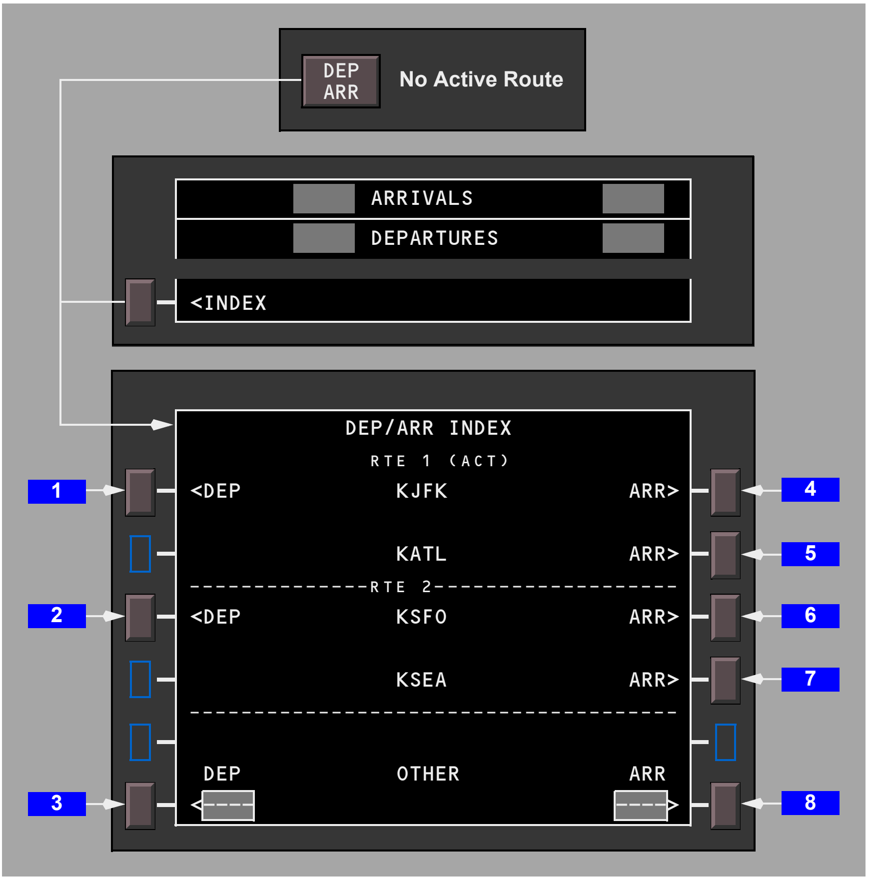
Valid waypoint entries for airways are waypoints or fixes on the airway.

Dashes display on the first TO waypoint after the end of the route.

Departure/Arrival Index Page

The departure and arrival index page is used to select the departure or arrival page for the origin and destination airports for each route. The index also allows reference to departure or arrival data for any other airport in the navigation database.

Departure and arrival prompts are available for the origin airport. Destination airports have only arrival prompts.



1 Departure (DEP) – Route 1

Push – displays the departure page for route 1 origin airport.

2 Departure (DEP) – Route 2

Push – displays the departure page for route 2 origin airport.

3 Departure (DEP) — Other

Displays the departure page for the airport entered into this line through the scratchpad.

DEP prompt for OTHER allows display of departure data about airports that are not an origin or destination. The data can be viewed but cannot be selected because the airport is not on the route.

4 Arrival (ARR) – Route 1 Origin

Push – displays the arrival page for route 1 origin airport. Origin airport arrivals selection is used during a turn–back situation.

5 Arrival (ARR) – Route 1 Destination

Push – displays the arrival page for route 1 destination airport.

6 Arrival (ARR) – Route 2 Origin

Push – displays the arrival page for route 2 origin airport. Origin airport arrivals selection is used during a turn–back situation.

7 Arrival (ARR) – Route 2 Destination

Push – displays the arrival page for route 2 destination airport.

8 Arrival (ARR) – Other

Displays the arrival page for the airport entered in this line through the scratchpad.

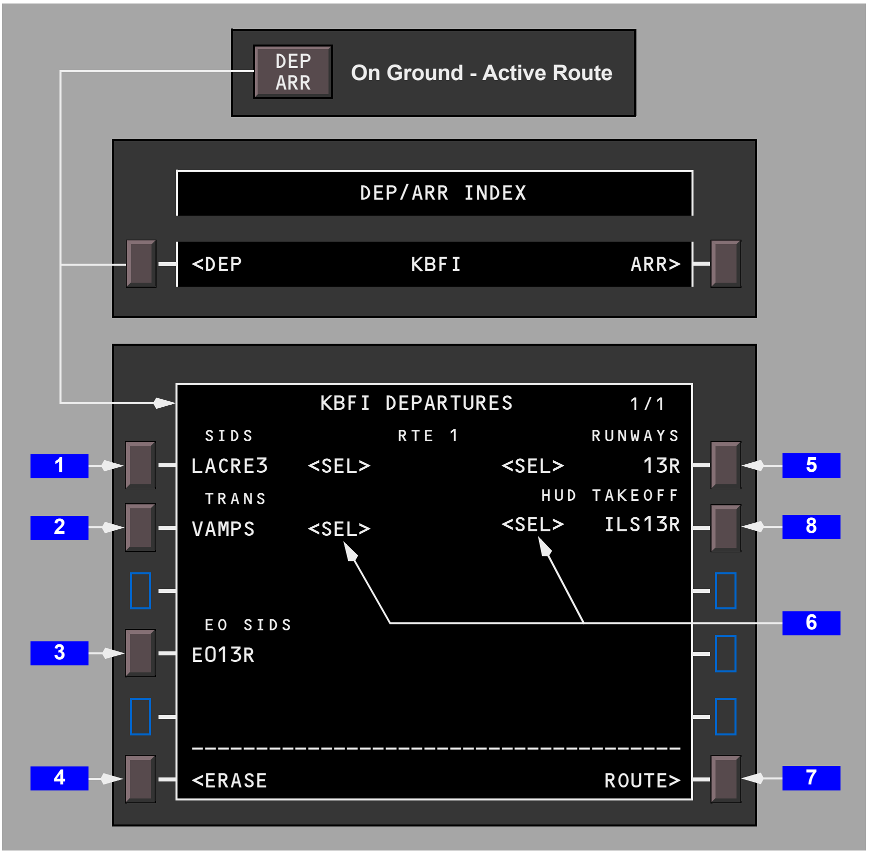
ARR prompt for OTHER allows display of arrival data about airports that are not an origin or destination. The data can be viewed but cannot be selected because the airport is not on the route.

Departures Page

The departures page is used to select the departure runway, SID, and transition for the route origin airport.

The departures page for the inactive route displays when the DEP ARR function key is pushed with an inactive RTE or RTE LEGS page displayed.

[Option – HUD low visibility T/O]



1 Standard Instrument Departures (SIDS)

Displays a list of SIDS for the airport.

Push –

- selects SID for use in the route
- other SIDs no longer display and transitions for the selected SID display
- runways for selected SID remain and others no longer display

2 **Transitions (TRANS)**

Displays transitions compatible with the selected SID.

Push –

- selects transition for entry in the route
- other transitions no longer display

3 **Engine Out (EO) SIDS**

Displays airline-defined single engine-out SIDs for selected airport. EO SID can be viewed before takeoff by line selecting and selecting the Legs page. EO SID automatically selected during takeoff if an engine-out detected prior to “flaps up”. The modification can be either executed or erased. If an EO SID does not exist, NONE displays.

PUSH - displays EO SID as the selected SID.

4 **ERASE or INDEX**

Erase displays when a route modification is pending. INDEX displays when no route modification is pending.

ERASE push – removes route modifications not executed and displays the original route.

INDEX push – displays the DEP/ARR INDEX page.

5 **RUNWAYS**

Displays a list of runways for the selected airport.

The runway selected on the RTE 1/X page displays as <SEL> or <ACT>.

Push –

- selects runway for use in the route. All other runways no longer display
- SIDs associated with selected runway remain, all others no longer display
- subsequent change of a runway deletes departure procedures previously selected

6 **Selecting Options**

Selecting an option displays <SEL> inboard of the option and creates a route modification. After executing the modification, <SEL> becomes <ACT>. Executing a modification or leaving the page and returning displays all options and the <SEL> or <ACT> prompts.

7 **ROUTE**

Push – displays the related RTE page.

[Option – HUD low visibility T/O]

8 HUD TAKEOFF

When available, HUD TAKEOFF options are shown on the DEPARTURES page. Selecting a HUD TAKEOFF runway provides highly accurate HUD guidance during low visibility takeoffs.

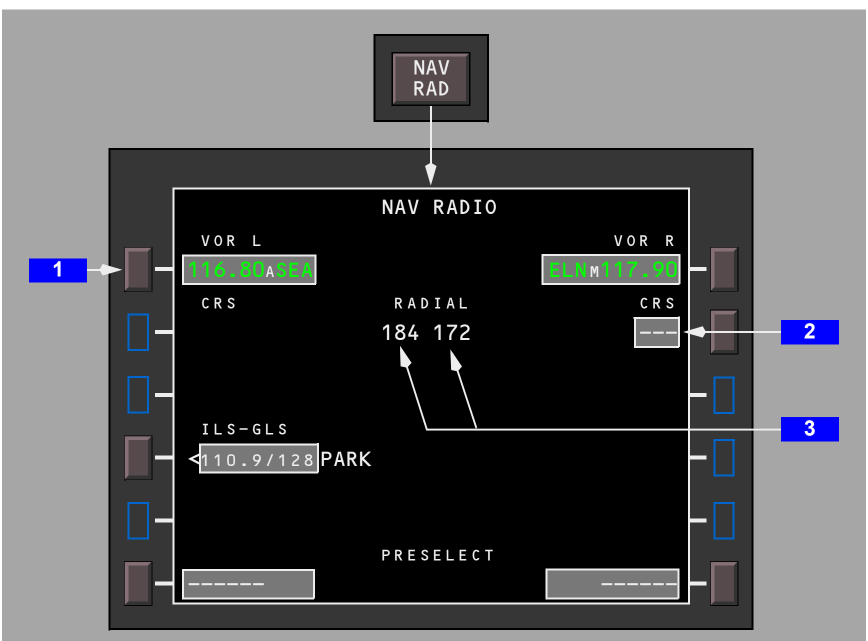
Push –

- selects runway to be used in low visibility takeoff, all other runways are removed from the display
- the FMC tunes the selected navaid to provide low visibility takeoff guidance through the HUD
- SIDs associated with selected runway remain, all other SIDs and TRANs are removed from the display
- subsequent change of a runway deletes departure procedures previously selected

Navigation Radio Page

VOR, ILS and GLS navigation radios are normally autotuned by the FMC. The NAV RADIO page displays the VOR and ILS-GLS status and allows manual control of these radios. Entering data on this page tunes the selected navigation radio. VOR courses can also be entered.

VOR



1 VOR Frequency and Tune Status

The tuning status displays adjacent to left and right VOR frequencies. Entry of a frequency or identifier manual–tunes a VOR. FMC autotunes VORs for procedure flying and route operations. The FMC also tunes related DMEs. The tuning status displays are:

- P (procedure autotuning) – FMC selects navaids for approach or departure procedure guidance
- R (route autotuning) – FMC selects navaids on the active route. The navaid is the previous VOR or a downpath VOR within 250nm of aircraft position
- A (autotuning) – FMC selects a navaid for best position orientation
- M (manual) – VOR is manual–tuned. Manual–tuning takes priority over FMC autotuning. Deletion of a manual–tuned frequency returns system to autotuning

Valid entries:

- VOR or non–ILS DME identifiers (XXX) or VOR or non-ILS DME frequencies (YYY.Y or YYY.YY)
- VOR identifier/course (XXX/ZZZ) or frequency/course (YYY.Y/ZZZ or YYY.YY/ZZZ); the course displays on the CRS line

The identifier and frequencies are green and tuning status is white.

Note: When magnetic variation at the airplane and VOR locations are significantly different, the ND VOR radial and ND POS green radial do not point directly to the VOR. This difference decreases as the airplane approaches the VOR.

2 CRS

Blank when in autotune.

Valid entry is a three–digit course. Data can be entered when dashes or a course are displayed.

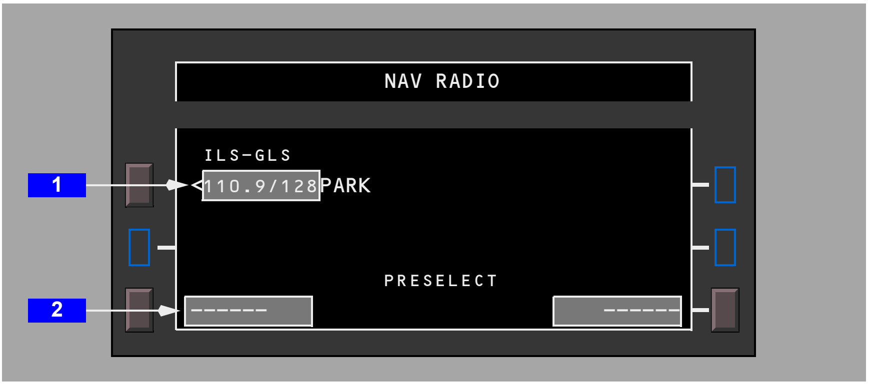
With a VOR approach selected, sequencing an IAF/FAF causes the FMC to procedure autotune the VOR frequency. When the approach has a runway waypoint, the FMC selects the inbound course.

VOR course is green. Radial is white.

3 RADIAL

Displays radial from left and right VOR stations to the airplane.

ILS-GLS



1 ILS-GLS Tuning

The tuning status displays adjacent to the ILS frequency/course or GPS channel. The ILS and GPS receivers operate in FMC autotune or manual tuning modes. The FMC autotunes the ILS frequency/course or the GPS channel depending upon the approach selected in the flight plan. When the ILS or GPS is not necessary, the FMC sets the ILS-GPS status to PARK. This removes the displays from the PFD.

Airplane position on the route determines the ILS-GPS operating mode. The operating mode displays are:

- PARK – the ILS or GLS is not being used and is not tuned
- XXX.XX/YYY PARK – the ILS is tuned for the selected approach but is not being used
- “A” indicates autotuning under FMC control for approach guidance
- “M” indicates the ILS or GLS is manually tuned

ILS autotuning is inhibited for ten minutes after takeoff and during manual–tuning. Autotuning and manual–tuning are inhibited when:

- the autopilot is engaged and either the localizer or glideslope is captured
- only the flight director is ON and either the localizer or glideslope is captured and the airplane is below 500 feet radio altitude
- on the ground with the localizer alive, the airplane heading within 45 degrees of the localizer front course and the groundspeed is greater than 40 knots

Subsequent manual–tuning is enabled when:

- either TOGA switch is pushed
- the autopilot is disengaged and both flight directors are switched off
- the MCP approach switch is deselected when the airplane is above 1500 feet radio altitude

Valid entries:

- ILS frequency and front course (XXX.XX/YYY)
- front course, with a frequency already entered (/YYY)
- GPS channel (XXXXX) in the range of 20000 to 99999

2 **PRESELECT**

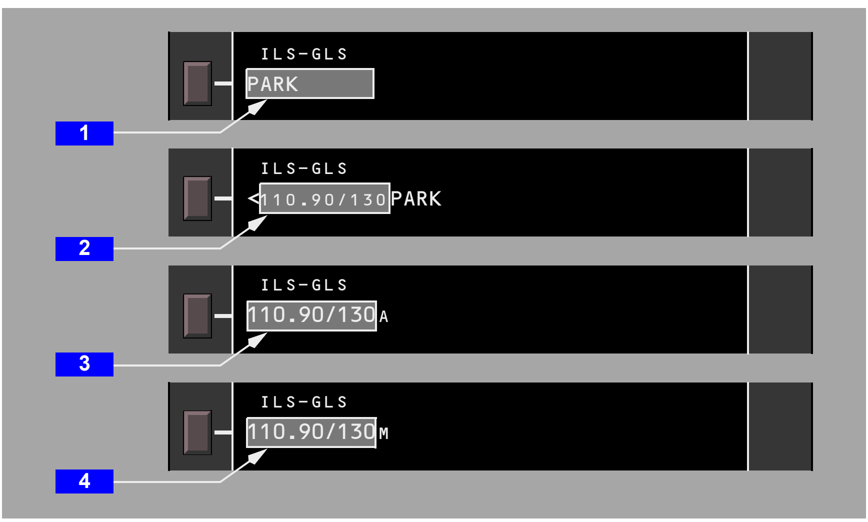
Any valid page data may be entered.

Put data into this line for later use. Data can be moved to the appropriate line when necessary.

ILS-GLS Tuning Status

The display initializes to PARK. When PARK displayed, the ILS or GLS is not tuned. The tuning status displays are:

- XXX.XX/YYY PARK – the ILS is autotuned for the selected approach but is not being used
- XXXXX PARK – the GLS is autotuned for the selected approach but is not being used
- A (autotune) – ILS or GLS is autotuned for approach guidance
- M (manual) – ILS or GLS is manual tuned



1 **Park**

PARK displays when:

- electrical power is first applied
- more than 200 nm from the T/D, or
- less than halfway to the destination

2 Tuning Status – Frequency, Course, and Park

ILS frequency, front course, and PARK display when an ILS, LOC, back course, LDA (localizer-type directional aid), or SDF (simplified directional facility) is selected, and:

- less than 200 nm from the T/D, or
- more than halfway to the destination, whichever represents the lesser distance to destination

Line selection manually tunes ILS–GLS.

3 Tuning Status – Autotune

ILS frequency, front course, and A display when an ILS, LOC, back course, LDA (localizer-type directional aid), or SDF (simplified directional facility) is selected, and:

- less than 50 nm from the T/D, or
- less than 150 nm from the runway threshold, or
- FMC is in descent mode

4 Tuning Status – Manual

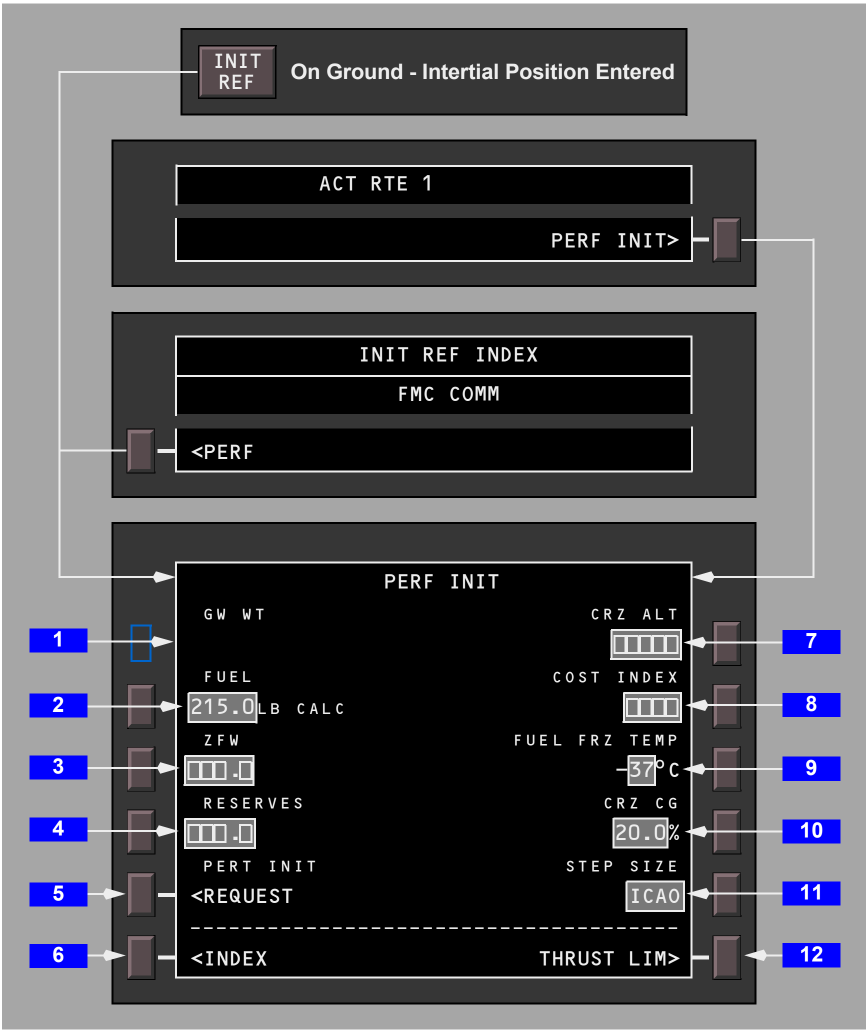
Receiver tuned manually and valid frequency/course display.

Preflight Pages – Part 2

Performance Initialization Page

The performance initialization page allows the entry of airplane and route data to initialize performance calculations. This data is required for VNAV calculations.

[Option – English units, Fuel freeze temp]



1 Gross Weight (GR WT)

Calculated gross weight is displayed after Zero Fuel Weight is entered.

Manual entry is not allowed.

2 FUEL

Fuel on board displays when the fuel totalizer calculations are valid. The source for the display is included in the line:

- SENSED – fuel quantity is from the totalizer. Manual entry is not possible
- CALC (calculated) – fuel quantity is from FMC calculations. Manual entry is possible
- MANUAL – fuel quantity has been manually entered. Manual entries blank totalizer on PROGRESS page 2/4

Box prompts indicate invalid totalizer signals received from the fuel quantity system. Manual entry required.

Valid entry is XXX or XXX.X.

Only manual entries can be deleted.

3 Zero Fuel Weight (ZFW)

Normally, ZFW is entered from the airplane dispatch papers and the FMC calculates the airplane gross weight.

Valid entry is XXX or XXX.X.

Entry of a value after takeoff speeds have been accepted deletes takeoff speeds and displays the CDU help window message TAKEOFF SPEEDS DELETED.

ZFW can be manually entered or uplinked. When a performance uplink is pending, uplinked values (small font) display beside the entered values (large font).

4 RESERVES

Valid entry is XXX or XXX.X.

Can be manually entered or uplinked. When a performance uplink is pending, uplinked values (small font) display beside the entered values (large font).

5 Performance Initialization Request (PERF INIT REQUEST)

Push – transmits a datalink request for performance data uplink.

Flight crew can fill in ZFW, CG, cruise altitude, reserves, cost index, or fuel temperature to qualify request.

6 INDEX

Push – displays the INIT/REF INDEX page.

7 Cruise Altitude (CRZ ALT)

Cruise altitude can be entered by the flight crew or from a company route or uplink.

Valid entry is XXX, XXXX, XXXXX or FLXXX.

Entry displays this cruise altitude on the CLB and CRZ pages.

8 **COST INDEX**

Cost index is used to calculate ECON climb, cruise, and descent speeds. Larger values increase ECON speeds. Entering zero results in maximum range airspeed and minimum trip fuel. Cost index can be entered by the flight crew or from a company route or uplink.

Valid entries are 0 to 9999.

[Option – Fuel freeze temp]

9 **Fuel Freeze Temperature (FUEL FRZ TEMP)**

Displays minimum fuel operating temperature (3 degrees C warmer than the fuel freeze temperature for a given fuel).

Default value from the AIRLINE POLICY page displays in small font and may not be deleted.

Valid entries are -99 to -1 in degrees C.

Flight crew entered value displays in large font.

When actual fuel temperature reaches the displayed value, the EICAS advisory message FUEL TEMP LOW displays.

10 **Cruise Center of Gravity (CRZ CG)**

Used by FMC to compute maximum altitude and maneuver margin to buffet.

[Option – FAA rules]

Displays default value of 30.0% in small font and may not be deleted.

Flight crew entered value displays in large font.

Valid entry is 14.0 through 44.0.

11 **STEP SIZE**

Displays the climb altitude increment used for planning the optimum climb profile.

Default value is ICAO.

Valid manual entries are 0 to 9000 in 1000 foot increments.

In–flight entries are inhibited. In–flight step size changes are made on the CRZ page.

For a non–zero entry, performance predictions are based on step climbs at optimum points. For a zero entry, performance predictions are based on a constant CRZ ALT.

12 **Thrust Limit (THRUST LIM)**

Push – shows the THRUST LIM page.

Thrust Limit Page

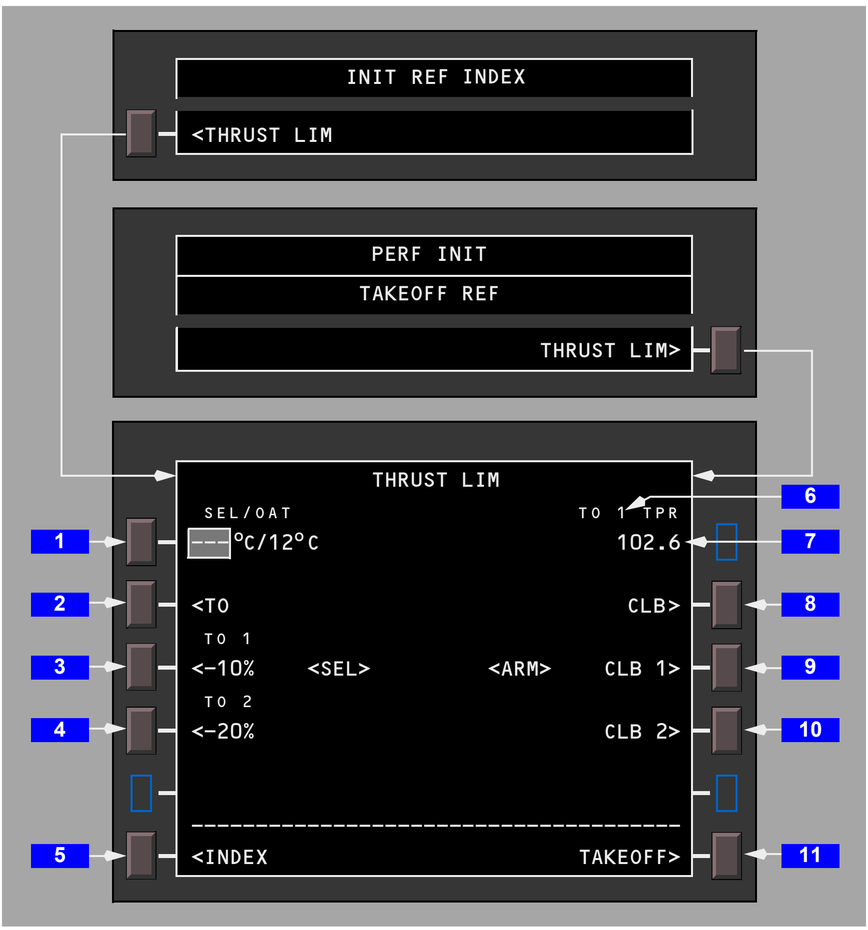
The thrust limit page allows selection and display of reference thrust for takeoff. Takeoff thrust derate by use of assumed temperature is also accomplished on this page.

Additional page data displays are:

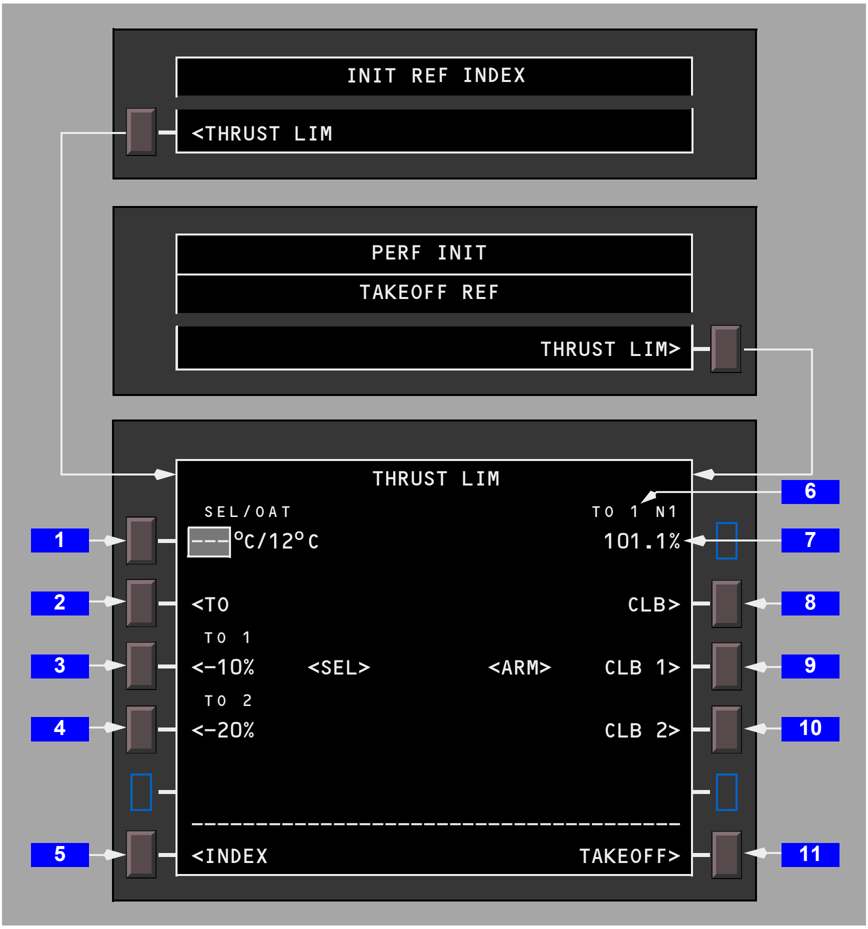
- <SEL> – identifies the selected takeoff thrust reference mode
- <ARM> – identifies the armed climb thrust reference mode

The <ARM> prompt changes to <SEL> when the armed climb mode becomes active.

[Option – RR engines]



[Option – GE Engines]



1 Assumed Temperature (SEL), Outside Air Temperature (OAT)

Entry of assumed temperature is allowed when the airplane is on the ground and dash prompts or large font temperature data is displayed.

Entry of an assumed temperature warmer than the OAT reduces takeoff thrust and displays D as part of the thrust reference mode.

Valid entries are 0 to 99 degrees Celsius (C) or 32 to 210 degrees Fahrenheit (F).

Entry of one, two, or three character temperature followed by “F” displays assumed temperature in degrees F; otherwise, assumed temperature displays in degrees C.

Uplinked temperatures display on both the THRUST LIM and TAKEOFF REF pages.

Flight crew entered or uplinked values replace previously displayed values.

Entry of a value after takeoff speeds have been accepted deletes takeoff speeds and displays the CDU help window message TAKEOFF SPEEDS DELETED.

OAT defaults to degrees C unless a manual OAT degrees F entry has been made. When SEL temperature is in degrees F, the OAT also displays in degrees F.

When sensed OAT is not available, the slash is followed by box prompts allowing manual OAT entry using one of the following formats:

- /SNN where S represents the sign and NN is a temperature value in the range of -99 to +60 inclusive
- /SN where S represents the sign and N is a single digit temperature value in the range of 0 to 9 inclusive
- /NN where NN is a two digit positive temperature value in the range of 00 to 60 inclusive, and
- /N where N is a single digit positive temperature value in the range of 0 to 9 inclusive
- a Fahrenheit entry must include an “F” as the last character

The assumed temperature thrust derate is not the same as TO 1 and TO 2 fixed thrust derates described below. If TO 1 or TO 2 is selected and an assumed temperature is then entered, thrust is further derated.

If entry results in greater than a 25% reduction in thrust, the entered value is dialed back to a value that results in a 25% reduction.

2 **Takeoff (TO)**

Push – selects full rated (TO) takeoff thrust limit.

Selection of a new rating after takeoff speeds have been accepted deletes takeoff speeds and displays the CDU help window message TAKEOFF SPEEDS DELETED.

3 **Takeoff 1 (TO 1)**

Push – selects percentage derate (TO 1) for takeoff thrust limit.

Takeoff thrust derate can be entered by uplink.

TO 1 default thrust derate can be modified on the AIRLINE POLICY page.

Selecting TO 1 arms CLB 1.

Selection of a new TO 1 rating after takeoff speeds have been accepted deletes takeoff speeds and displays the CDU help window message TAKEOFF SPEEDS DELETED.

4 **Takeoff 2 (TO 2)**

Push – selects percentage derate (TO 2) for takeoff thrust limit.

Takeoff thrust derate can be entered by uplink.

TO 2 default thrust derate can be modified on the AIRLINE POLICY page.

Selecting TO 2 arms CLB 2.

Selection of a new TO 2 rating after takeoff speeds have been accepted deletes takeoff speeds and displays the CDU help window message TAKEOFF SPEEDS DELETED.

5 **INDEX**

Push – displays the INIT/REF INDEX page.

6 **Thrust Reference Mode**

Displays selected takeoff thrust mode.

D displays when the takeoff thrust derate uses an assumed temperature.

[Option – RR engines]

7 **Takeoff TPR Limit**

Displays the takeoff TPR calculated by the thrust management function. Displays N1 when the engines are operated in the alternate mode.

[Option – GE engines]

7 **Takeoff N1 Limit**

Displays the takeoff N1 calculated by the thrust management function.

8 **Climb (CLB)**

Push – selects the full rated (CLB) climb thrust limit.

Pushing a climb line select key overrides an automatic selection.

9 **Climb 1 (CLB 1)**

Push – selects a percentage derate (CLB 1) climb thrust limit.

Climb thrust derate can be entered by uplink.

10 **Climb 2 (CLB 2)**

Push – selects a percentage derate (CLB 2) climb thrust limit.

Climb thrust derate can be entered by uplink.

11 **TAKEOFF**

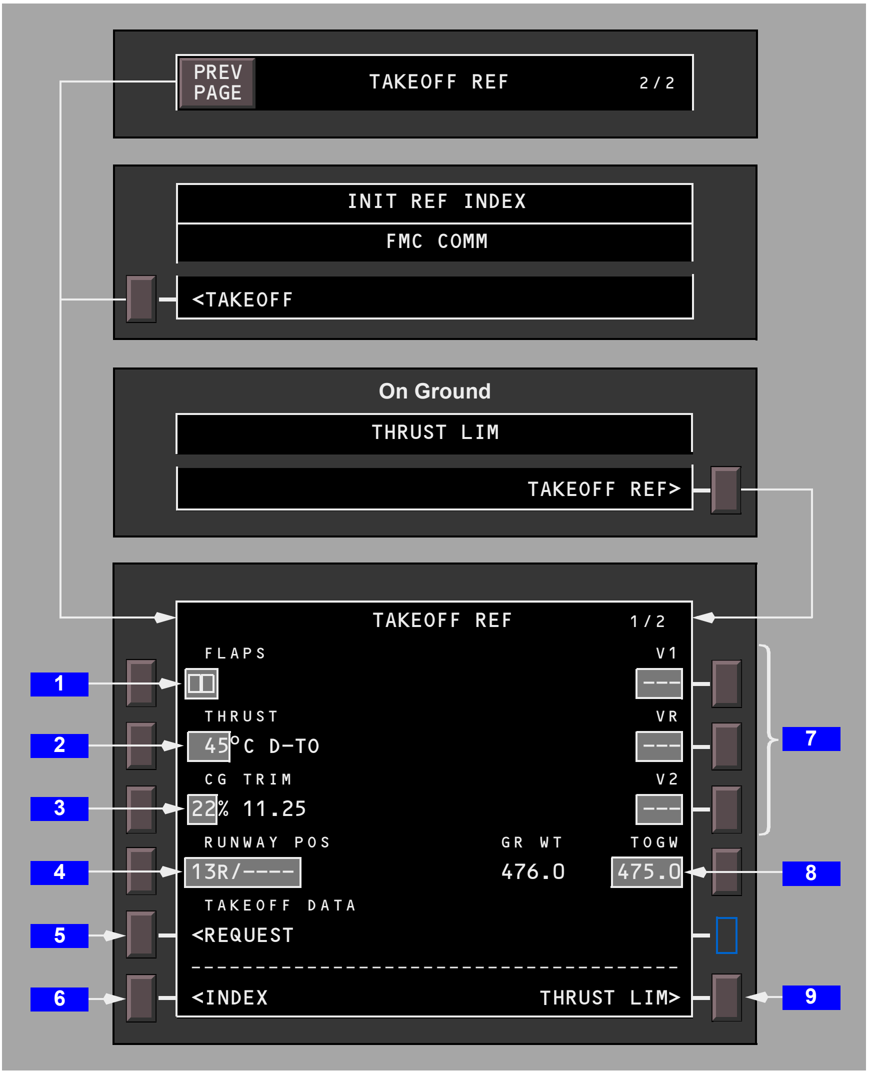
Push – displays the TAKEOFF REF page.

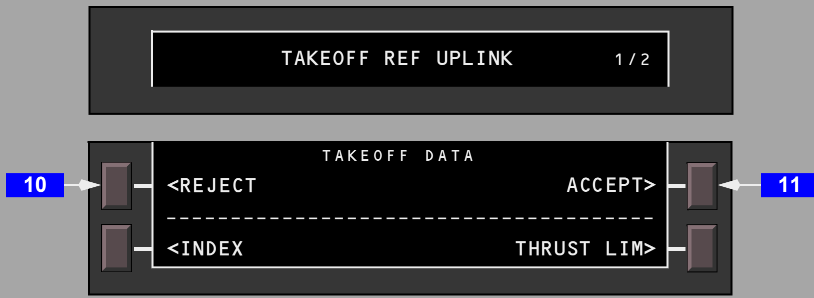
Takeoff Reference Page 1/2

The takeoff reference page allows the flight crew to manage takeoff performance. Takeoff flap setting and V speeds are entered and verified. Thrust limits, takeoff position, and takeoff gross weight can be verified or changed. Preflight completion status is annunciated until complete.

Takeoff reference page entries finish the normal preflight. The takeoff flap setting must be entered and V speeds should be set before completion.

[Option – English units]





CDU following line selection of REQUEST and receipt of TAKEOFF uplink pending ACCEPT/REJECT.

1 FLAPS

Displays takeoff flap setting. Valid entries are 5, 15, or 20.

Flight crew entry or uplink.

Entry of 5 when FLAPS 5 is the climb thrust reduction point displays the CDU help window message INVALID ENTRY.

Entry of a value after takeoff speeds have been accepted deletes takeoff speeds and displays the CDU help window message TAKEOFF SPEEDS DELETED.

2 THRUST

Displays takeoff thrust selected on THRUST LIM page, or flight crew or uplink entered assumed temperature for takeoff thrust derate calculations.

Entry is only allowed when the airplane is on the ground and dash prompts or large font temperature data is displayed.

Valid entries are 0 to 99 degrees C or 32 to 210 degrees F. Fahrenheit entries must be appended with an “F”.

Entry of a value after takeoff speeds have been accepted deletes takeoff speeds and displays the CDU help window message TAKEOFF SPEEDS DELETED.

3 Center of Gravity (CG), TRIM

Valid entry is CG within the valid range.

After CG entered, the FMC:

- calculates and displays the stabilizer takeoff setting to the right of the CG entry (trim display is in 0.25 unit increments)
- updates the takeoff green band displayed on stabilizer position indicator

4 Runway/Position (RWY/POS)

Displays the selected takeoff runway, and TO/GA push distance from the runway threshold or runway intersection identification.

Displays the takeoff runway from the active RTE page if previously selected. Runway entry does not change runway entered on RTE or DEPARTURES page.

Flight crew may enter or uplink runway and intersection data.

Valid entry of a runway intersection is an alphanumeric up to three characters, preceded by a slash (/).

[Option – Runway position shift, English units]

Valid position entry is a one or two numeric in the range 0-99. It must be followed by two zeros and preceded by a slash (preceding the entry with a "-"means a longer takeoff distance is available; for example, -0300 is 300 feet before the runway threshold).

Entry of a value after takeoff speeds have been accepted deletes takeoff speeds and displays the CDU help window message TAKEOFF SPEEDS DELETED.

RWY/POS update inhibited when GPS is primary FMC navigation source.

5 TAKEOFF DATA REQUEST

Push – transmits a company datalink request for takeoff data.

Flight crew can enter RWY, intersection or position shift, CG, TOGW, or OAT to qualify the request.

6 INDEX

Push – displays the INIT/REF INDEX page.

7 V Speeds (V1, VR, V2)

Dashes display when:

- required information not entered
- IRS not aligned

EFB calculated speeds display in small font. The takeoff data comes from the EFB performance page and is sent as an uplink to the FMC after the pilot initiates "Send to FMC" from the EFB.

Flight crew entered speeds display in large font and replace EFB uplinked or AOC uplinked speeds. The following applies to manually entered or accepted uplinked speeds:

- V1 speeds less than V1MIN are indicated by display of "MIN V1" in the header line and the value of V1MIN in the data line
- VR speeds less than V1MIN or VRMIN are indicated by display of "MIN" in the header line and the greater value of V1MIN or VRMIN in the data line
- V2 speeds less than V2MIN or V2MINA are indicated by display of "MIN" in the header line and the greater value of V2MIN or V2MINA in the data line

Push –

- crew entered V speeds replace EFB uplinked or AOC uplinked speeds

If performance data changes:

- existing speeds are replaced with dashes
- V speeds are removed from the PFD
- amber PFD speed tape message NO V SPD displays
- CDU help window message TAKEOFF SPEEDS DELETED displays

8 Gross Weight (GR WT), Takeoff Gross Weight (TOGW)

GR WT displays airplane gross weight from the PERF INIT page.

TOGW – entry of a TOGW followed by selection of the <REQUEST prompt transmits a request for an uplink of new takeoff data based on the entered TOGW.

Valid entry is any weight within the allowable airplane takeoff gross weight range.

Entry of a TOGW after takeoff speeds have been accepted deletes takeoff speeds and displays the CDU help window message TAKEOFF SPEEDS DELETED.

A takeoff uplink displays the uplinked TOGW and associated V speeds.

9 Thrust Limit (THRUST LIM)

Push – displays the THRUST LIM page.

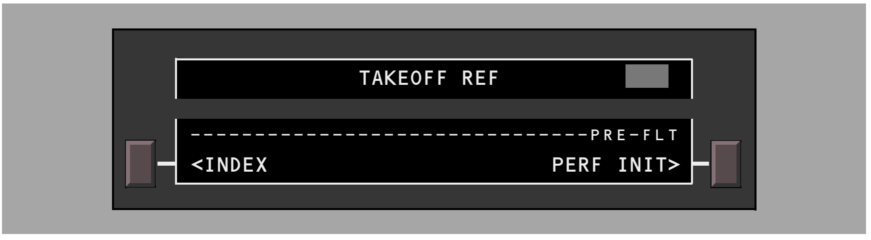
10 REJECT

Push – rejects the takeoff data uplink and returns the REQUEST prompt.

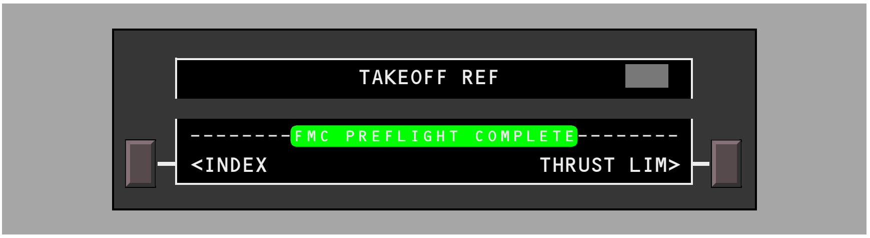
11 ACCEPT

Push – accepts the uplink takeoff data; all pending uplink values are treated as if entered by the flight crew.

Preflight Status



If the required preflight entries are not complete, the words PRE–FLT display on the right side of the dashed line. Preflight pages requiring entries display below the dashed line as prompts.

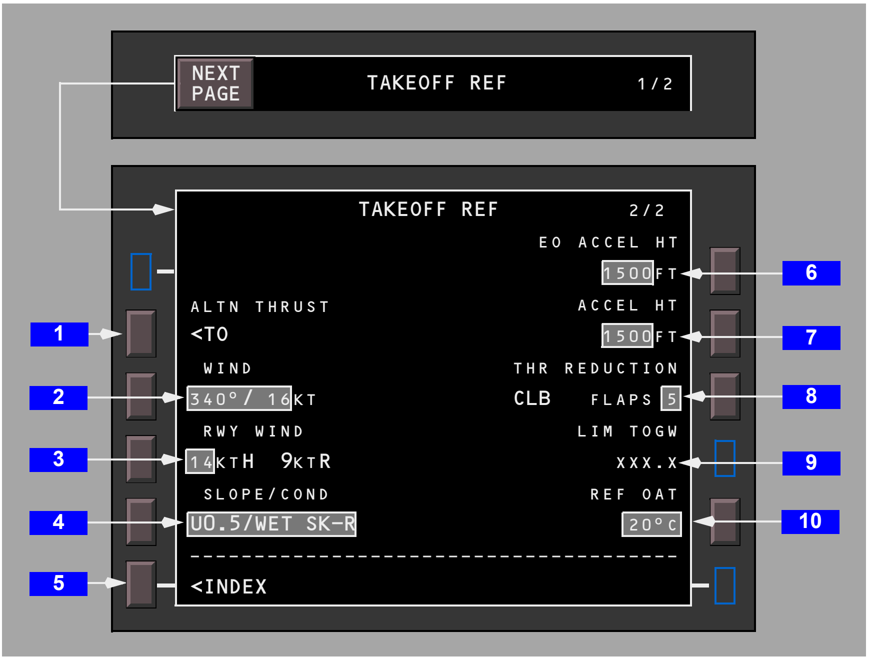


When preflight entries are complete, the line 6 header displays FMC PREFLIGHT COMPLETE in white letters on a green background. The THRUST LIM prompt displays at LSK 6R. The line 6 header FMC PREFLIGHT COMPLETE is also displayed on the PERF INIT and THRUST LIM pages.

Takeoff Reference Page 2/2

TAKEOFF REF 2/2 provides additional takeoff data and the ability to modify the climb profile. Preflight entries are required on page 2 before page 1 can be completed. Data may be entered by the aircrew or uplinked from either the company or EFB.

Note: Acceleration/thrust reduction heights are added to runway elevation causing acceleration/thrust reduction at the desired MSL altitude. For example, for a runway elevation of 980 feet, an entry of 2020 acceleration height causes acceleration at 3,000 feet MSL.



1 **Alternate Thrust (ALTN THRUST)**

Display is active if a TAKEOFF REF uplink has been accepted which includes alternate thrust data.

Line title may display:

- ALTN THRUST
- ALTN THR/FLAPS

[Option – T/O thrust derate]

Data may display temperature and:

- TO, TO/FLAPS
- TO 1, TO 1/FLAPS

- TO 2, TO 2/FLAPS
- yy° TO x (assumed temperature), yy° TO x/FLAPS

Push (with data on the line) – selects alternate thrust or alternate thrust/flaps for takeoff resulting in:

- the line title displays STD THRUST or STD THR/FLAPS
- the ACCEPT/REJECT prompt displays on the TAKEOFF REF page 1/2
- new takeoff data displays
- the EICAS •FMC message displays
- the CDU help window message TAKEOFF DATA LOADED displays

2 WIND

Displays uplinked surface wind direction and speed.

Wind direction and speed can be entered by the flight crew or uplink.

Valid directions are from 0 to 360 degrees. (0 and 360 are shown as 000).

Valid speeds are from 0 to 250 knots.

Subsequent entries may be wind direction or speed only.

Entry of wind direction/speed results in calculation and display of RWY WIND.

Entry or uplink of a value after takeoff speeds have been accepted deletes takeoff speeds and displays the CDU help window message TAKEOFF SPEEDS DELETED.

3 Runway Wind (RWY WIND)

Displays the calculated headwind/tailwind and crosswind components for the takeoff runway and surface wind.

Calculated values display in small font.

Speed displays in knots and:

- H for headwind
- T for tailwind
- R for right crosswind
- L for left crosswind

Flight crew entry is limited to headwind/tailwind entry.

Valid flight crew entries are a two digit number followed by H or T.

Flight crew speed entry without a letter defaults to a headwind component.

A flight crew entry clears the WIND line.

Entry results in display of the CDU help window message TAKEOFF SPEEDS DELETED.

4 Slope/Condition (SLOPE/COND)

Flight crew entered or uplinked data entry.

Valid runway slope is U for up or D for down followed by 0.0 through 2.0 in percent gradient.

Valid runway condition is “D” or “DRY” for dry, “W” or “WET” for wet or “S” or “WET SK-R” for a wet skid resistant runway.

Entry of a value displays the CDU help window message TAKEOFF SPEEDS DELETED.

5 **INDEX**

Push – displays the INIT/REF INDEX page.

6 **Engine Out Acceleration Height (EO ACCEL HT)**

Displays acceleration height for flap retraction with an engine out.

Default value is from the airline policy file.

Valid entry is a height from 400 to 9999 feet.

7 **Acceleration Height (ACCEL HT)**

Displays acceleration height for flap retraction.

Default value is from the airline policy file.

Entry is Optional. Valid entry is a height from 400 to 9999 feet.

8 **Climb Thrust and Thrust Reduction (THR REDUCTION) Altitude**

Displays armed climb thrust rating and the altitude for reduction from takeoff thrust to climb thrust. Default THR REDUCTION value is from the AIRLINE POLICY file.

Entry:

- is optional for preflight completion
- is a height from 400 to 9999 feet, or
- 1 for flaps 1 and 5 for flaps 5 (entry of 5 when FLAPS 5 is specified as the takeoff flap setting displays the CDU help window message INVALID ENTRY)

If a manual entry creates a situation in which thrust reduction and takeoff flaps are the same, the takeoff flap entry is automatically deleted and the CDU help window message TAKEOFF FLAPS DELETED is displayed.

9 **Limit Takeoff Gross Weight (LIM TOGW)**

Displays takeoff gross weight limit for the uplinked data. Manual entry not allowed.

Prefix ALT or STD is added to line title when alternate or standard takeoff data is pending.

10 **Reference Outside Air Temperature (REF OAT)**

A temperature value entered in this field is downlinked with other takeoff data if the takeoff data <REQUEST prompt on TAKEOFF REF 1/2 is selected.

Crew entry results in display of the CDU help window message TAKEOFF SPEEDS DELETED.

Flight crew entered or uplinked data entry.

Valid entries are -54 to 99 degrees C or -65 to 199 degrees F.

Entry is optional for preflight completion.

Flight Management, Navigation — Chapter 11
FMC Takeoff and Climb — Section 41

Introduction

The FMC takeoff phase starts with the selection of takeoff/go–around (TO/GA). Preparation for this phase starts in the preflight phase and includes entry of the TAKEOFF REF page data.

The takeoff phase changes to the climb phase when the FMC commands climb thrust. The climb phase continues to the top of climb point, where the cruise phase starts.

During takeoff and climb, the specific page listed below is used to:

- TAKEOFF REF page – make last minute changes to the departure runway
- DEPARTURES page – make last minute changes to the SID
- CLIMB page – modify climb parameters and monitor airplane climb performance
- RTE X LEGS page – modify the route and monitor route progress
- PROGRESS page – monitor the overall progress of the flight
- THRUST LIM page – select alternate climb thrust limits
- DEP/ARR INDEX page – select an approach during a turn–back

Takeoff

When changes are made to the departure runway and SID, the TAKEOFF REF and DEPARTURES pages must be modified to agree. The modified data are entered the same as during preflight.

With correct takeoff parameters, the FMC commands the selected takeoff thrust when the TO/GA switch is pushed. During the takeoff roll, the autothrottle commands the thrust and the FMC commands acceleration to between V2+15 and V2+25 knots, based on rate of rotation.

Usually, VNAV is armed before takeoff. When armed before takeoff, LNAV activates at 50 feet radio altitude and commands roll to fly the active route leg. VNAV activates at 400 feet above runway elevation and commands pitch to fly the climb profile.

Climb

At acceleration height or the first movement of the flap lever during flap retraction, VNAV commands acceleration to a speed 5 knots below the flap placard speed for the existing flap setting. When flaps are retracted, VNAV commands the speed displayed on the SPD TRANS line.

At the climb thrust reduction point, the FMC commands a reduction to the armed climb thrust. Passing the transition altitude displayed on the SPD TRANS line, VNAV commands an acceleration to the economy climb speed, which is maintained until entering the cruise phase. Waypoint speed constraints take priority, provided they are greater than VREF+80 or the transition speed.

During the climb, VNAV complies with the LEGS page waypoint altitude and speed constraints. A temporary level–off for a crossing altitude restriction is accomplished at the commanded speed. The commanded speed is magenta.

When the climb speed profile causes an anticipated violation of a waypoint altitude constraint, the FMC displays the CDU help window message UNABLE NEXT ALTITUDE. A different speed profile that gives a steeper climb angle must be manually selected.

Altitude Intervention

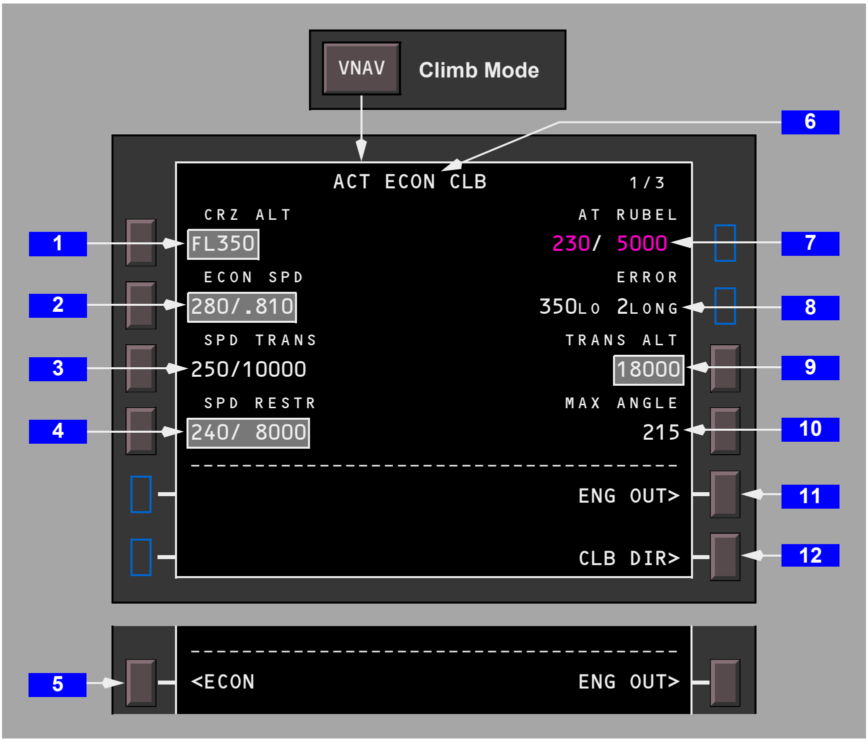
If an unplanned level-off is required, setting the altitude window to the required altitude causes the airplane to level at the set altitude. VNAV SPD changes to VNAV ALT. The climb can be continued by setting the altitude window to a higher altitude and pushing the altitude selector. If the altitude window is set to an altitude above other altitude constraints, each altitude constraint can be deleted by each push of the altitude selector. If cruise altitude is set in the altitude window, all waypoint altitude climb constraints to the T/C can be deleted by selection of the CLB DIR> prompt on the CLB page.

Climb Page

The climb page is used to evaluate, monitor, and modify the climb path. The data on the climb page comes from preflight entries made on the route and performance pages, and from the airline policy file.

The climb page is the first of the three pages selected with the VNAV function key. When the FMC changes to the cruise mode, the climb page data is blanked.

FMC climb can be economy, fixed speed, or engine out.



1 Cruise Altitude (CRZ ALT)

Displays cruise altitude entered on PERF INIT page.

Valid entries are: XXX, XXXX, XXXXX, or FLXXX. Altitude displays in feet or flight level depending on transition altitude.

The altitude can be changed by two methods:

- a new cruise altitude can be manually entered from the CDU at any time. The modified cruise altitude displays in shaded white until executed
- a new cruise altitude can be entered from the MCP, if intermediate altitude constraints do not exist between the airplane altitude and the MCP altitude. Set cruise altitude in the altitude window and push the altitude selector. The cruise altitude changes without modification or execution

2 Economy Speed (ECON SPD), Selected Speed (SEL SPD)

ECON SPD:

- speed based on cost index in CAS or Mach
- used by FMC at altitudes above all waypoint speed constraints, speed restrictions, and speed transition altitudes

Valid entries are CAS or Mach.

SEL SPD:

- displays when intermediate level off required below an existing speed constraint
- displays when flight crew enters speed

Valid entries are CAS or Mach.

The FMC commanded speed is magenta. Below CAS/Mach transition altitude, CAS is magenta and Mach is white. Above CAS/Mach transition altitude, Mach is magenta and CAS is white.

3 Speed Transition (SPD TRANS)

The speed transition line displays the transition speed/altitude from one of these sources:

- the navigation database value for the origin airport
- the value specified from the airline policy page
- the greater of the transition speed associated with the origin airport or VREF+80 knots (example 250/10000)

Magenta when it is FMC command speed.

Not displayed above transition.

Can be deleted.

4 Speed Restriction (SPD RESTR)

Speed restrictions for an altitude less than the cruise altitude are manually entered on this line.

Dashes before entry by flight crew.

Valid entry is a CAS and altitude (example 240/8000).

An entry creates a modification. Entry is shaded white until executed; magenta when it is FMC command speed.

5 Economy (ECON)

Push – changes climb speed to ECON. Must be executed.

Prompt displays when the climb speed is not ECON.

6 Page Title

The page title displays the type of climb:

- ECON – speed based on a cost index
- LIM SPD – speed based on airplane configuration limiting speed
- MCP SPD – MCP speed intervention selected
- EO – engine out mode selected
- VREF+80 – engine failure detected during the takeoff portion of the climb
- XXXKT – fixed CAS climb speed profile
- M.XXX – fixed Mach climb speed profile
- ACT – displays prefix when climb phase active
- MOD – displays prefix in shaded white text when a modification is pending

Fixed climb speeds are for:

- takeoff/climb acceleration segment constraints
- waypoint speed constraints
- a speed constraint associated with an altitude
- a speed transition
- a flight crew selected speed (SEL SPD)

7 Waypoint Constraint (AT XXXXX)

Displays altitude or airspeed/altitude constraint at waypoint XXXXX.

Can also display HOLD AT XXXXX followed by a speed/altitude constraint.

FMC commands the slower of constraint speed or performance speed.

Constraints are entered on RTE LEGS page.

Delete here or on RTE LEGS page.

Blank if no constraint exists.

Magenta when it is FMC command speed or altitude.

8 ERROR at Waypoint

Displays altitude discrepancy and distance past waypoint where altitude will be reached.

Blank if no error exists.

9 Transition Altitude (TRANS ALT)

Transition altitude for origin airport contained in navigation database. FMC uses 18,000 feet if transition altitude is not available.

Manually change transition altitude here or on DESCENT FORECAST page.

Valid entries are XXX, XXXX, XXXXX, or FLXXX.

CDU altitude data change from altitudes to flight levels above the transition altitude.

10 Maximum Angle (MAX ANGLE)

Displays maximum angle of climb speed.

Push – displays speed in the scratchpad for pilot selection to the speed line.

11 Engine Out (ENG OUT)

Push (below speed transition or restriction altitude) –

- displays MOD EO CLB page
- deletes climb speed transition or restriction data

Push (below engine-out maximum altitude) – displays MOD EO CLB page.

Push (above engine-out maximum altitude) –

- displays MOD EO D/D or MOD EO LRC D/D page
- cruise altitude (1L) lowered to engine-out maximum altitude if that altitude is less than the active cruise altitude

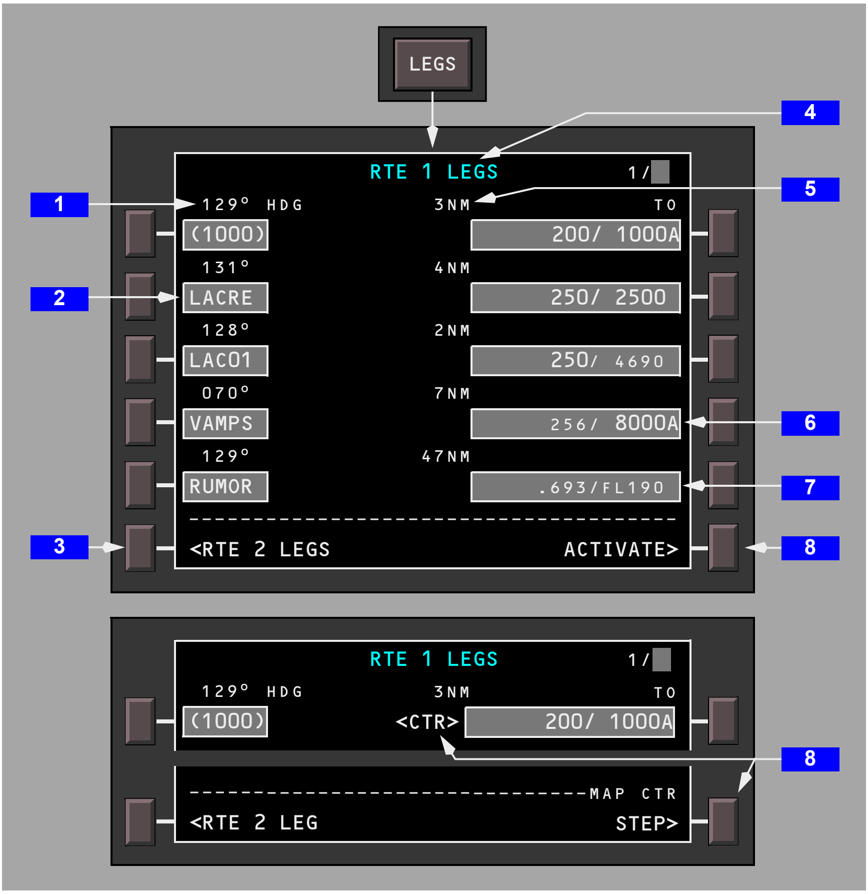
Shaded white until the modification executed. Upon execution, thrust reference limit becomes CON in all cases above.

12 Climb Direct (CLB DIR)

Displays when climb altitude constraint exists between current altitude and FMC cruise altitude.

Push – deletes all waypoint altitude constraints between the airplane altitude and the MCP altitude or FMC cruise altitude, whichever is lower. FMC cruise altitude is not affected.

RTE X LEGS Page



1 Leg Direction

Leg segment data in line title:

- courses – magnetic (xxx°) or true (xxx° T)
- arcs – distance in miles, ARC, turn direction (example: 24 ARC L)
- heading leg segments – xxx° HDG or xxx° THDG (when referenced to true north)
- track leg segments – xxx° TRK or xxx° TTRK (when referenced to true north)
- special procedural instructions from database - HOLD AT, PROC TURN, or PROC HOLD (FMC exits hold when crossing the fix after entry)

Calculated great circle route leg directions may be different than chart values.

Dashes display for an undefined course.

2 Waypoint Identifier

Active leg is always the first line of the first active RTE X LEGS page.

Active waypoint is on active leg and is magenta. Modified waypoints are shaded white until executed.

All route waypoints display in flight sequence. Waypoints on an airway are included on the route legs page.

Waypoints can be modified. Examples:

- add waypoints
- delete waypoints
- change waypoint sequence
- connect route discontinuities

Displays the waypoint by name or condition.

Boxes display for route discontinuities.

Dashes display after the end of the route.

3 Route 2 Legs (RTE 2 LEGS)

Push –

- displays the RTE 2 LEGS
- when RTE 2 LEGS page displayed, prompt changes to RTE 1 LEGS

4 Page Title

Title format displays route status:

- RTE X LEGS (cyan) – inactive route
- ACT RTE X LEGS (white) – active route
- MOD (shaded white) RTE X LEGS (white) – modified active route

5 Distance to Waypoint

Distance (decreasing) from airplane to active waypoint or from waypoint to waypoint. Blank for some leg types (e.g. HDG or VECTORS).

6 Waypoint Speed/Altitude Constraints

Waypoint speed or altitude constraints display in large font.

Manual entry allowed in climb or descent phase. Entered by FMC when constraints are part of a procedure.

Magenta when it is an FMC commanded speed/altitude. Airspeed constraint may be magenta in one line with magenta altitude in another line.

Speed constraint is assumed to be at or below the displayed speed.

Valid entries are:

- speed entry can be airspeed or Mach
- altitude entry can be thousands of feet or flight level (19000, FL190)
- XXX/XXXXX – airspeed/altitude entered simultaneously

- XXX, XXXX, XXXXX or /XXX, /XXXX, /XXXXX– altitude only.
- enter FL 190 or 19,000 feet as 190 or 19000. Enter FL090 or 9,000 feet as 090 or 9000. Enter 900 feet as 009 or 0900. Enter 90 feet as 0090

Altitude constraint suffixes:

- blank – cross at altitude
- A – cross at or above altitude
- B – cross at or below altitude
- both – altitude block. If constraint is to cross between two altitudes when climbing, enter lower altitude followed by "A"; then, enter higher altitude followed by "B". Example: 220A240B. Reverse the order for descent
- S – planned step climb. (Refer to Planned Step Climb in Chapter 11, Section 42, for additional information)

7 Waypoint Speed/Altitude Predictions

Waypoint speed and altitude predictions display in small font.

Dashes display in predicted descent region prior to descent path calculation. Descent path calculation requires an altitude constraint below cruise altitude.

Manual entry allowed in climb or descent phase.

8 ACTIVATE, Route (RTE) DATA

Push –

- ACTIVATE – activates inactive flight plan; displays RTE DATA prompt
- RTE DATA – displays route data page
- MAP CTR STEP (map center step)– changes centered waypoint on ND. <CTR> is adjacent centered waypoint on the RTE LEGS page

ACTIVATE prompt displays when RTE and RTE LEGS flight plan is inactive.

RTE DATA displays after ACTIVATE prompt pushed.

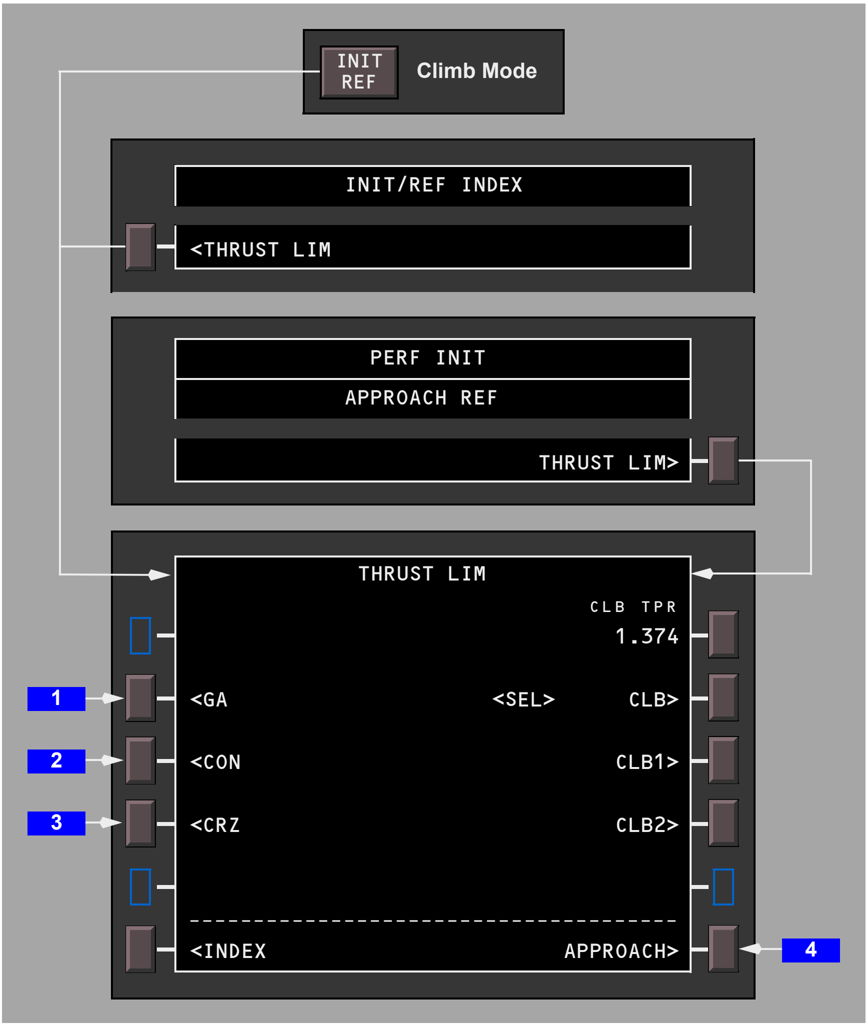
MAP CTR STEP prompt displays when the PLAN is selected on the map display.

Thrust Limit Page

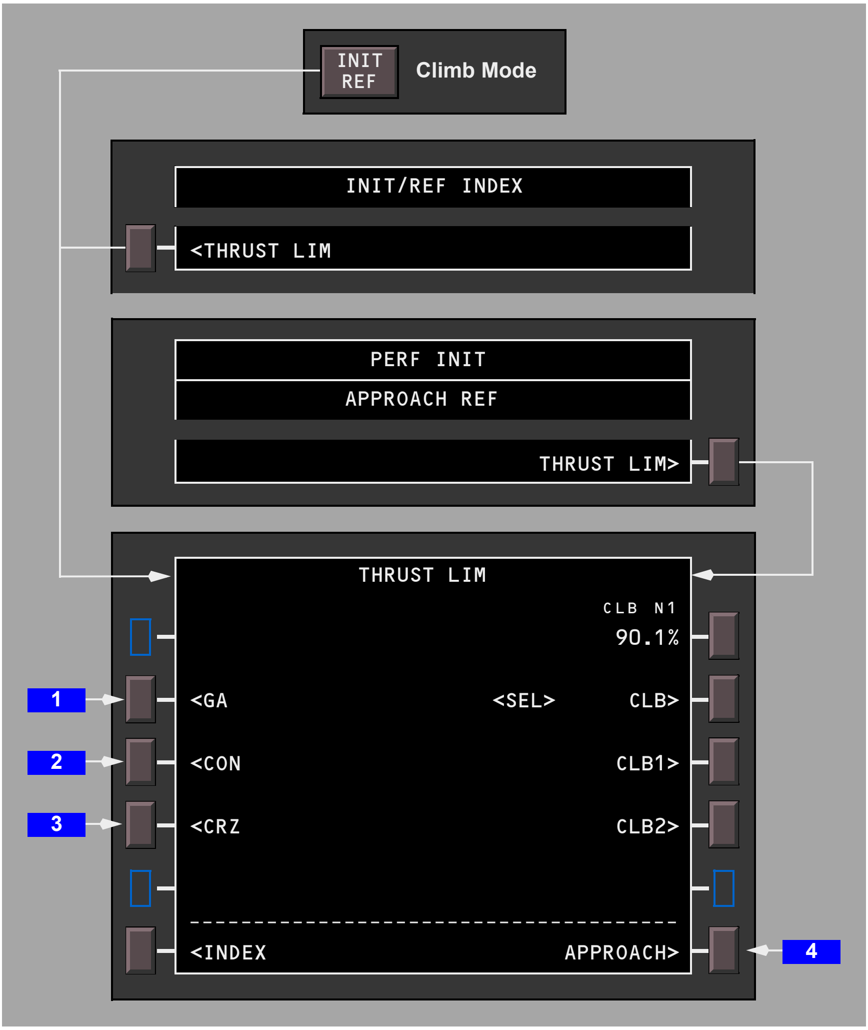
Thrust limits are selected on the thrust limit page. In flight, this display replaces the takeoff thrust limits with applicable thrust limits for climb. The selected limits display here and on the EICAS display.

Fixed thrust derates can be selected for climb. Go-around, continuous and cruise thrust limits are available also.

[Option – RR engines, Climb thrust derate]



[Option – GE engines, Climb thrust derate]



1 **Go–Around (GA)**

Push – selects go–around thrust limit.

2 **Continuous (CON)**

Push – selects maximum continuous thrust limit.

3 **Cruise (CRZ)**

Push – selects cruise thrust limit.

4 APPROACH

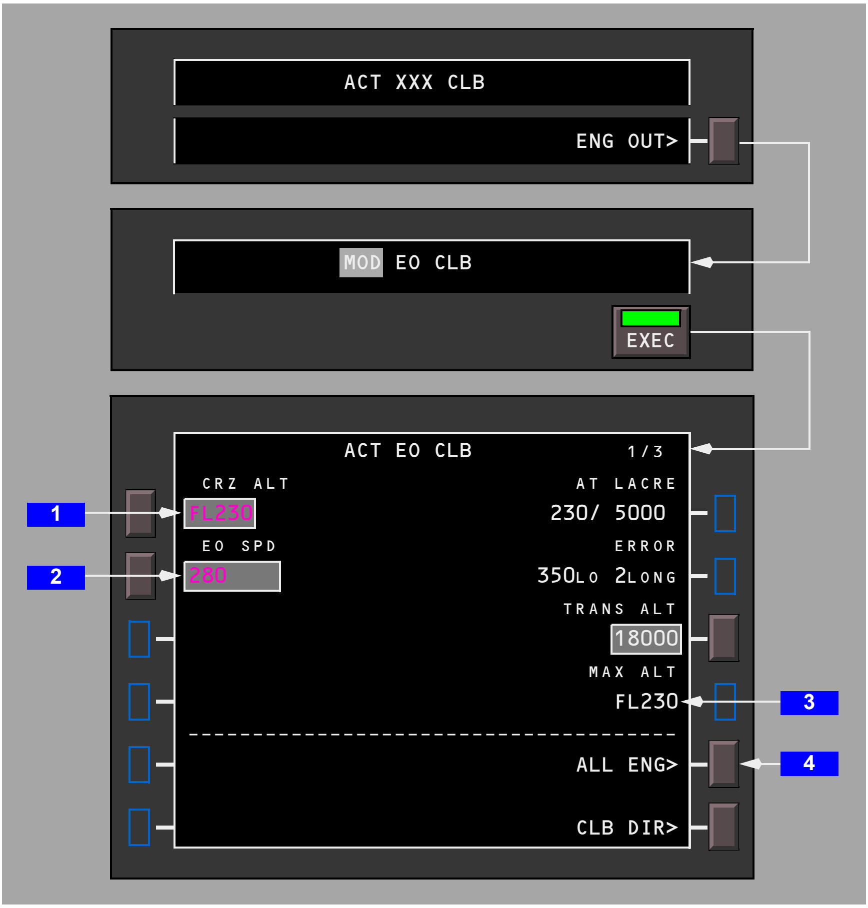
Push – displays APPROACH REF page.

Engine Out Climb

Engine out (EO) VNAV climb guidance is available on the EO CLB page. The EO CLB page must be selected and executed by the flight crew. Engine out data is available with both engines operating. The engine out climb phase changes to the engine out cruise phase at the top of climb.

EO CLB Page

The modified page displays engine out performance limitations. Manual entries are allowed. After execution, VNAV gives EO guidance in the climb and reference thrust limit changes to CON.



1 Cruise Altitude (CRZ ALT)

Displays cruise altitude if less than MAX ALT.

Displays MAX ALT if less than cruise altitude.

Manual entry is allowed.

2 **Engine Out Speed (EO SPD)**

Displays engine out climb speed.

Valid entry is XXX for CAS.

Valid entry is 0.XXX for Mach. Trailing zeros can be omitted.

A manual entry may cause MAX ALT to change.

3 **Maximum Altitude (MAX ALT)**

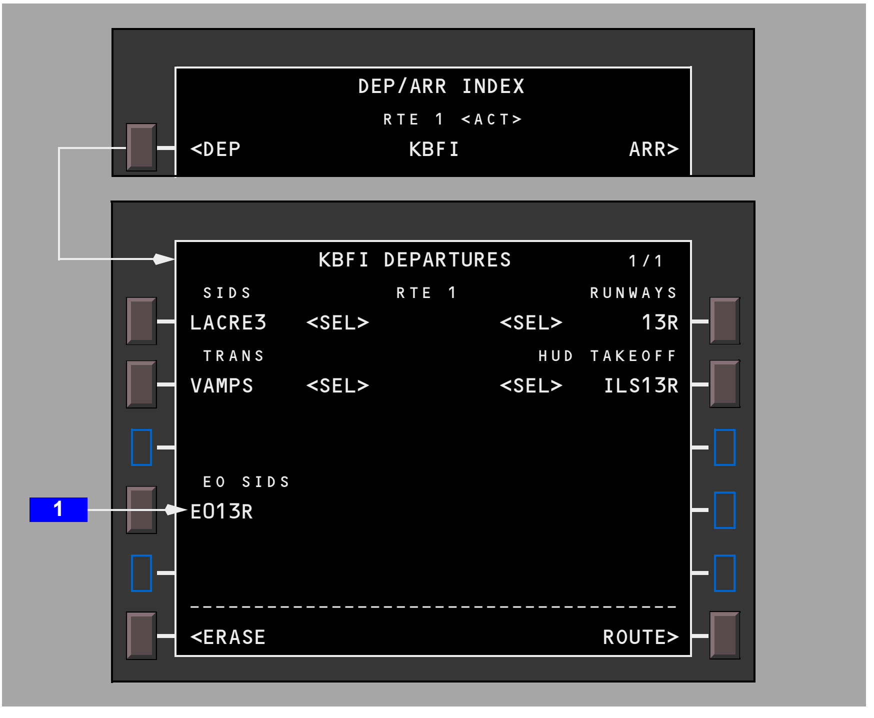
Displays lower of maximum altitude at engine out climb speed or cruise speed.

Entry not allowed.

4 **ALL ENG**

Push – modifies page to display all engine (ALL ENG) performance data.

Engine Out Departure



1 **Engine Out Standard Instrument Departure (EO SID)**

Engine out SIDs can be created by the airline for specific runways.

The FMC puts the EO SID into the route as a modification if:

- an engine failure is sensed
- flaps extended
- and the navigation database has an EO SID for the departure runway

The modification can be executed or erased.

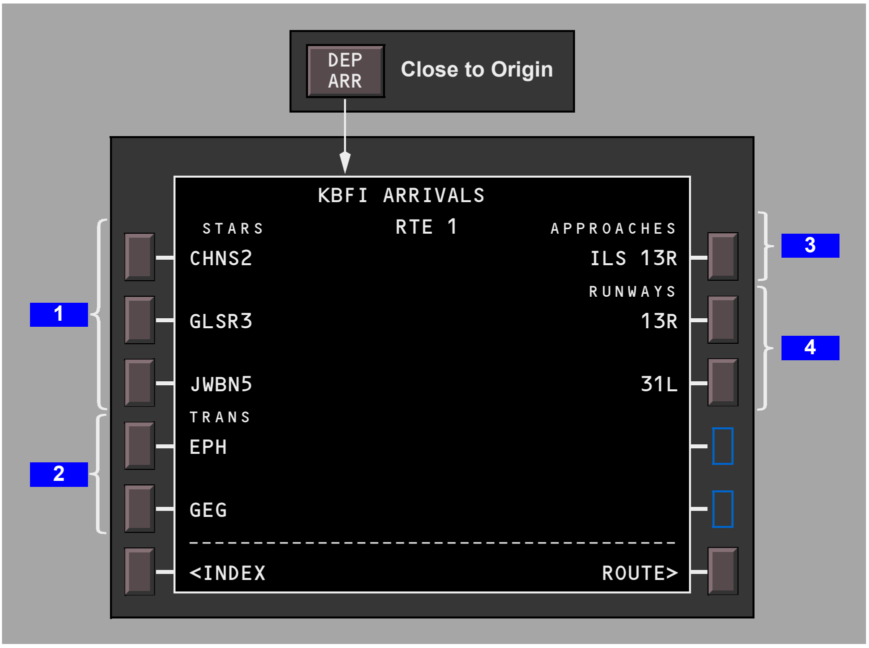
-NONE- is displayed if no EO SID exists.

Air Turnback

Arrivals Page

During a turn–back situation, the flight crew requires quick access to the arrivals data for the origin airport. The arrivals page allows access without changing the destination on the route page.

During climb, less than 400 miles from the origin, and while nearer to the origin than the destination, push the DEP ARR function key to show the ARRIVALS page for the origin airport.



1 **STARS**

Displays STARS for origin airport.

2 **Transitions (TRANS)**

Displays transitions for origin airport.

3 **APPROACHES**

Displays approaches for origin airport.

4 **RUNWAYS**

Displays runways for origin airport.

Introduction

The cruise phase starts at the top of climb.

During cruise, the primary FMC pages are:

- RTE X LEGS
- CRZ
- PROGRESS

The RTE LEGS pages are used to modify the route. The CRZ pages display VNAV related data. The PROGRESS pages display flight progress data. During cruise, the specific page listed below is used to:

- POS REF page – verify the FMC position
- RTE DATA page – display progress data for each waypoint on the RTE LEGS page
- WINDS page – enter forecast wind and temperature
- REF NAV DATA page – display data about waypoints, navaids, airports, or runways, and can be used to inhibit navaids
- RTE X page – use to select a route offset
- FIX INFO page – display data about waypoints. Page data can be transferred to other pages to create new waypoints and fixes
- SELECT DESIRED WAYPOINT page – shows a list of duplicate waypoints from the navigation database. The flight crew selects the correct waypoint from the list
- POS REPORT page – display data for a position report

The CLB page changes to CRZ at the top of climb. The CRZ CLB and CRZ DES pages change to CRZ at the new cruise altitude. The CRZ page changes to DES at top of descent.

LNAV Modifications

This section describes typical techniques to modify the route. The modifications include:

- add and delete waypoints
- change waypoint's sequence
- remove discontinuities
- intercept a course

RTE LEGS Page Modifications

When modifications are made to a RTE LEGS page, several prompt or identifying features help the flight crew make the modifications, such as:

- ERASE
- INTC CRS TO
- INTC CRS FROM

Modified entries display in shaded white.

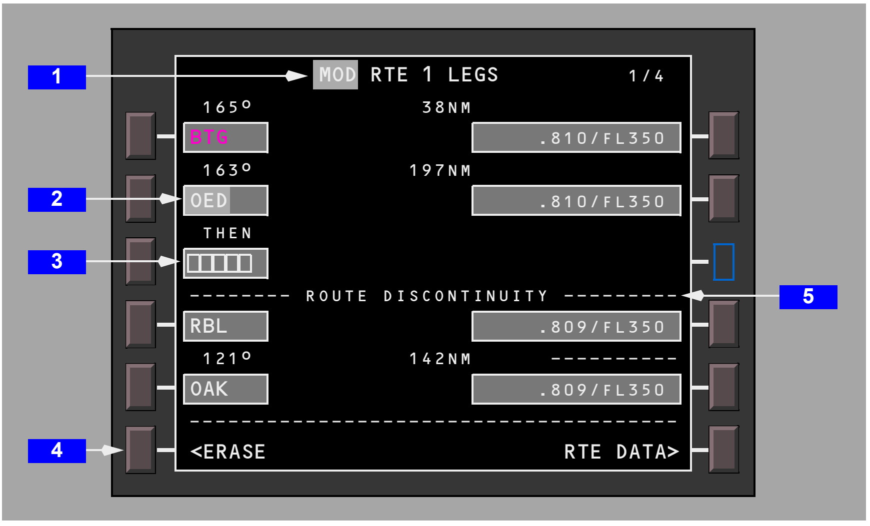
Add Waypoints

Waypoints can be added to the route at any point. Added waypoints are followed by route discontinuities.

First, enter the waypoint name in the scratchpad.

Second, locate the desired line in the flight plan and push the adjacent line select key. The scratchpad waypoint name is put into the selected line. The entered waypoint is connected to the waypoint above it via a direct route. A route discontinuity follows the waypoint.

For example, OED is typed into the scratchpad. Push line select key 2L to put OED into line 2. The FMC assumes BTG direct OED. RBL and the rest of the flight plan follow the route discontinuity.



1 Page Title

MOD (shaded white) – replaces ACT when modification in progress.

ACT (white) – replaces MOD when ERASE selected or execute key pushed.

2 **Modified Waypoint**

Waypoint name is shaded white until executed.

OED waypoint entered into the route after BTG. Modification creates a route discontinuity because OED was not in active route. The FMC now requires routing beyond OED.

3 **Discontinuity Waypoint**

Discontinuity is removed when applicable waypoint is entered in boxes.

4 **ERASE**

Push – removes all modifications and shows active data.

Displays when the FMC contains modified data.

Removed when selected or modifications executed.

5 **ROUTE DISCONTINUITY**

Line title separates route segments when there is a discontinuity.

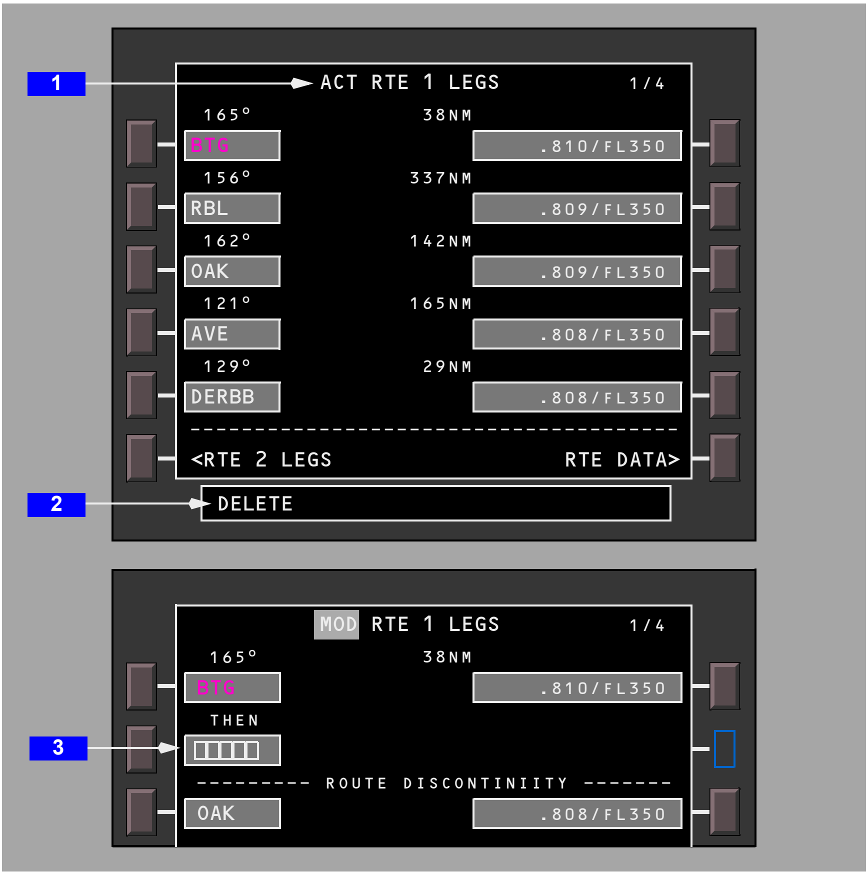
Note: Performance predictions to destination on the PROGRESS page are calculated assuming the route of flight is direct between waypoints on either side of a route discontinuity.

Delete Waypoints

Use the RTE LEGS page to remove waypoints from the route. The active waypoint can not be deleted. Two methods to remove a waypoint are:

- delete the waypoint with the DELETE function key
- change the waypoint’s sequence

The data in the route before and after the deleted waypoint does not change. A discontinuity is put in the route when the DELETE function key is used to remove a waypoint.



1 Active Route

The active route shows RBL followed by OAK and AVE.

2 DELETE Entry

Pushing the DEL function key arms the delete function and selects DELETE to the scratchpad.

3 Route Discontinuity

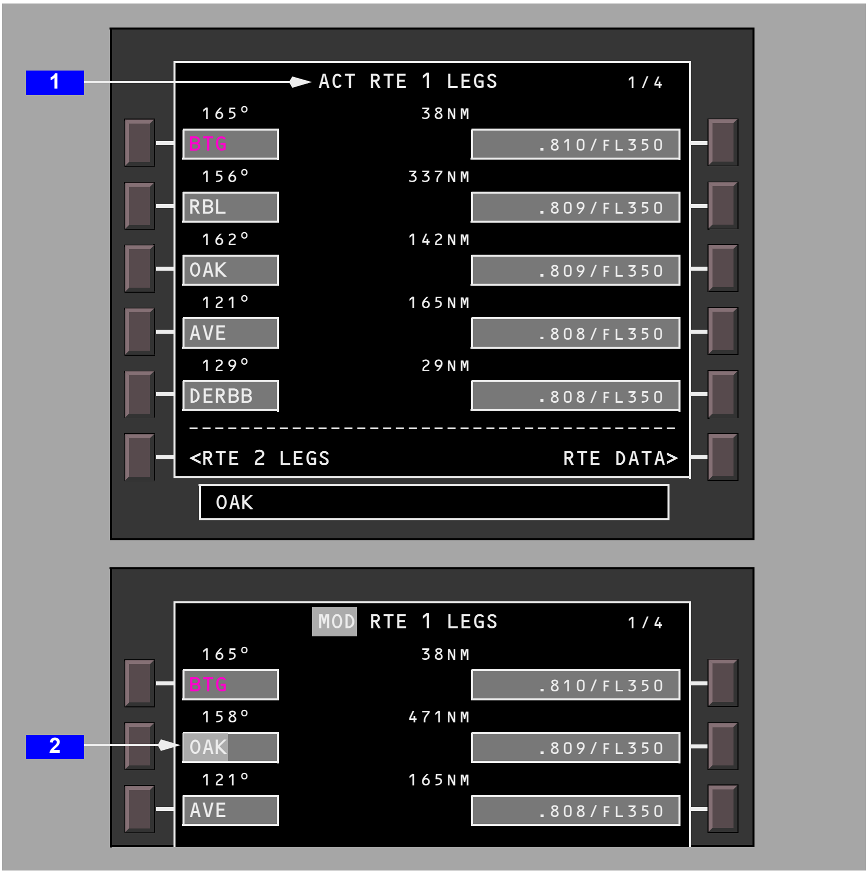
With DELETE in the scratchpad, pushing the line select key for RBL deletes the waypoint. Boxes replace RBL and a route discontinuity displays.

Change Waypoint Sequence

Waypoints moved from one position in the flight plan to another do not cause route discontinuities.

The waypoint may be typed in the scratchpad or copied from the flight plan. To copy a waypoint from the flight plan, find the applicable waypoint on one of the RTE LEGS pages. Push the line select key adjacent to the waypoint.

The example below shows the flight plan being modified to fly from BTG direct OAK. Push the line select key adjacent to OAK to put OAK in the scratchpad. Push the line select key adjacent to RBL. RBL is removed from the flight plan and the routing is direct from BTG to OAK to AVE. The modification does not cause a route discontinuity. Several waypoints can be removed from the flight plan at a time with this method.



1 **Active Route**

The active route shows RBL followed by OAK and AVE. The clearance is to fly from BTG direct OAK. The OAK waypoint is selected to the scratchpad.

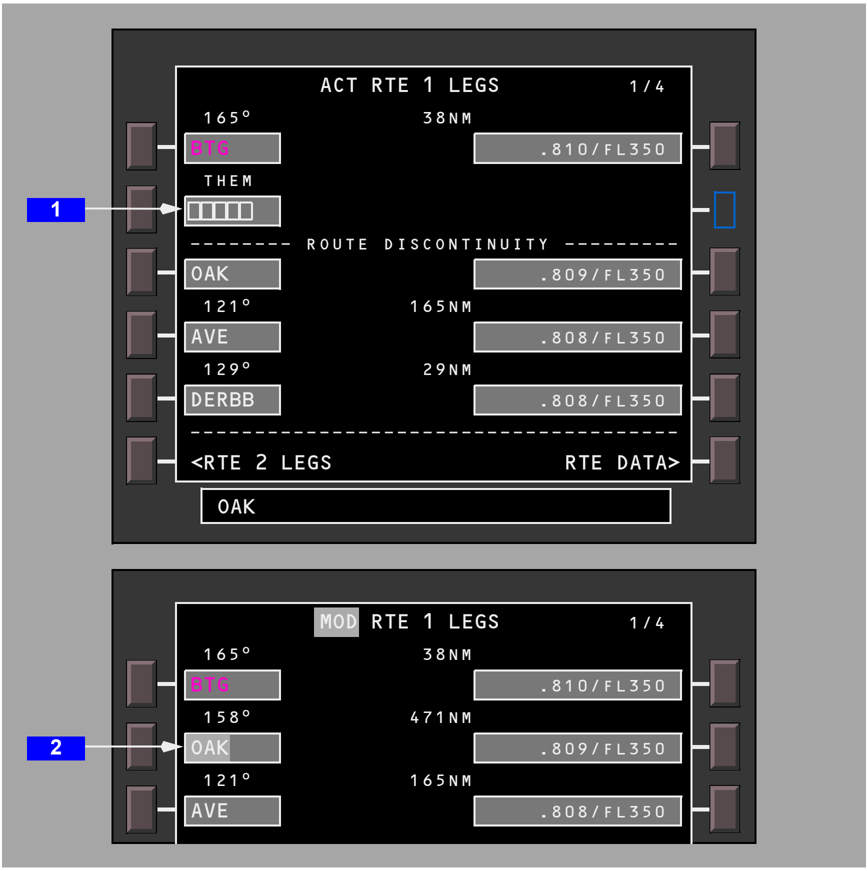
2 **Change OAK's Sequence**

OAK is selected to the waypoint after BTG. RBL is removed with no discontinuity.

Remove Discontinuities

A discontinuity exists when two waypoints are not connected by a route segment. Connect a route segment after the discontinuity to the route segment before the discontinuity to remove the discontinuity.

Copy the subsequent waypoint from the route into the scratchpad and enter it into the discontinuity, just as when adding a waypoint.



1 **Route Discontinuity**

The active route has a discontinuity after BTG. The example shows how to fly direct from BTG to OAK. Copy OAK to the scratchpad. Any subsequent waypoint in the route can be selected to the scratchpad to remove the discontinuity.

2 **Continuous Route**

Select OAK to the boxes to remove the discontinuity.

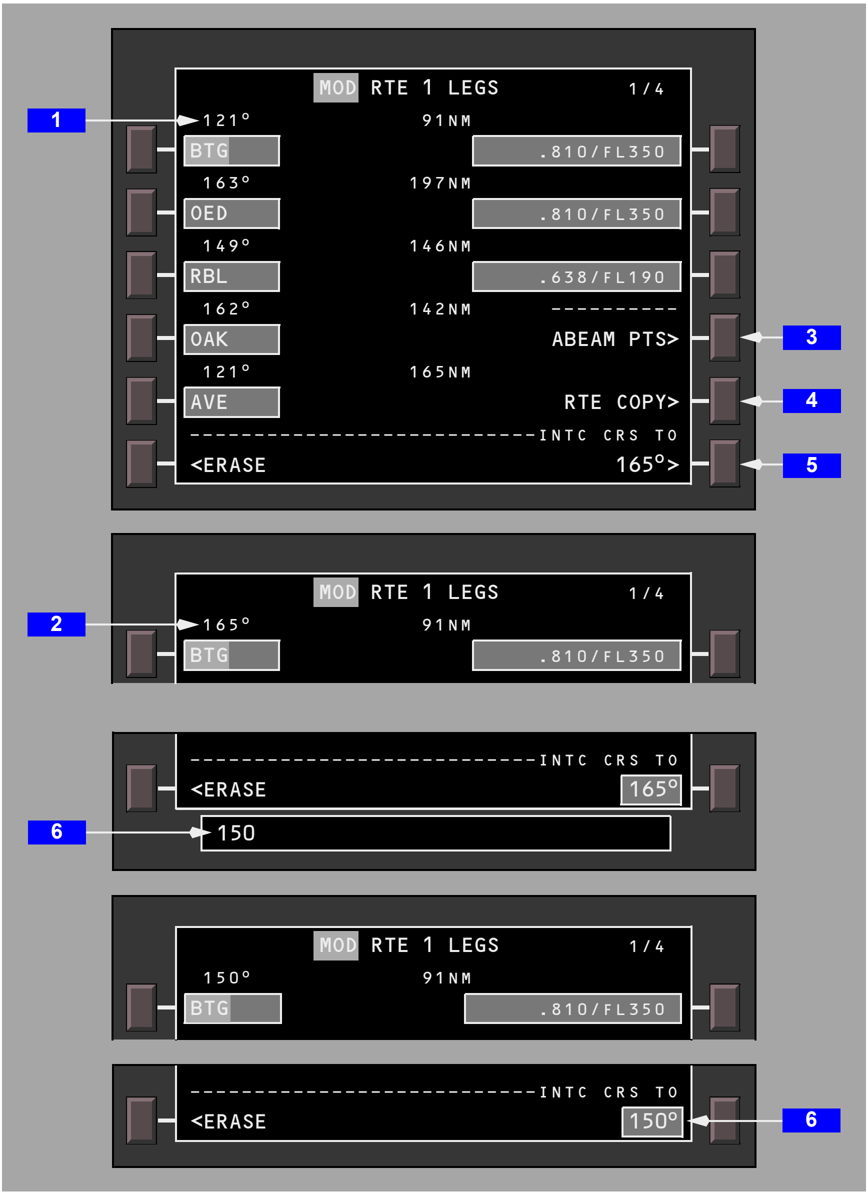
Entering a waypoint in the boxes which does not already exist on the route moves the discontinuity one waypoint further down the route.

Direct To And Intercept Course To

If the airplane passes the last active route waypoint (or offset) or the last waypoint prior to a route discontinuity, LNAV maintains the current heading. The EICAS message FMC INTERCEPT HDG is displayed. If LNAV is not active, activation can be accomplished in the following three ways:

- when the airplane is within 2.5 miles of the active leg and on an intercept heading to the active leg, pushing the LNAV switch activates LNAV. The airplane turns to intercept the active leg. If the intercept angle is large, the airplane may overshoot the active leg
- when more than 2.5 miles from the active leg, pushing the LNAV switch when the airplane is on an intercept heading to the active leg arms LNAV and displays the intercept path on the ND map. Activation occurs as necessary to intercept the active leg with no overshoot. The intercept heading must intersect the active leg inbound before the active waypoint
- fly direct to a waypoint or intercept a course to a waypoint. Enter a waypoint in the RTE LEGS page active waypoint line to fly direct. Use the INTC CRS TO prompt in line 6R to create an intercept course to the waypoint. Pushing the LNAV switch arms or activates LNAV, depending on the distance to the active leg

The example below depicts the airplane being off course to the right, followed by a modification to fly direct to BTG..



1 **Leg Direction**

Direct course from airplane present position to entered waypoint.

Execute to proceed direct to active waypoint.

2 **Intercept Course**

After pushing INTC CRS TO and prior to execution, displays direct–to inbound course at the waypoint; changed by entry in intercept course to (INTC CRS TO) line or by selecting intercept course to. After execution, displays current required track to fly inbound course to the waypoint.

3 **Abeam Points (ABEAM PTS)**

Push –

- creates place bearing distance waypoint on the Direct To leg abeam the bypassed waypoint if the bypassed waypoint was a database airport, navaid, NDB, or waypoint
- creates latitude/longitude waypoint on the Direct To leg abeam the bypassed waypoint if the bypassed waypoint was a latitude/longitude waypoint
- creates a new place bearing distance waypoint based on the original "place" on the Direct To leg abeam the bypassed waypoint if the bypassed waypoint was a place bearing distance waypoint
- creates a new latitude/longitude reporting point on the Direct To leg based on the entered latitude or longitude reporting point
- line title displays ABEAM PTS and line data displays SELECTED
- altitude/speed constraints for bypassed waypoints are removed

ABEAM PTS prompt displays whenever the active waypoint name is modified, usually for direct–to routing.

4 **Route Copy (RTE COPY)**

Push –

- copies the active route into the inactive route
- erases previous inactive route
- line title displays RTE COPY and line data displays COMPLETE
- subsequent route modifications remove RTE COPY prompt

5 **Intercept Course TO (INTC CRS TO) – Select**

Displays whenever the active waypoint name is modified.

Displays boxes if entered waypoint not in the active route.

Displays current route course and prompt caret if entered waypoint in the active route.

When boxes displayed, valid entry is intercept course from 000° through 360°. May be changed until executed. Entered or selected value displays in large font.

Push –

- when current route course (165°) displayed, selects it as intercept course to active waypoint
- displays entry or current route course as course to active waypoint
- removes ABEAM PTS and RTE COPY prompts

6 Intercept Course TO (INTC CRS TO)

To change intercept course:

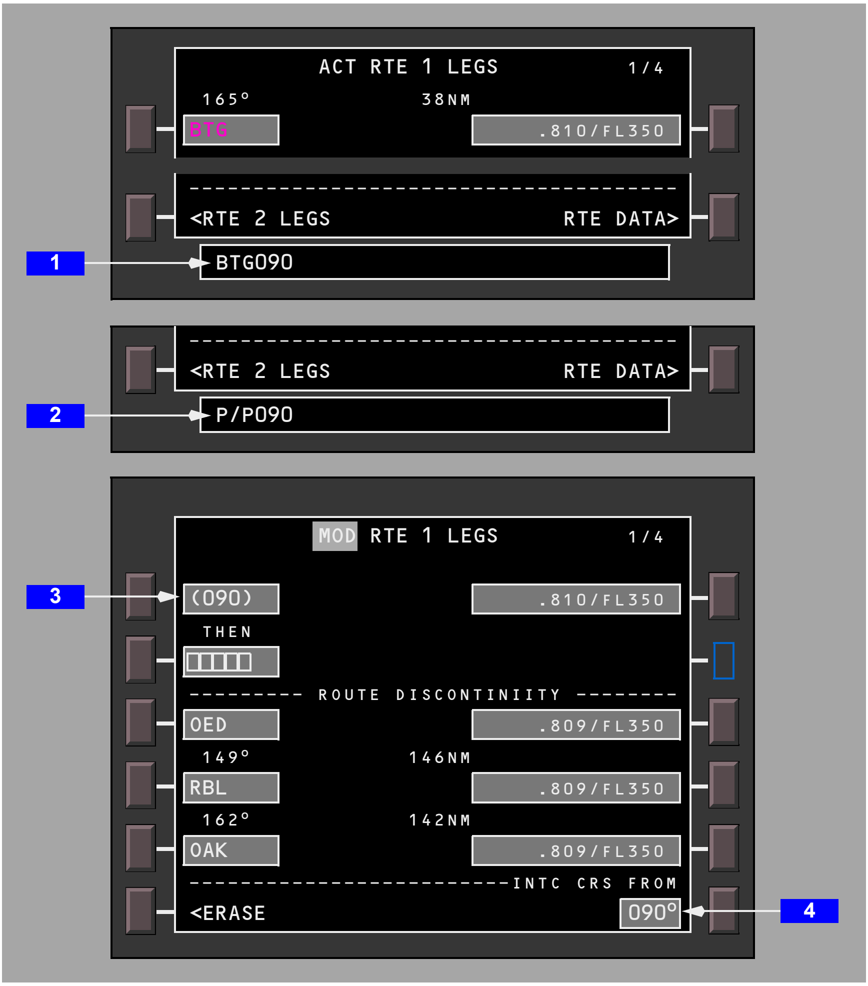
- enter the inbound intercept course (150°) in the scratchpad
- select the INTC CRS TO line to change the leg direction; intercept course to BTG of 150° is entered in the INTC CRS TO line and above the active waypoint

Intercept Course From

The steps to create an intercept course from a waypoint are like the steps for an intercept course to. The waypoint name in the scratchpad is suffixed with the outbound course.

An intercept course can be created outbound from a waypoint in the navigation database or from present position. The waypoint does not have to be in the route. Entering a waypoint and course pair in the active waypoint line displays the INTC CRS FROM prompt. The FMC calculates a route leg with the waypoint as the origin of the entered course.

The example shows a 090° course from BTG, entered as BTG090. When this course intercept is line selected to the active waypoint line, the course (090°) displays in the leg direction and the waypoint displays as a conditional waypoint consisting of a course intercept (090°).



1 **Waypoint and Outbound Course**

Enter the waypoint name and outbound course in the scratchpad.

2 **Present Position and Outbound Course**

Enter P/P and outbound course in the scratchpad.

3 **Active Outbound Course Entry**

After the active waypoint line is selected, the outbound course displays. The waypoint name is not used.

For example, BTG090 is entered into the active waypoint line. The FMC calculates a new route leg with BTG as the origin on a outbound course of 090°.

4 **Intercept Course From (INTC CRS FROM)**

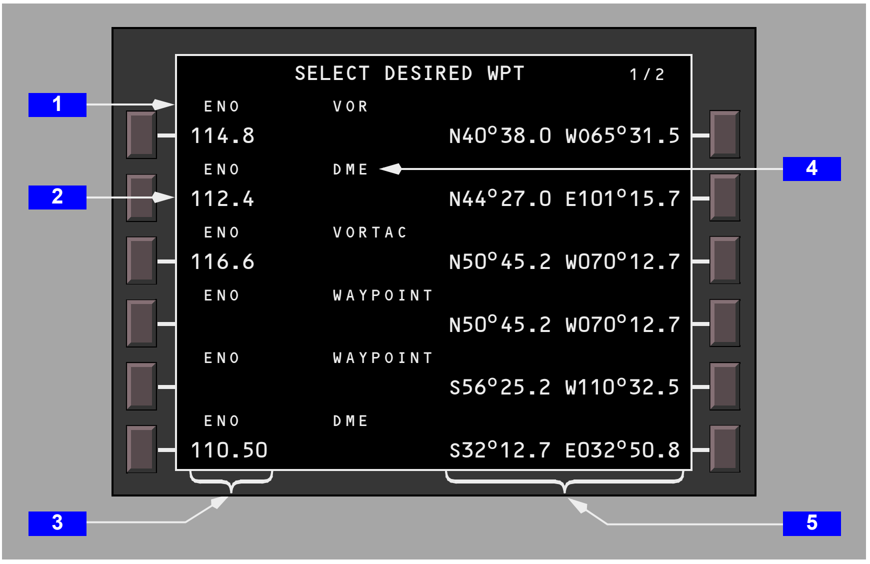
Displays outbound course from entered waypoint.

Shows the active waypoint name is modified with P/P or waypoint outbound entry.

Valid input is any course from 000° through 360°. May be changed until executed.

Select Desired Waypoint Page

The SELECT DESIRED WPT page displays after a waypoint entry when the FMC encounters more than one location for the same waypoint name. Selection of a waypoint returns the display to the previous page.



1 **Identifier**

Displays the identifier for the duplicate named waypoints. Select the correct waypoint by pushing the applicable left or right line select key.

2 **Waypoint Lines**

Display a sorted list of waypoints with identifier, navaid type, frequency, and coordinates:

- when page is accessed as a result of a flight plan modification, sort is based on proximity to the waypoint preceding the entered waypoint
- when page is accessed as a result of a PROGRESS 1/4, FIX INFO, DIR/INTC, REF NAV DATA or CENTER MAP entry, sort is based on proximity to current aircraft position

Push - selects waypoint location for use; returns display to page previously in use.

Pushing any CDU function key exits page without selecting a waypoint.

3 Frequency

Displays frequency of the navaid.

Blank if the waypoint is not a navaid.

4 Type

Displays the type of navaid for each duplicate name.

5 Latitude/Longitude

Displays the latitude/longitude for each duplicate name.

Airway Intercept

Just as in intercept to/from, LNAV can be used to intercept an airway. An airway intercept changes the active waypoint on the RTE and LEGS pages.

Enter the airway identifier under VIA on line 1 of the RTE page. Boxes display under TO. Enter the desired airway exit waypoint in the boxes. For this open-ended airway intercept, the FMC selects the waypoint preceding the closest abeam location as the starting waypoint of the airway. This waypoint displays on line 1. The entered airway and the desired exit point display on line 2. Executing the modification makes the leg to the FMC selected airway start waypoint the active leg segment.

If the clearance heading intercepts the active leg segment, LNAV can be armed and the intercept will occur. In most airway intercept situations, the commanded heading will not intercept the active leg.

If the clearance heading does not intercept the active leg segment, use the intercept–course–to procedure to make the course inbound to the waypoint (after the crossing location) the active leg segment.

Example

The active route is direct to EPH, then direct to MWH. ATC clears the airplane to:

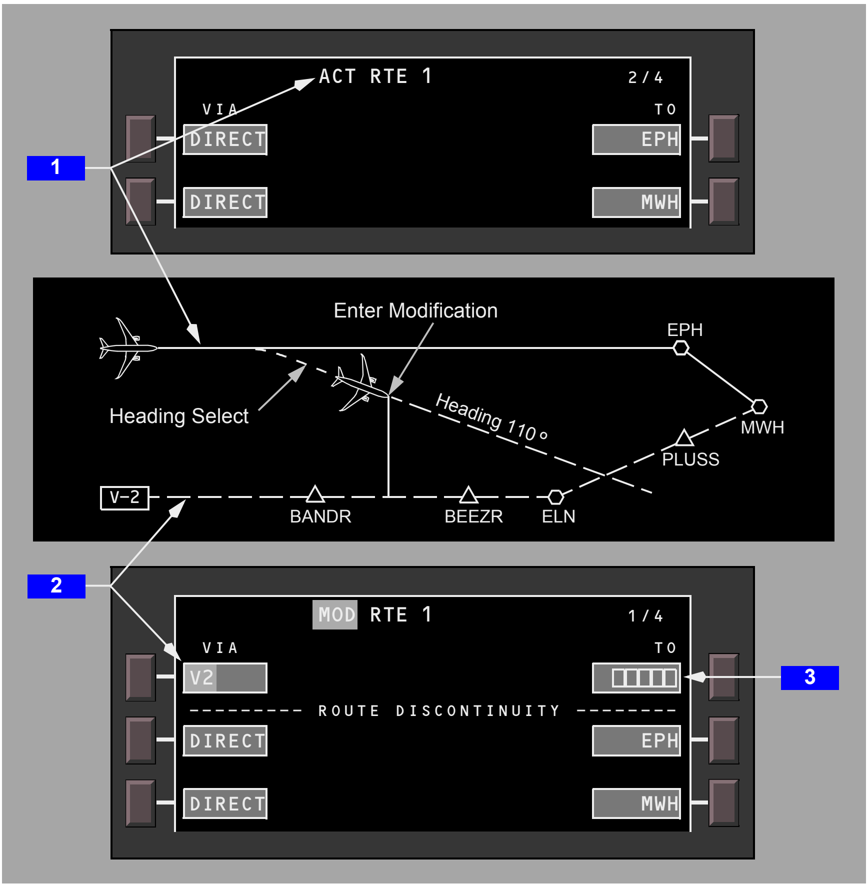
- turn right heading 110°
- intercept V2 to MWH

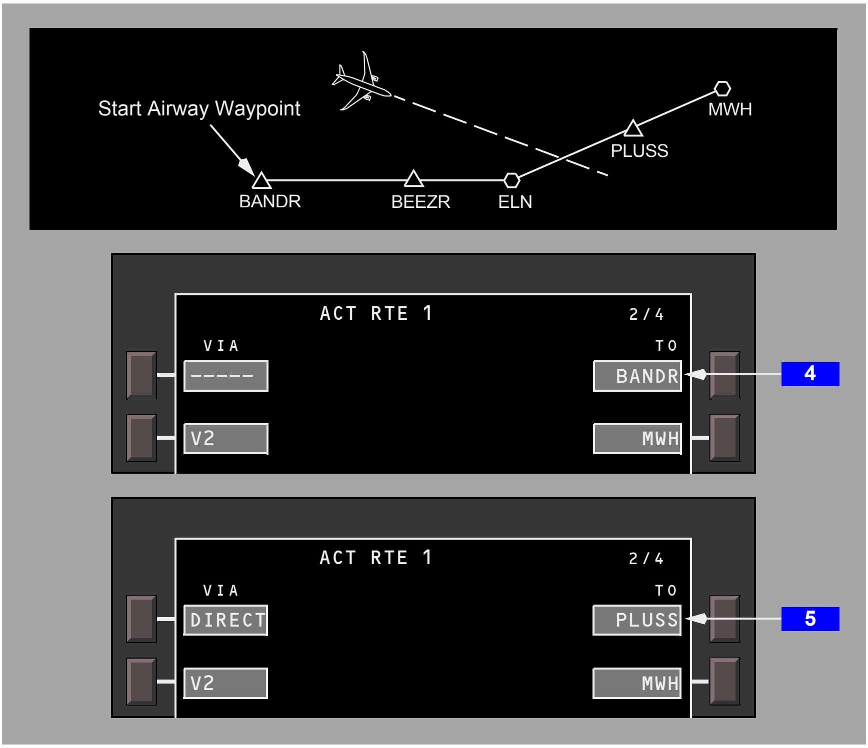
Following the V2 modification to MWH and execution, the LEGS page displays this waypoint sequence:

- BANDR
- BEEZR
- ELN
- PLUSS
- MWH

Modify the LEGS page using a course intercept to the waypoint after the crossing location. In this case, it would be PLUSS. PLUSS becomes the active waypoint on the V2 airway. The LEGS page now displays:

- PLUSS
- MWH





1 **Active RTE 1 Page**

The route page before the ATC clearance.

2 **Input Airway**

Enter the airway in the first VIA position on the RTE page. Boxes display in the TO position. A route discontinuity follows on the next line.

3 **Airway Exit**

Enter desired airway exit point in the boxes.

4 **Start Airway Waypoint**

After entering MWH in the boxes:

- the FMC selects BANDR as the airway start waypoint
- the airway line moves down one line
- dashes display in the VIA to the start airway waypoint

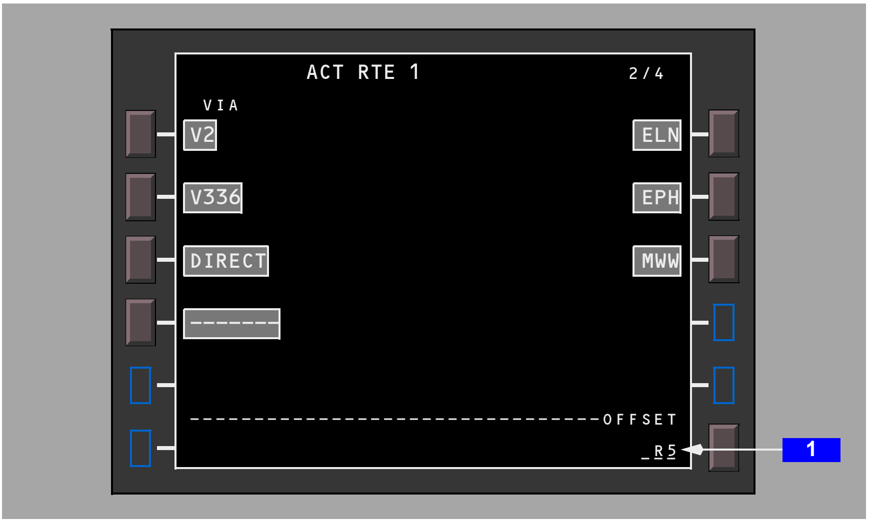
5 **New Active Waypoint**

Following modification and execution of the course intercept procedure to PLUSS, the LEGS page displays PLUSS as the active waypoint. LNAV can be armed and the airway intercept can be completed.

Route Offset

Select route offsets on the RTE page 1. The OFFSET prompt displays when the airplane is in flight and not on a SID, STAR, or transition. The offset displays as a white dashed line on the ND until the offset modification is executed or erased. After execution, the offset route displays as a dashed magenta line. The original route continues to display as a solid magenta line. When executing the offset modification with LNAV active, the airplane turns to capture the offset course.

When on the route offset, active route waypoints sequence normally. However, during transition to or from an offset route greater than 21 nm, the crosstrack limit is extended to 200 nm.



1 OFFSET

Enter the necessary offset. When executed, the entered offset is displayed on the ND as a dashed magenta line. The ND also displays a 45° entry path to and exit path from the offset.

Valid entries are L (left) or R (right) XX (XX is any number from 0 to 99 nm).

An offset propagates along the route to a Standard Terminal Arrival Route (STAR), approach or approach transition, discontinuity, end of route, track change greater than 135°, or holding pattern. An offset can be removed by deleting the offset, entering an offset value of zero, or proceeding direct to a waypoint.

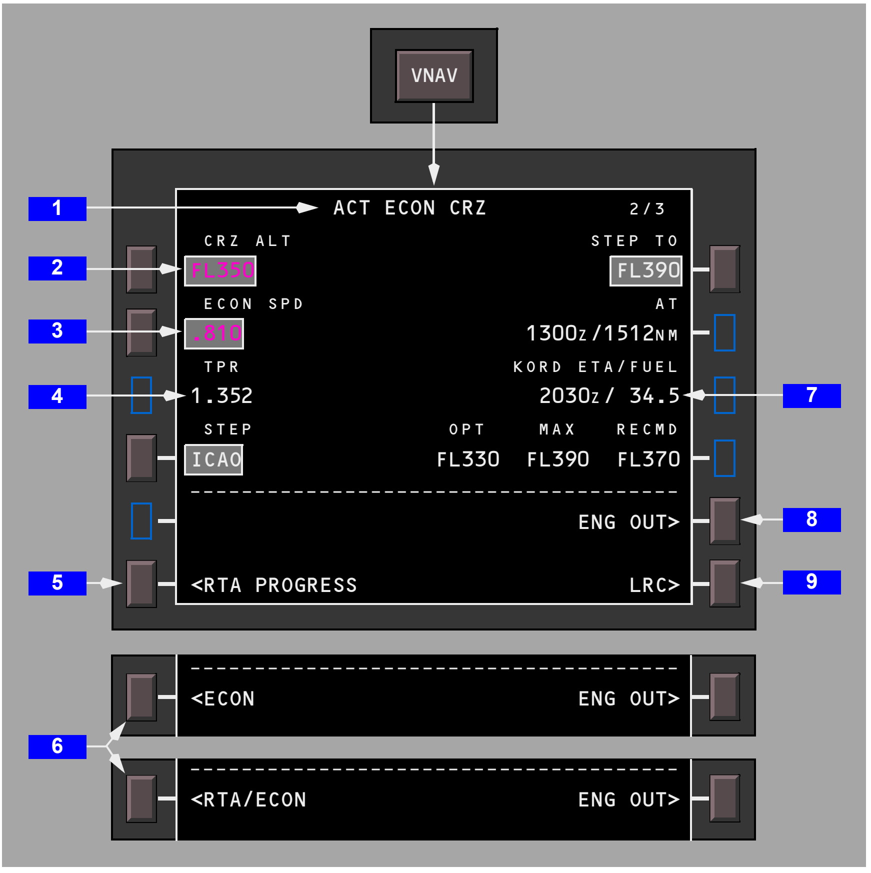
Cruise Page

All Engine Cruise

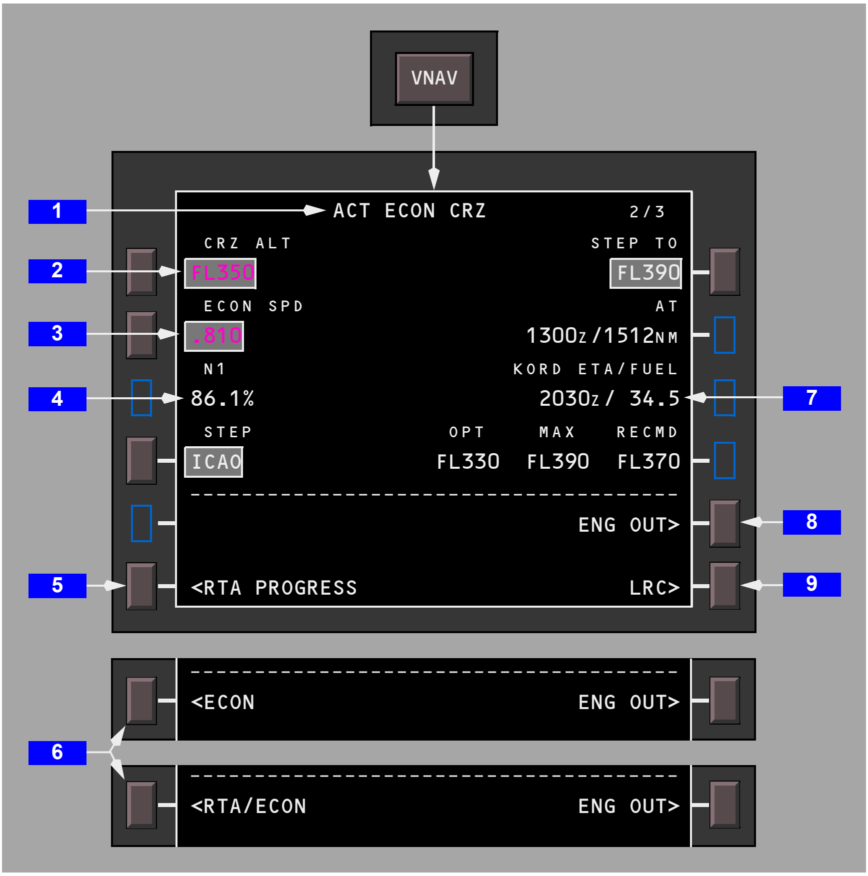
The cruise page is used to monitor and change cruise altitude and speed. Speed changes can be manually selected or automatically selected with the selection of other VNAV modes. Cruise climbs, cruise descents, and step climbs can be accomplished from the cruise page.

When using VNAV in economy mode, page data is based on operating at ECON SPD. Economy cruise speed is based on cost index. When the flight crew enters a selected speed, page data changes. When the FMC is in the engine out mode, the data reflects airplane capabilities with one engine inoperative. The long range cruise (LRC) mode calculates speeds to maximize airplane range.

[Option – RR engines]



[Option – GE engines]



1 Page Title

The page title displays active (ACT) or modified (MOD) cruise. Usually, the title contains ECON for economy cruise. Selected speeds, engine out, and long range cruise modify the title.

Page titles include:

- ECON CRZ – speed based on cost index
- ECON CRZ CLB or CRZ DES – cruise climb or descent with ECON selected
- LRC CRZ – long range cruise selected
- LRC CRZ CLB or DES - cruise climb or descent with LRC selected
- RTA CRZ - RTA cruise selected
- RTA CRZ CLB or DES - cruise climb or descent with RTA selected
- MCP SPD CRZ – selected MCP cruise speed

- EO CRZ – engine out mode with EO SPD selected
- EO D/D – engine out mode with the airplane altitude above the maximum altitude for engine out performance
- CO CRZ – engine out mode with CO speed selected
- LRC D/D - engine out mode with LRC selected
- EO LRC CRZ - displays after descending to engine out maximum altitude

2 Cruise Altitude (CRZ ALT)

Displays cruise altitude entered on PERF INIT page.

Valid entries are: XXX, XXXX, XXXXX, OR FLXXX. Altitude displays in feet or flight level depending on the transition altitude.

Modified values display in shaded white.

A new entry changes the page title to CRZ CLB or CRZ DES.

Changing the MCP altitude and pushing the altitude selector enters the MCP altitude as the active cruise altitude, without creating a modification.

3 Economy Speed (ECON SPD), Selected Speed (SEL SPD)

Displays target speed or Mach in magenta.

MOD displays in the page title in shaded white until the modification is erased or executed.

SEL SPD displays when flight crew enters speed.

LRC SPD, ECON, RTA SPD, EO SPD or company speed (CO SPD) display when selected, depending on the VNAV mode.

[Option – RR engines]

4 TPR

Displays required TPR setting to maintain level flight at the target airspeed.

[Option – GE engines]

4 N1

Displays required N1 setting to maintain level flight at the target airspeed.

5 Required Time Of Arrival (RTA) PROGRESS

Push – displays RTA PROGRESS 3/4.

6 Economy Speed or Required Time Of Arrival/Economy

ECON

- Push – selects VNAV ECON mode.
- Displays when an RTA waypoint is not in the flight plan and VNAV is not in the economy mode

RTA/ECON

- Push – selects RTA speed mode. Displays ECON prompt.
- Displays when an RTA waypoint is in the flight plan and VNAV is not in the RTA mode

7 Destination ETA/FUEL

Estimated time of arrival and calculated fuel remaining at the destination.

Displays the same data for the alternate airport when a DIVERT NOW modification is selected from the ALTN page.

When a route modification is pending, the header displays ETA/FUEL W/MOD.

Calculations are based on optimum step climbs and cruise altitudes.

8 Engine Out (ENG OUT)

Push (below engine-out maximum altitude) –

- displays MOD EO CRZ page
- changes target speed line title to EO SPD
- upon execution, thrust reference limit changes to CON

Push (above engine-out maximum altitude) –

- displays MOD LRC D/D page
- lowers CRZ ALT to engine-out maximum altitude
- changes target speed line title to LRC SPD
- upon execution, thrust reference limit becomes CON

9 Long Range Cruise (LRC)

Push – displays long range cruise page.

Engine Out Cruise

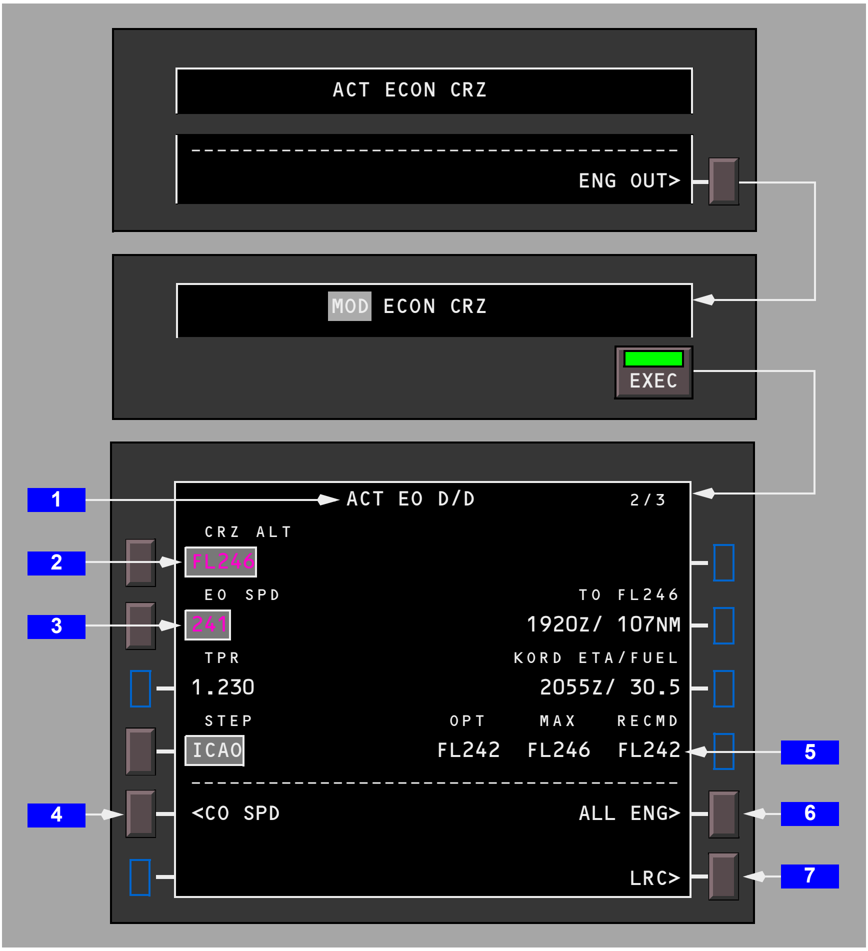
Engine out VNAV guidance displays on the EO CRZ or EO D/D page. Engine-out data is also available with both engines operating by selecting the ENG OUT prompt.

The modified page displays engine-out performance limitations. Manual entries are allowed. When above the maximum engine-out cruise altitude, VNAV calculates engine-out guidance for drift down (D/D). The EO D/D page changes to the EO CRZ page when reaching the engine-out cruise altitude. Subsequent engine-out cruise climb or descent is accomplished the same as two engine cruise climb or descent.

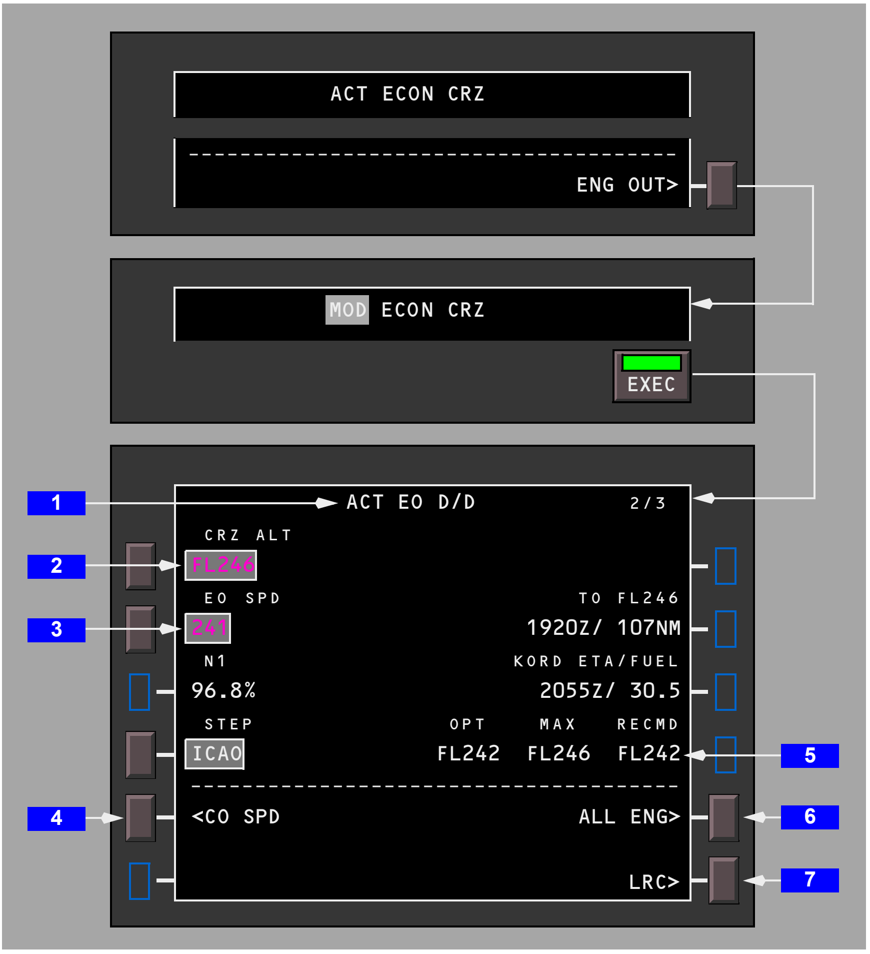
As the airplane gross weight decreases, maximum altitude increases. A step climb may be possible under these conditions.

The example is based on a cruise altitude above the maximum engine-out altitude. When ENG OUT is first selected, the default target speed is EO SPD.

[Option – RR engines]



[Option – GE engines]



1 **Page Title**

Displays LRC D/D when LRC selected

Displays MCP SPD D/D when MCP speed selected

Displays EO LRC CRZ when reaching engine out cruise altitude

Displays EO CRZ CLB or EO CRZ DES when EO SPD selected and the airplane is below the engine-out maximum altitude.

2 **Cruise Altitude (CRZ ALT)**

Displays altitude from MAX ALT line when current CRZ ALT above MAX ALT.

Manual entry of an altitude above maximum engine-out altitude results in the CDU help window message, “MAX ALT FLXXX”.

Valid entries are the same as all engine cruise page.

3 Engine Out Speed (EO SPD)

Displays the target speed or Mach in magenta.

Manual entry is allowed.

Valid entries are the same as all engine cruise page.

A manually entered speed changes the line title to SEL SPD.

ECON can be replaced with long range cruise (LRC), company (CO SPD), or engine out (EO SPD) speed using prompts at the bottom of the page.

Selecting any speed shows engine out speed (EO SPD) as a select prompt at 6L.

Manual entries may change MAX altitude.

4 Company Speed (CO SPD)

Push – Modifies the page with company speed, engine out data from the Airline Policy page.

5 Optimum Altitude, Maximum Altitude, and Recommended Altitude

OPT – displays the optimum altitude based on airplane gross weight and speed displayed on the speed line.

MAX – displays the maximum cruise altitude based on:

- current gross weight
- engine out operation
- selected speed option
- disregarding any altitude or speed constraints, and
- residual climb rate of 100 feet per minute

RECMD – displays the most economical altitude to fly based on airplane gross weight and cruise winds.

6 ALL Engine (ENG)

Push – displays a MOD XXX CRZ page with performance based on both engines operating.

Selection and execution allows subsequent selection of two engine economy VNAV modes.

7 Long Range Cruise (LRC)

Push – enables execution of engine out long range cruise.

Displayed when EO, CO SPD or SEL SPD is the active mode.

VNAV Modifications

During the cruise phase, VNAV can calculate two types of climbs: cruise and step climbs. Cruise and planned climbs can be entered by the flight crew. Optimum step climbs are calculated by the FMC. In all cases, the new climb altitude must be selected in the MCP altitude window before VNAV commands the climb.

Cruise Climb

Setting an altitude above the current cruise altitude in the MCP altitude window and pushing the altitude selector causes the cruise altitude to be set to the MCP altitude and the airplane to climb to the new cruise altitude. The reference thrust limit is CLB and the pitch flight mode annunciation is VNAV SPD.

Another method to accomplish a cruise climb: set a higher MCP altitude, enter the altitude in the CRZ ALT line, and execute.

1 During Cruise Climb

VNAV page title displays CRZ CLB in a climb to cruise altitude.

2 End of Cruise Climb

VNAV page title displays ECON CRZ after level off at cruise altitude.

Planned Step Climb

When a step climb is planned to start at a waypoint, the data can be entered on the RTE LEGS page. The FMC performance predictions assume the airplane will start the climb at the identified waypoint.

The FMC displays the distance and ETA to the step point on the PROGRESS page. The corresponding altitude profile point and identifier is shown on the ND.

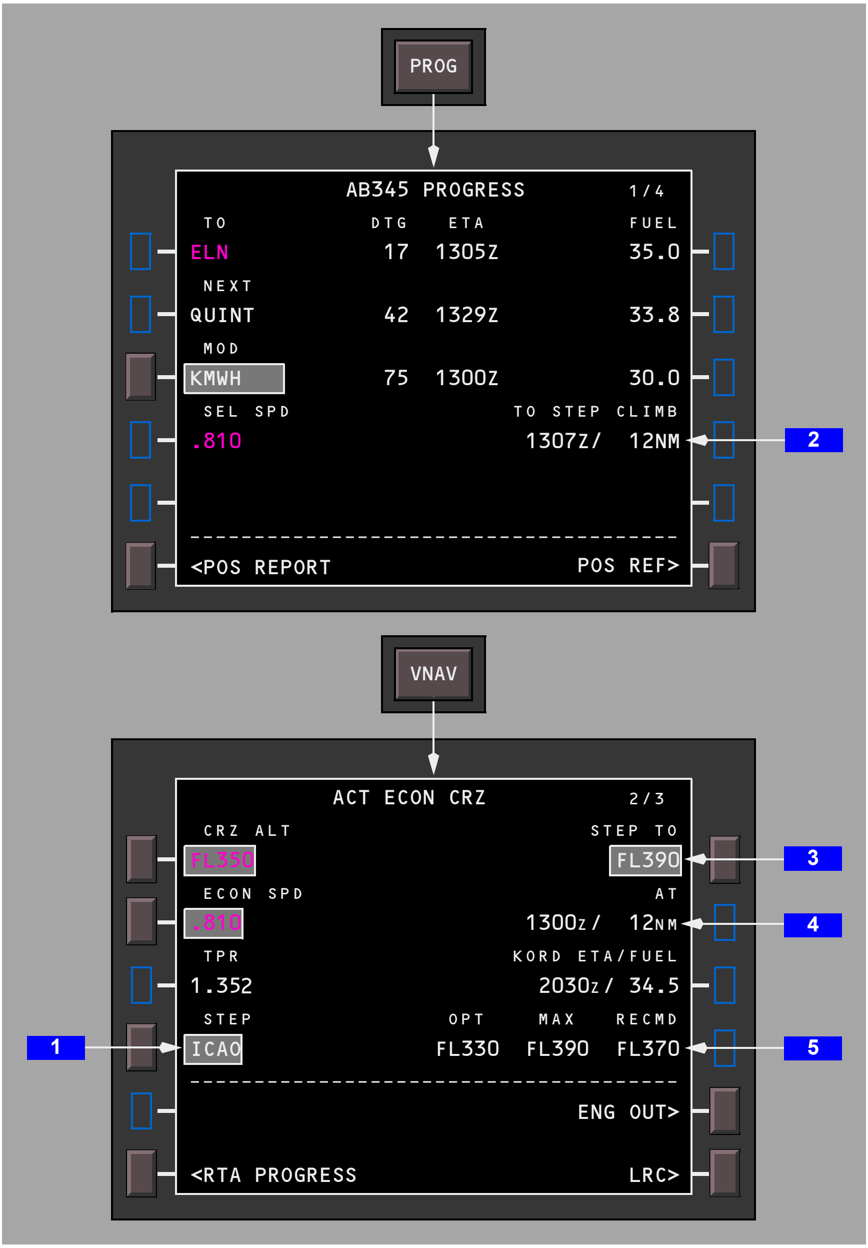
1 **Step Climb Altitude**

Enter the cruise altitude as an altitude constraint and the letter S. The FMC assumes the step climb starts at the waypoint. Accomplish the step climb at the waypoint with the steps described in cruise climb.

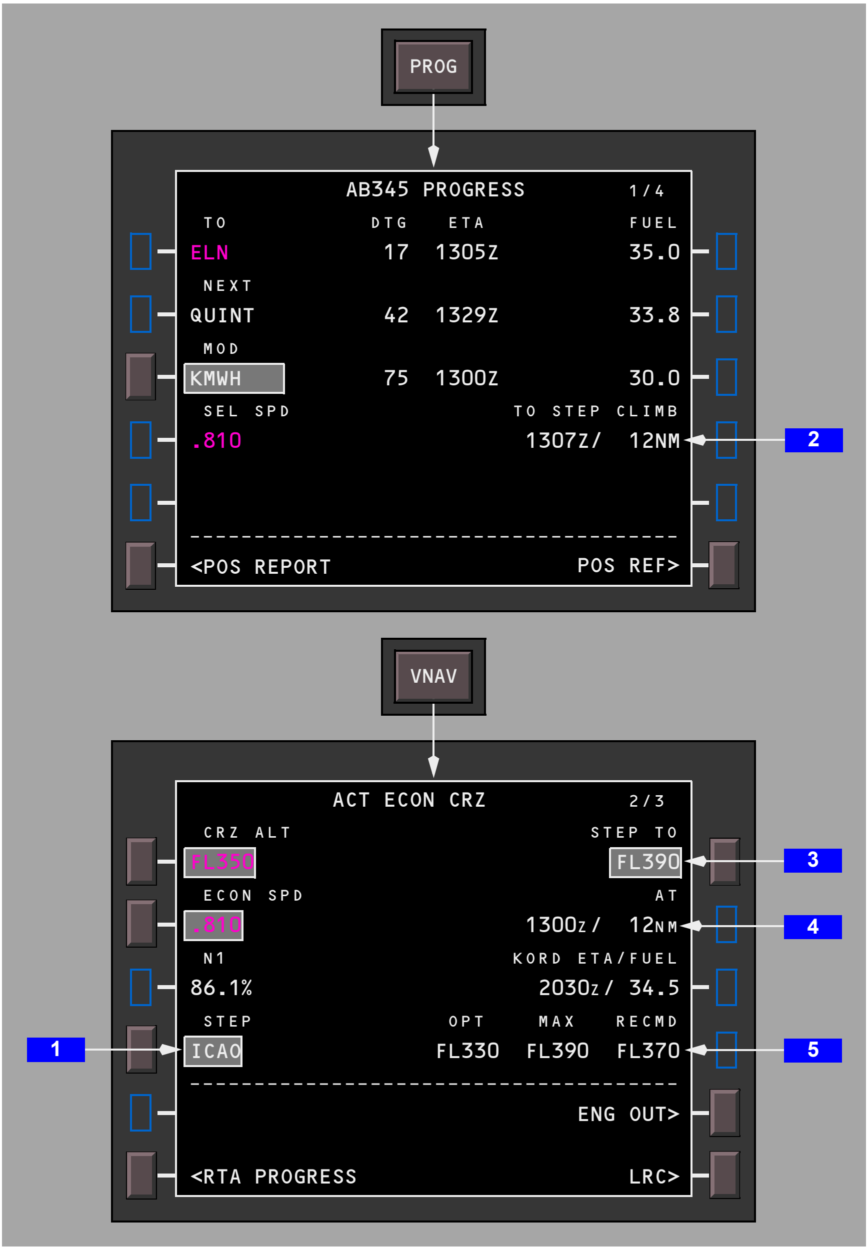
Calculated Step Climb

When a non–zero value is entered into the STEP SIZE line on the PERF INIT or CRZ page, the FMC calculates optimum points for step climbs as the airplane performance permits. The climb altitude is determined by the value in STEP SIZE. Multiple step climbs are possible based on performance and route length. VNAV commands the step climbs, if the MCP altitude and the FMC CRZ ALT are set to the new altitude.

[Option – RR engines]



[Option – GE engines]



1 **STEP SIZE**

Displays the default step climb size of ICAO.

Valid entries are altitudes from 0 to 9000 in 1000 foot increments.

Entry of a "0" value causes the FMC to compute ETA and fuel predictions for a constant cruise altitude.

Used for calculation of optimum step point and step climb predictions.

Deletion of a manual entry defaults back to ICAO.

2 TO STEP CLIMB

When the cruise climb start point is the next VNAV event, the line title changes to TO STEP CLIMB.

Displays the ETA and DTG to the point where the step climb starts.

If the airplane passes the step climb point and has not started to climb, the ETA and DTG are replaced with the word NOW.

When the FMC calculates a step climb is not advised, the ETA and DTG are replaced with the word NONE.

3 STEP TO

An altitude can be entered for a step climb evaluation. The FMC calculates the predicted step climb data and displays the results on this page and the PROGRESS page.

Entering a zero value for STEP SIZE causes the FMC to calculate performance based on a constant altitude flight at the CRZ ALT. Entering a valid, non–zero increment or ICAO step size causes the FMC to calculate performance based on accomplishing step climbs at calculated step climb points.

Step climb altitudes entered on the RTE LEGS page can be higher or lower than the CRZ ALT. These step climb altitudes cannot be overwritten on the CRZ page.

When using the ICAO step size, the STEP TO altitude is the next higher altitude above the OPT altitude corresponding to the direction of flight, based on the CRZ ALT entered before takeoff. Changes to CRZ ALT while in flight do not affect calculation of STEP TO altitudes using ICAO step sizes. However, if an alternate route (for example, Route 2) is activated in flight, the hemispheric altitude is calculated using the current CRZ ALT.

When using an altitude increment step size, the STEP TO altitude is the next higher altitude above OPT calculated by adding the STEP SIZE increment to the FMC CRZ ALT.

When entering a cruise altitude above maximum altitude, the CDU help window message MAX ALT FLXXX displays.

Entry of a new cruise altitude deletes all waypoint altitude constraints at or above the new cruise altitude.

Displays:

- the STEP TO altitude from the RTE LEGS page
- a calculated step climb altitude based on the step size

Manual entry is allowed.

Blank when:

- there is no active flight plan, or
- within 200 nm of the T/D point, or
- within 500 nm of the destination, or
- in the EO D/D phase

4 AT

Displays the ETA and DTG to the step climb point where a climb to the STEP TO altitude minimizes trip cost (ECON CRZ) or fuel (other CRZ speed).

Displays NOW passing the step climb point.

Displays NONE if planned step cannot be accomplished.

Line title changes to AVAIL AT when the climb is restricted by thrust or buffet.

Line title changes to TO T/D when within 200 nm of the top of descent or within 500 nm of the destination. ETA and DTG are relative to the T/D point.

The data is the same as displayed on the PROGRESS page.

5 Optimum Altitude, Maximum Altitude, and Recommended Altitude

Blank when RTA is active.

OPT –

- with ECON speed selected, displays altitude which minimizes trip cost based on weight and cost index
- with LRC, EO, CO, or SEL speed selected, displays altitude which minimizes trip fuel based on weight
- does not reflect the effect of speed if speed intervention (MCP IAS/MACH window) is selected

MAX – displays maximum sustainable altitude based on:

- current gross weight
- temperature
- number of engines operating
- cruise reference thrust limit default set by airline (CRZ or CLB)
- speed (ECON, LRC, SEL, EO, or CO) option
- residual rate of climb default set by airline (range: 100 to 999 feet per minute)
- disregarding altitude or speed constraints
- does not reflect the effect of speed if speed intervention (MCP IAS/MACH window) is selected

RECMD – displays the most economical altitude to fly for the next 500 nm based on gross weight; selected cruise speed, including specified cruise speed segments; and constant altitude cruise over a fixed distance taking into account the route of flight, entered winds, and temperature forecast. The FMC evaluates altitudes up to 9,000 feet below the current CRZ ALT and up to less than MAX altitude. Recommended altitudes are selected consistent with the step climb schedule and specified step size. If a step size of zero has been selected, the recommended cruise level is selected assuming a 2,000 foot step size. The recommended altitude is set to the CRZ ALT when within 500 nm of the T/D.

Refer to Route Data Page in Chapter 11, Section 42, for additional information.

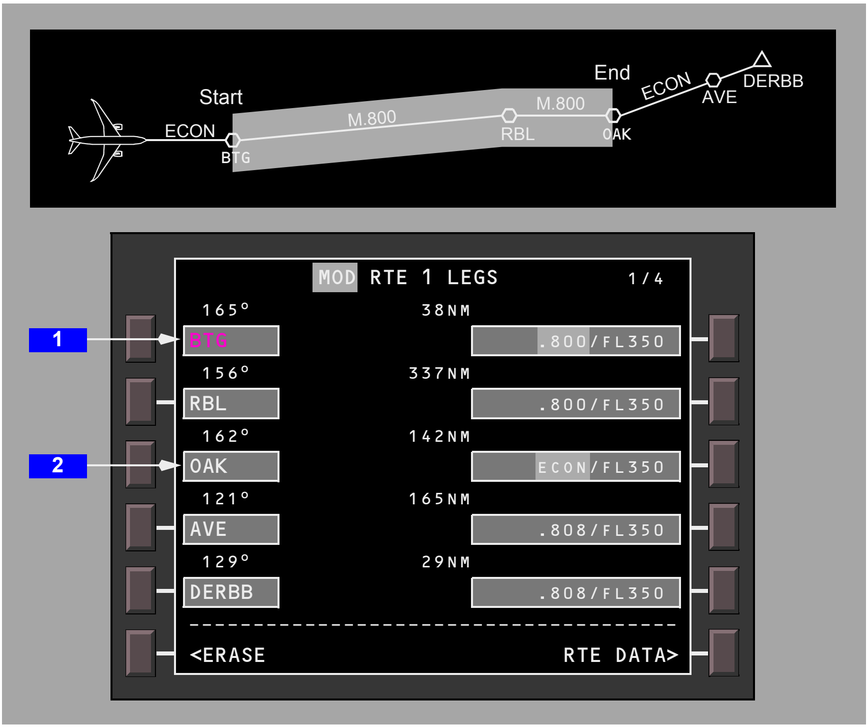
Refer to Wind Data in Chapter 11, Section 42, for additional information.

For RTA CRZ mode active: OPT, MAX, and RECMD are not computed. OPT, MAX, and RECMD headers are blank.

Constant Speed Cruise

A speed for a cruise segment can be specified. A cruise segment has a start waypoint and an end waypoint. The airplane maintains a constant speed between the two waypoints. The waypoints must be in the cruise phase. The FMC controls the speed after the end waypoint or top of descent.

Modification must be executed.



1 **Start Waypoint for Constant Speed Cruise**

The constant speed cruise starts at BTG at .800 Mach. Entry is in Mach.

2 **End Waypoint for Constant Speed Cruise**

The constant speed cruise ends at OAK then ECON speed is used. If an RTA waypoint exists at RBL or OAK, the RTA is deleted.

Entry can be a Mach number, ECON/ or E/, LRC/ or L/. If an RTA waypoint is in the flight plan, RTA/ or R/ may be entered.

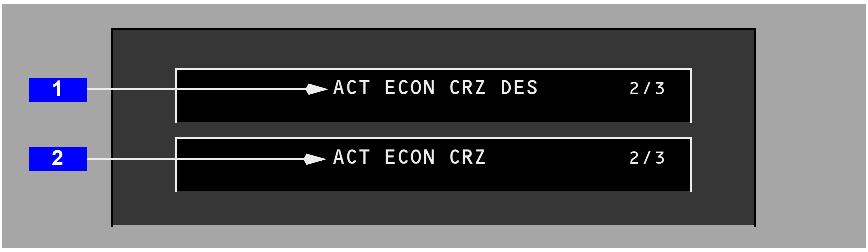
If no end waypoint is specified, the constant speed terminates at top of descent.

The FMC may select the end waypoint if an RTA waypoint is entered. The FMC selects the end waypoint to allow enough distance to arrive at the RTA waypoint on time. In the example, if the FMC selected OAK as the end waypoint, RTA would replace ECON.

Refer to RTA Progress Page 3 in Chapter 11, Section 42, for additional information.

Cruise Descent

Setting an altitude below the current altitude in the MCP altitude window and pushing the altitude selector (more than 50 nm from a T/D) causes the cruise altitude to be set to the MCP altitude and the airplane to descend to the new altitude. The CRZ page displays ACT ECON CRZ DES. If the altitude set in the altitude window is below the speed transition (SPD TRANS) or restriction (SPD RESTR) altitude displayed on the DES page, those altitudes and speeds are deleted. Transition or speed restrictions must be maintained by flight crew action. The autothrottle sets a calculated thrust value for an approximate 1250 foot per minute descent. Pitch changes maintain the commanded cruise speed. Thrust levers can be manually positioned to adjust the descent rate.



1 During Cruise Descent

VNAV page title displays cruise phase in a descent to a new cruise altitude.

2 End of Cruise Descent

VNAV page title displays cruise phase after level off at new cruise altitude.

Early Descent

An early descent is a descent started prior to the T/D. The VNAV descent page becomes active.

During cruise, setting an altitude below the current altitude in the MCP altitude window and pushing the altitude selector activates the DES NOW function when the airplane is within 50 nm of the T/D or if the MCP altitude is set below the highest descent altitude constraint in the VNAV descent profile.

The autothrottle sets thrust to maintain the target descent rate; then annunciates HOLD. Pitch maintains the commanded speed. Thrust levers can be manually positioned to adjust the descent rate.

Another method to accomplish an early descent: set a lower MCP altitude, page forward to the VNAV DES page and line select DES NOW, and execute.

1 Descend Now (DES NOW)

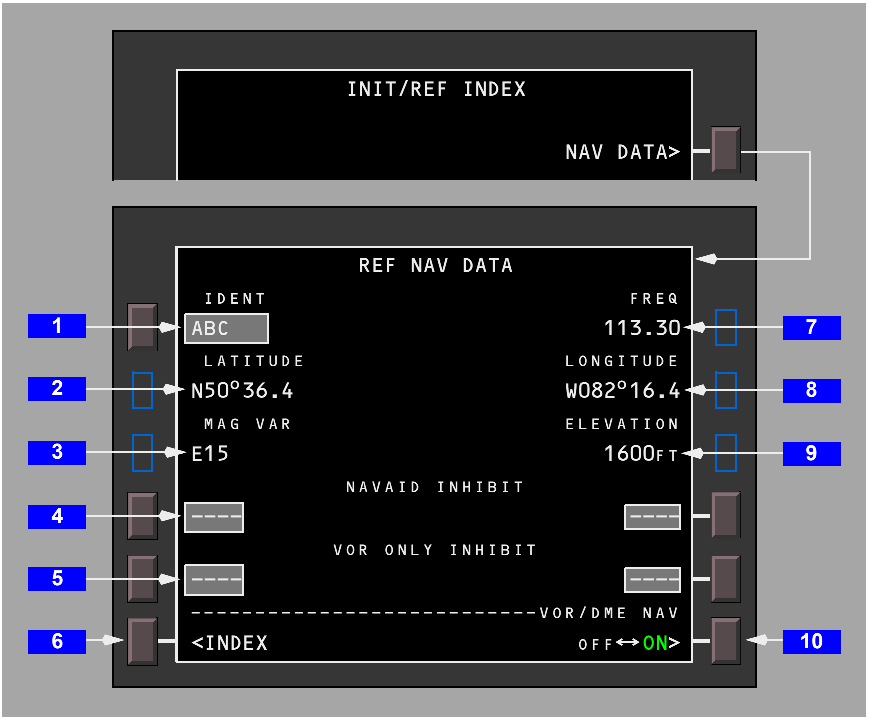
The DES NOW prompt is shown on the descent page when the cruise phase is active. Select the DES NOW prompt and execute to start a VNAV ECON descent of approximately 1250 feet per minute at ECON speed.

Upon reaching the planned descent path, VNAV commands pitch to maintain the planned descent path and ECON speed. If the airplane reaches an altitude constraint, VNAV changes to VNAV ALT until the planned descent path is intercepted.

Navigation Data

Reference Navigation Data Page

The reference navigation data page displays data about waypoints, navaids, airports, and runways. Use this page to inhibit FMC position updates from radio navaids. The navaids are always available for manual tune, autotune and the ND.



1 Identification (IDENT)

Valid entries are any waypoint, navaid, airport, or runway from the navigation database.

Entry changes to dashes when page is exited and then reselected.

2 LATITUDE

Displays latitude of entered identifier.

3 Magnetic Variation (MAG VAR), LENGTH

MAG VAR - displays magnetic variation when entered identifier is a navaid.

LENGTH - displays runway length when entered identifier is a runway.

4 **NAVAID INHIBIT**

Valid entries are: VOR, VOR/DME, VORTAC, or DME identifiers from the navigation database.

Inhibits use of entered navaids for updating by the FMCs.

Entries are blanked at flight completion.

Deleting or overwriting removes a previous inhibit.

5 **VOR ONLY INHIBIT**

Valid entries are VOR identifiers from the navigation database.

Inhibits use of only VOR portion of entered navaid for updating by the FMCs. DME–DME position updating is not inhibited.

Entries are blanked at flight completion.

Deleting or overwriting removes a previous inhibit.

6 **INDEX**

Push – displays the INIT/REF INDEX page.

7 **Frequency (FREQ)**

Displays frequency of entered identifier when it is a navaid.

8 **LONGITUDE**

Displays longitude of entered identifier.

9 **ELEVATION**

Displays elevation of entered identifier when it is a navaid, airport, or runway.

10 **VOR/DME NAV**

Push – alternately selects VOR/DME NAV ON (active) and OFF (inactive).

ON – VOR/DME data is supplied to the FMC for position updates. ON displays in large green letters; OFF displays in small white letters.

OFF – VOR/DME data is not available to the FMC. OFF displays in large green letters; ON displays in small white letters. DME–DME position updating is not inhibited.

Selecting OFF displays ALL in both locations of the VOR ONLY INHIBIT line.

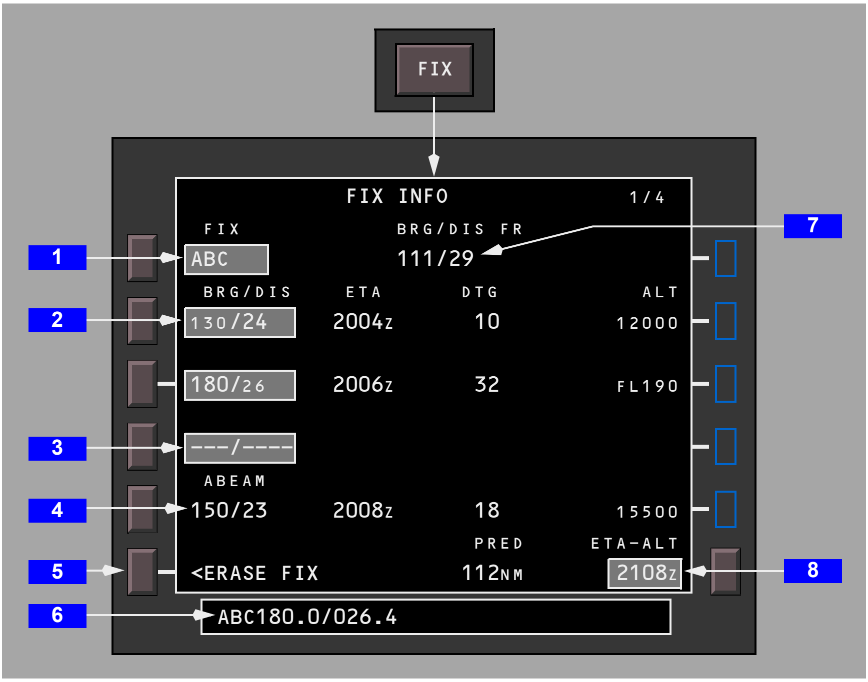
Fix Information Page

Four identical FIX INFORMATION pages are used to create waypoint fixes and waypoints for the ND. Some of the created waypoints can be copied into the route. The page can be cleared by selecting the ERASE FIX prompt or by using the DEL key.

Magnetic/True Bearing

Magnetic or true fix bearings depend on airplane location.

Refer to FMC Polar Operations in Chapter 11, Section 31, for additional information.



1 FIX

Valid entries are airports, navaids, place bearing distance, place bearing/place bearing, along track, latitude/longitude, and waypoints from the navigation database. The selected fix displays on the ND and is highlighted by a green circle.

2 Bearing/Distance (BRG/DIS), ETA, DTG, ALT

Valid entries are XXX/YYY.Y:

- decimal values can be omitted
- leading zeros can be omitted for distance entries
- distance (up to 9999 nm) only entries must start with a slash (/)

Distances from the fix display on the ND as a circle around the fix.

When the circle intersects the active route, the ETA, DTG, and predicted altitude at the intersection display for the closest of the two intersections.

Bearings from the fix display on the ND as radial lines from the fix.

When the bearing intersects the active route, the ETA, DTG, and predicted altitude at the intersection display.

ETA – displays the estimated time if arrival to the intersection point.

DTG – displays the distance to go to the intersection point.

ALT – displays the predicted altitude at the intersection point.

Push - copies the fix place/bearing/distance into the scratchpad. This fix can be placed in the route on a LEGS or page as a waypoint.

3 Bearing/Distance (BRG/DIS) – Dashes

Enter a bearing, distance, or both bearing and distance from the fix. A bearing and distance from the fix displays on the ND as a waypoint fix point. ETA, DTG, and predicted do not display.

4 ABEAM

Displays ABEAM prompt.

Push - displays bearing and distance from the fix perpendicular to the nearest segment of the flight plan path, and ETA, DTG, and altitude at the intersection point.

Second push - copies the fix place/bearing/distance into the scratchpad. This fix can be placed in the route on a LEGS or RTE page as a waypoint.

5 ERASE FIX

Push – removes all fix data from the page and the ND.

6 Route Intersection Point Copied

Pushing the line select key for one of the BRG/DIS entries copies the fix place/bearing/distance definition into the scratchpad. This fix can be placed into the route on a LEGS page as a waypoint.

7 Bearing/Distance From (BRG/DIS FR)

Displays the bearing and distance of the airplane from the fix.

8 Predicted Distance to ETA or Altitude (PRED ETA-ALT)

Valid entry is altitude, flight level, or time. Time entry must be followed by “Z”.

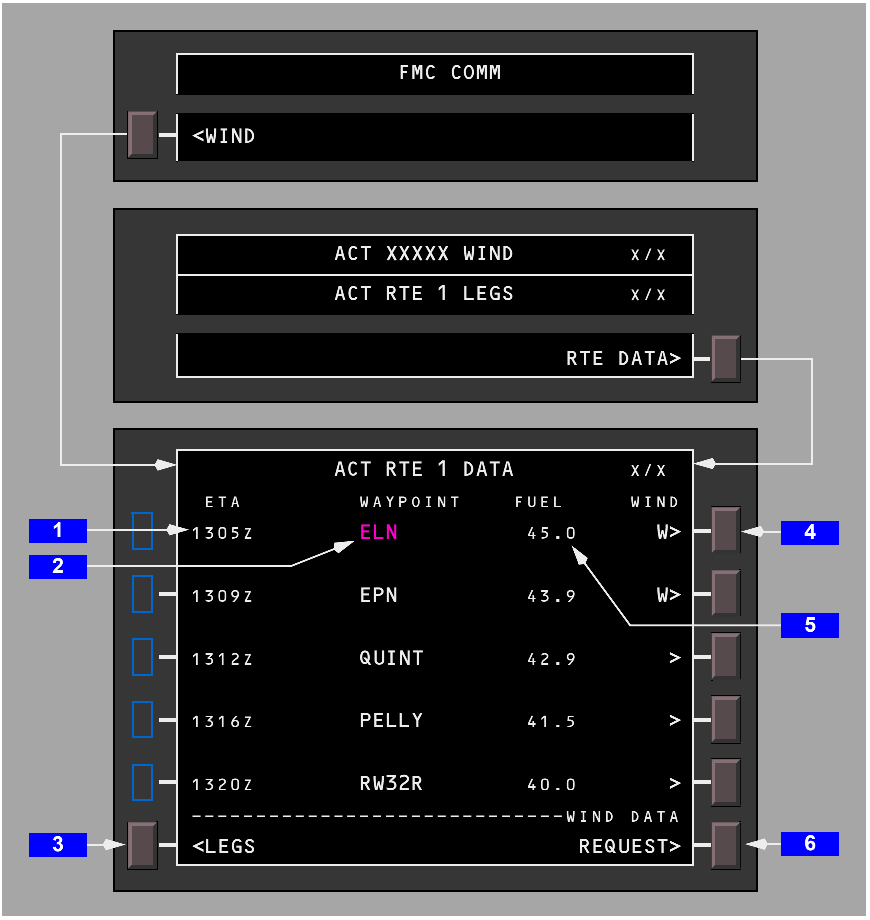
Entering an altitude or flight level displays the predicted along track distance and altitude or flight level on this line. The predicted airplane position displays on the ND route line as a green circle with the entered altitude/flight level.

Route and Waypoint Data

Route Data Page

The route data page displays data for each waypoint on the ACT RTE X LEGS page. This page also allows access to the WIND page. This page is available only for the active route.

The ETA and calculated fuel remaining at the waypoint display for each waypoint. Manual entry is not possible.



1 ETA

Displays ETA for waypoint.

2 Waypoint (WPT)

Displays identifier for waypoint.

3 LEGS

Push –displays RTE LEGS page.

4 WIND (W>/>)

W> - indicates waypoint winds have been entered.

> - winds not entered.

Push – selects WIND page for the selected waypoint.

5 **FUEL**

Displays the FMC calculated fuel remaining at the waypoint.

Note: ETA and estimated fuel calculations assume a direct flight across route discontinuities.

6 **WIND DATA REQUEST**

Push – transmits a datalink request for wind and descent forecast data.

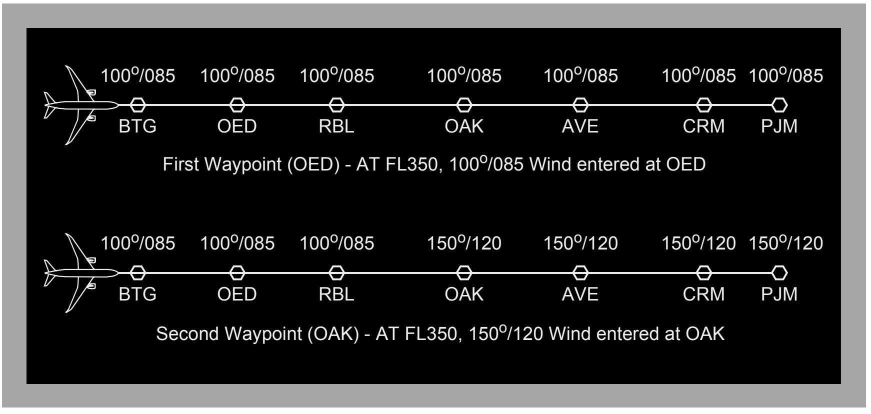
Flight crew may enter up to four altitudes on any wind page to qualify the request.

Wind Data

The FMC uses wind data to improve performance prediction accuracy. Wind data includes altitude and direction/speed.

The FMC applies the first entered wind data to all waypoints in the flight plan. Wind data entered at another waypoint (at the same altitude) changes wind data downtrack from the second entered waypoint either to the end of the track, or to the next entered wind. The wind data before the second entered waypoint does not change. Therefore, enter wind data for waypoints closest to the airplane, then enter wind data for waypoints downtrack from the airplane.

For example: at FL 350, 100°/085 is entered at waypoint OED. All waypoints in the route have the OED wind data. Then, additional wind data entered at OAK changes the wind data at OAK and through the end of the route.



Entered wind data are mixed with sensed wind data for performance predictions. The FMC uses entered winds for predictions far ahead of the airplane and sensed winds close to the airplane. The FMC mixes these winds for predictions in between. Sensed winds display on the progress page 2/4.

Inaccurate forecast wind and temperature information degrades the accuracy of the recommended altitude displayed on the cruise page.

The FMC adjusts ECON climb speed and top of climb using entered and/or sensed wind speed. FMC calculated ECON climb speed may fluctuate if top of climb is near a waypoint with approximately a 45 degree or larger track change and if a significant wind velocity has been entered or is predicted for that waypoint. This fluctuation does not occur when using a manually entered climb speed or speed intervention.

Wind Page

The wind page is used to enter forecast winds and temperatures at waypoints for up to four altitudes to enhance VNAV performance.

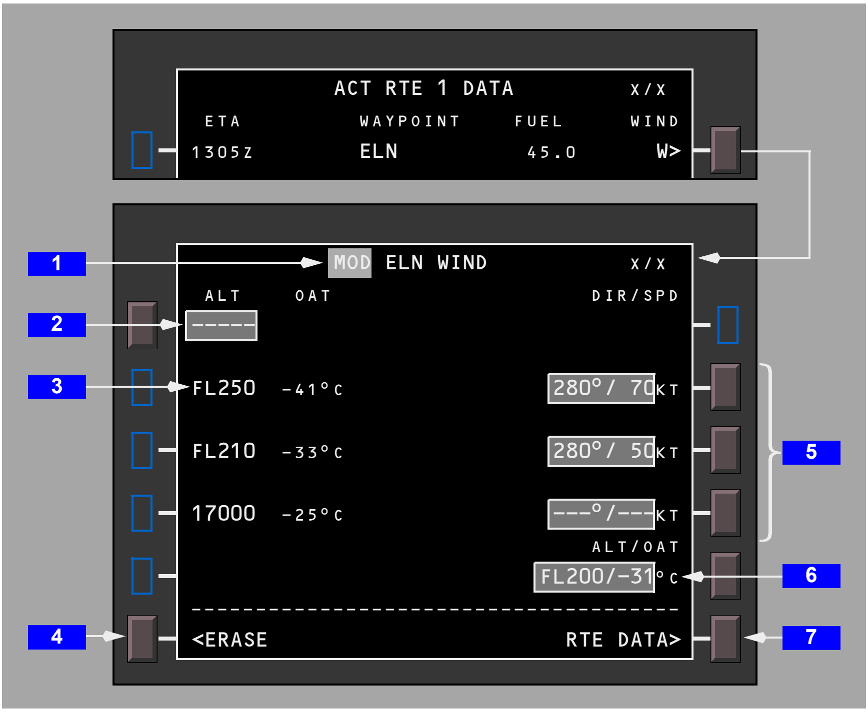
This data can be uplinked or manually entered.

Wind speed and direction are entered for the specific altitudes.

OAT can be entered for any one altitude. The FMC calculates the temperature for the entered altitudes using the standard lapse rate.

The altitudes are entered first. The altitudes can be entered in any order and are sorted and displayed in ascending order.

The FMC calculates step climb points as a function of lateral flight plan, speed mode, present and step to altitude, and gross weight. The gross weight for a step from present CRZ ALT to STEP TO altitude is the gross weight at which the optimum altitude is halfway between the two altitudes.



1 **Page Title**

Displays ACT XXXXX, where XXXXX is the waypoint at which winds have been entered.

When a route is being modified, MOD in shaded white as shown in the page title.

2 **Altitude (ALT)**

Enter altitude or flight level for wind entries. Altitude data entry possible only on line 1L.

After data entry, data is sorted by altitude and placed in lines 1 through 4. Dashes display on right side of line for wind direction and speed entry.

When all four lines have data, one must be deleted before new data can be entered.

3 **Altitude/Flight Level Data**

Displays the altitude or flight level for wind or OAT entries.

Data entered on 1L displays on lines 1 through 4. Data entry is not possible in lines 2L through 4L.

OAT entries made using the ALT/OAT line display in large font. Calculated OAT based on standard lapse rate display in small font.

4 ERASE

Push – removes modified data.

5 Direction and Speed (DIR/SPD)

Displays dashes after altitude/flight level entry in the ALT line. Enter wind direction and speed for the altitude.

Displays entered wind direction and speed for related altitude.

Values propagate in both directions for the first wind entered and downtrack for other entered winds. Propagated values display in small white font.

Manual entries display in shaded white until executed, then in large white font.

6 Altitude/Outside Air Temperature (ALT/OAT)

Blank unless at least one altitude entry has been made.

Enter altitude and OAT. The altitude for OAT does not have to be one of the wind altitudes. The FMC uses standard lapse rate to calculate the temperature at the other altitudes.

Manual entries display in shaded white until executed.

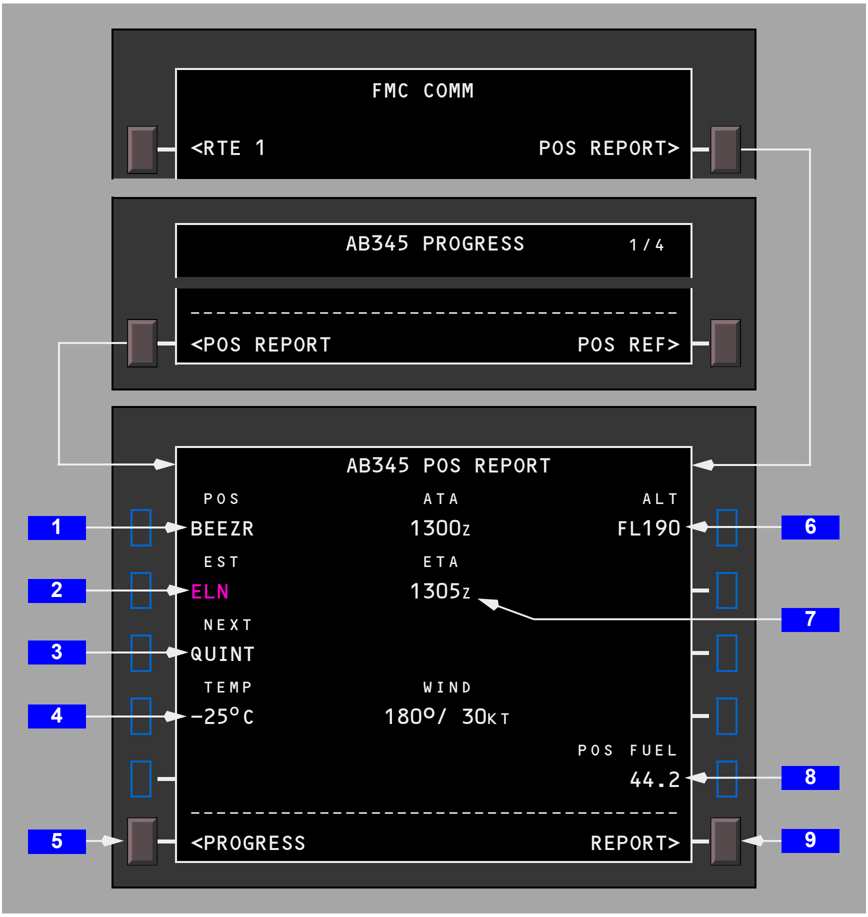
7 Route Data (RTE DATA)

Push – displays the RTE DATA page.

Position Report Page

The position report page displays data for a position report. A position report can be datalinked from the page.

The page contains reference data only. Manual entries are inhibited.



1 Position (POS)

Waypoint used to report position. This is the previous active waypoint.

2 Estimate (EST)

The active waypoint displays in magenta.

3 NEXT

Waypoint after active waypoint.

4 **Temperature and Wind (TEMP WIND)**

TEMP displays the OAT in degrees C.

WIND displays the wind direction and speed.

5 **PROGRESS**

Push – displays the PROGRESS page.

6 **Actual Time of Arrival and Altitude (ATA ALT)**

ATA displays the actual time of arrival for the POS waypoint.

ALT displays the airplane altitude at last waypoint.

7 **ETA**

Displays the estimated time of arrival for the active waypoint.

8 **Position Fuel (POS FUEL)**

Displays the fuel on board at the POS waypoint.

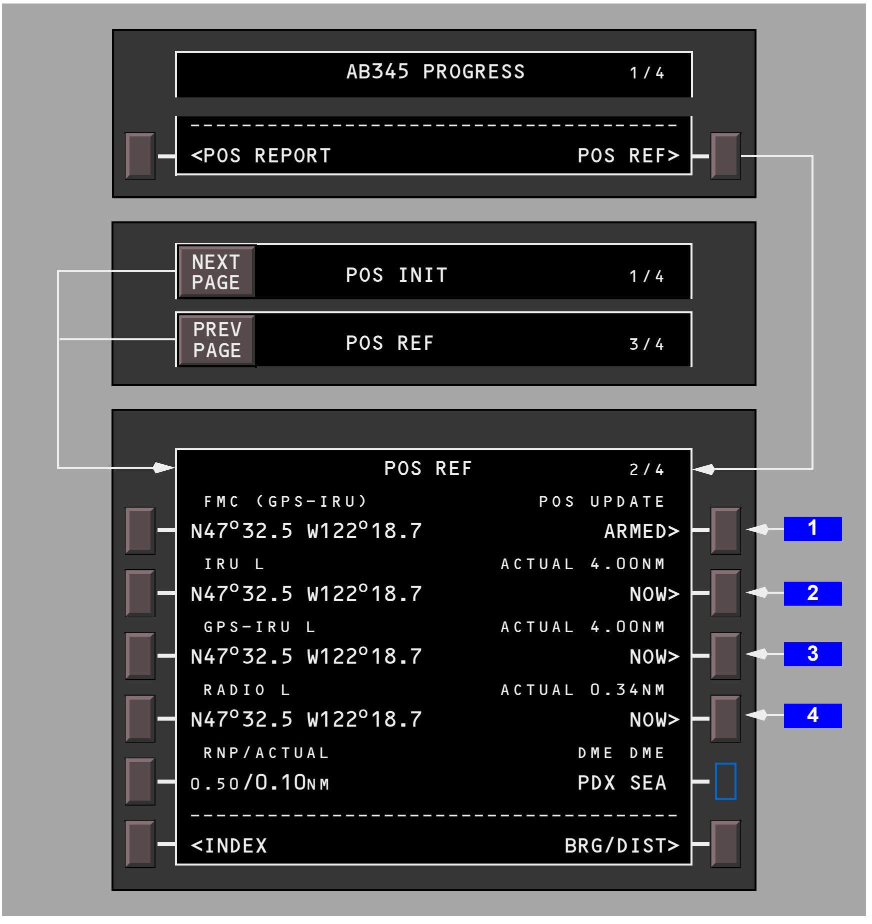
9 **REPORT**

Push – transmits a datalink downlink of the data on this page.

The datalink transmission of a position report requires the datalink option be enabled, operational, and not in the voice or no–communications mode.

In–Flight Position Update

FMC position update can be accomplished on the POS REF 2/4 page in flight.



1 **UPDATE ARMED**

Pushing the ARM prompt arms the position update function. ARM changes to ARMED. Each of the position update sources have a NOW prompt.

2 **IRU NOW**

Push – updates the FMC position to the indicated IRU sensor position.

Header displays position uncertainty (ANP) in nautical miles.

3 **GPS NOW**

Push – updates the FMC position to the indicated GPS sensor position.

Header displays position uncertainty (ANP) in nautical miles.

4 **RADIO NOW**

Push – updates the FMC position to the indicated RADIO sensor position.

Header displays position uncertainty (ANP) in nautical miles.

Progress Pages

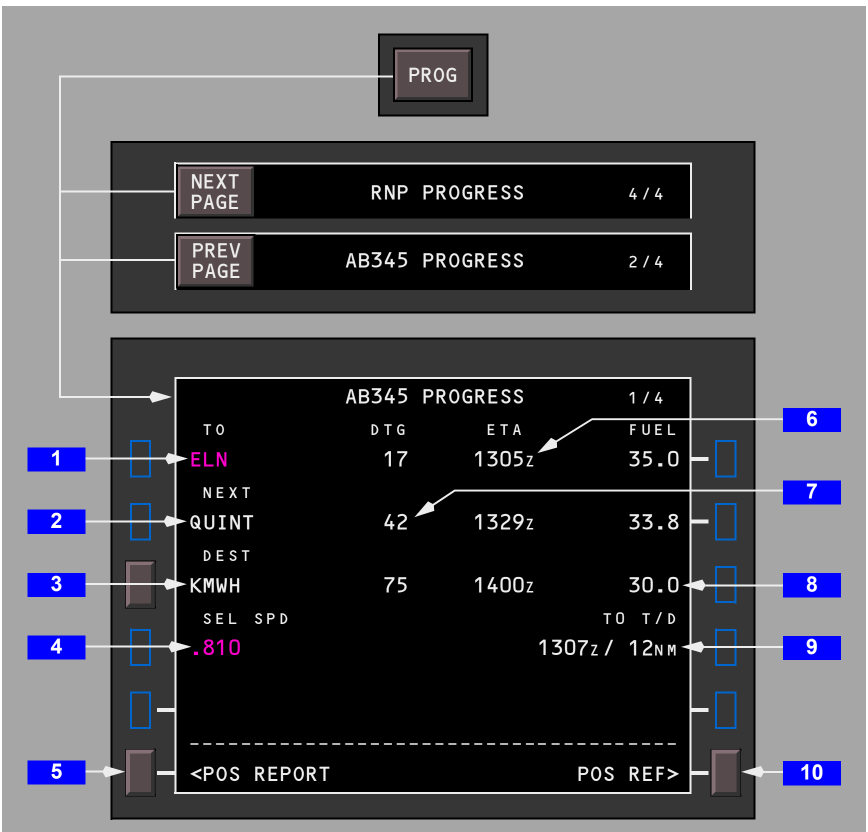
Progress Page 1

The progress page displays general flight progress data. The FMC Communication section of Chapter 5, Communications describes position reports.

The page title displays the company flight number entered on the RTE page.

Page one of the progress pages displays general data about:

- waypoints (active and next)
- destination data
- FMC speed
- T/C, T/D, etc.



1 **TO**

Active waypoint displays in magenta.

Can not be modified.

2 **NEXT**

Waypoint after TO waypoint displays in white.

Can not be modified

3 **Destination (DEST)**

Any waypoint or airport in navigation database can be entered. The line titles are:

- DEST – performance predictions to destination. Default display
- DIR TO FIX – when entered waypoint is not in flight plan. Data is based on flying present position direct to the waypoint
- EN ROUTE WPT – when entered waypoint is in flight plan. Line data are based on flying the flight plan route to the waypoint
- MOD – a modification has been made on another page. Performance predictions include modification

Remove entries with DELETE key or change all CDU displays to a different page.

4 **Selected Speed (SEL SPD)**

The FMC active command speed displays in magenta.

The active speed mode is the same as on the performance page, unless changed by the MCP or a limit. The speed modes are:

- ECON SPD – economy speed
- LRC SPD – long range cruise speed
- SEL SPD – selected speed manually entered on the CDU
- EO SPD – engine out speed
- CO SPD – engine out operations at airline specified engine out company speed
- LIM SPD – speed is limited by VMO, MMO, flap limit, or buffet limit
- MCP SPD – MCP speed entered on the MCP IAS/MACH indicator
- VREF +80 – for engine out operations during takeoff
- RTA SPD – RTA speed is active

5 **Position Report (POS REPORT)**

Push – displays the POS REPORT page.

6 **ETA**

Estimated time of arrival at waypoint or destination.

7 **Distance To Go (DTG)**

Distance to go to waypoint or destination.

8 **FUEL**

Estimated fuel remaining at waypoint or destination.

9 **TO T/C**

Data line displays ETA and DTG to line title point.

Data line displays NOW when the airplane is past the climb/descent point when STEP CLB or T/D displays in the line title.

Data line displays NONE when the line title is STEP CLB and the step has not been entered on the CRZ page or the FMC calculates a step climb is not advised.

Line titles are:

- T/C - top of climb
- STEP CLB – step climb data
- T/D – top of descent data
- E/D – end of descent data
- LEVEL AT – time and distance to level off in Drift Down mode

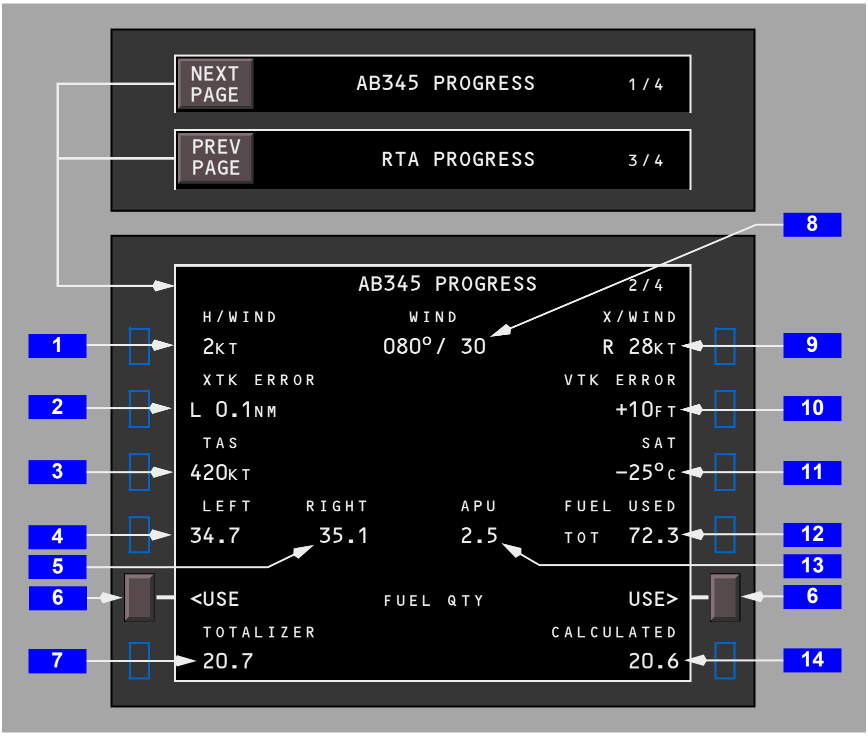
10 **Position Reference (POS REF)**

Push – displays position reference page.

Progress Page 2

Progress page two contains:

- wind data
- fuel data
- static air temperature
- true airspeed
- track error data



1 **Headwind (H/WIND), Tailwind (T/WIND)**

Displays headwind (H/WIND) or tailwind (T/WIND) component.

Wind component data is relative to the airplane.

2 **Crosstrack Error (XTK ERROR)**

Displays crosstrack (XTK) error in nautical miles left or right of the active route.

3 **TAS**

Displays airplane true airspeed.

4 **LEFT FUEL USED**

Displays fuel used by left engine sensed by fuel flow meters.

5 **RIGHT FUEL USED**

Displays fuel used by right engine sensed by fuel flow meters.

6 **USE**

Push – selects method to calculate fuel quantity, either TOTALIZER or CALCULATED.

When one is selected:

- it is used for remainder of flight
- the other fuel calculation method blanks
- scratchpad clears

7 **Fuel Quantity Totalizer (FUEL QTY TOTALIZER)**

Displays fuel quantity calculated by the fuel system quantity processor.

The fuel remaining line displays two independent fuel remaining values, TOTALIZER and CALCULATED. They can be compared to validate FMC calculations.

Blank if fuel has been manually entered on the PERF INIT page.

8 **WIND**

Displays current wind direction and speed referenced to true north.

9 **Crosswind (X/WIND)**

Displays left (L) or right (R) crosswind component relative to airplane heading.

10 **Vertical Track (VTK) Error**

Displays error above (+) or below (-) the vertical path.

11 **Static Air Temperature (SAT)**

Displays outside static air temperature.

12 **FUEL USED Total (TOT)**

Displays sum of the LEFT, RIGHT and APU fuel used values.

13 **APU**

Displays fuel used by the APU.

Blank until valid APU fuel flow exist.

When the APU is turned off, total fuel used by the APU remains displayed and the value is used in the total fuel used calculation.

14 **FUEL Quantity (QTY) CALCULATED**

Displays fuel remaining as calculated by the FMC with these methods:

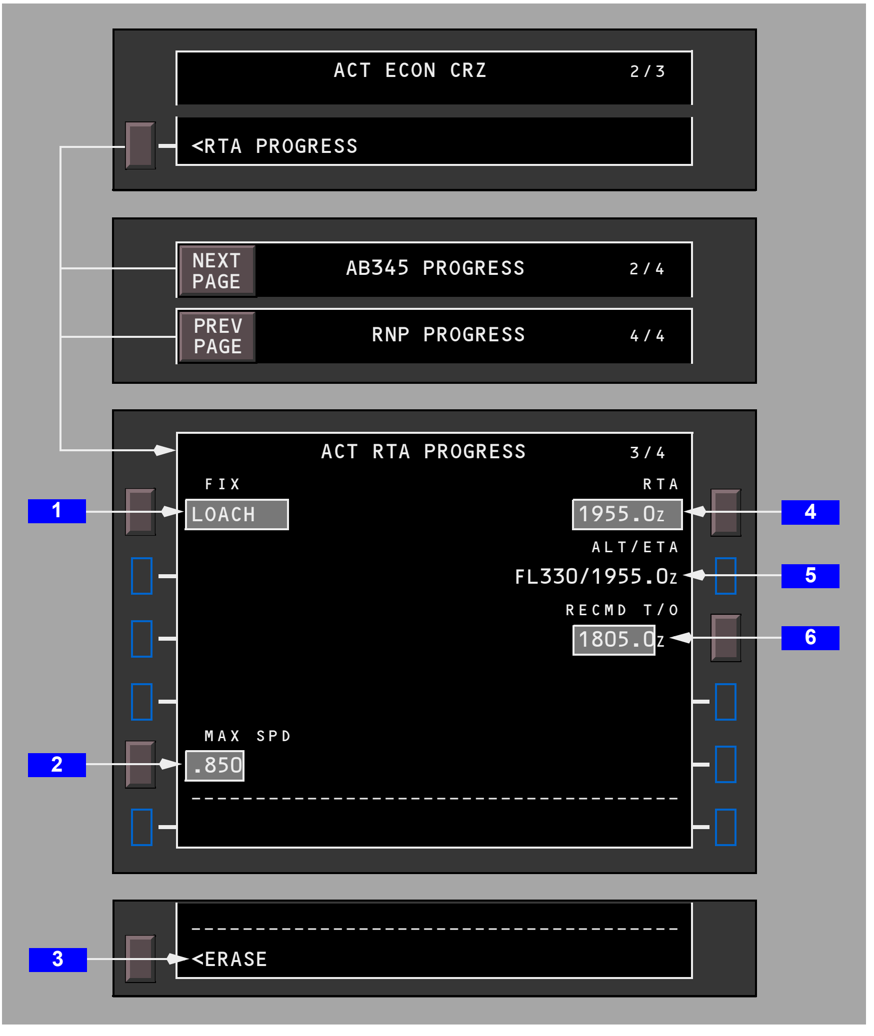
- before engine start, fuel quantity calculated by fuel quantity system totalizer
- after engine start, fuel quantity at engine start decreased by EICAS engine fuel flow rate

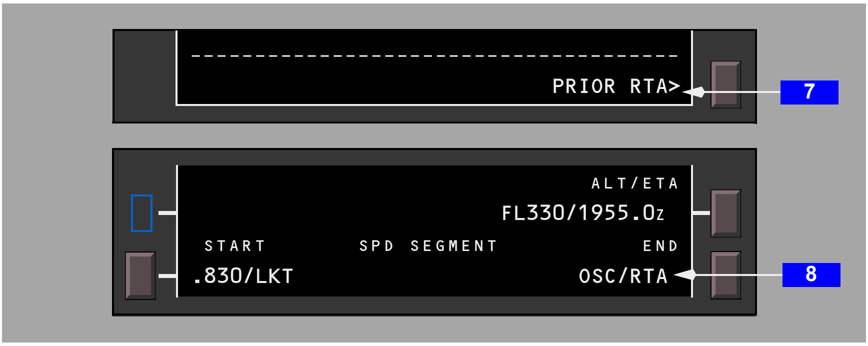
- after fuel dump, resets to fuel quantity system totalizer
- after landing, resets to fuel quantity system totalizer

The fuel remaining line displays two independent fuel remaining values, TOTALIZER and CALCULATED. They can be compared to validate FMC calculations.

RTA Progress Page 3

Progress page three is used to enter data for required time of arrival (RTA). RTA can be entered or changed during preflight or in flight. Creating an RTA changes CRZ page title to RTA CRZ. RTA operates only in cruise.





1 **FIX**

Valid entry is a waypoint in the active or pending active route. Waypoints defined by coordinates must be down selected to the scratchpad, then selected to the FIX line.

Entry by flight crew or datalink.

Entry displays ALT/ETA data in line 2R.

When RTA active, deletion of FIX terminates RTA and resumes ECON. Display returns to boxes.

When RTA not active, deletion of FIX erases a pending RTA MOD. Display returns to boxes.

Displays boxes when an active or modified route exists.

Displays blank if engine out has been selected.

2 **Maximum Speed (MAX SPD)**

Valid entry is Mach .100 to .990; displays in large font.

Deletion of entered value displays default Mach .850 in small font.

3 **Displays ERASE when modification pending**

Push - displays previous unmodified page, or if no previous active values, deletes RTA in 1R.

4 **Required Time Of Arrival (RTA)**

Boxes display after entry of RTA FIX in 1L.

Valid entry is time from 0000.0 to 2359.9. Decimal entry of .0 is optional.

Suffix to RTA indicates:

- no suffix – arrive at entered time
- A – arrive at or after entered time
- B – arrive at or before entered time

Entry before takeoff causes recommended T/O time to display in small font.

Deletion terminates RTA and returns ECON as cruise mode.

5 Altitude/ETA (ALT/ETA)

Displays predicted altitude and ETA at RTA fix after entry of FIX in 1L.

Blank until performance data is entered.

6 Recommended Takeoff (RECMD T/O)

Displays recommended takeoff time to meet RTA at ECON speed.

Dashes until FIX is entered.

Blanks in flight.

Valid entry is time from 0000.0 to 2359.9. Decimal entry of .0 is optional.

Manual entry recalculates all flight plan time predictions.

Changes to NOW after recommended takeoff time.

7 PRIOR RTA

Displays when prior RTA fix and time exists.

Push -

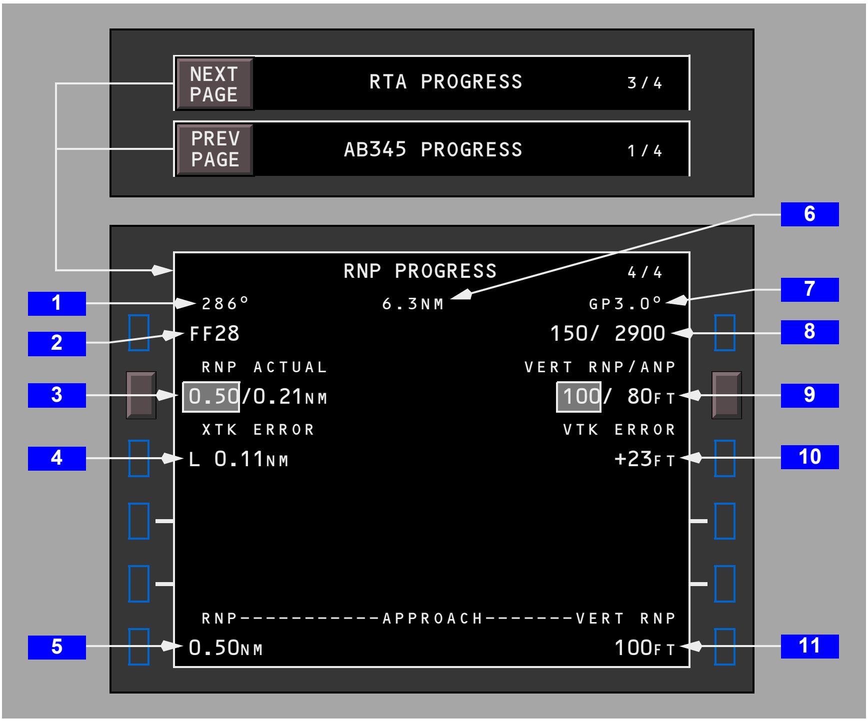
- displays previous RTA fix and time
- initiates RTA flight plan modification

8 Cruise Speed Segment

Displays cruise speed segment start and end waypoints.

RNP Progress Page 4

Progress page four displays concise RNP information. Some of the information on page 2 has been repeated to display all related RNP information together.



1 **Leg Direction**

Leg segment data in line title:

- courses – magnetic (xxx°) or true (xxx° T)
- arcs – distance in miles, ARC, turn direction (example: 24 ARC L)
- heading leg segments – xxx° HDG
- track leg segments – xxx° TRK
- special procedural instructions from database - HOLD AT, PROC TURN, or PROC HOLD (FMC exits hold when crossing the fix after entry)

Calculated great circle route leg directions may be different than chart values.

Dashes display for an undefined course.

2 **Waypoint Identifier**

Displays the next waypoint.

3 Required Navigation Performance and Actual Navigation

Display same as 5L POS REF 2/4. Manual entry displays in large font; propagated to 5L POS REF 2/4 page.

4 Crosstrack Error (XTK ERROR)

Displays present crosstrack error from the desired LNAV course. L or R indicates left or right of course. Errors in excess of 99.99 nm display as 99.99 nm.

5 Lateral RNP (Approach)

Displays lowest applicable RNP for the approach. Entry not allowed at 6L.

Manual entry at 2L displays in large font.

RNP values from the navigation database display in small font; or, if there are none, displays the default value for the approach navigation flight phase stored in the FMC.

6 Distance To Go

Displays the distance remaining to the next waypoint.

7 Glidepath

Displays the FMC computed glidepath for the approach.

8 Waypoint Speed/Altitude

Displays waypoint speed or altitude constraints in large font. Displays FMC predicted value in small font when no restrictions have been specified.

9 Vertical Navigation Performance

Displays both vertical RNP and ANP for the current leg.

Valid display range for vertical ANP is 0 to 999 feet.

Manual entries are allowed and display in large font.

Valid entries are 10 to 999 feet and may be suffixed with an optional "/".

Entries clear at flight completion.

Values from the navigation database display in small font.

10 Vertical Track Error (VTK ERROR)

Displays error above (+) or below (-) the vertical path.

11 Vertical RNP (Approach)

Displays the lowest applicable vertical RNP for the approach.

Manual entries (entered in 2R) display in large font.

Values from the navigation database display in small font.

Flight Management, Navigation — Chapter 11
FMC Descent and Approach — Section 43

Introduction

The descent phase starts at the top of descent point and continues to the end of descent point. Planning for the descent phase starts during cruise.

The approach phase starts when the airplane is in the descent phase and flaps are out of up. In general, the approach starts no later than sequencing the final approach fix.

Refer to Approach in Chapter 11, Section 31, for additional information.

Alternates are available from preflight through approach phase of flight and can be selected or updated at any time. Diversion to an alternate can be accomplished during all phases of flight.

The only automatic page change in the descent/approach phases is the VNAV selected page change from cruise to descent at the top of descent.

Early Descent

Refer to Early Descent in Chapter 11, Section 42, for additional information.

Descent

During descent, LNAV is managed using the RTE LEGS and PROGRESS pages, as in the cruise phase. VNAV descent management is accomplished primarily on the DES page.

During descent, the specific page listed below is used to:

- DESCENT FORECAST page – enter forecast wind data to aid descent planning
- OFFPATH DES page – analyze descent performance with and without the use of speedbrakes
- ALTN page – manage the selection of alternate airports and diversions

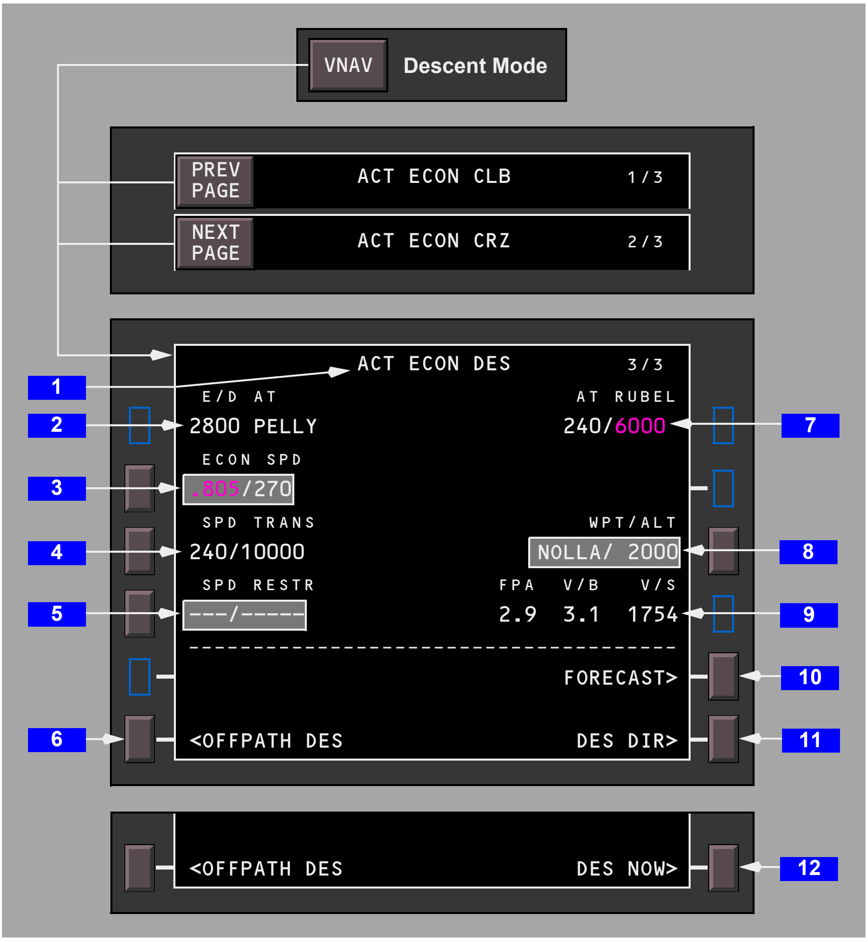
Altitude Intervention

If an unplanned level-off is required, setting the altitude window to the required altitude causes the airplane to level at the set altitude. VNAV PTH changes to VNAV ALT. The descent can be continued by setting the altitude window to a lower altitude and pushing the altitude selector. If the altitude window is set to an altitude below other altitude constraints, each altitude constraint can be deleted by each push of the altitude selector. Or, all waypoint altitude constraints between the current airplane altitude and the altitude window setting can be deleted by selection of the DES DIR> prompt on the DES page.

Descent Page

The descent page is used to monitor and revise the descent path. Descent speeds are economy (ECON) and fixed speed (SEL). The default VNAV descent mode is ECON. A fixed speed descent is flown when speed intervention is used or a speed is entered on the DES page. The descent page is blank with DES as the title until an altitude constraint below the cruise altitude is entered.

This page title includes the VNAV speed mode. The ECON mode controls descent speed at the economy speed until reaching a lower speed restriction. The fixed speed mode controls descent speed at the fixed speed until a lower speed restriction is reached.



1 Page Title

The page title displays active (ACT) or modified (MOD) descent. Usually, the title displays ECON for economy descent. Fixed speed descents modify the title.

The page title displays the type of descent:

- ECON – speed based on a cost index
- LIM SPD – speed based on airplane configuration limiting speed
- MCP SPD – MCP speed intervention is selected
- XXXKT – fixed CAS descent speed profile
- M.XXX – fixed Mach descent speed profile
- END OF DES – E/D AT waypoint reached if not followed by a climb segment

Fixed descent speeds are for:

- a flight crew entered selected speed (SEL SPD)
- a speed transition
- a speed restriction associated with an altitude constraint
- waypoint speed constraints

2 End Of Descent At (E/D AT)

Displays the end of descent altitude and waypoint.

The end of descent point is a waypoint in the descent phase with the lowest altitude constraint.

The altitude displays in magenta when altitude becomes the FMC altitude target.

Page is blank if no E/D point exists.

3 Economy Speed (ECON SPD), Selected Speed (SEL SPD)

Both CAS and Mach values display.

ECON SPD –

- economy speed based on cost index
- displays CAS and Mach values

SEL SPD –

- displays when flight crew enters speed
- displays constraint speed on transitioning into a selected speed segment (waypoint speed constraint, SPD RESTR, or SPD TRANS)
- valid entries are CAS or Mach

The FMC commanded speed is magenta. Initially, Mach is magenta and CAS is white. Below CAS/Mach transition altitude, CAS is magenta and Mach is white.

4 Speed Transition (SPD TRANS)

The transition speed is usually 10 knots less than the destination airport limiting speed from the navigation database. When no airport limit speed exists, the default speed of 240 knots displays. The transition altitude is the point the transition speed is active for the destination airport. When no altitude exists in the navigation database, the default of 10,000 feet displays.

Speed displays in magenta when it is the FMC speed target.

Blanks below SPD TRANS altitude.

Deleting causes the airplane to fly economy or selected speed if not limited by a waypoint constraint or speed restriction.

5 Speed Restriction (SPD RESTR)

Speed restrictions at altitudes higher than E/D altitude and not associated with specific waypoints are manually entered on this line.

Valid entry is a CAS and altitude (example 240/8000). Entry may be deleted.

Magenta when it is FMC command speed.

6 Off Path Descent (OFFPATH DES)

Push – displays the OFFPATH DES page.

7 AT XXXXX

Displays the next waypoint constraint from the RTE LEGS page.

XXXXX is:

- the waypoint identifier
- HOLD AT XXXXX
- AT VECTORS
- AT (INTC)

The constraint is speed/altitude. Blank when no constraint exists.

Can be deleted on this page.

VNAV commands the lesser of constraint speed or present performance speed.

Speed and/or altitude display in magenta when they are the FMC target values.

8 Waypoint/Altitude (WPT/ALT)

Displays the reference vertical bearing waypoint identifier and altitude.

Displays pilot entered waypoint/altitude data if entered.

Defaults to the next descent waypoint constraint (displayed in 1R) if no pilot entry.

For window altitude constraints, displays the upper altitude if the airplane is above it, otherwise the lower altitude is displayed.

Displays dashes if no constraint exists in the descent portion of the flight plan.

Valid entry is any waypoint/altitude combination where the waypoint exists in the Nav Database, or in the flight plan (including lat/lon waypoints and reporting points) and the altitude is below the current airplane altitude.

9 **Flight Path Angle (FPA), Vertical Bearing (V/B), Vertical Speed (V/S)**

Display is blank if no waypoint/altitude combination is displayed at line select key 3R or if the airplane is below the altitude displayed at line select key 3R.

FPA –

- Displays the current flight path angle of the airplane
- Display is blank for FPA greater than positive 0.05 degrees

V/B displays the calculated vertical bearing required to achieve the waypoint altitude displayed at line select key 3R.

V/S displays the vertical speed required to achieve the waypoint altitude displayed at line select key 3R.

10 **FORECAST**

Push – displays the DESCENT FORECAST page.

11 **Descend Direct (DES DIR)**

Push – deletes all waypoint altitude constraints between the airplane altitude and the MCP altitude. FMC cruise altitude is not affected.

Displays in descent phase with altitude constraint between airplane and E/D.

12 **Descend Now (DES NOW)**

Push –

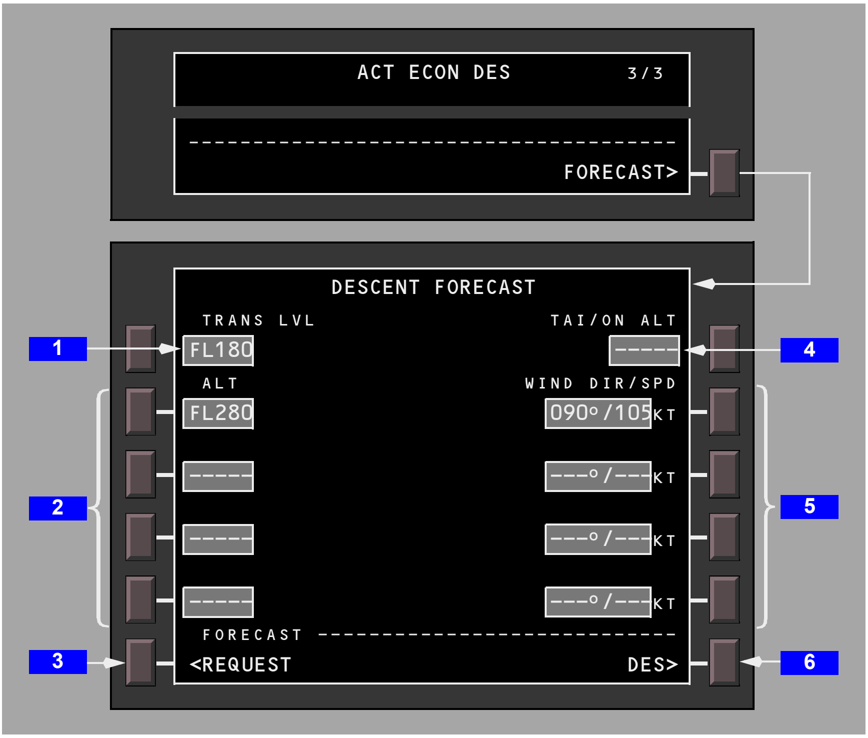
- starts a 1250 feet per minute descent schedule until intercepting the planned descent path
- activates the FMC descent phase

Displays when the descent phase is not active.

Descent Forecast Page

The descent forecast page is used to enter wind data for descent, and the altitude at which anti–ice use is anticipated for more accurate descent path calculation.

The primary entries are wind direction and speed for up to four descent altitudes, and the altitude that anti–ice is turned on.



1 Transition Level (TRANS LVL)

Displays the transition level.

The transition level can be specified by the arrival procedure. The default transition level is FL180.

Above transition level, altitudes are in flight levels. Below transition level, altitudes are in thousands of feet.

Valid entry is an altitude or flight level.

2 Altitude (ALT)

Enter altitude of forecast wind data.

Altitudes and flight levels can be entered in any order. Entries are not sorted.

Execute not necessary.

3 FORECAST REQUEST

Push – transmits a datalink request for descent wind data.

4 Thermal Anti–Ice On Altitude (TAI/ON ALT)

Enter the altitude where anti–ice is first turned on during the descent.

5 Wind Direction/Speed (WIND DIR/SPD)

Enter the wind direction/speed for the specified altitude. Initial entry must have wind direction and speed, subsequent entries may have one or the other.

Execute not necessary.

6 Descent (DES)

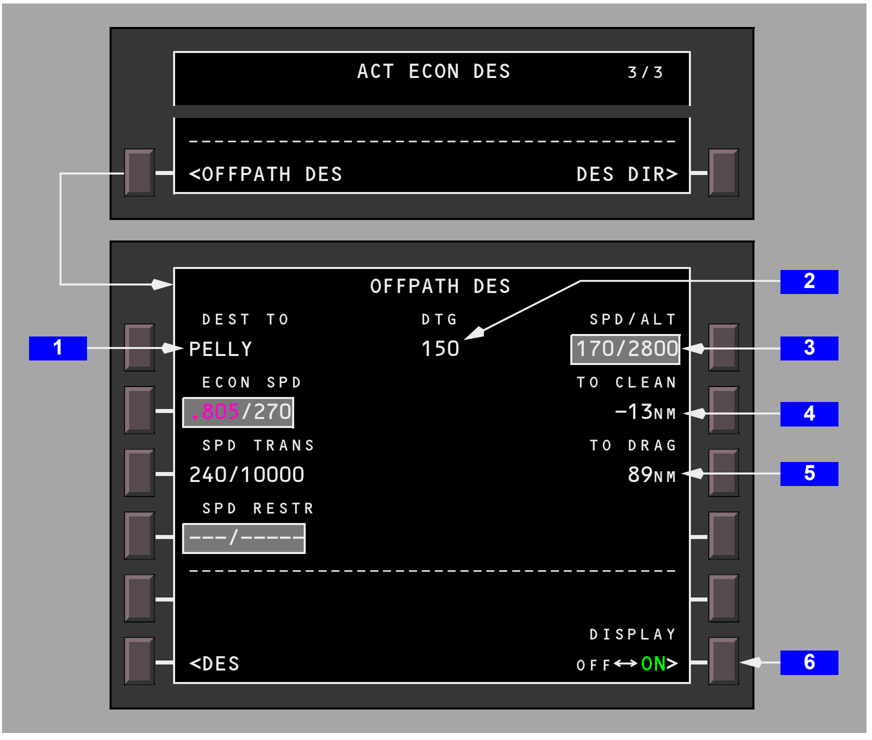
Push – displays the DES page.

Offpath Descent Page

The offpath descent page allows the analysis of descent performance off the present route of flight, direct to a selected waypoint. Data entered on the page shows clean and drag descent ranges on the page and on the ND. The ranges are based on an entered waypoint and altitude constraint. The range can be used to determine if the altitude constraint can be met in a direct descent to the waypoint.

The FMC puts the last descent waypoint with an altitude constraint into DES TO.

The ECON SPD, SPD TRANS, SPD RESTR, and DES data are the same as the DES page.



1 Descend To (DES TO)

The waypoint for a direct–to descent. Usually, this is the E/D waypoint from the active route. Manual entry of waypoints on or off of the route are allowed. The DTG calculations are for a descent direct to the selected waypoint.

When within 150 feet of the DES TO altitude for a waypoint other than the E/D waypoint, the display automatically changes the DES TO waypoint to the E/D waypoint from the DES page.

A waypoint is entered for direct–to analysis.

2 **Distance To Go (DTG)**

Displays the straight line distance to the entered waypoint.

3 **Speed/Altitude (SPD/ALT)**

Displays the speed/altitude constraint for the entered waypoint.

A manual waypoint entry displays boxes for manual speed and altitude entry.

4 **TO CLEAN**

Distance to the clean descent circle. The distance is negative when a clean descent is no longer possible.

A clean circle assumes no drag devices are used for descent.

A direct descent to the DES TO waypoint at a SPD/ALT constraint is possible when the airplane is outside the clean circle. The clean circle displays on the ND when the DISPLAY prompt is ON.

5 **TO DRAG**

Distance to the drag descent circle. The distance is negative when a drag descent is no longer possible.

A drag circle assumes speedbrakes are UP for descent.

A direct descent to the DES TO waypoint at a SPD/ALT constraint is possible when the airplane is outside the drag circle. The drag circle displays on the ND when the DISPLAY prompt is ON and the airplane is inside the clean circle.

6 **DISPLAY**

Push – alternates between ON and OFF.

ON – displays the clean and drag circles on the ND. The drag circle does not display until the airplane position is inside the clean circle.

OFF – removes the clean and drag circles from the ND.

Selected state is large green font, otherwise small white font.

Automatically changes to OFF within 150 feet of the waypoint constraint altitude.

Engine Out Descent

There are no specific engine out pages for descent. Use the two engine descent planning features and pages.

Approach

During approach, roll and pitch modes usually change to the approach guidance supplied by navigation radios. The FMC continues to calculate and show present position and can supply LNAV and VNAV approach guidance for certain types of approaches when radio navigation is not used.

The RTE LEGS and PROGRESS pages are used to manage the airplane until other approach guidance becomes active. Other pages which support approaches are:

- ARRIVALS page – to select arrival and approach procedures
- APPROACH REF page – to specify approach flap settings and set the approach VREF
- HOLD page – to manage holding patterns

Holding is described in this section but it can be used during any phase of flight.

Arrivals Page

The arrivals page allows selection of a runway, approach, approach transition, standard terminal arrival route (STAR) or profile descent, and an arrival transition to the destination airport.The INDEX key accesses the DEP/ARR INDEX and provides arrival/departure data for any other airport in the navigation database. Route 1 and route 2 have separate arrival pages.

Airports are using multiple RNAV/ILS approaches to the same runway. ICAO has developed a naming convention which adds an additional character to the approach name; Z, Y, X, ... in the approach title following the guidance source. The primary approach is identified as the “Z” approach; all subsequent procedures (normally with different missed approach paths) use the alpha characters in reverse order beginning with Y. This change requires approach names with up to eight characters to be encoded in the navigation database.

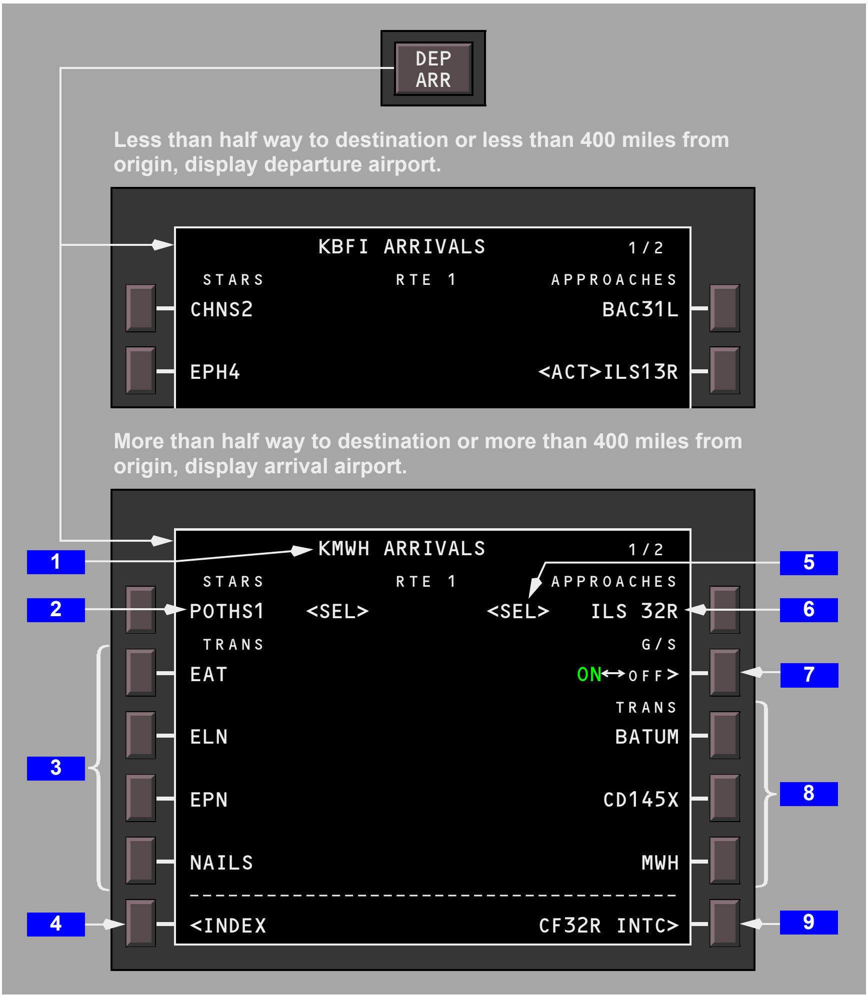
Selecting Options

Selecting a runway, approach, approach transition, STAR/profile descent, or arrival transition displays <SEL> inboard of the selection and displays MOD in the page title. The other options within the same category are removed from the list. When the modification is executed, <SEL> changes to <ACT>. Selecting another page and returning to ARRIVALS displays all options; the applicable <SEL> or <ACT> prompts display.

When a STAR is selected followed by selection of an approach or runway and a transition exists in the navigation database, the transition waypoints with associated speed/altitude constraints are inserted into the flight plan linking the STAR to the approach or runway. If more than one transition exists, selection of the applicable transition is made under TRANS on the left side of the page. Some STARs serve more than one runway. If a STAR and runway are selected and subsequently a different runway is selected, and if the STAR is compatible with the new runway, the transition waypoints are inserted into the flight plan linking the STAR to the runway.

If a different STAR, runway, or STAR-runway combination is desired, selecting another page and returning to the ARRIVALS displays all options.

Arrivals Page – IFR Approaches



1 **Page Title**

The destination airport identifier displays in the title.

Airports with more than 5 runways or STARs produce multiple arrivals pages.

2 **Standard Terminal Arrivals (STARS), Profile Descents (PROF DES)**

STARS display in a list under the STARS line title. Profile descents display below STARS under the PROF DES line title.

NONE displays when there are no STARS in the database.

Push -

- selects STAR or PROF DES for entry into the route, <SEL> displays
- all other arrival procedures no longer display and transitions for the selected procedure display
- deletes a previously selected procedure
- displays ERASE prompt

3 STAR Transitions (TRANS)

Displays list of transitions for the selected arrival procedure.

Push -

- selects transition for entry into the route
- all other transitions no longer display

4 INDEX

Push – displays the DEP/ARR INDEX page.

5 Route 1 (RTE 1)

Displays the active route number (RTE 1 or RTE 2).

6 APPROACHES

Displays the destination airport approaches.

ICAO eight character approach names are supported. Example: RNVZ 08R.

Selection and execution of an ILS approach autotunes the ILS receivers and displays the course. Selection and execution of a back course (BAC) approach autotunes the ILS and displays the front course.

Push -

- selects approach for entry into the route; <SEL> displays; TRANS replaces RUNWAYS
- displays profile descents for the selected approach; deletes all other approaches and runways
- displays INTC prompt for the selected approach
- displays ERASE prompt

7 Glideslope (G/S)

Displays whenever a localizer based approach (ILS, IGS, LOC, BAC, LDA, SDF) is in the currently displayed, selected or active flight plan.

Provides a means of using IAN glidepath guidance when ILS glideslope guidance is not available.

Default state:

- ON (large green font) for ILS or IGS approaches
- OFF (large green font) for LOC, BAC, LDA or SDF approaches

Push – toggles glideslope on or off.

8 Approach Transitions (TRANS)

Displays a list of transitions to the selected approach.

Approach transitions include IAFs, feeder fixes, and fixes providing routing to the FAF.

When a transition is not selected, the FMC displays a straight-in approach starting at a waypoint outside of the FAF. The waypoint may be conventionally named (i.e. LACRE) or a charted fix (i.e. CFXXX, where XXX is the runway number). The waypoint distance from the FAF is not fixed and varies depending upon the waypoint chosen.

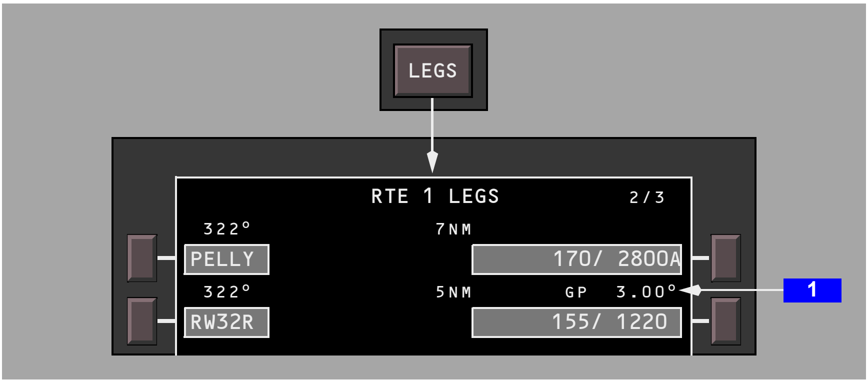
Push –

- selects transition for entry into the route
- deletes all other transitions
- displays INTC prompt for selected transition

9 Final Approach Fix Intercept (XXXXX INTC)

Selecting the prompt displays a modified RTE LEGS page with an intercept course to the approach transition fix (usually the IAF) for the selected approach.

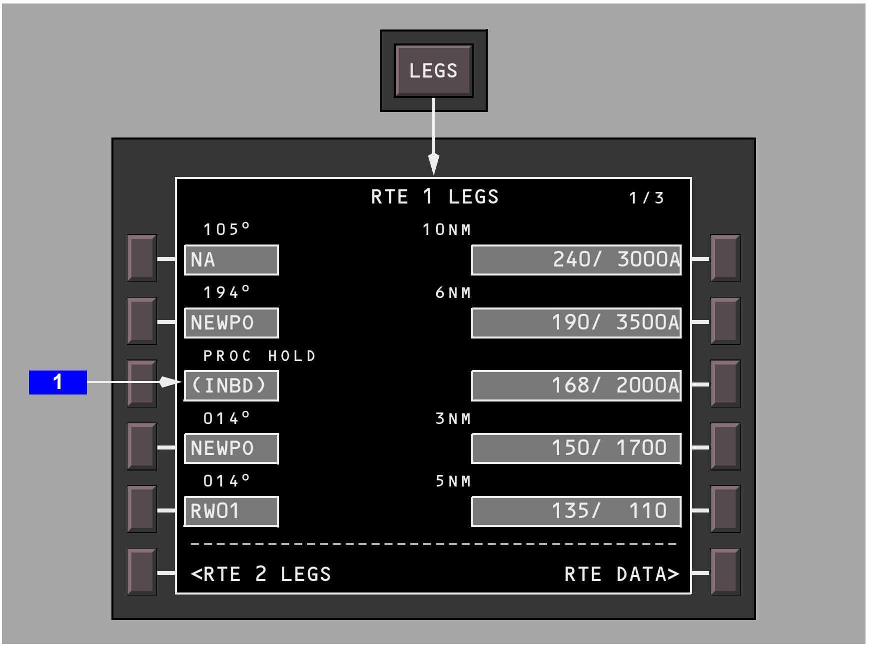
Arrivals Legs Page



1 Glidepath Display

Displays the glidepath angle used by VNAV on final approach to the runway.

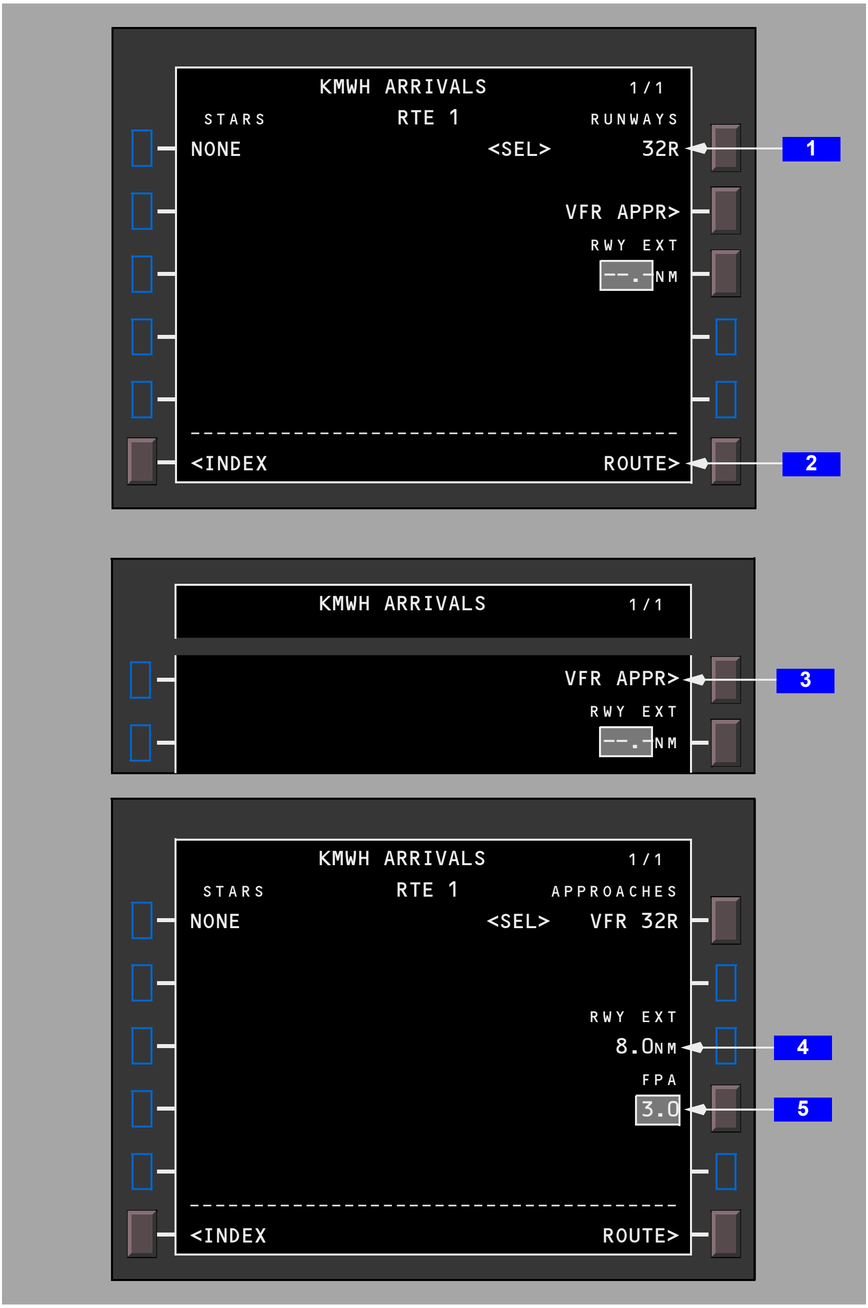
Procedure Hold (in lieu of procedure turn) Legs Page

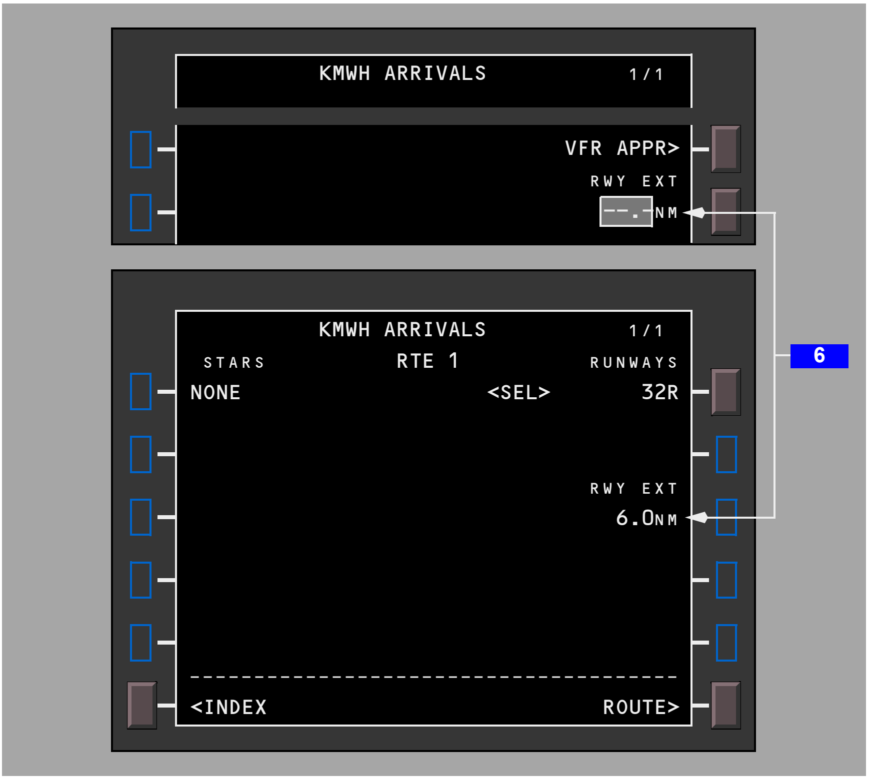


1 Inbound Waypoint

A conditional waypoint (“INBD”) is created at the end of the procedure turn. This waypoint displays on the ND as a small circle. The next line displays inbound heading and distance to the holding fix. The procedure hold is not displayed on a Hold page.

Arrivals Page – VFR Approaches





1 **RUNWAYS**

Displays a list of runways for destination airport.

Push –

- selects runway for entry into the route
- deletes previously selected approach
- allows selection of VFR approach or entry of RWY EXT data
- deletes all other runways and approaches
- displays approach intercept fix for selected runway

2 **ROUTE**

Push – displays the active route page 2/X.

3 **VFR Approach (VFR APPR)**

Push – makes a transition waypoint, FAXXX at 8 nm and 2000 feet above the runway.

Creates a descent constraint 50 feet above runway threshold.

Displays when a VFR approach is in navigation database for selected runway.

LNAV and VNAV guidance to the runway is available. VNAV programs arrival at the FAF at 170 knots.

4 Runway Extension (RWY EXT)

After VFR APPR selected, displays RWY EXT 8.0 nm; RWY EXT can not be modified.

5 Flight Path Angle (FPA)

Displays flight path angle. Displays only after VFR APPR is selected.

Default is 3.0 degrees. Valid entries are from 2.4 to 3.7 degrees.

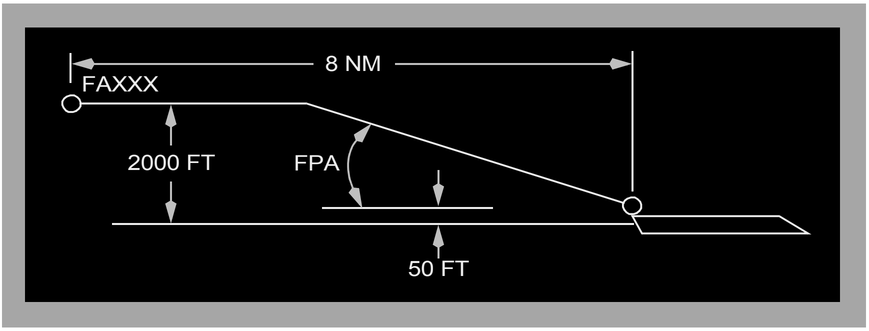
6 Runway Extension (RWY EXT)

Valid entries are from 1.0 to 25.0 miles from the runway threshold.

Entry allowed if VFR APPR is not selected. Entry removes VFR APPR prompt. Example shows 6 nm entered.

Makes waypoint RXYYY, where YYY is the runway; example: RX32R. Makes a route discontinuity before and after the waypoint.

VFR Approach Path

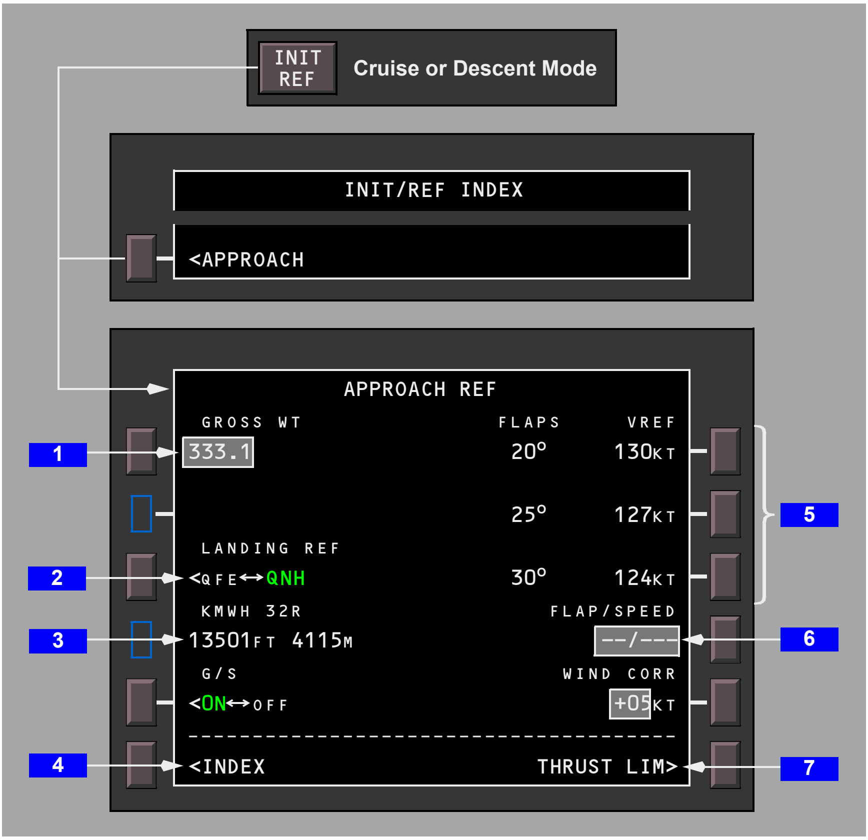


The VFR approach is a level path until the VNAV descent path is intercepted. The descent path begins at the FAXXX waypoint altitude and terminates at the runway threshold at 50 feet. Default values display in RWY EXT and FPA.

Approach Reference Page

The approach reference page displays approach planning data and approach reference speed (VREF) selection.

[Option – English units, QFE landing reference prompt]



1 Gross Weight (GROSS WT)

FMC calculated airplane gross weight usually displays.

Manual entry is allowed in case the FMC calculated gross weight is unavailable or invalid, or to allow previewing recommended approach speeds at other than the calculated FMC gross weight. The manually entered gross weight becomes the FMC calculated gross weight when a different page is selected and the APPROACH REF page is reselected. Permanent changes to gross weight result in recalculation of all performance data and may only be made on the PERF INIT page.

Displays boxes when gross weight is not available from the FMC.

Valid entry is XXX.X.

2 **Landing Reference (LANDING REF)**

Landing reference is selectable between QNH and QFE. Usually, QNH is the operating mode.

Selecting QFE sets the cabin pressurization schedule, and the destination landing altitude indication to zero altitude. With the landing reference set to QFE, changing the barometric setting from STD to QFE changes the PFD altitude tape background color to green. With QFE selected and climb phase active, changing the barometric setting from QFE to STD causes the landing reference to toggle from QFE to QNH and the green background color is removed.

Refer to QFE Operation in Chapter SP, Section 10, for additional information.

Toggles between QFE and QNH. The active mode displays in large green font. The inactive mode displays in small white font.

3 **Runway Length**

The displayed runway reference changes based on route progress. The destination runway is the reference when the present position is more that halfway to the destination or more than 400 nm from the origin airport. The origin airport runway is the reference when less than halfway or less than 400 nm from the origin airport.

Displays length of the new destination runway following a change of destination on the ROUTE page or following execution of a DIVERT.

Displays the length in feet and meters of the referenced runway.

4 **INDEX**

Push – displays the INT/REF INDEX page.

5 **FLAPS VREF**

A gross weight is necessary for VREF speed calculation. Push the applicable line select key to select the correct VREF speed. The three VREF speeds are based on landing flap setting.

Displays the calculated reference speed for flaps 20°, 25°, and 30°.

At lighter landing weights the VREF for flaps 25° and flaps 30° is the same. In this condition, the line select key adjacent to the flap 30° is displayed in cyan and is not selectable due to noise certification requirements for the airplane.

Display is blank prior to having a valid gross weight on the PERF INIT page or entering gross weight on this page.

6 **FLAP/SPEED**

The flap position and VREF speed is entered for landing.

The VREF speed displays on the PFD.

Deletion of the data removes VREF from the PFD.

7 Thrust Limit (THRUST LIM)

Push – displays the THRUST LIM page.

Alternate Airport Diversions

ALTN page 1/2 data aids the flight crew in finding a suitable alternate airport. The page displays four airports in an ETA sequence. Each airport on the list has an XXXX ALTN page with more data. Select the XXXX ALTN page by pushing the associated right LSK. ALTN LIST page 2/2 may contain a list of uplinked alternate airports.

Three alternate airport uplinks can be received. ALTN LIST page 1/2 can get an uplink for the entire page or for just the ALTN INHIB line. ALTN LIST page 2/2 can receive an uplink of alternate airport names.

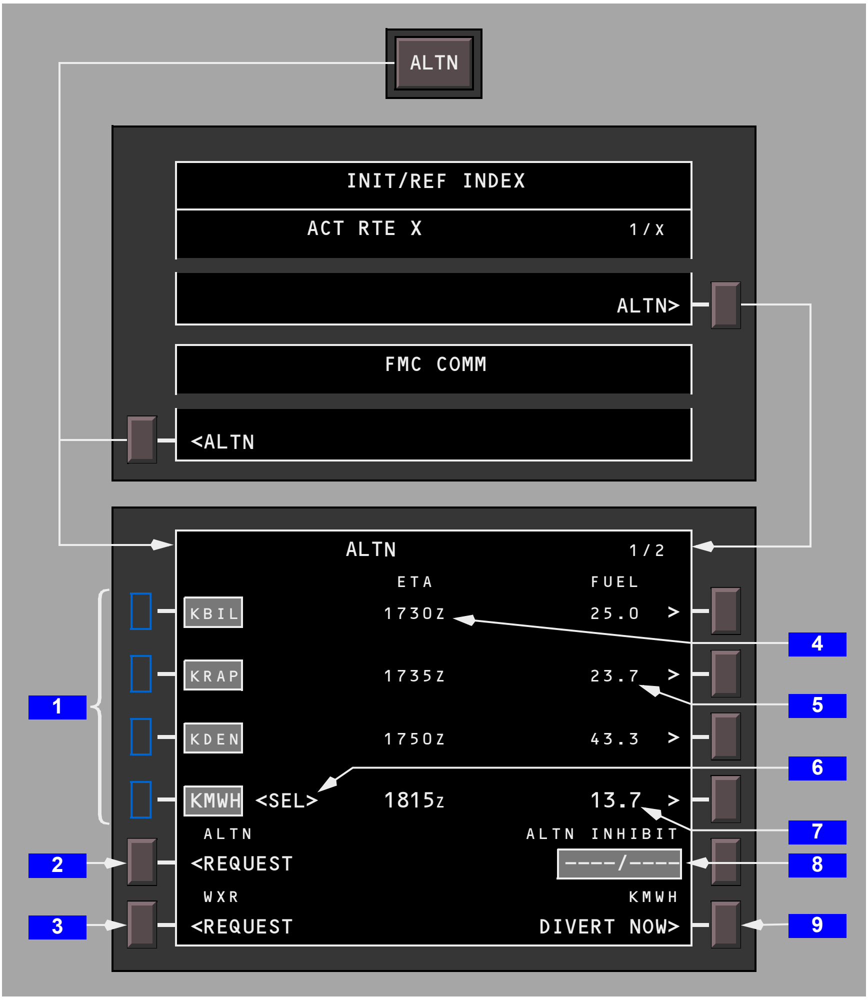
Alternate Page 1/2

The first alternate page displays alternate airport data. An alternate airport can be selected to change the flight plan destination.

The source of alternate airports can be:

- an uplink directly to this page
- automatic selection from the ALTN LIST page
- automatic selection from the navigation database
- manual entry

Alternate airports automatically selected from the alternate list or the navigation database display in small font. When in range, all four alternates display on the ND in cyan. The alternate airport symbols display when the ND is in the plan mode. When in range, the selected alternate airport displays at all times on the ND map. When in range, other alternates display on the ND when the ARPT selection is made on the ND pull down menu. Alternates outside the 640 nm display range are considered offscale airports and display on the ND as directional arrows with airport ICAO identifier and distance in nm.



1 Alternate Airports

Displays the identifier of the four alternate airports in ETA order when airborne; and, in distance order when on the ground.

Valid manual entry is an airport from the navigation database.

A manual entry into a field displaying a small font value overwrites the small font value, but does not delete it from the Alternates Candidates list. After predictions are complete, the overwritten small font value is placed on the list according to ETA order. A manual entry into a field displaying a large font value overwrites and deletes the large font value. Manual entries display in large font.

The DELETE function key can be used to remove manually entered alternate airports from the ALTN page.

2 Alternate Request (ALTN REQUEST)

Push – transmits a datalink request for a preferred list of alternates (up to four).

Uplinked airports display in ETA order but are assigned a preference number by the transmitting site. The CDU help window message ALTN UPLINK is displayed when the alternate airport data arrives.

3 Weather Request (WXR REQUEST)

Push – transmits a datalink request for alternate airport weather data.

4 ETA

ETA is calculated based on the routing, altitude, and speed displayed on the XXXX ALTN page.

Displays the alternate airport ETA.

Blank when airplane is on the ground.

5 FUEL

Predicted arrival fuel is calculated based on the routing, altitude, and speed displayed on the XXXX ALTN page. The message UNABLE FUEL displays in the FUEL column if the predicted arrival fuel is less than zero.

Displays the alternate airport predicted arrival fuel.

Blank when airplane is on the ground.

6 Selected (<SEL>)

The selected alternate is identified with an <A> or <SEL> to the right of the airport identifier.

The FMC selects the alternate airport with the earliest ETA. FMC selected alternates display <A> to the right of the airport identifier.

A manual selection of an alternate airport is made by pushing the line select key left of the airport identifier. Manually selected alternates display <SEL> to the right of the airport identifier.

Entering a new airport into the list of four does not select the new airport.

Use the DELETE function key on a manually selected alternate to remove <SEL>. The automatic selection function selects a new alternate.

7 Alternate Select

Push - displays the XXXX ALTN page for the alternate airport adjacent to the > prompt.

8 Alternate Inhibit (ALTN INHIBIT)

An airport is not one of the four alternate airports if entered into the alternate inhibit line.

One or two airports can be entered.

Alternate inhibits can be manually entered or uplinked. The inhibited airports may be uplinked with the ALTN UPLINK or separately. If uplinked separately, the CDU help window message ALTN INHIBIT UPLINK is displayed.

Valid entries are airports from the navigation database.

9 DIVERT NOW

Selecting DIVERT NOW displays the route from the present position to the selected alternate using the route displayed on the XXXX ALTN page for the diversion airport. The details of the route can be confirmed or modified before the diversion is executed.

Execution of the diversion:

- changes the route destination airport
- includes the route modification into the active flight plan
- deletes all parts of the original route that are not part of the diversion
- if a descent path exists, deletes all descent constraints (the CDU help widow message DESCENT PATH DELETED displays when DIVERT NOW is selected)

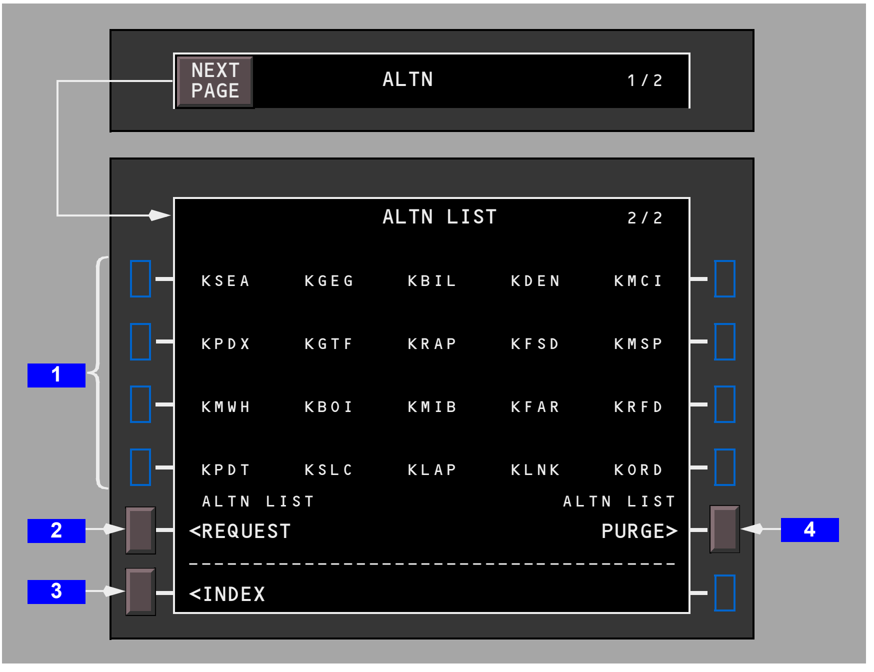
After a divert is executed the XXXX ALTN page is not updated until all CDU displays are selected off of the XXXX ALTN page.

Push –

- makes an LNAV route modification for a divert to the selected alternate
- displays the MOD XXXX ALTN page for the selected alternate
- displays SELECTED in place of DIVERT NOW
- blank on ground
- blank in the air when a diversion is not permitted

Alternate List Page 2/2

The second alternate page displays a list of previously uplinked alternate airports. The alternates on the ALTN 1/2 page are selected from this list or from the navigation database when a list does not exist.



1 Alternate Airports List

These four lines contain up to 20 airports from which alternates can be selected and displayed on ALTN page 1/2 when preferred uplinked airports do not use all four lines.

The list is uplinked directly to this page. No manual entry is allowed. Manual airport entries are accomplished on the ALTN 1/2 page.

2 Alternate List Request (ALTN LIST REQUEST)

Push – transmits a datalink request for an alternate airport list uplink.

3 INDEX

Push – displays the INIT/REF INDEX page.

4 Alternate List Purge/Confirm (ALTN LIST PURGE/CONFIRM)

When no list exists, alternate airports can be selected from the navigation database.

Selecting the PURGE prompt arms the purge function and displays a CONFIRM prompt before the list is deleted.

Push – deletes all airports from the list.

A new list must be uplinked after a purge.

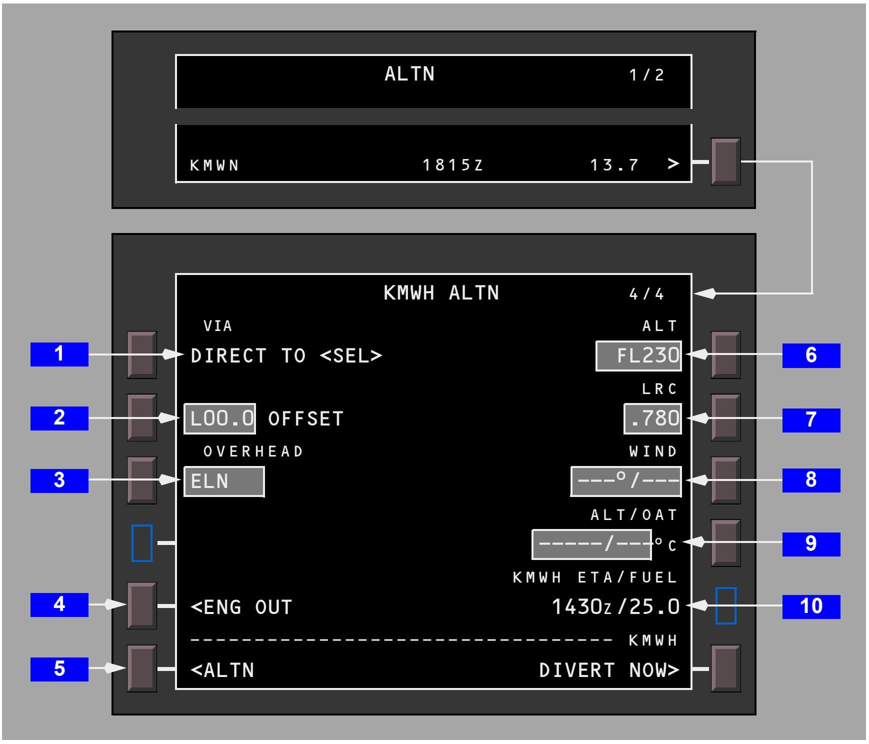
XXXX Alternate Page

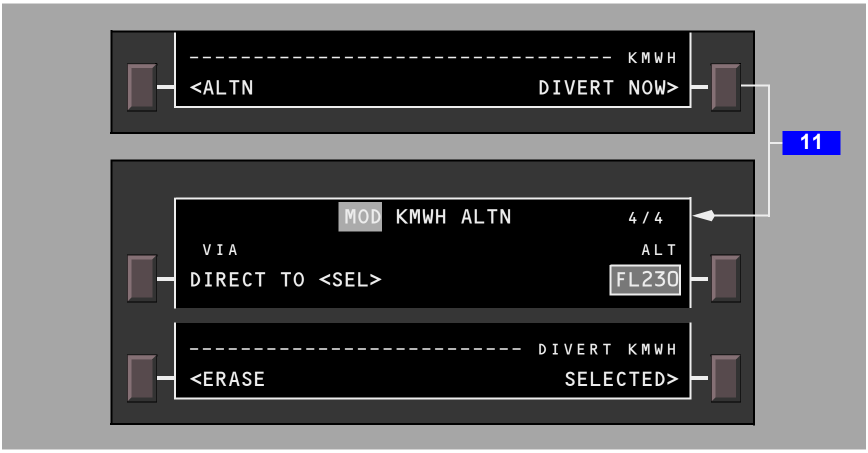
Each of the four alternate airports displayed on the ALTN page 1/2 has a related XXXX ALTN page. The XXXX ALTN pages display specific data about alternate airports, the route used for a diversion, and the conditions on which the ETA and fuel calculations are based. All data on the page is related to the alternate airport displayed in the page title.

Three route options to the airport can be selected:

- DIRECT TO – direct to alternate
- OFFSET – flight plan route with an offset
- OVERHEAD – flight plan route to a waypoint, then direct to alternate

The selected route option has an effect on ETA and fuel remaining. It is identified by <SEL>. Selection of a route option for one alternate selects the same route option for the other three alternates.





1 VIA DIRECT TO

Push – selects DIRECT TO route option.

All flight plan waypoints are deleted.

2 VIA OFFSET

Push –

- with scratchpad empty, selects OFFSET route option
- with offset data in scratchpad, enters offset data. Does not select option

Entry and exit to the offset is the same as for the RTE page offset. Flight plan waypoints are retained.

3 VIA OVERHEAD

Push –

- with scratchpad empty, selects OVERHEAD option
- with overhead data in scratchpad, enters overhead data. Does not select route option

Displays active waypoint in flight plan.

The waypoints up to the selected or entered overhead waypoint are retained, then routing is direct to the alternate airport. All waypoints after overhead waypoint are deleted.

Enter any waypoint in the active or modified route.

4 Engine Out (ENG OUT)

This prompt performs the same function as described on the cruise page in the FMC Cruise section. It can be selected before or after the diversion is selected.

5 Alternate (ALTN)

Push – displays the ALTN 1/2 page.

6 **Altitude (ALT)**

Entry of any valid altitude or flight level into this line causes a recomputation of ETA and arrival fuel. Altitude entries do not become part of the diversion modification. Altitude entries apply to all four alternates.

Displays the altitude for which ETA and arrival fuel are calculated.

7 **Speed (SPD)**

Entry of speed or Mach number into this line causes a recomputation of ETA and arrival fuel. Speed entries do not become part of the diversion modification. Speed entries apply to all four alternates.

Speed modes available are:

- ECON (economy)
- LRC (long range cruise)
- EO (engine out)
- EO LRC (engine out long range cruise)
- CO (company speed)
- any CAS or Mach

8 **WIND**

Entry of data causes recomputation of ETA and arrival fuel. A wind entry may be made for each of the four alternates. A wind entry applies to only one alternate.

Valid entry is a direction in degrees/speed in knots from 1 to 250.

9 **Altitude/Outside Air Temperature (ALT/OAT)**

Entry of data into these lines causes a recomputation of ETA and arrival fuel. A separate ALT/OAT entry may be made for each of the four alternates.

Displays the OAT for a specific altitude.

Valid entry is an altitude/temperature in degrees C.

10 **Alternate Airport ETA/Fuel (XXXX ETA/FUEL)**

Displays calculated airport ETA and arrival fuel based on the selected route, altitude, and speed displayed on this page.

11 **XXXX DIVERT NOW**

This prompt performs the same function as described on the ALTN 1/2 page.

Note: After a divert is executed, the XXXX ALTN page data is not updated until all CDU displays change to a page other than the XXXX ALTN page.

Holding

The FMC computes holding patterns with constant radius turns based on current wind and FMC commanded airspeed. The pattern size is limited to FAA or ICAO protected airspace. In LNAV, the AFDS tracks the holding pattern using up to a 30 degree bank angle. Strong winds or airspeed in excess of FAA or ICAO entry speeds may result in the airplane flying outside the protected airspace.

With LNAV active before sequencing the holding fix, holding pattern entries are determined by the following:

- airplane track, not heading or direction from which the active route approaches the holding pattern, determines the entry method used (parallel, teardrop, or direct entry)
- the airplane flies the initial outbound leg a computed distance from the holding fix, rather than a specific time. The computed distance is a function of the command airspeed and computed wind at the time the holding pattern becomes active
- teardrop entries use a 40 degree offset angle

Holding Entry

Airplane track to the holding fix determines the entry type; direct, teardrop, or parallel. To make efficient use of the holding airspace, lateral guidance may direct the initial turn to the holding pattern prior to crossing the holding fix (fly-by). The holding entry path displays on the ND. For all holding entry types, lateral guidance directs the airplane to fly-by or fly-over the holding fix and to remain on the holding side of the inbound holding course. Depending on the entry track for a direct entry, the flight path may extend slightly beyond the displayed outbound holding turn. For teardrop and parallel entries, the flight path remains within the confines of the depicted holding pattern displayed on the ND. Remaining within the prescribed holding airspace requires the airplane to be at holding airspeed at the holding fix.

Hold Page (First Hold)

The hold page is used to enter a holding pattern in the route.

When the flight plan does not contain a holding pattern, pushing the HOLD function key displays the RTE X LEGS page with the HOLD AT line.

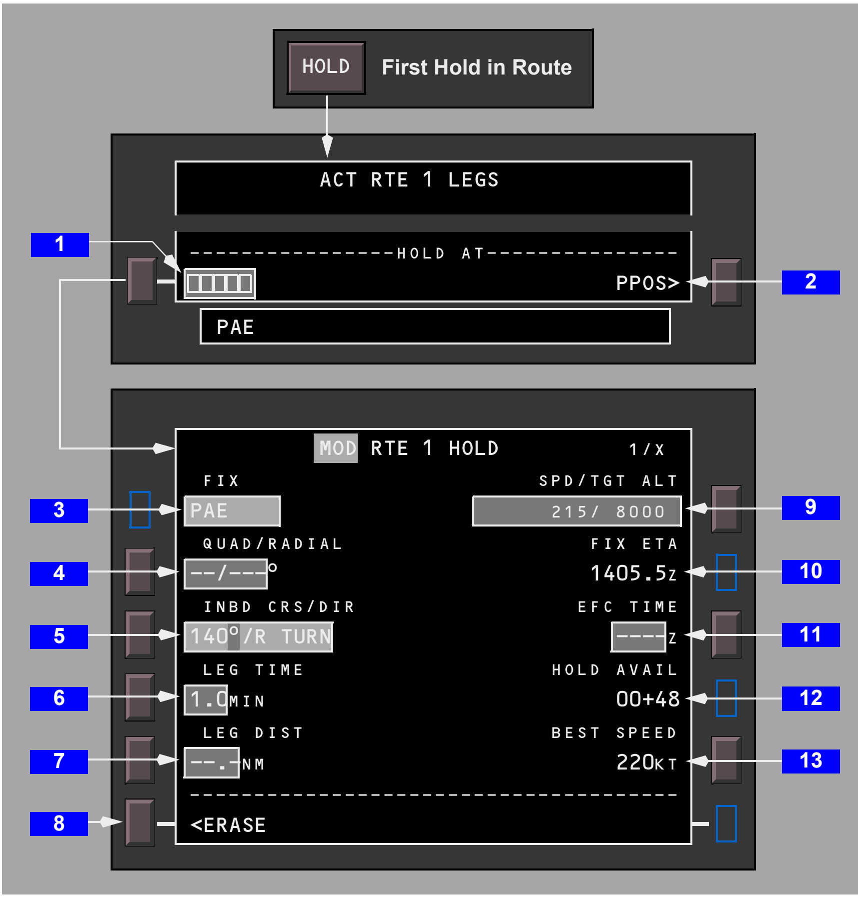
Two versions of the hold page are possible:

- an airway or procedure holding pattern
- a flight crew–entered holding pattern

The holding page displays actual or default data about the holding pattern.

Entries modify the route. Modifications can be erased or executed.

Active holding patterns are magenta on the ND.



1 HOLD AT

Displays boxes to enter the holding fix: a RTE LEGS, database, or pilot-defined waypoint; a navaid or airport identifier; or a FAF already in the flight plan.

Entering a holding fix displays the RTE X HOLD page.

2 HOLD AT Present Position (PPOS)

Push –

- creates a holding pattern at present position
- execution establishes the holding fix at the position when EXEC is pushed and displays RTE HOLD

3 Holding FIX

Displays the holding fix.

4 Quadrant/Radial (QUAD/RADIAL)

Normally displays dashes.

Valid entry is X/XXX, XX/XXX, or /XXX. Example: NW/330.

Entry changes INBD CRS/DIR to agree.

5 Inbound Course/Direction (INBD CRS/DIR)

Displays inbound course and turn direction.

Valid entry is XXX (inbound course), XXX/X (inbound course/turn direction), /X or X (turn direction).

Entry changes QUAD/RADIAL to agree.

Displays magenta when the holding fix is the active waypoint.

Displays T if mag/true reference is in TRUE.

6 Leg Time (LEG TIME)

Displays 1.0 MIN (minute) at or below 14,000 feet.

Displays 1.5 MIN above 14,000 feet.

Displays dashes when an entry made on LEG DIST line.

Valid entry is X, X.X, or .X.

When climbing/descending through 14,000 feet with VNAV active and the SPD/TGT ALT at 1R displays in large font, the FMC adjusts the leg time (1.0 MIN at or below 14,000 feet; 1.5 MIN above 14,000 feet).

7 Leg Distance (LEG DIST)

Normally displays dashes. Allows entry of leg distance for hold.

Entry displays dashes on LEG TIME line.

Valid entry is X, XX, X.X or XX.X, where X is any integer.

8 ERASE

Erases all FMC modifications.

9 Speed/Target Altitude (SPD/TGT ALT)

Dashes display or fix speed/altitude constraint from the RTE LEGS page.

Manual entries are in large font.

During cruise, entry of a target altitude lower than CRZ ALT modifies the DESCENT page and displays a T/D. After T/D, the DESCENT page remains active unless a new cruise altitude is entered.

Speed or altitude may be entered.

10 FIX ETA

With no EFC TIME entry, displays time the airplane will next pass the holding fix.

With EFC TIME entry, displays time the airplane will pass the holding fix after the EFC time. The FMC uses this time to calculate downtrack ETAs and fuel values based on departing the holding fix at the new FIX ETA.

11 Expect Further Clearance Time (EFC TIME)

Normally displays dashes.

Valid entry is XXXX (time).

Entry changes performance predictions for the route after holding.

12 Hold Available (HOLD AVAIL)

Displays holding time available before requiring reserve fuel to reach the destination.

13 BEST SPEED

Displays the best holding speed for the airplane gross weight, altitude, and flap setting.

Note: May exceed ICAO limit speed.

HOLD Page (Existing Hold)

When one or more holding patterns exist in the route, push the HOLD key to display the hold page for the first holding pattern. When the hold is the next LNAV event, active commands display in magenta. Holding parameters can be monitored and changed on this page. New holding patterns are added using the NEXT HOLD prompt.

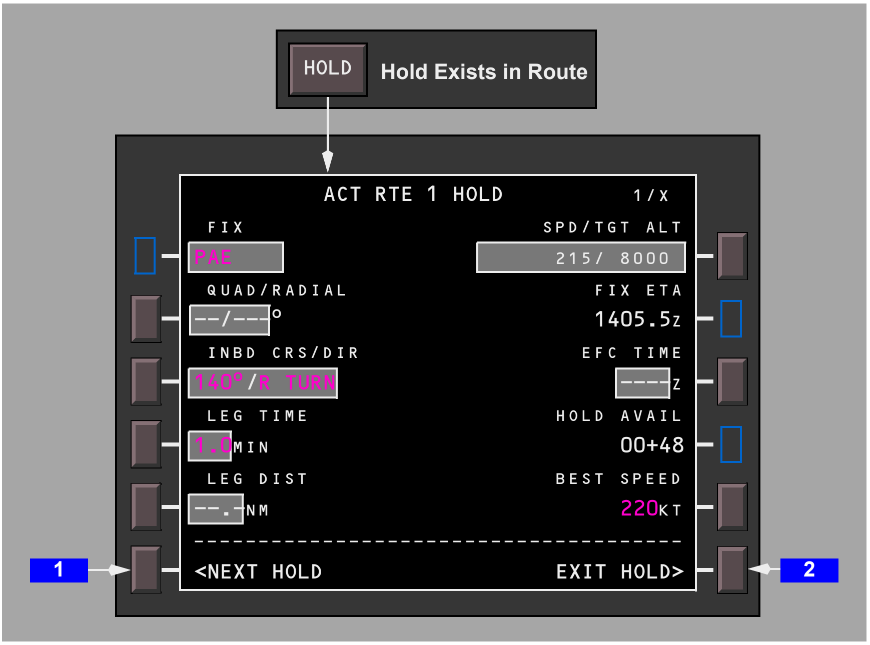
Most holding patterns are part of a procedure or airway and remain active until the flight crew executes an exit from holding. This may be accomplished in one of two ways:

- on the ACT RTE LEGS page, deleting or bypassing the HOLD AT waypoint causes LNAV to command a direct to the next waypoint
- on the ACT RTE HOLD page, selecting and executing EXIT HOLD> causes LNAV to command the airplane to continue in the holding pattern until arriving at the holding fix, at which time the airplane exits the holding pattern

Following execution of the exit hold, only the remaining portion of the holding pattern back to the holding fix displays. Exit from the holding pattern may occur prior to crossing the holding fix (“fly-by”) if the course to the next waypoint is not closely aligned with the holding inbound course. The exiting flight path remains within the confines of the protected holding airspace. The exit flight path displays on the ND.

The FMC automatically commands an exit from some holding patterns in procedures under the following conditions:

- for instrument approach holding patterns designed as a course reversal in lieu of a procedure turn, the airplane exits holding upon arrival at the holding fix inbound. Header at 1L displays PROC HOLD
- for some holding patterns in SIDs, the airplane exits holding when arriving at an altitude. Header at 1L displays HOLD AT



1 **NEXT HOLD**

Push – displays a new hold page for a new holding pattern entry.

2 **EXIT HOLD**

Push –

- arms a holding pattern exit
- EXIT ARMED displays in shaded white; when executed, airplane returns to the holding fix via the inbound course for holding pattern exit

Introduction

In the unlikely event that loss of all displays or loss of all three FMCs occurs, a backup navigation capability has been provided through the Tuning and Control Panel (TCP). Alternate navigation information is displayed on the ISFD allowing the aircrew to safely fly to and land at the nearest suitable airport. Alternate navigation capability is accessed by pushing the NAV key on any of the three TCPs. VNAV is not available. Autothrottles may be available. The left TCP must be used to tune ILS/GLS frequencies into the left integrated navigation receiver.

Alternate Navigation Waypoint

The TCPs do not have a performance or navigation database. A single waypoint may be manually entered by the flight crew on the ALTN NAV page. The waypoint may be updated as necessary.

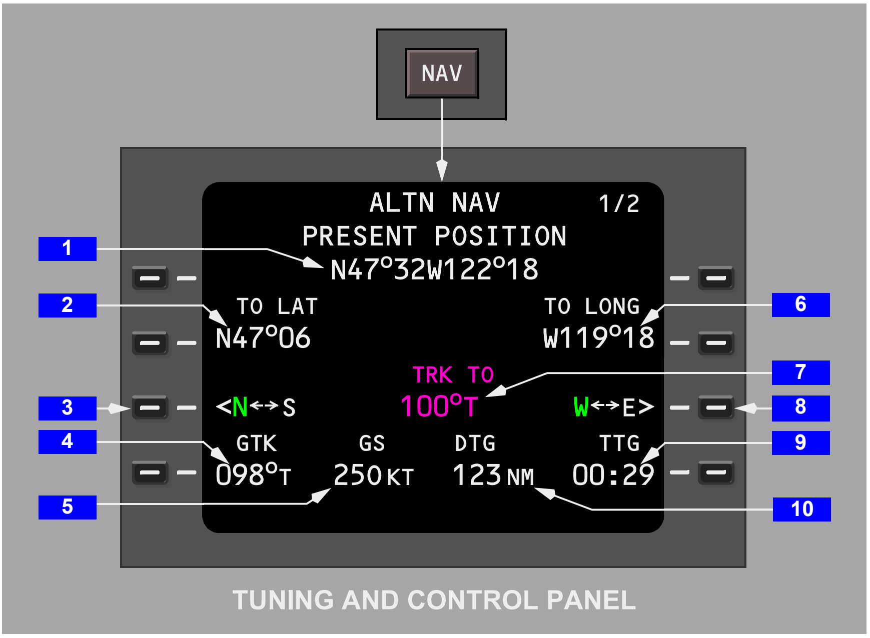
Alternate Navigation TCP Pages

The alternate navigation system operates from two TCP pages:

- ALTN NAV
- ALTN NAV RADIO

Alternate Navigation Page

The ALTN NAV page displays general information on flight progress.



1 Present Position

Displays current left integrated navigation receiver latitude and longitude to the nearest whole minute.

2 To Latitude (TO LAT)

Enter a to waypoint latitude into the TCP scratchpad:

- select N or S on the latitude hemisphere selection key
- enter latitude in degrees (D) and minutes (M) using DDDMM format
- default is current latitude hemisphere

Line select into the TO LAT field.

3 Hemispherical Selection Key (Latitude)

Push – toggles between northern and southern hemispheres.

Selection is displayed in large green font.

Default is current latitude hemisphere.

4 Ground Track (GTK)

Displays current left integrated navigation receiver true ground track to the nearest whole degree.

5 Groundspeed (GS)

Displays current left integrated navigation receiver true groundspeed to the nearest whole knot.

6 To Longitude (TO LONG)

Enter a to waypoint longitude into the TCP scratchpad:

- select W or E on the longitude hemisphere selection key (default is the current longitude hemisphere)
- enter longitude in degrees (D) and minutes (M) using DDDMM format

Line select into the TO LONG field.

7 Track To (TRK TO)

Displays true track from current aircraft position to entered waypoint in whole degrees.

Displayed in magenta font.

8 Hemispherical Selection Key (Longitude)

Push – toggles between western and eastern hemispheres.

Default is current longitude hemisphere.

Selection is displayed in large green font.

9 Time To Go (TTG)

Displays time to go from current aircraft position to entered waypoint, based on current aircraft groundspeed.

Displayed in hours (H) and minutes (M) using HH:MM format.

Accuracy better than or equal to 1 minute.

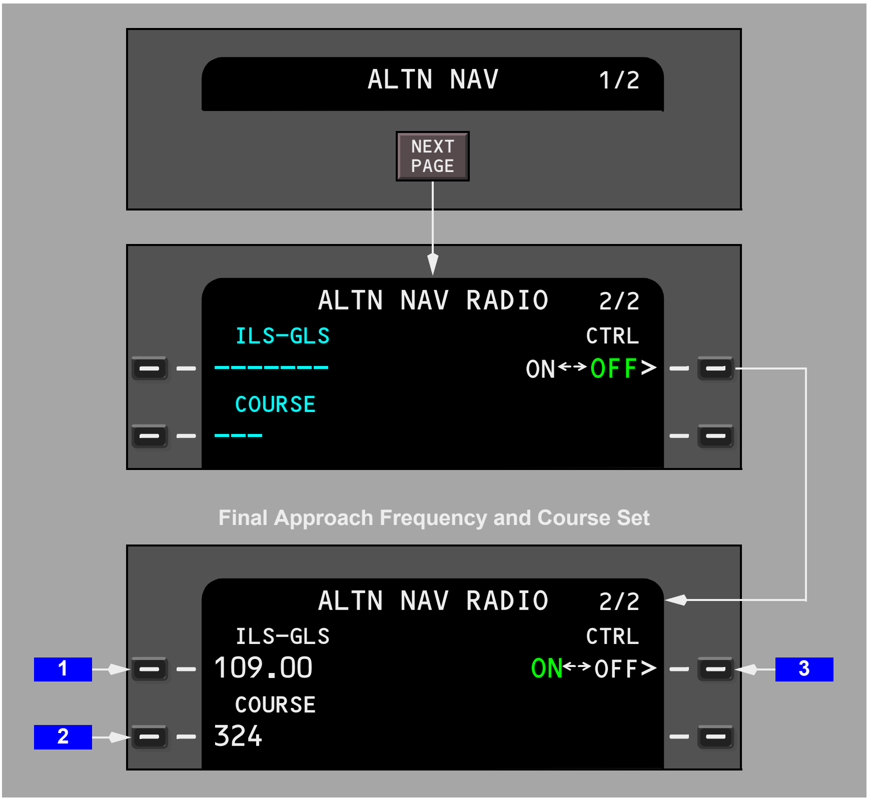
10 Distance To Go (DTG)

Displays distance to go from current aircraft position to entered waypoint in nautical miles.

Accuracy better than or equal to 10 nautical miles.

Alternate Navigation Radio Page

The display on the ALTN NAV RADIO page defaults to the last tuned ILS/GLS. The left (Captain) TCP must be used when setting a ILS/GLS course and frequency on the ALTN NAV RADIO page. The left TCP tunes the left integrated navigation receiver which is displayed on the ISFD.



1 ILS-GLS Frequency

Push – enters an ILS or GLS frequency from the scratchpad when in backup mode.

Defaults to most recently tuned ILS/GLS frequency if available.

Cyan when inactive.

White when active.

2 Course

Push – enters an ILS or GLS course from the scratchpad when in backup mode.

Defaults to most recently tuned ILS/GLS course if available.

Cyan when inactive.

White when active.

3 Control (CTRL)

Push – alternately selects backup navigation tuning ON (enabled) and OFF (disabled).

ON –

- ON displayed in large green font
- ILS/GLS frequency and course change color from cyan to white
- ILS/GLS frequency and course may be changed/updated as required
- EICAS message TCP ALTN NAV displayed
- ISFD displays backup guidance information

OFF –

- OFF displayed in large green font
- ILS/GLS frequency and course change color from white to cyan
- ILS/GLS frequency and course may not be changed/updated
- EICAS message TCP ALTN NAV not displayed
- Backup guidance information not available to the ISFD

Intentionally
Blank

EICAS Messages

The following EICAS messages can display.

Message	Level	Aural	Condition
AHRU ALIGN MODE L	Memo		The left AHRU is in the Align mode.
AHRU ALIGN MODE L+R	Memo		The left and right AHRUs are in the Align mode.
AHRU ALIGN MODE R	Memo		The right AHRU is in the Align mode.
FMC	Advisory		All 3 FMCs are failed.
FMC HOLD AIRSPACE	Advisory		The FMC calculated holding pattern is larger than the holding pattern airspace protection.
FMC INTERCEPT HDG	Advisory		Both of these occur: • LNAV is armed • The airplane is not on an intercept heading to the active leg
FMC MESSAGE	Advisory		An alerting message is in the FMC message window.
FMC PERF UNAVAIL	Advisory		VNAV is selected and one or more of these is not entered: • Gross weight • Cost index • Cruise altitude

[Option - FMC Runway Disagree]

FMC RUNWAY DISAGREE	Caution	Beeper	The airplane is not on the FMC origin runway during takeoff.

FMC UNABLE RTA	Advisory		The FMC cannot reach the waypoint near the needed arrival time.
FMC VERIFY POSITION	Advisory		The inputs to the FMC position disagree.

Message	Level	Aural	Condition
G/S ALERT INHIBITED	Memo		The Glideslope aural alert is inhibited, with the ISS/TAWS option “Glideslope Cancel at Any Altitude” set.
GPS	Advisory		Both GPS receivers are failed.
INERTIAL ALIGN MODE	Memo		Any two or more of the IRUs or AHRUs are in the alignment mode.
INSUFFICIENT FUEL	Advisory		FMC estimated fuel at the destination is less than the entered RESERVES fuel.
IRU ALIGN MODE L	Memo		The left IRU is in the Align mode.
IRU ALIGN MODE L+R	Memo		The left and right IRUs are in the Align mode.
IRU ALIGN MODE R	Memo		The right IRU is in the Align mode.
IRS MOTION	Advisory		The airplane moves while the IRS aligns.

[Option - GPWS Callout Bank Angle]

LNAV BANK ANGLE LIM	Advisory		The airplane cannot follow an LNAV turn because a thrust- or buffet-related bank angle limit occurs.

NAV AIR DATA SYS	Advisory		Both of these occur: • The normal air data sources for airspeed and altitude are failed • The backup sources supply airspeed and altitude data
NAV AIRSPEED DATA	Advisory		Backup source for airspeed is being used instead of air data.
NAV UNABLE RNP	Caution	Beeper	The required navigational performance is not sufficient.
RWY/APP CRS ERROR	Advisory		The selected ILS course and the FMC arrival runway course disagree.

Message	Level	Aural	Condition
RWY/APP TUNE ERROR	Advisory		One of these occurs: • The tuned ILS frequency and the FMC arrival runway frequency disagree • The tuned GLS channel and the FMC arrival runway channel disagree
SINGLE FMC	Advisory		Two FMCs are failed.
SGL SOURCE APPROACH	Caution		Both PFDs are using the same source for ILS information.
SINGLE SOURCE FD	Advisory		Both primary flight displays use the same flight director source.
TCP ALTN NAV	Advisory		The tuning and control panel alternate navigation control is used.
TRANSPONDER	Advisory		The transponders are failed.
TRANSPONDER PANEL	Advisory		One of these occurs: • The transponder panel is failed • Tuning and control panel backup control of the transponder is used
WEATHER RADAR SYS	Advisory		The weather radar system is inoperative.

FMC Messages

FMC messages indicate: degraded system operation, data input errors, or datalink status. The messages are categorized as:

- alerting messages
- advisory messages
- communications messages
- entry–error advisory messages

Some of the CDU help window messages clear automatically when the condition is removed. Others, such as INVALID ENTRY, INVALID DELETE and NOT IN DATABASE must be manually cleared using the CLR MSG key. The CDU help window messages display according to their level of importance. A less important message replaces another message in the CDU help window when the CLR MSG key is pushed or for some messages when the condition is corrected.

The EICAS displays the advisory message FMC MESSAGE when there is an FMC alerting message. The EICAS displays the message •FMC when there is an FMC communications message. Clear the message or correct the condition to cancel the message.

FMC Alerting Messages

FMC alerting messages:

- display in the CDU help window
- cause the EICAS advisory message FMC MESSAGE to display

Some CDU help window messages clear automatically when the condition is removed. Others must be manually cleared using the CLR MSG key.

Help Window Title	Condition	Help Window Text
ALIGNMENT REINITIATED	IRU alignment has automatically restarted due to airplane motion disturbing the alignment process or due to the crew entered initial position failing the internal comparison tests.	IRS ALIGNMENT FAILED - AUTOMATICALLY RESTARTED
CHECK ALT TGT	VNAV is selected when the airplane is between the MCP window altitude and the FMC target altitude. VNAV holds level flight.	VNAV TARGET ALTITUDE AND MCP ALTITUDE DISAGREE RESET MCP OR MODIFY VNAV ALTITUDE TARGET

Help Window Title	Condition	Help Window Text
CHECK AIRLINE POLICY	After loading a new airline modifiable information file, the FMC determines a parameter is invalid. The FMC uses the loaded value and notifies the flight crew of the difference. Also displayed if the AMI is incompatible with current Operational Program Config (OPC) file. This is a maintenance function.	INVALID AMI VALUE(S) VERIFY AMI **Note:** Once the CDU help window message is cleared, it does not display again for that load.
DESCENT PATH DELETED	VNAV active and all waypoint altitude constraints defining the descent profile deleted.	ALL DESCENT CONSTRAINTS DELETED ERASE MOD OR ENTER NEW CONSTRAINT **Note:** This message displays before execution of the modification which deletes the descent path.

Help Window Title	Condition	Help Window Text
DISCONTINUITY	LNAV active and the route is not defined after the waypoint (except when the waypoint is before a manually terminated leg, such as FM, VM, HM legs). FM – a course from a fix to a flight crew entered manual route termination. VM – a heading leg from a fix to a flight crew entered manual route termination. HM – a holding pattern to a flight crew entered manual route termination.	LNAV IN HEADING HOLD MODIFY ACTIVE WAYPOINT
DRAG REQUIRED	VNAV active and additional drag required or autothrottle off and less thrust required to maintain the VNAV descent path.	UNABLE TO MAINTAIN VNAV DESCENT SPEED EXTEND SPEEDBRAKES AS REQUIRED
END OF OFFSET	LNAV active and two minutes prior to end of active route offset. AFDS maintains last heading if active route offset overflown.	APPROACHING END OF OFFSET DELETE OFFSET OR MODIFY ACTIVE WAYPOINT

Help Window Title	Condition	Help Window Text
END OF ROUTE	LNAV active and end of active route overflown. AFDS maintains last heading.	PASSING LAST WAYPOINT IN ACTIVE ROUTE MODIFY ROUTE
ENTER INERTIAL POSITION	The crew entered present position did not pass one of the IRU comparison checks, or the IRU is ready to transition to NAV and has not received a present position.	INERTIAL REFERENCE SYSTEM REQUIRES POSITION INPUT TO COMPLETE ALIGNMENT ENTER PRESENT POSITION ON POS REF 1/X **Note:** The crew must press the CLR key on the MKB to manually clear this message.
FMC APP MODE UNAVAIL-GP	Final approach angle check for selected FMC IAN approach has failed.	SELECTED APPROACH HAS NO GLIDE PATH ANGLE SPECIFIED CONFIRM APPROACH SELECTION
FMC APP MODE UNAVAIL-QFE	FMC IAN approach selected while QFE landing reference enabled.	FMC APPROACH GUIDANCE NOT AVAILABLE WITH QFE SELECTED
INSUFFICIENT FUEL	A change in the route is made which causes the computed fuel burn to exceed the total fuel on board, less reserves.	MODIFICATION REQUIRES MORE FUEL THAN AVAILABLE REVIEW MOD
LIMIT ALT FLXXX	The flight crew or FMC elected altitude is greater than the VNAV limit altitude.	SELECTED ALTITUDE IS ABOVE VNAV ALTITUDE LIMIT MODIFY CRUISE ALTITUDE OR VNAV TARGET SPEED
NAV DATA OUT OF DATE	The clock calendar date is after the active navigation database valid calendar cycle.	END DATE OF THE ACTIVE DATA BASE HAS PASSED SELECT NEW CYCLE ON IDENT PAGE

Help Window Title	Condition	Help Window Text
NAV INVALID–TUNE XXXX	RNAV or VOR approach procedures must have a specific navaid tuned. It is either not tuned or a valid signal is not being received.	APPROACH NAVAID NOT TUNED VERIFY NAV RADIO PAGE TUNING
NO ACTIVE ROUTE	LNAV selected and no active route activated.	ACTIVATE ROUTE TO ENGAGE LNAV
PREDICTIONS UNAVAILABLE	FMC performance predictions are not available for remainder of flight.	PERFORMANCE PREDICTIONS INHIBITED FOR DURATION OF FLIGHT MAINTENANCE ACTION REQUIRED
RESET MCP ALT	2 minutes prior to the top of descent point with VNAV active and MCP not set to altitude below cruise altitude.	MCP ALTITUDE IS SET TO CRUISE ALT SET LOWER ALTITUDE TO ENABLE VNAV DESCENT
RTA FIX DELETED	RTA fix has been deleted from the modified flight plan.	MODIFICATION DELETES EXISTING RTA FIX TO RETAIN RTA ERASE MOD
TAKEOFF FLAPS DELETED	Deletion of entered thrust reduction flap value results in invalidating takeoff flap setting.	DELETION OF ENTERED THRUST REDUCTION INVALIDATED TAKEOFF FLAPS ENTER TAKEOFF FLAPS
TAKEOFF SPEEDS DELETED	Selected V speeds are invalid.	SPEEDS DELETED DUE TO CHANGE IN TAKEOFF CONDITIONS VALIDATE OR ENTER SPEEDS ON TAKEOFF REF PAGE

Help Window Title	Condition	Help Window Text
THRUST REQUIRED	VNAV active, autothrottle disconnected, and additional thrust required to track VNAV descent path and maintain speed.	UNABLE TO MAINTAIN VNAV DESCENT SPEED ADD THRUST OR ENGAGE AUTOTHROTTLE
UNABLE FLXXX AT RTA FIX	Predicted crossing altitude at RTA fix less than FLXXX, but predicted ETA within tolerance.	VNAV WILL NOT ATTAIN ALTITUDE AT RTA FIX RTA TIME WILL BE MET REVIEW RTA CONDITIONS
UNABLE NEXT ALT	VNAV active and climb not sufficient to comply with waypoint altitude constraint.	VNAV WILL NOT ATTAIN ALTITUDE AT RTA FIX RTA TIME WILL BE MET REVIEW RTA CONDITIONS
UNABLE TO SEND MSG	Airplane is unable to transmit downlink message as commanded by crew or airplane is unable to automatically send message at required time for planned event.	TEMPORARY COMMUNICATION SYSTEM INTERRUPT RESEND MESSAGE
VERIFY RNP – PROG 4/X	The default RNP has changed due to a change in flight phase and the crew has previously entered a larger RNP value than the default on PROG page 4/X.	ENTERED VALUE GREATER THAN DEFAULT RNP OR LESS THAN ANP CONFIRM RNP - RNP PROGRESS PAGE 4/X

Help Window Title	Condition	Help Window Text
VERIFY VERT RNP -PROG 4/X	The default Vertical RNP has changed due to flight phase and the crew has previously entered a larger RNP value than the default vertical RNP on PROG page 4/X.	ENTERED VALUE GREATER THAN DEFAULT VERTICAL RNP OR LESS THAN VERTICAL ANP CONFIRM VERTICAL RNP - RNP PROGRESS PAGE 4/X
VIA OFFSET INVALID	Flight conditions invalidate the modification with a divert to an alternate airport via OFFSET.	OFFSET ROUTING IS NO LONGER VALID FOR THE SELECTED ALTERNATE

FMC Communications Messages

FMC communications messages:

- display in the CDU help window
- cause the EICAS communications message •FMC to display
- cause the communications aural high–low chime to sound

Help Window Title	Condition	Help Window Text
ALTN UPLINK	Up to four company–preferred alternate airports and associated data has been received and is available for preview on the ALTN page.	ALTERNATE AIRPORT DATA READY TO ACCEPT OR REJECT ON ALTN PAGE 1/X
ALTN INHIBIT UPLINK	A company list of up to two alternate airports, which is inhibited from automatic selection and displayed on the ALTN page, has been received and is available for preview on the ALTN page.	INHIBITED ALTERNATE AIRPORT DATA READY TO ACCEPT OR REJECT ON ALTN PAGE 1/X

Help Window Title	Condition	Help Window Text
ALTN LIST UPLINK	A company list of up to 20 alternate airports has been received and is available on the ALTN LIST page.	ALTERNATE AIRPORT LIST READY TO CONFIRM ON ALTN PAGE 2/X
DES FORECST UPLINK READY	Descent forecast data has been received and is available for loading on the DESCENT FORECAST page.	DESCENT FORECAST DATA READY TO LOAD OR PURGE ON DES FORECAST PAGE
FLT NUMBER UPLINK	A new flight number has been received and is available on the RTE page 1/X.	FLIGHT NUMBER LOADED ON RTE PAGE 1
INVALID TAKEOFF XXX/YYY	Takeoff data for up to six runways or runway intersection pairs has been received but some data for one runway or runway intersection pair (RWXXX/YYY) is invalid.	CANNOT USE LOADED RUNWAY/INTERSECTION FOR TAKEOFF UNDER CURRENT CONDITIONS
PERF INIT UPLINK	Performance initialization data has been received and is available for preview on the PERF INIT page.	PERFORMANCE DATA READY TO ACCEPT OR REJECT ON PERF INIT PAGE
ROUTE X UPLINK READY	A new route or route modification has been received and is available for loading on the RTE X page.	FLIGHT PLAN IS READY TO LOAD OR PURGE ON RTE PAGE

Help Window Title	Condition	Help Window Text
TAKEOFF DATA LOADED	The crew has entered a new runway on the TAKEOFF REF page, which matches a runway from a previous takeoff uplink; or the crew has selected a different takeoff thrust on the THRUST LIM page or the crew has selected alternate takeoff thrust on the TAKEOFF REF page 2/2. Data displayed on the TAKEOFF REF page along with the ACCEPT> <REJECT prompts.	RUNWAY OR THRUST SETTING CHANGED TAKEOFF DATA READY TO ACCEPT OR REJECT ON TAKEOFF REF PAGES
TAKEOFF DATA UPLINK	A takeoff uplink, (contains data for a runway), which matches the takeoff runway, has been received and is available for preview on the TAKEOFF REF page 1/2 & 2/2 and THRUST LIM page.	TAKEOFF DATA READY TO ACCEPT OR REJECT ON TAKEOFF REF PAGES
WIND DATA UPLINK READY	Wind data has been received and is available for loading on the RTE DATA page.	LOAD ON RTE DATA PAGE

FMC Advisory Messages

FMC advisory messages display in the CDU help window.

Help Window Title	Condition	Help Window Text
DELETE	DELETE key pushed.	None, message displayed in scratchpad.
HOLD AT XXXXX	A waypoint not contained in the active route is entered into the HOLD AT box on the RTE LEGS page, after selection of the HOLD function key. Selection of HOLD AT XXXXX into a RTE LEGS page waypoint line makes a holding fix at the XXXXX waypoint.	None, message displayed in scratchpad.
ATC RTE CLEARANCE UPLINK	ATC route clearance uplink ready to be loaded into FMC for review. This message also displays a LOAD select button in the CDU help window. Selection of the LOAD button clears the message.	SELECT LOAD FMC TO MODIFY RTE
INVALID ALTN UPLINK	A company preferred list of alternate airports and associated alternate data has been received but the data is not valid and can not be displayed.	ALTERNATE AIRPORT DATA UPLINK REJECTED DUE TO MESSAGE ERROR
INVALID ALTN LIST UPLINK	A company list of up to 20 alternate airports has been received but the data is not valid and cannot be displayed.	ALTERNATE AIRPORT LIST UPLINK REJECTED DUE TO MESSAGE ERROR

Help Window Title	Condition	Help Window Text
INVALID FLT NO UPLINK	A new flight number has been received but the data is not valid and cannot be displayed.	FLIGHT NUMBER UPLINK REJECTED DUE TO FAILED ERROR CHECK
INVALID FORECAST UPLINK	Descent forecast data has been received but the data is not valid and cannot be displayed.	FORECAST DATA UPLINK REJECTED DUE TO MESSAGE ERROR
INVALID PERF INIT UPLINK	Performance initialization data has been received but the data is not valid and cannot be displayed.	PERFORMANCE DATA UPLINK REJECTED DUE TO MESSAGE ERROR
INVALID ROUTE UPLINK	A new flight plan route or modification to the active flight plan route has been received but the data is not valid and cannot be displayed.	FLIGHT PLAN UPLINK REJECTED DUE TO MESSAGE ERROR
INVALID SUPP DATA UPLINK	Uplinked Supplemental Navigation database is rejected due to exceeding database size.	NAV DATA BASE CAPACITY EXCEEDED
INVALID SUPP DATA UPLINK	Uplinked Supplemental Navigation database is rejected due to bad data.	REJECTED DUE TO MESSAGE ERROR
INVALID TAKEOFF UPLINK	Takeoff data for up to six runways or runway–intersection pairs has been received but the data is not valid and cannot be displayed.	TAKEOFF DATA UPLINK REJECTED DUE TO MESSAGE ERROR

Help Window Title	Condition	Help Window Text
INVALID WIND DATA UPLINK	En route wind data has been received but the data is not valid and cannot be displayed.	WIND DATA UPLINK REJECTED DUE TO MESSAGE ERROR
MAX ALT FLXXX	Entered speed or altitude would cause cruise altitude to be greater than max altitude.	CDU help window text varies and is specific to entry error made.
RESET MCP APP MODE	A change in the expected approach or G/S ON/OFF is made with an approach mode armed or engaged.	CHANGE IN EXPECTED APPROACH CONFIRM MCP APP MODE
SUPP DATA LOADING	Data is being loaded into the FMC supplemental nav database.	AOC SUPPLEMENTAL NAV UPLINK BEING LOADED PLEASE WAIT
SUPP DATA UPLINK	Supplemental nav database uplink has completed loading.	LOAD SUCCESSFUL
UNABLE CRZ ALT	Performance predicts a zero cruise time at the entered cruise altitude.	COMPUTED CRUISE TIME IS ZERO COMPUTED TOP OF DESCENT IS BEFORE TOP OF CLIMB CONFIRM CRUISE ALTITUDE
UNABLE TO LOAD CLEARANCE	ATC clearance contains invalid data or requires an active route.	CDU help window text varies and is specific to entry error made.

Help Window Title	Condition	Help Window Text
V SPEEDS UNAVAILABLE	The EFB cannot compute takeoff speeds for the current high thrust/low gross weight condition. Adjust gross weight and/or thrust limit to enable calculation of takeoff speeds.	UNABLE TO COMPUTE TAKEOFF SPEEDS FOR CURRENT CONDITIONS
XXXXXXX - MAX ALT FLXXX or XXXXXXX - MAX ALT XXXXX	Predicted altitude at a waypoint with a Cruise Speed Segment or RTA will be above maximum altitude.	ALTITUDE PREDICTED AT <XXXXXXX> IS ABOVE MAXIMUM ALTITUDE FOR PLANNED CRUISE SPEED CONFIRM PLANNED CRUISE SPD

FMC Entry Error Messages

FMC entry–error messages:

- display in the CDU help window
- push the CLR MSG key or for some messages enter a corrected entry on the CDU to clear the message

Help Window Title	Condition	Help Window Text
APP TUNE INHIBITED-MCP	ILS or GLS tuning is inhibited with autopilot engaged, approach switch (on MCP) selected and localizer or glideslope captured; and crew attempts to enter and execute a new runway or approach; or crew attempts to enter a new ILS frequency or GLS channel on the NAV RADIO page.	DISENGAGE A/P AND FLIGHT DIRECTOR TO ENABLE TUNING

Help Window Title	Condition	Help Window Text
CRS REVERSAL AT FA FIX	A conflict exists between the default final approach (FA) waypoint (result of a runway or VFR approach selection) and the flight plan before it.	ACTIVE ROUTE REVERSES DIRECTION AT THE FINAL APPROACH WAYPOINT MODIFY ROUTE TO FA FIX
ENG OUT SID MOD	An engine failure is sensed after takeoff before the flaps are fully retracted; the FMC has automatically loaded an available engine out standard instrument departure as a route modification to the active route.	ENGINE OUT DETECTED EO DEPARTURE ROUTE LOADED EXECUTE TO COMPLY
IN NAV DATA BASE	Attempted entry into SUPP NAV DATA airport waypoint or navaid field already in NDB.	ENTERED IDENTIFIER ALREADY EXISTS IN NAV DATA BASE REVISE ENTERED INDENTIFIER
INVALID DELETE	Deletion of selected data is not allowed.	SELECTED LINE CAN NOT BE DELETED
INVALID ENTRY	Attempted entry into a CDU field is not properly formatted.	CDU help window text varies and is specific to entry error made.
INVALID ENTRY - RTA ACTIVE	Attempted entry of ECON/ or E/ on the ACT RTE LEGS page to terminate a constant speed cruise segment, when an active RTA exists down path in the flight plan.	DELETE RTA TO ENABLE SPEED ENTRY OR TO RESUME RTA ENTER R/ OR RTA/

Help Window Title	Condition	Help Window Text
INVALID OFFSET	A flight plan modification caused the down path offset to no longer contain any offsetable legs.	FLIGHT PLAN MODIFICATION CAUSED INVALID OFFSET REVISE FLIGHT PLAN
NO OFFSET AT LEG XXXXXXX	Entered start or end of offset waypoint is not valid.	ENTERED Z OFFSET WAYPOINT NOT VALID FOR OFFSET CONFIRM OFFSET Z (Z = START or END)
NOT IN DATABASE	Search of Nav Database and route did not result in finding the required data.	CDU help window text varies and is specific to item not found.
NOT IN FLIGHT PLAN	Entered start of offset waypoint is not in flight plan.	START OFFSET WAYPOINT CORRECT FORMAT BUT NOT IN CURRENT FLIGHT PLAN
OFFSET DELETED	Flight plan modification deleted start of offset waypoint.	START WAYPOINT DELETED ENTER NEW START ON LATERAL OFFSET PAGE
OFFST ENDS ABEAM YYYYYYY	A flight plan change or crew entered waypoint results in the FMC being unable to construct or maintain the desired offset. Offset will end at or abeam YYYYYYY.	CDU help window text varies and is specific to type of offset error occurring.
ROUTE FULL	The route is filled to the allowable capacity.	WAYPOINT STORAGE CAPACITY HAS BEEN REACHED MODIFY ROUTE
RUNWAY N/A FOR SID	Selected runway not compatible with SID.	RUNWAY CAN NOT BE USED WITH ENTERED DEPARTURE PROCEDURE CONFIRM RUNWAY

Help Window Title	Condition	Help Window Text
STANDBY ONE	The FMC temporarily prevents further CDU inputs.	FMC PROCESSING LAST ENTRY PLEASE WAIT
SUPP DATA BASE FULL	Supplemental Nav Database is full, entry not accepted.	ENTRY EXCEEDED SUPP NAV DATA BASE CAPACITY
UNABLE FLIGHT PLAN ENTRY	Attempted flight plan entry is incompatible with loaded navigation database.	ENTRY NOT ACCEPTED WITH CURRENT NAV DATA BASE REVISE ENTRY
UNABLE TO OFFSET	Entered offset not flyable.	SELECTED OFFSET NOT FLYABLE REVISE OFFSET DATA
VERIFY RNP ENTRY	The entered RNP value is greater than the default RNP value for the present flight phase or, less than the present Actual Navigation Performance.	ENTERED VALUE GREATER THAN DEFAULT RNP OR LESS THAN ANP CONFIRM RNP
VERIFY VERT RNP ENTRY	Entered vertical RNP value is greater than the default vertical RNP for the current flight phase, or less than the present ANP.	ENTERED VALUE GREATER THAN DEFAULT VERTICAL RNP OR LESS THAN VERTICAL ANP CONFIRM VERTICAL RNP

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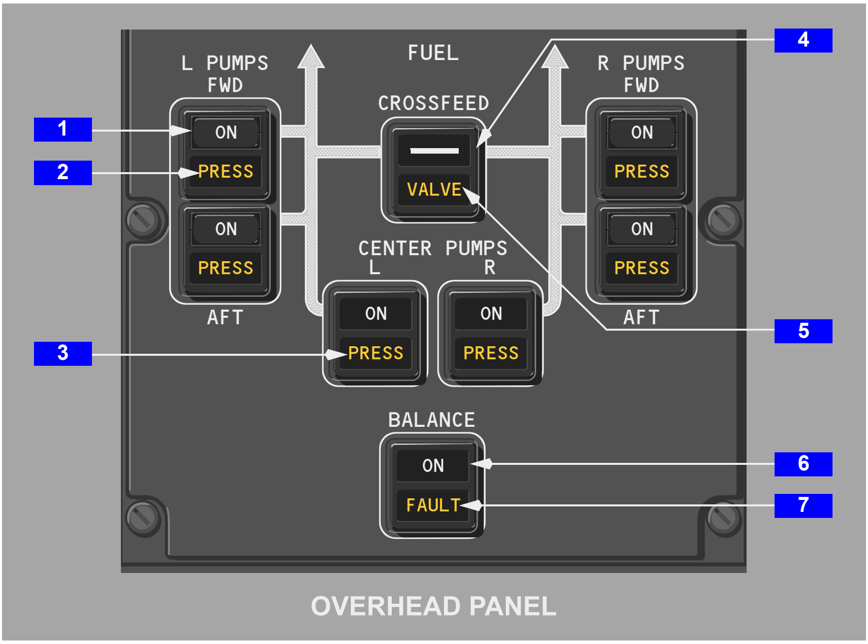
Fuel — Chapter 12
Table of Contents — Section 0

Fuel System



1 Fuel Pump Switches

ON – the fuel pump is selected ON.

Off (ON not visible) – the fuel pump is selected off.

2 Forward and Aft Fuel Pump Pressure (PRESS) Lights

Illuminated (amber) – fuel pump output pressure is low.

3 Center Fuel Pump Pressure (PRESS) Lights

Illuminated (amber) –

- fuel pump output pressure is low with the pump selected ON
- illumination is inhibited when the center tank fuel pump switch is selected off

4 CROSSFEED Switch

On (bar visible) – the crossfeed valve is selected open.

Off (bar not visible) – the crossfeed valve is selected closed.

5 **CROSSFEED VALVE Light**

Illuminated (amber) – the crossfeed valve is not in the selected position.

6 **BALANCE Switch**

ON – the balance system is selected on.

Off (ON not visible) –

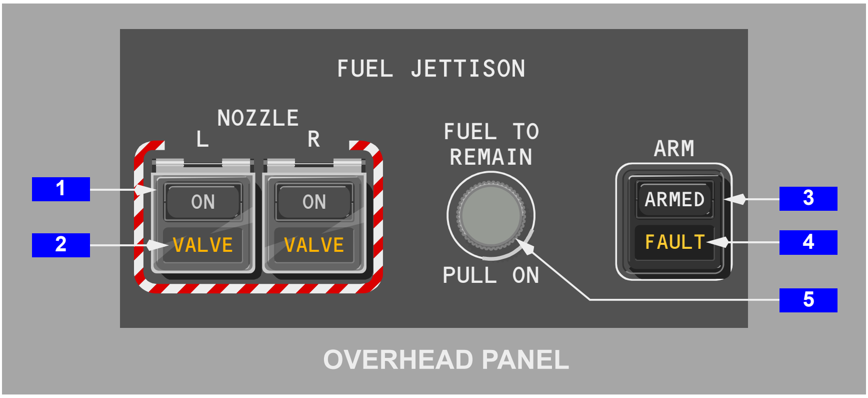
- system is not commanded ON
- off is manually selected
- fuel balance is automatically commanded off for one of the following:
  - fuel is balanced
  - jettison system is active
  - FUEL DISAGREE message is displayed
  - FUEL QTY LOW message is displayed
  - airplane is on ground and either engine running

7 **Fuel BALANCE FAULT Light**

Illuminated (amber) –

- a system fault has occurred
- fuel balance system is inoperative

Fuel Jettison System



1 **Fuel Jettison NOZZLE Switches**

ON –

- the jettison nozzle valve is selected open in flight
- if in flight and jettison is armed, opens main tank defuel/isolation valves and center tank jettison isolation valves

Off (ON not visible) – the jettison nozzle valve is selected closed.

2 **Fuel Jettison Nozzle VALVE Lights**

Illuminated (amber) – the jettison nozzle valve is not in the selected position.

3 **Fuel Jettison ARM Switch**

ARMED –

- arms the jettison system
- initializes fuel–to–remain at the MLW fuel quantity

Off (ARMED not visible) – disarms the jettison system.

4 **Fuel Jettison FAULT Light**

Illuminated (amber) –

- a system fault has occurred
- fuel jettison is inoperative

5 **FUEL TO REMAIN Selector**

PULL ON – changes the mode from MLW (maximum landing weight) to MAN (manual).

Rotate –

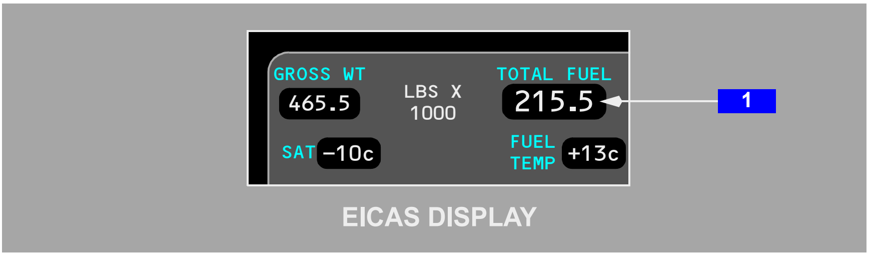
- CW to increase the MANUAL fuel–to–remain quantity
- CCW to decrease the MANUAL fuel–to–remain quantity

Push – automatically selects the MLW fuel–to–remain quantity.

Fuel Indications

Normal Fuel Indications

[Option – English units]



1 **Normal Fuel Indications**

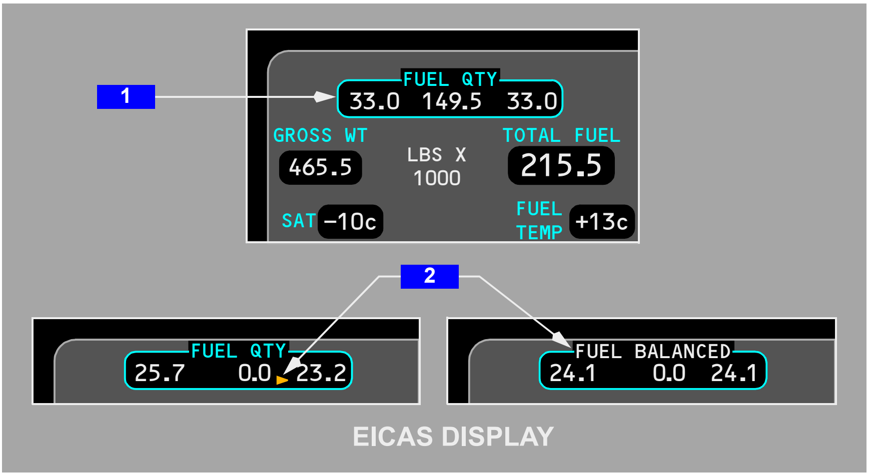
[Option – English / Metric units]

Total fuel quantity (pounds / kilograms x 1000).

Fuel temperature (degrees Celsius).

Expanded Fuel Indications

[Option – English units]



1 Expanded Fuel Indications

The expanded FUEL QTY display (left main, center, and right main tank quantities) appears for any of the following conditions:

- crossfeed valve open
- one or more fuel tank quantity indications are inoperative
- the FUEL IN CENTER alert message is displayed (center tank quantity is amber)
- the FUEL QTY LOW alert message is displayed (low main tank quantity is amber)
- the FUEL LOW CENTER alert message is displayed (low center tank quantity is amber)
- the FUEL IMBALANCE alert message is displayed
- the airplane is on the ground and both engine(s) off
- the balance system is active
- the balance system is selected on and fuel is already balanced

2 Fuel Imbalance Indications

A fuel imbalance pointer is displayed on the expanded fuel quantity display next to the low tank quantity for the following imbalance conditions.

A solid amber fuel imbalance pointer is displayed if the FUEL IMBALANCE message is displayed.

[Option – English / Metric units]

A solid white fuel imbalance pointer is displayed if:

- the FUEL IMBALANCE message is not displayed and the main tank fuel differs by more than 200 pounds / 100 kilograms, and
- either the crossfeed valve is open or the balance system is ON

The difference in fuel quantity which causes the FUEL IMBALANCE message to be displayed varies with total main tank fuel quantity.

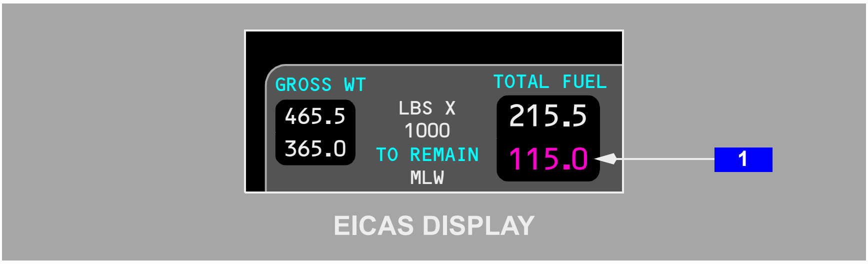
The pointer flashes if fuel balance or crossfeed is going in the wrong direction.

[Option – English / Metric units]

When fuel is back in balance within 200 pounds / 100 kilograms between the main tanks and the crossfeed valve is open or the balance system is ON, FUEL BALANCED replaces FUEL QTY on the expanded fuel quantity display and flashes for 5 seconds.

Fuel Jettison Indications

[Option – English units]



1 Fuel Jettison Indications

Fuel to remain (fuel jettison ARMED):

- the fuel to remain defaults to a fuel quantity that leaves the airplane at maximum landing weight (MLW) when jettison is complete
- the fuel to remain display replaces the fuel temperature and static air temperature displays

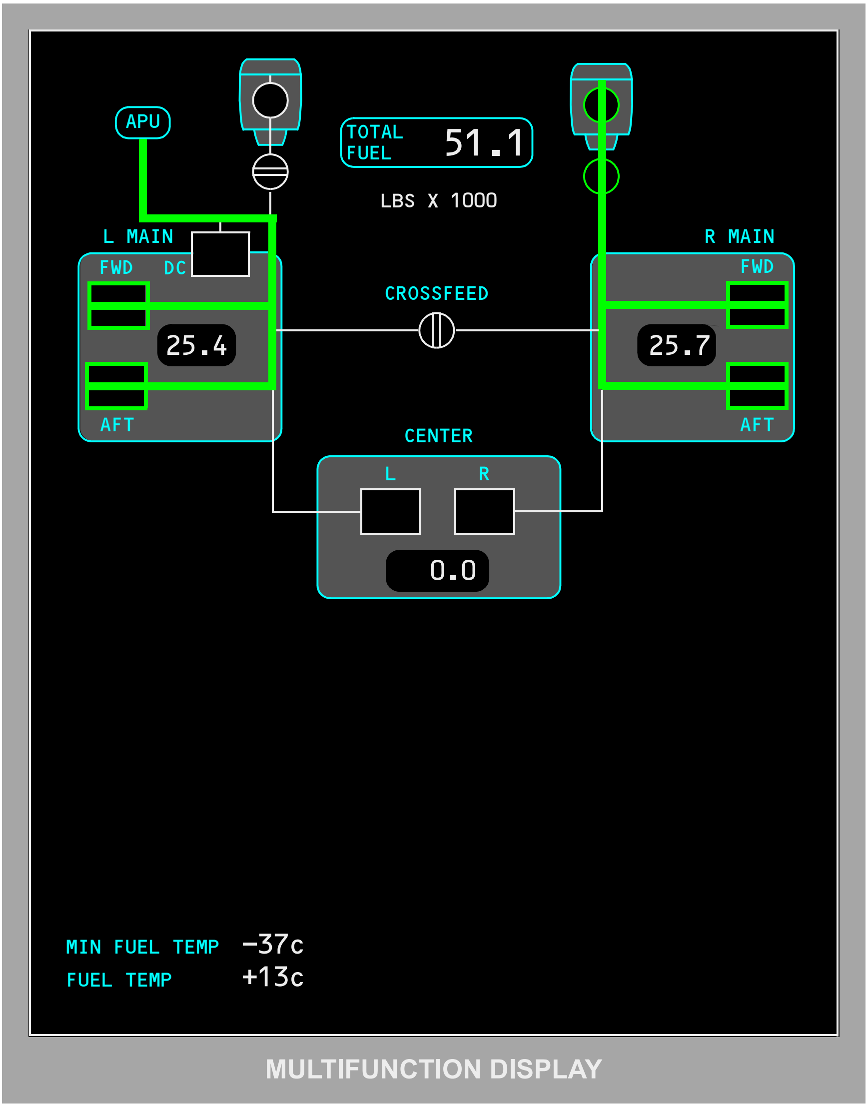
Fuel to remain MAN (manual) selection is displayed:

- fuel jettison system is ARMED
- the FUEL TO REMAIN selector is pulled on
- the quantity to remain can be changed by rotating FUEL TO REMAIN selector

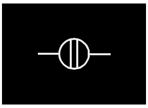
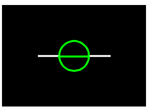
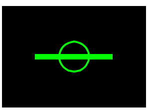
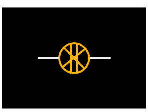
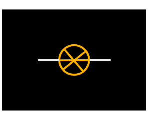
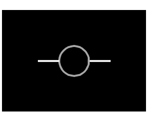
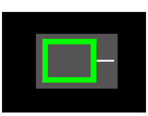
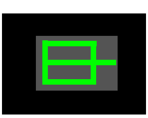
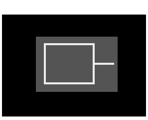
Fuel Synoptic Display

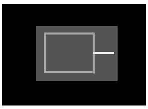
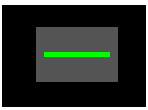
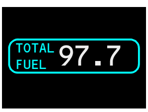
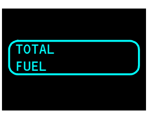
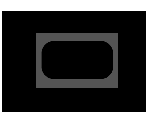
The fuel synoptic is displayed by pushing the systems (SYS) display switch on the display select panel, then selecting the FUEL synoptic key. Display select panel operation is described in Chapter 10, Flight Instruments, Displays.

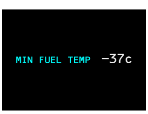
[Option – English units]

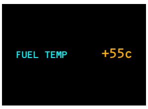


Fuel Synoptic Indications

Symbol	Indication	Description
	Fuel Valve (white)	Fuel valve is closed.
	Fuel Valve (green)	Fuel valve is in transit.
	Fuel Valve (green)	Fuel valve is in open.
	Fuel Valve (amber with crossout)	Fuel valve is failed. Valve is commanded open but remains closed.
	Fuel Valve (amber with crossout)	Fuel valve is failed. Valve is commanded closed but remains open or in transit.
	Fuel Valve (gray)	Fuel valve state is invalid.
	Fuel Pump (green rectangle)	Fuel pump switch is ON.
	Fuel Pump (green rectangle with line)	Fuel pump switch is ON and pressure sensor detects pressure greater than 7 to 8 psig.
	Fuel Pump (white rectangle)	Fuel pump switch is OFF or pump switch is ON and pump has been load shed.

Symbol	Indication	Description
	Fuel Pump (amber rectangle with crossout)	Fuel pump failed or pump switch is ON and pressure sensor detects pressure less than 7 to 8 psig. Also shown following automatic shutoff of center tanks
	Fuel Pump (gray rectangle)	Fuel pump state is invalid.
	Normal Fuel Feed (green)	Fuel line is pressurized. Pressure sensor detects pressure greater than 7 to 8 psig.
	Suction Feed (amber)	Fuel line is unpressurized and suction flow is occurring.
	Total Fuel (white)	Normal indication.
	Total Fuel (blank)	Invalid indication or any individual tank quantity blank.
	Main Tank Quantity (white)	Normal indication.
	Main Tank Quantity (amber)	Fuel tank quantity is low. FUEL QTY LOW message is displayed
	Tank Quantity (blank)	Tank quantity is invalid.
	Center Tank Quantity (white)	Normal indication.

Symbol	Indication	Description
	Center Tank Quantity (amber)	FUEL IN CENTER message is displayed.
	Center Tank Quantity (amber)	Center fuel tank quantity is low. FUEL LOW CENTER message is displayed.
	Pointer (amber)	FUEL IMBALANCE is displayed. The pointer is displayed next to the tank with the lower quantity.
	Pointer (white)	The crossfeed switch is ON or the balance switch is ON and the main tank quantities differ by more than 200 lbs (or 100 kgs). The pointer is displayed next to the tank with the lower quantity.
	Fuel Balanced (white)	Balanced indication. The fuel balanced indication flashes once fuel is within 200 lbs (or 100 kgs). of balanced.
	Minimum Fuel Temperature (temperature displayed white)	Normal indication. Displays the lowest of three tank temperatures.
	Minimum Fuel Temperature (temperature displayed as blank)	Invalid indication.

Symbol	Indication	Description
	Fuel Temperature (temperature displayed white)	Normal indication.
	Fuel Temperature (temperature displayed amber)	High fuel temperature indication when "+" is displayed. Low fuel temperature indication when "-" is displayed.
	Fuel Temperature (temperature displayed as blank)	Invalid indication.

Fuel
System Description

Introduction

The fuel system supplies fuel to the engines and the APU. The fuel is contained in a center tank, and left and right main tanks.

Refer to Chapter 7, Engines, APU for a description of the engine fuel system.

Fuel Quantity

Fuel quantity is measured by sensors in each tank. Total fuel quantity is displayed on the primary EICAS display. Tank quantities and total fuel quantity are displayed on the FUEL synoptic display.

Expanded fuel indications showing the left main, center, and right main tank quantities are displayed when non-normal conditions occur.

Fuel Temperature

Fuel temperature is displayed on the primary EICAS display. The temperature is normally displayed in white. It is displayed in amber when the fuel temperature approaches maximum or the fuel freeze temperature entered on the flight management system CDU. During jettison, the TO REMAIN quantity replaces the EICAS display static air temperature and fuel temperature indications.

Fuel temperature and minimum fuel temperature are also displayed on the fuel synoptic display.

Fuel Pumps

Each fuel tank contains two AC–powered fuel pumps. A single pump can supply sufficient fuel to operate one engine under all conditions.

The two center tank fuel pumps are override/jettison pumps. These pumps have a higher output pressure than the left and right main tank fuel pumps. The center tank pumps override the main tank pumps so that center tank fuel is used before wing tank fuel.

When the main tank fuel pump switches are off, the switch PRESS lights illuminate and the EICAS advisory messages FUEL PUMP (L, R, FWD, or AFT) display. When the center fuel pump switches are off, the switch PRESS lights and pump pressure EICAS messages are inhibited.

When less than all engines/generators are operating, there may not be sufficient electrical power to operate all fuel pumps. In such cases, the fuel system automatically determines the best pumps to operate depending on how much electrical power is available. Certain fuel pumps may be load shed until enough electrical power is available. The indications that a fuel pump has load shed are that the pump switch PRESS light is illuminated and the pump is labeled LOAD SHED on the fuel synoptic.

The left main tank contains a DC–powered fuel pump. It has no controls or indicators, other than the fuel synoptic display. The DC pump operates automatically to provide fuel to the APU when AC power is not available and the APU selector is ON.

Surge tanks are provided in each wing, outboard of each main tank. Fuel in the surge tanks and fuel remaining in the refueling manifold is drained into the main tanks.

Fuel Pump Operation

Before start, the main tank pump switches should all be pushed ON. If the FUEL IN CENTER message is displayed, the center tank pump switches should also be pushed ON.

During flight, when the FUEL LOW CENTER message displays, the center tank pump switches should be pushed off. The condition statement for this message is contained in Section 12.30, Fuel System EICAS Messages.

If a center pump has low output pressure, the fuel pump switch PRESS light illuminates and the message FUEL PUMP CENTER (L or R) displays.

[Option – English / Metric units]

With the main tank pumps ON, a scavenge system operates automatically to transfer any remaining center tank fuel to the main tanks. Fuel transfer begins when either main tank quantity is less than 36,000 pounds / 16,300 kilograms and the center tank pumps are off. The system is inhibited if the engine is on suction feed.

Suction Feed

When main tank fuel pump pressure is low, each engine can draw fuel from its corresponding main tank through a suction feed line that bypasses the pumps. As the airplane climbs, dissolved air is released from the fuel in the tank due to the decrease in air pressure. This air may collect in the suction feed line and restrict fuel flow. At high altitude, thrust deterioration or engine flameout may occur as a result of the fuel flow reduction.

The dissolved air in the fuel tank eventually depletes after reaching cruise altitude. The depletion time is dependent upon airplane altitude, fuel temperature, and type of fuel. Once the dissolved air is depleted, the engine should effectively operate on suction feed.

Fuel pressure can be provided from a main tank with operating fuel pumps to both engines by opening the fuel crossfeed valve. Continued crossfeed use results in a progressive fuel imbalance.

Fuel Crossfeed

The fuel manifolds are arranged so that any fuel tank pump can supply either engine. The crossfeed valve is closed during normal operations. The closed crossfeed valve isolates the left and right systems. The valve can be opened to feed an engine from the opposite fuel tank. If the valve position does not agree with the switch position, the CROSSFEED switch VALVE light illuminates and the EICAS advisory message FUEL CROSSFEED displays.

Fuel Balance System

Fuel can be transferred from main tank to main tank using the fuel balance system. Fuel transfer is initiated by pushing the fuel balance switch ON. Fuel from the higher quantity main tank is transferred through its defuel/jettison valve to the lower quantity main tank through its inboard refuel valve. Transfer stops automatically when fuel is balanced. If there is a system failure during fuel balance, the balance system shuts down, the BALANCE switch FAULT light illuminates, and the EICAS advisory message FUEL BALANCE SYS displays.

Fuel balance operation is automatically terminated when fuel jettision is commanded. If fuel balancing is desired after jettision is complete, fuel balance must be re-selected ON.

Fuel Imbalance

When the fuel quantity in left and right main tanks differ by a predetermined quantity, the EICAS alert message FUEL IMBALANCE displays.

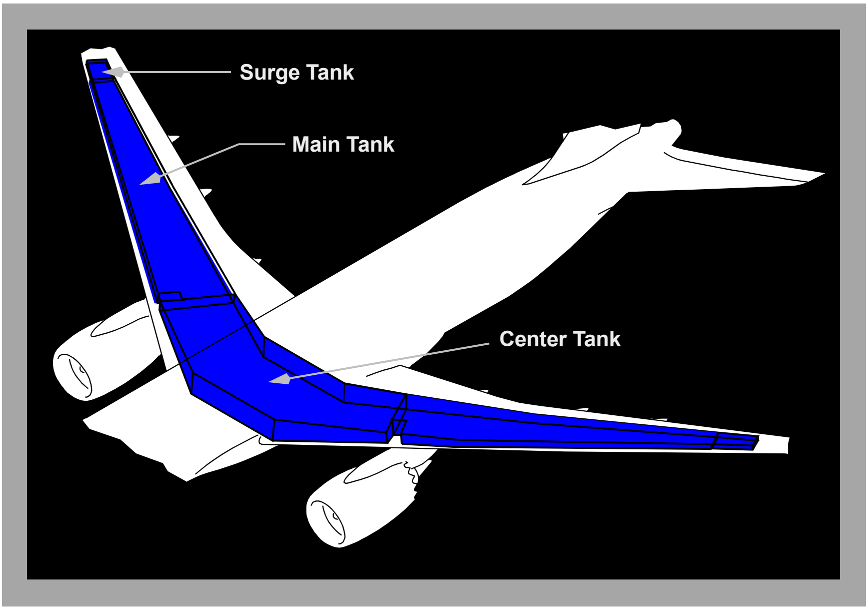
Fuel balancing is accomplished by using either manual crossfeed or the fuel balance system.

Manual crossfeed is initiated by opening the crossfeed valve and turning off the fuel pump switches for the fuel tank that has the lower quantity. Crossfeed may be done in any phase of flight.

The fuel balance system is initiated by pushing the fuel balance switch. The fuel balance system may be used in any phase of flight. It can be used on the ground if the engines are shutdown and the APU is running.

Fuel Tank Locations and Capacities

Fuel Tank Locations



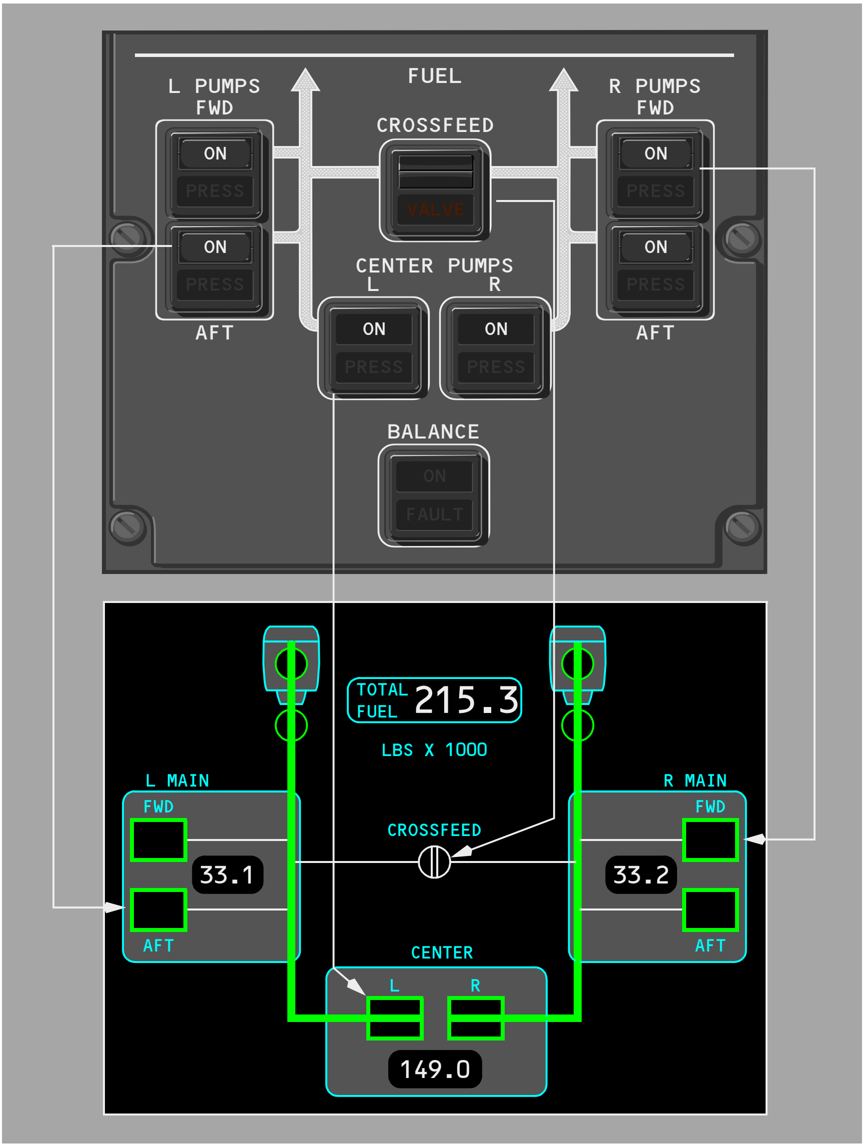
Fuel Tank Capacities

[Option – English / Metric units]

Tank	Gallons / Liters	Pounds / Kilograms *
Left Main	5,600 / 21,200	37,500 / 17,000
Right Main	5,600 / 21,200	37,500 / 17,000
Center	22,500 / 85,200	150,800 / 68,400
Total	33,700 / 127,600	225,800 / 102,400
* Usable fuel at level attitude, fuel density = 6.7 lbs per US gallon / 0.8029 kgs per liter.		

Fuel System Schematic

[Option – English units]



APU Fuel Feed

APU fuel is supplied from the left fuel manifold. APU fuel can be provided by any AC fuel pump supplying fuel to the left fuel manifold or by the left main tank DC fuel pump.

On the ground, with the APU switch ON and no AC power available, the DC pump runs automatically. With AC power available, the left aft AC fuel pump operates automatically, regardless of fuel pump switch position, and the DC fuel pump turns off.

Fuel Jettison

The fuel jettison system allows jettison from all fuel tanks. Fuel is jettisoned through jettison nozzle valves inboard of each aileron. Override/jettison pumps in the center tank and main tank pumps transfer fuel overboard through the jettison nozzle valves.

Fuel jettison is initiated by pushing the FUEL JETTISON ARM switch to select ARMED. The jettison system automatically sets the fuel–to–remain to the maximum landing weight (MLW) fuel quantity. The TO REMAIN quantity replaces fuel temperature on the EICAS display.

Pull on and rotate the TO REMAIN selector to manually decrease or increase the TO REMAIN quantity.

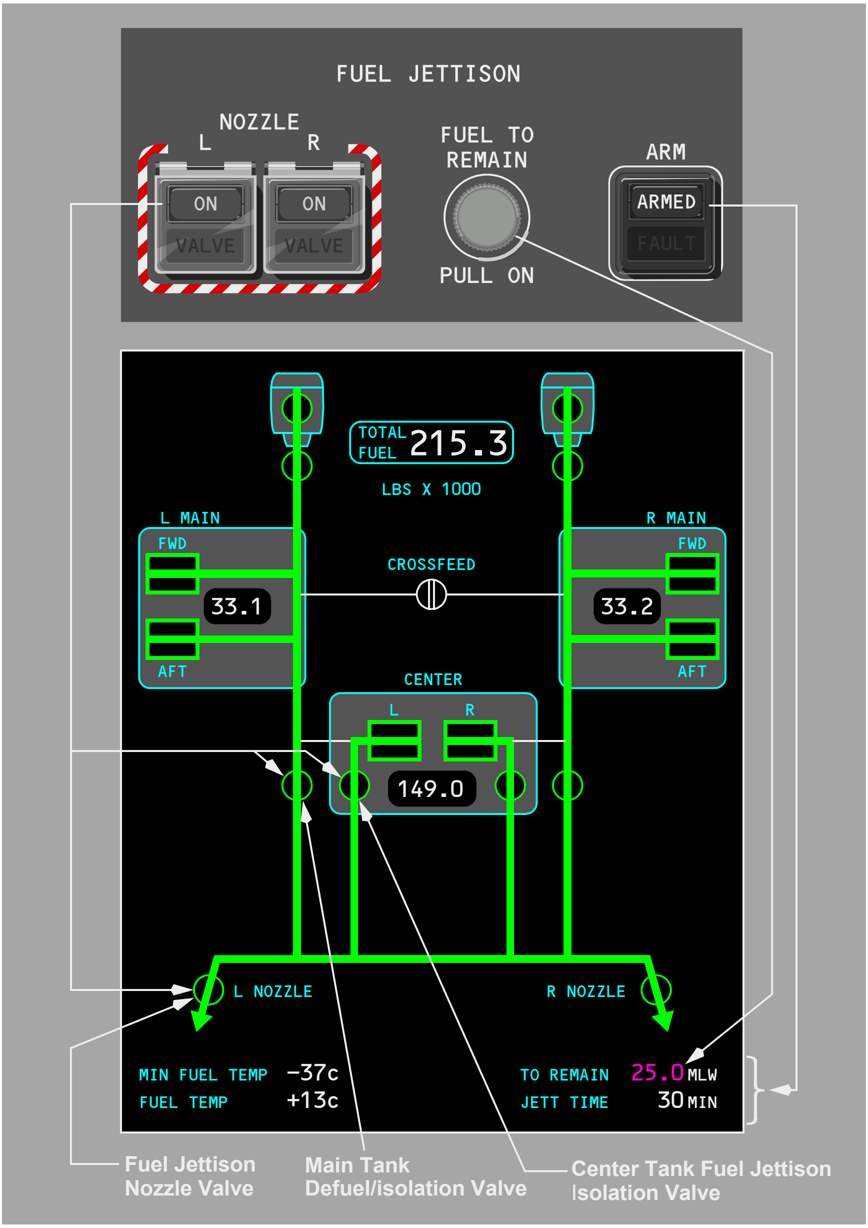
In flight, when the FUEL JETTISON ARM switch is armed and either fuel jettison NOZZLE switch is pushed ON, the defuel/isolation valves and jettison nozzle valves open. The fuel system automatically operates main tank boost pumps and center tank override/jettison pumps as required to jettison fuel based on the selected TO REMAIN quantity.

The nozzles cannot open on the ground, regardless of switch positions.

In flight, jettison time is displayed in minutes on the fuel synoptic when the jettison arm switch is positioned on while in the air. Jettison automatically stops when a value just above the FUEL TO REMAIN quantity is reached. The system shuts off the main tank pumps and closes the center tank jettison isolation valves.
[Option – English / Metric units]
At least 8700 pounds / 3900 kilograms of fuel remains in each main tank after jettison is complete.

Fuel Jettison Schematic

[Option – English units]



Nitrogen Generation System

The Nitrogen Generation System (NGS) provides automatic full time flammability protection for the fuel system. It generates nitrogen enriched air to displace fuel vapors in all fuel tanks. The nitrogen enriched air minimizes fuel flammability during normal flight and ground operations.

Fuel System FMS CDU Messages

The CDU can display the following messages.

INSUFFICIENT FUEL – Predicted fuel at destination is less than the FMC pilot–entered or uplinked reserves.

Fuel System EICAS Messages

The following EICAS messages can be displayed.

Message	Level	Aural	Condition
FUEL AUTO JETTISON	Caution	Beeper	Both of the following occur: • Total fuel quantity is less than the FUEL TO REMAIN • jettison nozzle valve is open.
FUEL BALANCE ON	Memo		The fuel balance function is on.
FUEL BALANCE SYS	Advisory		A fuel balance system fault occurs.
FUEL CROSSFEED	Advisory		The fuel crossfeed valve is not in the commanded position.
FUEL CROSSFEED ON	Memo		The FUEL CROSSFEED switch is in the ON position.
FUEL DISAGREE	Advisory		The totalizer fuel quantity and the FMC calculated fuel quantity disagree.
FUEL IMBALANCE	Advisory		There is a fuel imbalance between the main tanks.
FUEL IN CENTER	Advisory		The center wing tank fuel quantity is at the level where the pump switches must be ON.
FUEL JETT NOZZLE L, R	Advisory		A jettison nozzle valve is not in the commanded position.
FUEL JETTISON MAIN	Advisory		The main tank fuel jettison system is failed.
FUEL JETTISON SYS	Caution	Beeper	The fuel jettison system is failed.

Message	Level	Aural	Condition
FUEL LOW CENTER	Advisory		The center wing tank fuel quantity is at the level where the pump switches must be off.
FUEL PRESS ENG L, R	Caution	Beeper	The engine is on suction feed.
FUEL PRESS ENG L+R	Advisory		Both engines are on suction feed.
FUEL PUMP CENTER L, R	Advisory		The pump pressure is low.
FUEL PUMP CTR L+ R	Advisory		Both pump pressures are low.
FUEL PUMP L AFT, FWD	Advisory		The pump pressure is low.
FUEL PUMP R AFT, FWD	Advisory		The pump pressure is low.
FUEL QTY LOW	Caution	Beeper	The fuel quantity is low in a main tank.
FUEL TEMP HIGH	Advisory		Fuel temperature is near the maximum.
FUEL TEMP LOW	Advisory		Fuel temperature is near the minimum.
FUEL VALVE APU	Advisory		The APU fuel valve is not in the commanded position.

Hydraulics — Chapter 13
Table of Contents — Section 0

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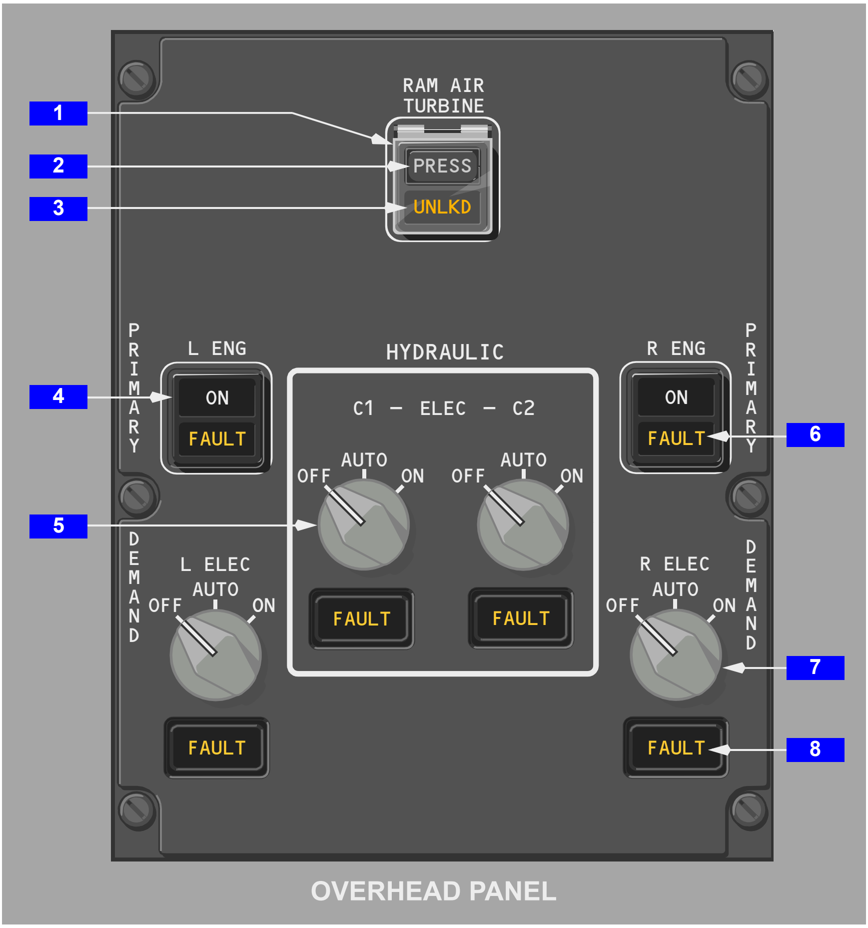
Hydraulic Panel



1 RAM AIR TURBINE Switch

Push – deploys the RAT.

2 Ram Air Turbine Pressure (PRESS) Light

Illuminated (white) –

- the RAT is deployed
- center system primary flight control hydraulic pressure is greater than 2000 psi

3 **Ram Air Turbine Unlocked (UNLKD) Light**

Illuminated (amber) – the RAT is not in the stowed position.

4 **Left/Right Engine (L/R ENG) PRIMARY Pump Switches**

ON – the engine-driven hydraulic pump pressurizes the related left or right hydraulic system when engine starts.

Off (ON not visible) – the engine-driven hydraulic pump is turned off and depressurized.

5 **C1/C2 Electrical (C1/C2 ELEC) Pump Selectors**

ON – the pump runs continuously.

AUTO – Pumps alternate as a primary pump and a demand pump. The primary pump operates continuously and the demand pump operates during high system demand.

OFF – the pump is off.

6 **Primary Pump FAULT Lights**

Illuminated (amber) –

- low primary pump pressure
- excessive primary pump fluid temperature, or
- pump selected OFF

7 **DEMAND (L/R ELEC DEMAND) Pump Selectors**

ON – the pump runs continuously.

AUTO – the pump operates when system and/or primary pump(s) pressure is low, or when control logic anticipates a large system demand.

OFF – the pump is off.

8 **Demand Pump FAULT Lights**

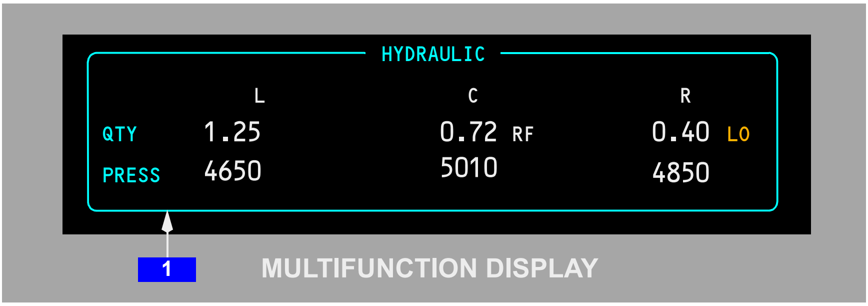
Illuminated (amber) –

- low demand pump pressure
- excessive demand pump fluid temperature, or
- demand pump is selected OFF

Hydraulic System Indications

Hydraulic system indications are displayed by pushing the systems (SYS) display switch on the display select panel, then selecting either the status (STAT) synoptic key or the hydraulic (HYD) synoptic key. Refer to Display Select Panel in Chapter 10, Section 10, for more information.

Status Display



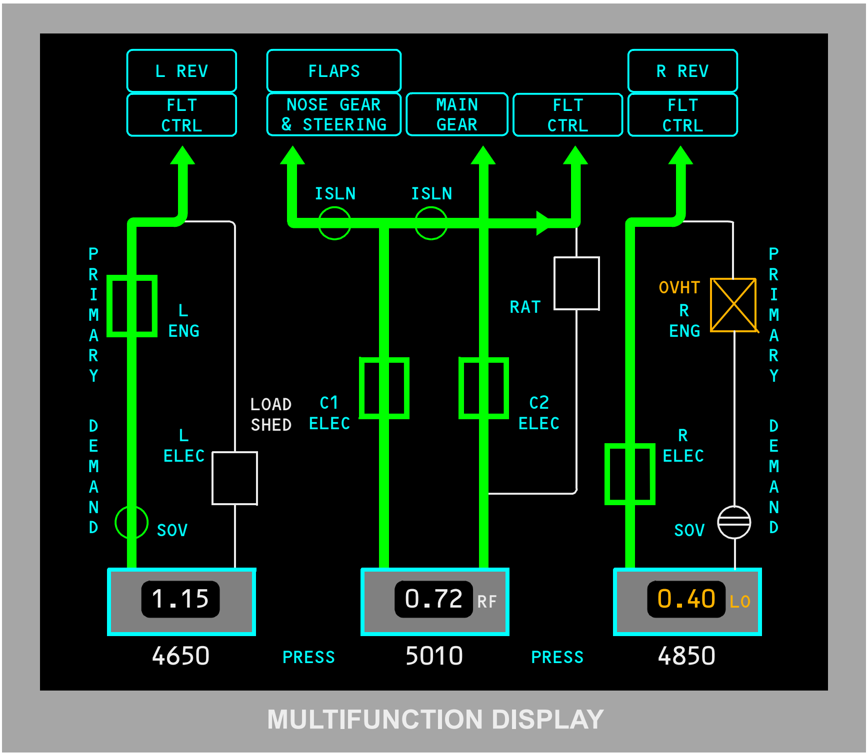
1 Hydraulic Display

QTY –

- displays system reservoir quantity as a percentage of the normal service level (1.00 is the normal service level)
- LO (amber) – displayed when the reservoir quantity is low
- OF (white) – displayed when the reservoir is over–full (inhibited in flight)
- RF (white) – displayed when the reservoir requires refilling (inhibited in flight).

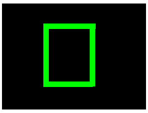
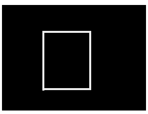
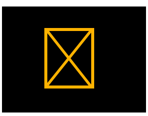
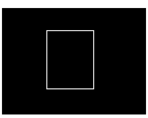
PRESSURE – displays hydraulic pressure in pounds per square inch of the pump with the highest pressure.

Hydraulic Synoptic Display

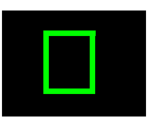
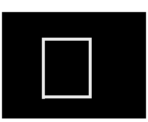
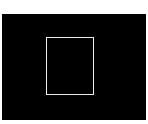


Synoptic Indication Symbology

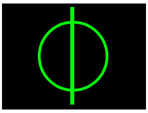
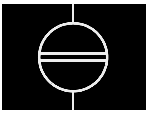
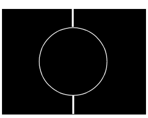
Electric Motor Pump (EMP) Synoptic Indications

Symbol	Condition	Remarks
	EMP on (green)	Pump output pressure exceeds 2000 psi.
	EMP off (white)	Pump output pressure less than 2000 psi and pump is commanded off.
	EMP failed (amber)	Pump output pressure less than 2000 psi when commanded on.
	EMP invalid on (white, low intensity)	

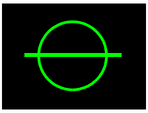
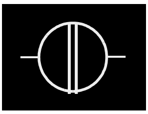
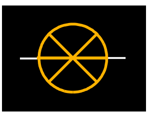
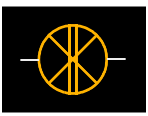
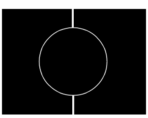
Engine Driven Pump (EDP) Synoptic Indications

Symbol	Condition	Remarks
	EDP on (green)	Pump output pressure exceeds 2000 psi.
	EDP off (white)	Pump output pressure less than 2000 psi and pump is commanded off.
	EDP failed (amber)	Pump output pressure less than 2000 psi and ENG switch is ON and engine is running.
	EDP invalid on (white, low intensity)	

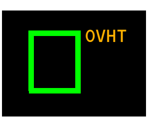
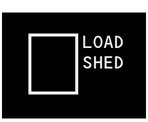
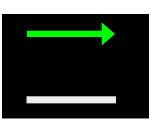
EDP Shutoff Valves (SOV) Synoptic Indications

Symbol	Condition	Remarks
	Valve open (green)	Engine fire handle not pulled.
	Valve closed (white)	Engine fire handle pulled.
	Valve failed open (amber)	
	Valve failed closed (amber)	
	Valve invalid (white, low intensity)	

Reserve Steering Isolation Valves (ISLN) Synoptic Indications

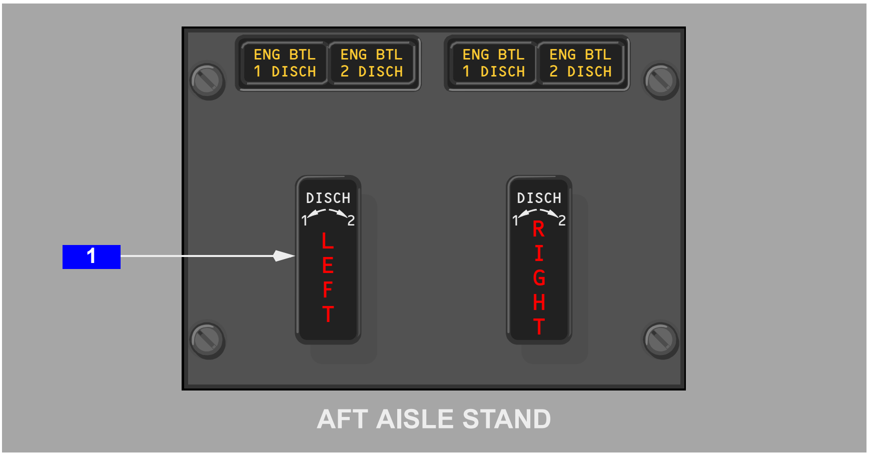
Symbol	Condition	Remarks
	Valve open (green)	
	Valve closed (white)	
	Valve failed open (amber)	Valve open when commanded closed.
	Valve failed closed (amber)	Valve closed when commanded open and center hydraulic system pressure greater than 3000 psi.
	Valve invalid (white, low intensity)	

Miscellaneous Synoptic Indications

Symbol	Condition	Remarks
	Pump overheat	Pump temperature exceeds limit
	Load shed indication	Pump has received load shed command
	Flow lines (green with arrow end or white solid)	Green flow lines with directional arrow display if a pump is on and no valves upstream or downstream are closed.

Miscellaneous Hydraulic System Controls

Engine Fire Panel



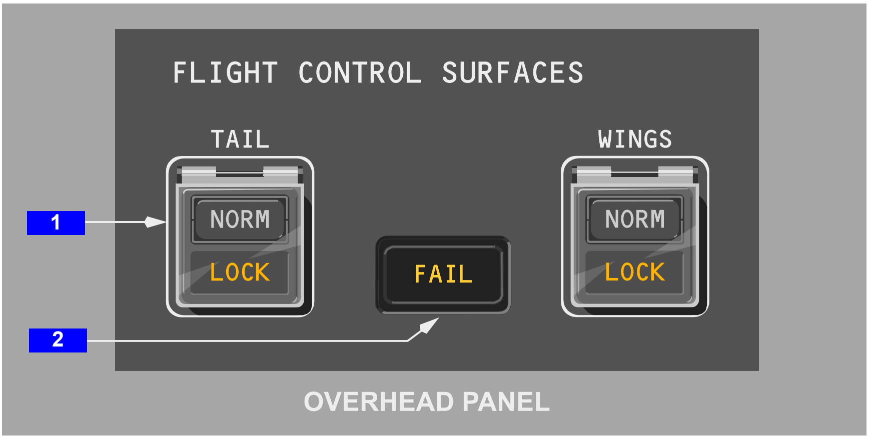
1 Engine Fire Switches

Pull –

- closes the engine–driven pump hydraulic supply shutoff valve
- depressurizes the engine–driven pump

Flight Control Surface Lockout Switches

Note: No flight crew normal or non–normal procedures require operation of the flight control surface lockout switches. These switches are for ground maintenance use only.



1 FLIGHT CONTROL SURFACES Lockout Switches (TAIL/WINGS)

NORM – associated flight control surface electronically unlocked.

LOCK – associated flight control surface electronically locked.

2 FLIGHT CONTROL SURFACES Lockout FAIL Light

Illuminated (amber) – the system lockout has failed.

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Hydraulics — Chapter 13
System Description — Section 20

Introduction

The airplane has three independent hydraulic systems: left, right, and center. The hydraulic systems power the:

- flight controls
- leading edge slats
- trailing edge flaps
- landing gear
- thrust reversers.
- nose gear steering

Flight control system components are distributed so that any one hydraulic system can provide adequate airplane controllability.

Hydraulic fluid is supplied to each hydraulic pump from the associated system reservoir. The reservoirs are pressurized by pump outlet pressure.

Left and Right Hydraulic Systems

The left and right hydraulic systems are identical. They differ only in the components they power.

The left hydraulic system powers:

- flight controls
- the left engine thrust reverser

The right hydraulic system powers:

- flight controls
- the right thrust reverser

Left and Right Hydraulic System Primary Pumps

The left and right hydraulic systems each have a primary pump. The left and right primary pumps are engine–driven by the related left and right engines.

Left and Right Hydraulic System Demand Pumps

The left and right hydraulic systems each have a demand pump. The demand pumps are electric motor–driven. The demand pumps provide supplementary hydraulic power for periods of high system demand. The demand pumps also provide a backup hydraulic power source for the engine–driven primary pumps.

The pumps are controlled by the ELEC DEMAND L and R pump selectors. In the ON position, the demand pump runs continuously. In the AUTO position, the L and R demand pumps operate under the following conditions:

- system low pressure
- on the ground and three minutes after the second engine indicates RUNNING
- from takeoff thrust set to flaps retracted
- during decent from flaps extended until speedbrakes are stowed (left pump only)
- thrust reverser operation

Center Hydraulic System

The center hydraulic system powers:

- flight controls
- leading edge slats
- trailing edge flaps
- landing gear actuation
- nose gear steering

The ram air turbine (RAT) can provide hydraulic power to the center hydraulic system primary flight control components only.

Center Hydraulic System Electric Pumps

Two electric motor-driven pumps (EMPs) provide hydraulic power sources for the center hydraulic system. The C1 and C2 ELEC pump selectors control pump operation.The two center pumps alternate as a primary pump and demand pump. The FMC determines which operates as primary or demand based on the day of the week. The primary pump operates continuously. The center demand pump operates under the following conditions:

- system low pressure
- from takeoff thrust set to flaps retracted

Center Hydraulic System Non–Normal Operation

If center hydraulic system quantity is sensed to be low and airspeed is greater than 60 knots the:

- nose gear actuation and steering are isolated
- leading edge slats are isolated and not allowed to operate in the primary (hydraulic) mode

The leading edge slats are reconnected to the center hydraulic system and allowed to operate in primary mode when:

- center hydraulic fluid quantity recovers to normal for 5 seconds, and
- the system determines that both engines have been running for more than 30 seconds

Nose gear actuation and steering are reconnected when:

- airspeed decreases below 60 knots, or
- hydraulic pressure to the center system flight controls goes low, or
- the landing gear is selected down, both engines are normal, and both engine–driven pumps are providing pressure

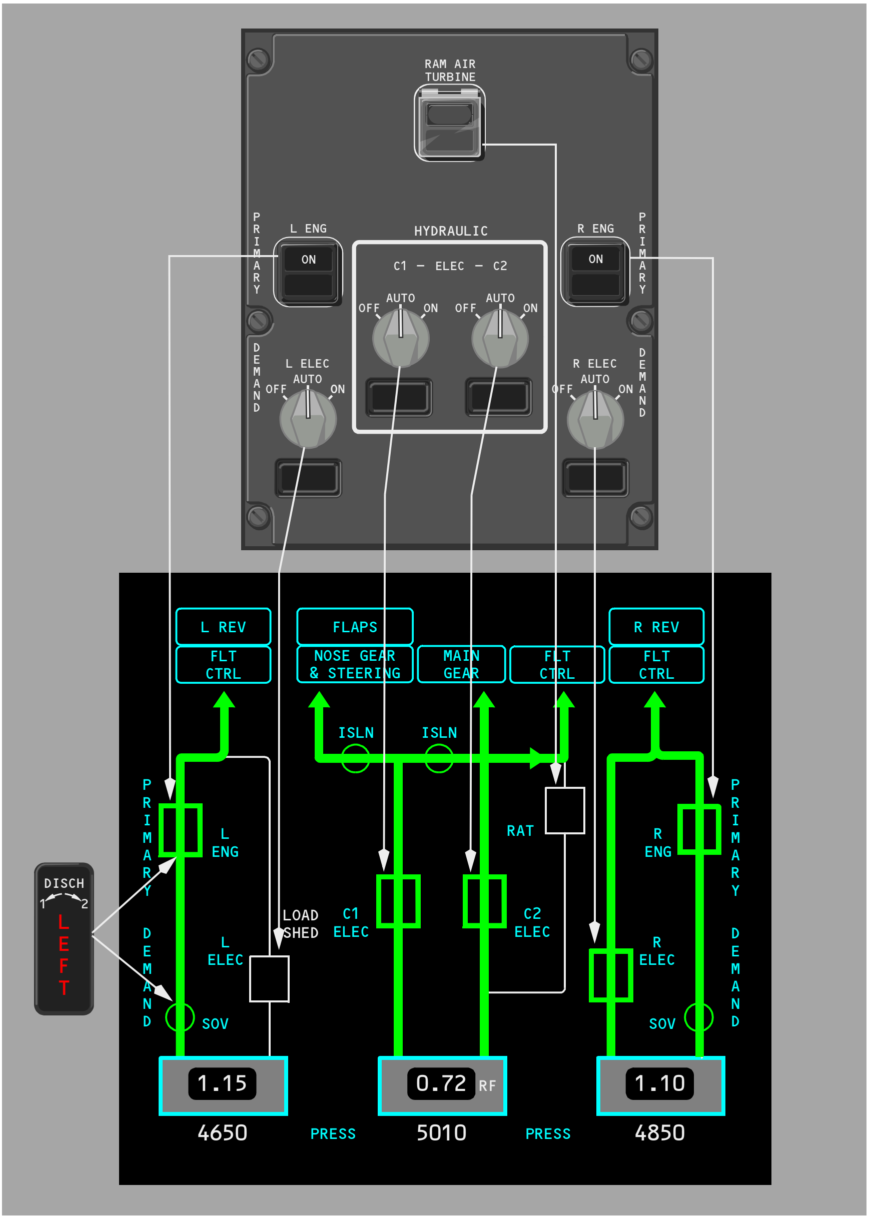
Ram Air Turbine (RAT)

The RAT, when deployed, provides hydraulic power only to the primary flight control components connected to the center hydraulic system. The RAT provides hydraulic and electrical power throughout the flight envelope. In flight, the RAT deploys automatically if:

- both engines are failed and center system pressure is low, or
- all three hydraulic system pressures are low
- loss of all electrical power generators occurs
- loss of all four EMPs occurs and an engine fails on takeoff or landing

The RAT can be deployed manually by pushing the RAM AIR TURBINE switch. The hot battery or APU battery bus must be powered. The center hydraulic system does not need to be powered. The RAT is deployed by a compressed spring. Once deployed, the RAT cannot be stowed in flight.

Hydraulic Systems Schematic



Hydraulics, Ram Air Turbine EICAS Messages

The following EICAS messages can be displayed.

Message	Level	Aural	Condition
HYD OVERHEAT C1	Advisory		The C1 pump temperature is high.
HYD OVERHEAT C2	Advisory		The C2 pump temperature is high.
HYD OVERHEAT DEM L, R	Advisory		The pump temperature is high.
HYD OVERHEAT PRI L, R	Advisory		The pump temperature is high.
HYD PRESS C1	Advisory		The C1 pump pressure is low.
HYD PRESS C2	Advisory		The C2 pump pressure is low.
HYD PRESS DEM L, R	Advisory		The pump pressure is low when commanded on.
HYD PRESS PRI L, R	Advisory		The pump pressure is low.
HYD PRESS SYS C	Caution	Beeper	The hydraulic system pressure is low.
HYD PRESS SYS L	Caution	Beeper	The hydraulic system pressure is low.
HYD PRESS SYS L+C	Caution	Beeper	Two hydraulic system pressures are low.
HYD PRESS SYS L+C+R	Caution	Beeper	All hydraulic system pressures are low.
HYD PRESS SYS L+R	Caution	Beeper	Two hydraulic system pressures are low.
HYD PRESS SYS R	Caution	Beeper	The hydraulic system pressure is low.
HYD PRESS SYS R+C	Caution	Beeper	Two hydraulic system pressures are low.
HYD QTY LOW C, L, R	Advisory		The hydraulic quantity is low.

Message	Level	Aural	Condition
RAT UNLOCKED	Advisory		The ram air turbine is not stowed and locked.

Landing Gear — Chapter 14

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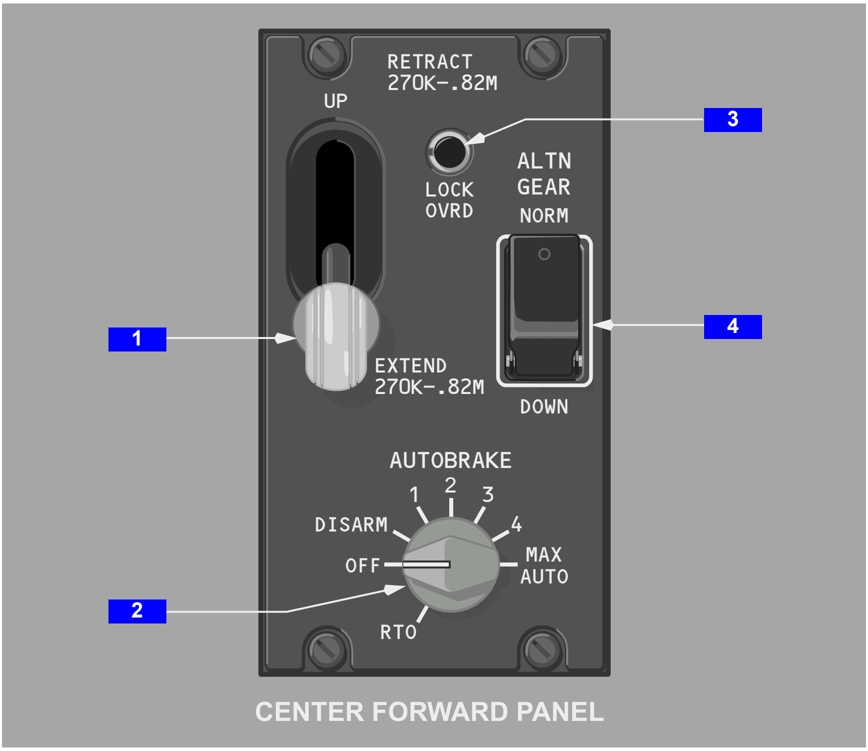
Landing Gear Panel



1 Landing Gear Lever

UP – the landing gear retracts.

DN – the landing gear extends.

2 AUTOBRAKE Selector

OFF – deactivates and resets the autobrake system.

DISARM –

- disengages the autobrake system
- releases brake pressure

1, 2, 3, 4, MAX AUTO – selects the desired deceleration rate.

RTO – automatically applies maximum brake pressure when the thrust levers are retarded to idle above 85 knots.

3 Landing Gear Lever Lock Override (LOCK OVRD) Switch

Push – releases the landing gear lever lock.

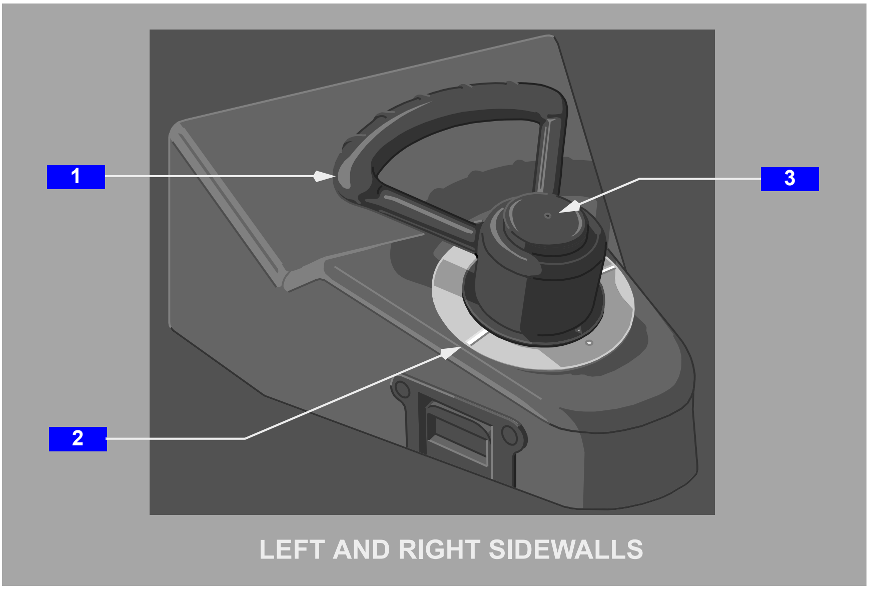
4 Alternate Gear (ALTN GEAR) Switch

NORM – the landing gear lever operates normally.

DOWN – the landing gear extends by the alternate extension system.

Note: Alternate extension may be selected with the landing gear lever in any position.

Nose Wheel Steering Tillers



1 Nose Wheel Steering Tiller

Rotate –

- turns the nose wheels up to 70 degrees in either direction
- overrides rudder pedal steering

2 Tiller Position Indicator

Shows tiller displacement from the straight–ahead, neutral position.

There are three tick marks on the tiller assembly. The center mark identifies the neutral position of the tiller, while the other two ticks identify the maximum left and right displacements.

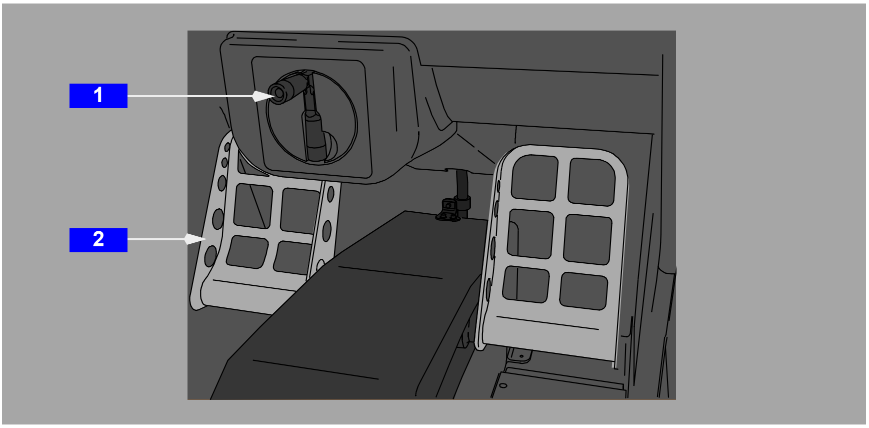
3 **Rudder Pedal Disconnect Switch**

A rudder pedal steering disconnect switch is provided to temporarily disable the rudder pedal inputs.

Note: The rudder pedal steering disconnect switch is used during flight controls freedom of motion check. Switch must be held down to function and is spring loaded to the out position.

Brake System

Rudder/Brake Pedals



1 **Rudder Pedal Adjust Crank**

Adjusts the rudder pedals forward or aft.

Note: To avoid inadvertent rudder pedal movement, the crank handle should be stowed when not in use.

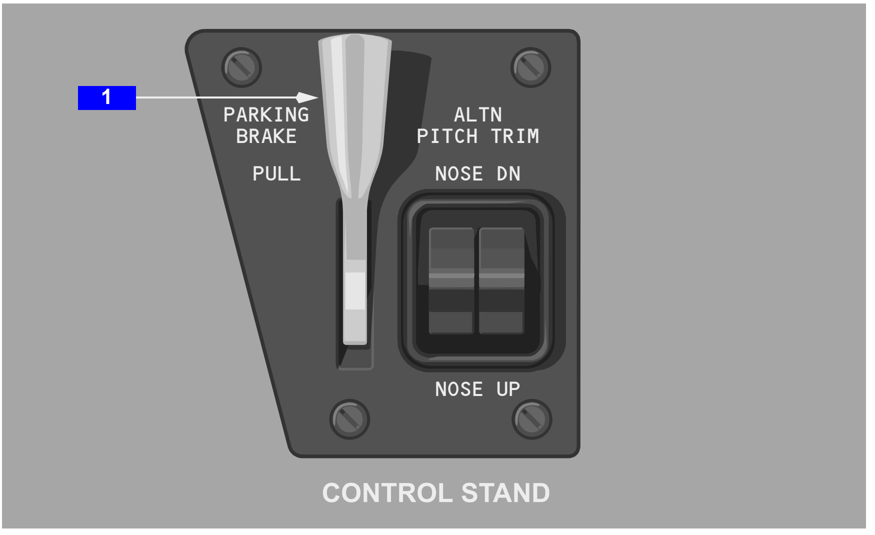
2 **Rudder/Brake Pedals**

Push the full pedal – turns the nose wheel up to 7 degrees in either direction.

Push the top of the pedals – actuates the wheel brakes.

Refer to Chapter 9, Flight Controls for the description of rudder operation.

Parking Brake Lever



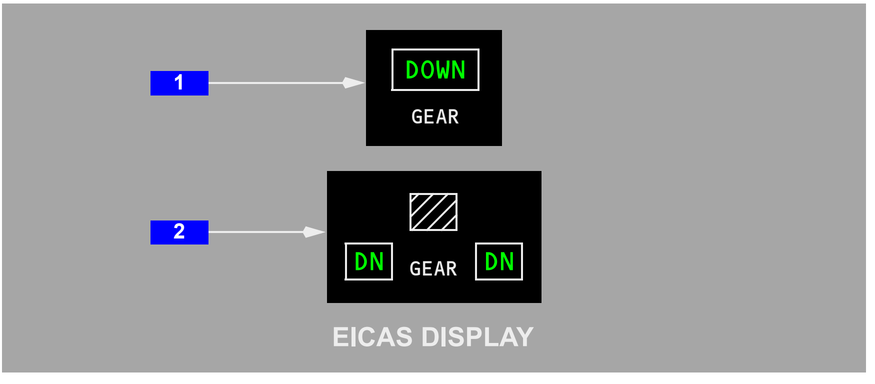
1 Parking Brake Lever

Pull – sets the parking brake when both brake pedals are simultaneously depressed.

Release – simultaneously depress both brake pedals.

Landing Gear System Indications

Landing Gear Position Indications



1 Gear Position Indication (Normal Display)

DOWN (green) – all landing gear are down and locked.

Crosshatched (white) – one or more landing gear are in transit.

UP (white) – all landing gear are up and locked (blanks after 10 seconds).

Empty box (white) – all landing gear position indicators are inoperative.

2 Expanded Gear Position Indication (Non–Normal Display)

DN (green) – the associated landing gear is down and locked.

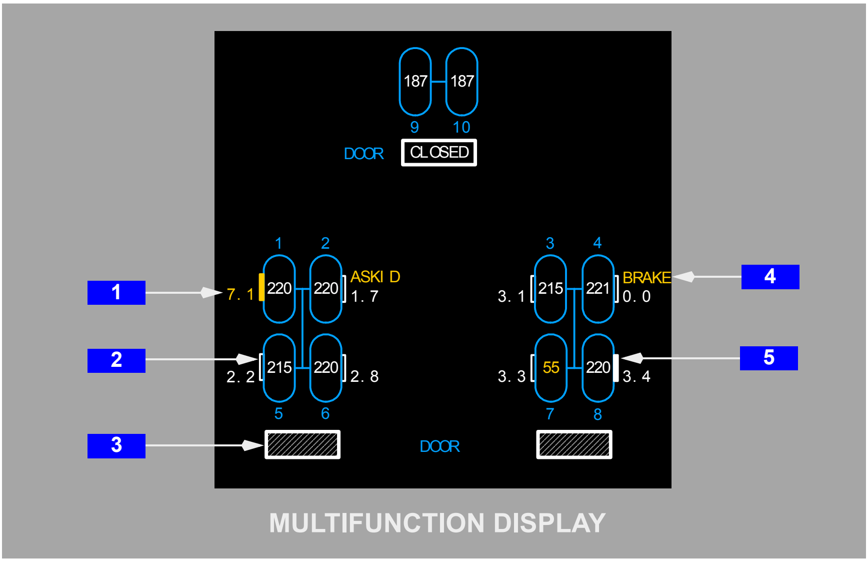
Crosshatched (white) – the associated landing gear is in transit.

UP (white) – the associated landing gear is up and locked.

Empty box(es) (white) – the associated landing gear position indicators are inoperative.

Gear Synoptic Display

The landing gear synoptic is displayed by pushing the systems (SYS) display switch on the display select panel, then selecting the landing gear (GEAR) synoptic key. Display select panel operation is described in Chapter 10, Flight Instruments, Displays.



1 Brake Temperature

Indicates a relative value of wheel brake temperature:

- values range from 0.0 to 9.9
- white – normal range
- amber – high range

2 Brake Symbol

Empty white box indicates any brake in normal range of 0.0 to 4.9.

Solid white box indicates hottest brake on each main gear within range of 3.0 to 4.9.

Solid amber box indicates brake overheat condition on each wheel within range of 5.0 to 9.9.

3 Gear Door Status

Crosshatched – the door is not closed.

CLOSED (white) – the door is closed.

Empty box(es) (white) – the associated landing gear door position indicators are inoperative.

4 **Fault Indication (amber)**

BRAKE – indicates brake deactivation on the associated wheel.

ASKID – indicates antiskid fault on the associated wheel.

5 **Tire Pressure Indication (amber)**

Tire pressure is indicated within each individual gear indication:

- white – normal pressure
- amber – low pressure (value = TBD)

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Landing Gear — Chapter 14
System Description — Section 20

Introduction

The airplane has two main landing gear and a single nose gear. The nose gear is a conventional steerable two–wheel unit. Each main gear has four wheels in tandem pairs.

Hydraulic power for retraction, extension, and steering is supplied by the center hydraulic system. An alternate extension system is also provided.

The Electro-Mechanical Brake System has four Electric Brake Actuator

Controllers (EBACs) and thirty-two Electric Brake Actuators (EBAs), four per wheel brake. Autobrakes and antiskid protection are provided. A brake temperature monitor system displays each brake temperature on the GEAR synoptic display.

A tire pressure monitor system displays each tire pressure on the GEAR synoptic display.

Air/Ground Sensing System

In–flight and ground operation of various airplane systems are controlled by the air/ground sensing system.

The system receives air/ground logic signals from sensors located on each main landing gear beam. These signals are used to configure the airplane systems to the appropriate air or ground status.

Landing Gear Operation

The landing gear are normally controlled by the landing gear lever. On the ground, the lever is held in the DN position by an automatic lever lock. The lever lock can be manually overridden by pushing and holding the landing gear lever LOCK OVERRIDE switch. In flight, the lever lock is automatically released through air/ground sensing.

Landing Gear Retraction

When the landing gear lever is moved to UP, the landing gear begins to retract. The landing gear doors open and the main gear wheels tilt to the retract position. The EICAS landing gear position indication display changes from a green DOWN indication to a white crosshatch in–transit indication as the landing gear retract into the wheel wells. After retraction, the landing gear are held up by uplocks. The EICAS landing gear position indication changes to UP for 10 seconds and then blanks. With the landing gear retracted and all doors closed, the landing gear hydraulic system is automatically depressurized.

If any gear is not up and locked up after the normal transit time, the EICAS caution message GEAR DISAGREE is displayed. The EICAS gear position indication changes to the expanded non–normal format, with the affected gear displayed as in–transit or down, if the gear never unlocked from the down position. The EICAS advisory message GEAR DOOR is displayed if any hydraulically actuated door is not closed after normal transit time.

Landing Gear Extension

When the landing gear lever is moved to DN, the landing gear doors open, the gear are unlocked, and the in–transit indication is displayed on the EICAS landing gear position indication.

The gear free–fall without hydraulic power to the down and locked position. The downlocks are powered to the locked position, all hydraulically actuated gear doors close, and the main gear trucks hydraulically tilt to the flight position. When all gear are down and locked, the EICAS gear position indication displays DOWN.

The EICAS caution message GEAR DISAGREE is displayed if any gear is not locked down (side and drag brace on the same main gear not locked, or nose gear drag brace not locked) after the normal transit time. The EICAS gear position indication changes to the expanded non–normal format, with the affected gear displayed as in transit (or UP if the gear never unlocked from the up position).

If only one brace on a main gear is locked (either drag or side brace not locked) after the normal transit time, the EICAS caution message MAIN GEAR DRAG BRACE L, R or MAIN GEAR SIDE BRACE L, R is displayed for the affected gear. The EICAS gear position indication changes to the expanded non–normal format, with the affected gear displayed as in transit. The EICAS advisory message GEAR DOOR displays if any hydraulically actuated door is not closed after the normal transit time.

Landing Gear Alternate Extension

The alternate landing gear extension system uses a dedicated DC powered electric hydraulic pump and center hydraulic system fluid to extend the landing gear. Selecting DOWN on the ALTERNATE GEAR switch releases all door and gear uplocks. The landing gear free–fall to the down and locked position. The landing gear lever position has no effect on landing gear alternate extension.

The EICAS landing gear position indication displays the expanded gear position indication when the alternate extension system is used. During alternate extension, the EICAS message GEAR DOOR is displayed because all the hydraulically powered gear doors remain open.

Following an alternate extension, the landing gear can be retracted by the normal system, if it is operating. Select DN then UP to retract the landing gear using the normal system.

Nose Wheel Steering

The airplane is equipped with nose wheel steering powered by the center hydraulic system.

Primary steering control is provided by a nose wheel steering tiller for each pilot. Limited steering control is available through the rudder pedals. The tillers can turn the nose wheels up to 70 degrees in either direction. A pointer on the tiller assembly shows tiller position relative to the neutral setting. The rudder pedals can be used to turn the nose wheels up to 7 degrees in either direction. Tiller inputs override rudder pedal inputs.

Brake System

Each main gear wheel has a multiple disc carbon brake. The nose wheels have no brakes. The brake system includes:

- electric brake system
- antiskid protection
- autobrake system
- parking brake

Electric Brake System

The brake system is powered by four electric brake power supply units. The brake pedals provide independent control of the left and right brakes.

Four Electric Brake Actuators (EBAs) are provided on each main landling gear wheel brake to control the application of braking force to the carbon disc. The EBA's are controller by an Electric Brake Actuator Controller (EBAC). There are four EBACs that control all eight main wheel brakes, each EBAC controlling the brake force of a fore-aft wheel pair.

Antiskid Protection

Antiskid protection is provided on an individual main gear wheel basis. When a wheel speed sensor detects a skid, the braking force is reduced until skidding stops.

Touchdown and hydroplaning protection is provided using airplane inertial groundspeed. Locked wheel protection is provided using a comparison with other wheel speeds.

The EICAS advisory message ANTISKID is displayed if an antiskid fault affecting the brake system is detected, or if parking brake force is applied with the parking brake lever released, or if the system is completely inoperative.

Autobrake System

The autobrake system provides automatic braking at preselected deceleration rates for landing and full pressure for rejected takeoff. Antiskid system protection is provided during autobrake operation.

EICAS memo messages display the selected autobrake settings:

- AUTOBRAKE 1 through 4
- AUTOBRAKE MAX
- AUTOBRAKE RTO

The EICAS advisory message AUTOBRAKE is displayed if the autobrake system is disarmed or inoperative, the autobrake selector is OFF but the system is armed, or an RTO is initiated above 85 knots but autobraking has not been applied.

Rejected Takeoff

Selecting RTO (rejected takeoff) prior to takeoff arms the autobrake system. The RTO mode can be selected only on the ground. The RTO autobrake setting commands maximum braking pressure if:

- the airplane is on the ground
- groundspeed is above 85 knots, and
- both thrust levers are retarded to idle

Maximum braking is obtained in this mode. If an RTO is initiated below 85 knots, the RTO autobrake function does not operate.

Taxi Brake Release

During each taxi brake application, the antiskid system releases the brakes of one axle pair of each main landing gear (if wheel speeds are less than 45 knots). The system sequences through the axle pairs at each brake application, thereby reducing the number of brake applications by each brake. This extends service life and reduces brake sensitivity during taxi.

All active brakes are applied for a heavy brake application, landing rollout, RTO, or when setting the parking brake.

Landing

Five levels of deceleration can be selected for landing. However, on dry runways, the maximum autobrake deceleration rate in the landing mode is less than that produced by full pedal braking.

After landing, autobrake application begins when:

- both thrust levers are retarded to idle, and
- the wheels have spun up

Autobrake application occurs slightly after main gear touchdown. If MAX AUTO is selected, deceleration is limited to the AUTOBRAKE 4 level until pitch angle is less than one degree, then deceleration is increased to the MAX AUTO level. The deceleration level can be changed (without disarming the system) by rotating the selector.

To maintain the selected airplane deceleration rate, autobrake pressure is reduced as other controls, such as thrust reversers and spoilers, contribute to total deceleration. The system provides braking to a complete stop or until it is disarmed.

Autobrake – Disarm

The autobrake system disarms and the EICAS advisory message AUTOBRAKE is displayed if any of the following occur:

- pedal braking applied
- either thrust lever advanced after landing
- speedbrake lever is moved to the DOWN detent after the speedbrakes have deployed on the ground
- DISARM or OFF position selected on the AUTOBRAKE selector
- autobrake fault
- normal antiskid system fault
- loss of inertial data from the Inertial Reference Units (IRUs)

When the autobrake system disarms after landing, the AUTOBRAKE selector automatically moves to the DISARM position, and removes power from the autobrake system.

When the autobrake system disarms during takeoff, the autobrake selector remains in the RTO position, but automatically moves to OFF after takeoff.

Parking Brake

The parking brake electric brake actuators are clamped in position during parking brake application and require no active power to maintain application. The parking brake system has a "park and adjust" feature which monitors condition of the brakes after parking brake application and adjusts clamping force as needed during brake cooling.

The parking brake is set by fully depressing both brake pedals, pulling the parking brake lever up, then releasing the pedals.

The parking brake is released by depressing the pedals until the parking brake lever releases.

When the parking brake is set, the EICAS memo message PARKING BRAKE SET is displayed. If the parking brake is set and either engine is set to takeoff thrust, the takeoff configuration aural alert sounds and the EICAS warning message CONFIG PARKING BRAKE is displayed.

Brake Temperature Indication

Wheel brake temperatures are displayed on the GEAR synoptic display. Numerical values related to wheel brake temperature are displayed adjacent to each wheel/brake symbol. These values range from 0.0 to 9.9 in increments of 0.1. The values tend to increase after the brakes are used.

Normal range values of 0 to 4.9 are white. For values of 3.0 to 4.9, the brake symbol for the hottest brake becomes solid white. Values of 5.0 and above are amber. For values of 5.0 and above, the EICAS advisory message BRAKE TEMP is displayed.

Tire Pressure Indication

Individual tire pressures, from 0 to TBD PSI, are displayed inside each individual gear indication on the GEAR synoptic. Normal values are depicted in white. Low tire pressure values are depicted in amber. Value will change to amber when the value is less than minimum threshold. The threshold value is TBD.

The EICAS advisory message TIRE PRESS is displayed if any tire pressure is above or below normal range, or there is an excessive pressure difference between two tires on the same axle.

Landing Gear EICAS Messages

The following EICAS messages can be displayed.

Note: Configuration warning messages are covered in Chapter 15, Warning Systems.

Brakes

Message	Level	Aural	Condition
ANTISKID	Advisory		An antiskid system fault occurs.
AUTOBRAKE	Advisory		One of these occurs: • The autobrake system is disarmed • The autobrake system is failed
AUTOBRAKE 1	Memo		Autobrake level 1 is selected.
AUTOBRAKE 2	Memo		Autobrake level 2 is selected.
AUTOBRAKE 3	Memo		Autobrake level 3 is selected.
AUTOBRAKE 4	Memo		Autobrake level 4 is selected.
AUTOBRAKE MAX	Memo		Autobrake MAX is selected.
AUTOBRAKE RTO	Memo		Autobrake RTO is selected.
BRAKE PEDALS CAPT, F/O	Caution		One or both brake pedals are failed.
BRAKE TEMP	Advisory		One or more brake temperatures are high.
BRAKES	Advisory		Two or more brakes are failed.
PARKING BRAKE SET	Memo		The parking brake is set.
TIRE PRESS	Advisory		Tire pressures are not normal.

Landing Gear

Message	Level	Aural	Condition
GEAR DISAGREE	Caution	Beeper	The gear position disagrees with the gear lever position.

Message	Level	Aural	Condition
GEAR DOOR	Advisory		One or more landing gear doors are not closed.
GEAR DRAG BRACE L, R	Caution		The main landing gear is down with the drag brace unlocked.
GEAR SIDE BRACE L, R	Caution		The main landing gear is down with the side brace unlocked.
NOSE WHEEL STEERING	Advisory		Nose wheel steering is not available.
STEERING LOCKED OUT	Memo		Steering is locked out because the airplane is in the tow mode.
TILLER L, R	Caution		The tiller is failed.

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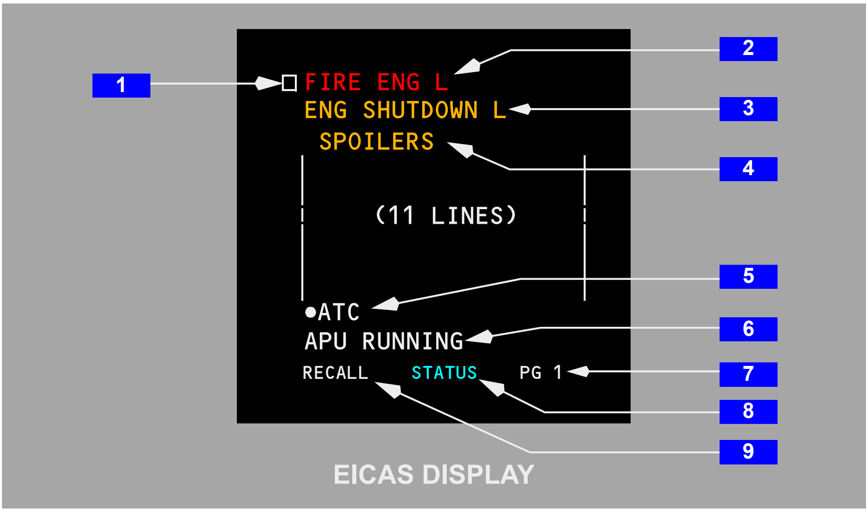
Engine Indication and Crew Alerting System (EICAS)

EICAS Messages



1 Checklist Icon

Displayed (white) –

- indicates that a checklist exists for this message
- no longer displayed when checklist complete
- no longer displayed when inhibited by checklist of another message

2 Warning Messages

Displayed (red) –

- highest priority alert messages
- red alert messages remain displayed and cannot be canceled by pushing the CANC/RCL switch

3 Caution Messages

Displayed (amber) –

- next highest priority alert messages after warning messages
- amber alert messages can be canceled or recalled by pushing the CANC/RCL switch

4 **Advisory Messages**

Displayed (amber) –

- lowest priority alert messages; indented one space
- amber alert messages can be canceled or recalled by pushing the CANC/RCL switch

5 **Communication Messages**

Displayed (white) –

- preceded with white dot
- COMM low messages indented one space
- cannot be canceled by pushing the CANC/RCL switch

6 **Memo Messages**

Displayed (white) –

- reminder of selected state of controls or systems
- cannot be canceled by pushing the CANC/RCL switch
- EICAS alert messages have display priority over memo messages; some or all memo messages not displayed on current EICAS message page if insufficient message lines are available below alert messages

7 **Page (PG) Number**

Displayed (white) –

- more than one page of alert or memo messages exists
- indicates number of page selected

8 **STATUS Cue**

Displayed (cyan) –

- new status message exists
- no longer displayed when status display selected

[Option – 30 min inhibit]

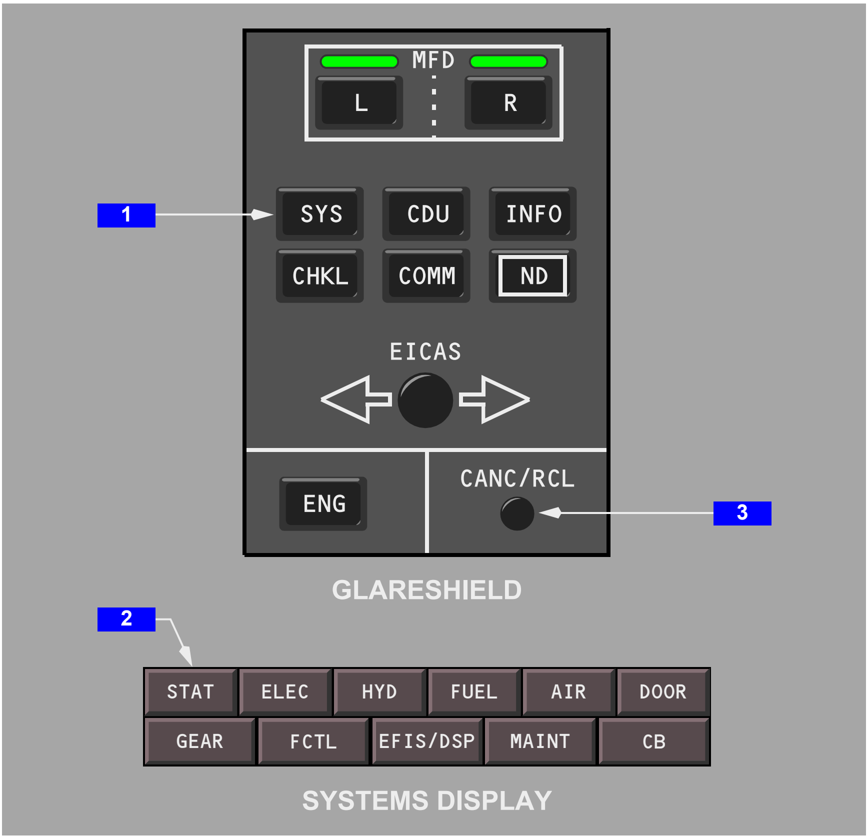
- inhibited from beginning of first engine start until 30 minutes after lift-off

9 **RECALL Indication**

Displayed (white) –

- when CANC/RCL switch pushed
- remains displayed for one second after switch released

Display Select Panel



1 System (SYS) Display Switch

Push – displays system display on selected MFD.

2 Status (STAT) Display Switch

Selected – displays status display on selected MFD.

Subsequent selection – displays next page of status messages when additional pages exist.

3 Cancel/Recall (CANC/RCL) Switch

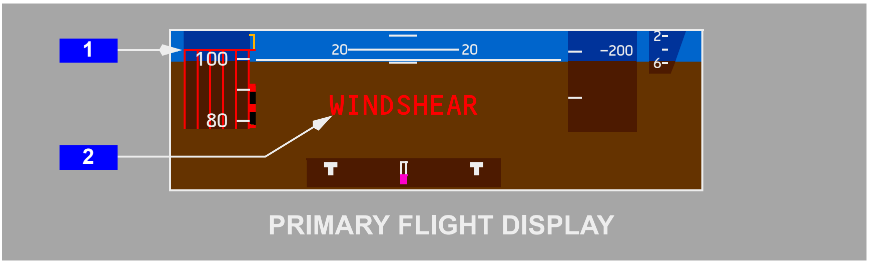
Push (when EICAS caution or advisory messages displayed) –

- displays the next page of EICAS messages when additional pages exist
- cancels caution and advisory messages when last page displayed; warning, memo, and communications messages remain displayed
- cancels red box for any engine parameter previously exceeded when the exceedance no longer exists

Push (when no EICAS caution or advisory messages displayed) –

- redisplays all caution and advisory EICAS messages, when non-normal condition exists
- displays first page of messages when multiple pages exist
- redisplays red box for parameters previously exceeded

Alerts Displayed on the PFD



1 Thrust Asymmetry Minimum Speed

Indicates the minimum control speed for operation with a large thrust asymmetry.

2 Time Critical Warnings

ENG FAIL (red) – ENGINE FAIL alert is occurring.

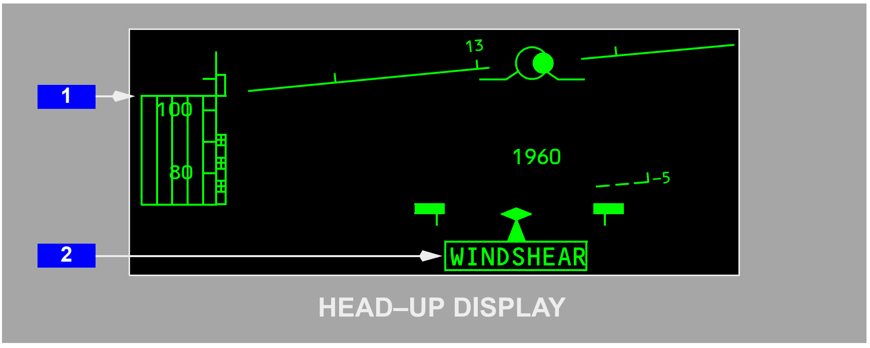
PULL UP (red) – PULL UP alert is occurring.

SPEEDBRAKE (red) – SPEEDBRAKE alert is occurring.

WINDSHEAR (red) –

- predictive WINDSHEAR AHEAD alert or immediate WINDSHEAR alert is occurring
- all other GPWS alerts inhibited

Alerts Displayed on the HUD



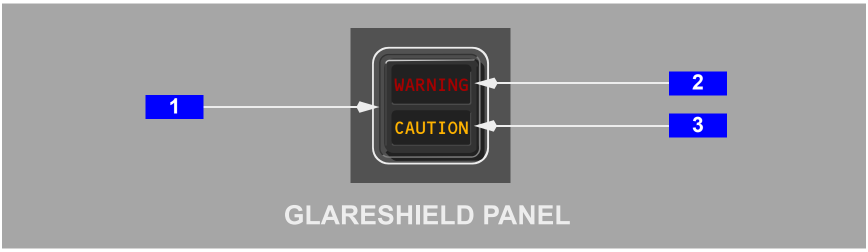
1 **Thrust Asymmetry Minimum Speed**

The TAMS display on the PDF speed tape is also displayed on the HUD.

2 **Time Critical Warnings**

All time critical warnings displayed on the PFD are also displayed on the HUD.

Master WARNING/CAUTION Reset Switches and Lights



1 **Master WARNING/CAUTION Reset Switch**

Push –

- extinguishes master WARNING lights
- extinguishes master CAUTION lights
- silences the aural that accompanies the EICAS warning messages:
  - CABIN ALTITUDE
  - CONFIG GEAR, if displayed because landing gear not down and locked, any thrust lever at idle, and radio altitude less than 800 feet
  - FIRE
  - PILOT RESPONSE (as configured by the airline)

2 **Master WARNING Light**

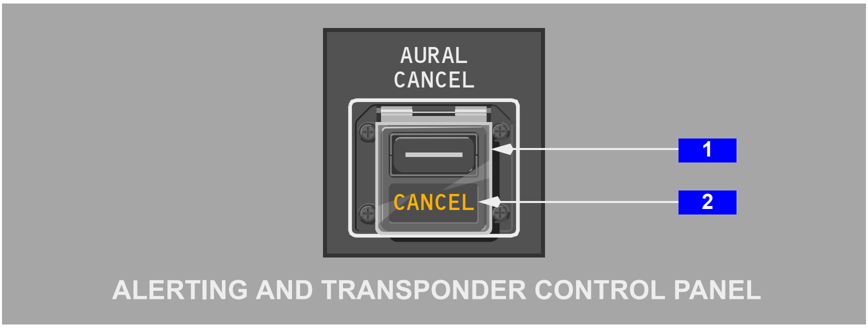
Illuminated (red) –

- new EICAS warning message displayed, or
- ENGINE FAIL, PULL UP, or WINDSHEAR alert displayed on PFD

3 **Master CAUTION Light**

Illuminated (amber) – new EICAS caution message displayed.

Aural Cancel Switch



1 Aural Cancel Switch

Push (guarded) – cancels the active aural alert.

2 Cancel Light

Illuminated (amber) –

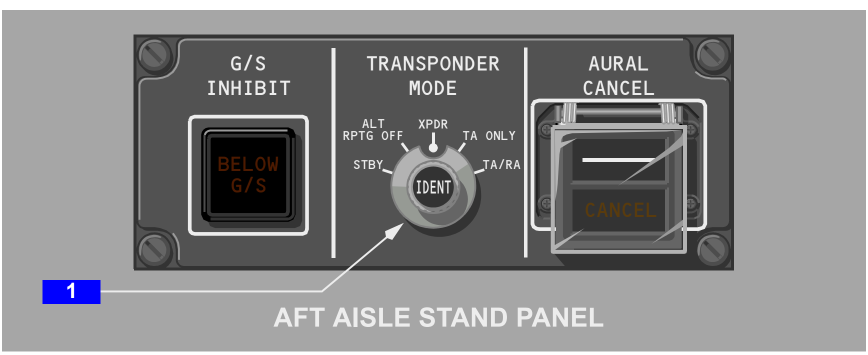
- aural alert is being inhibited
- extinguishes when no aural alerts are being silenced

The cancel function resets when –

- on the ground and both engines are shut down, or
- airplane power is cycled off and then on

Traffic Alert and Collision Avoidance System (TCAS)

TCAS Controls (Alerting and Transponder Control Panel)



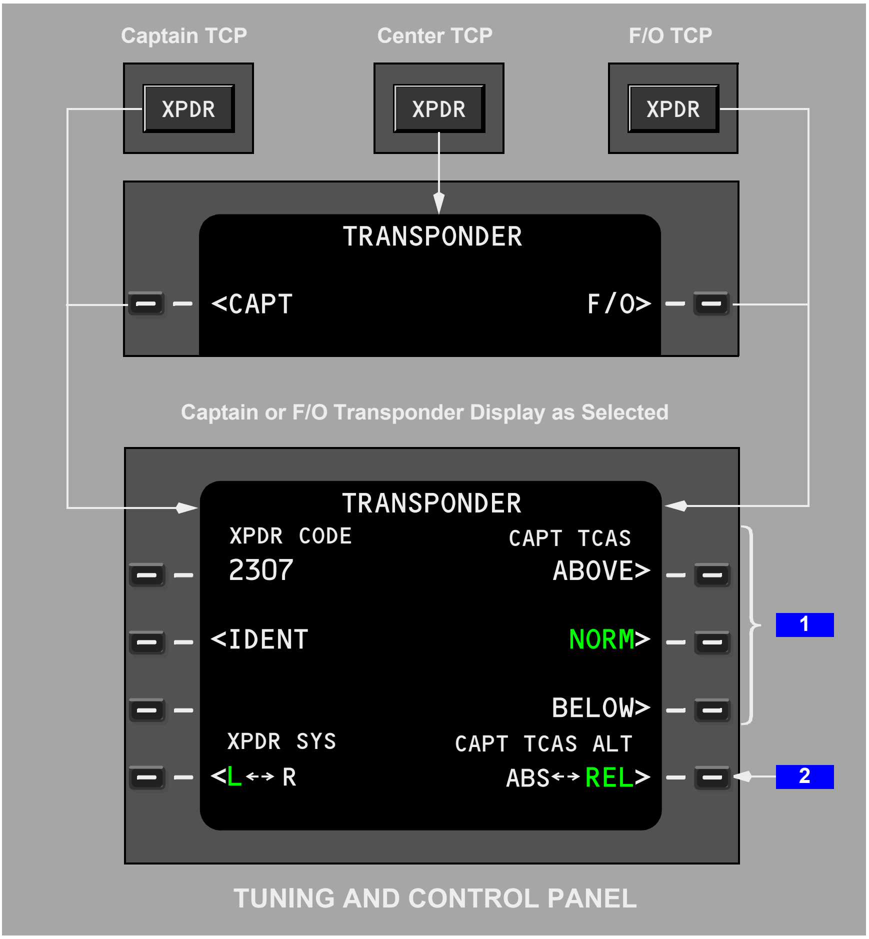
1 Transponder Mode Selector

TA ONLY (traffic advisory) –

- transponder and TCAS TA modes enabled
- all aircraft that would have been predicted as a RA are predicted as a TA

TA/RA (traffic advisory/resolution advisory) – transponder and TCAS TA and RA modes enabled.

TCAS Controls (Tuning and Control Panel)



1 XXXX TCAS Display

Push – selects the desired TCAS display mode.

ABOVE – displays TCAS traffic vertically from 2,700 feet below to 9,900 feet above current flight altitude.

NORM (normal) – displays TCAS traffic vertically from 2,700 feet below to 2,700 feet above current flight altitude.

BELOW- displays TCAS traffic vertically from 9,900 feet below to 2,700 feet above current flight altitude.

The selected mode is highlighted in large green font.

The default selection is NORM.

2 XXXX TCAS Altitude (ALT)

Push – toggles selection absolute and relative.

ABS – shows the altitude (in hundreds of feet) of TCAS traffic symbol data tags in absolute barometric altitude.

REL – shows the altitude (in hundreds of feet) of TCAS traffic symbol data tags relative to current flight altitude.

The default selection is configurable by the airline.

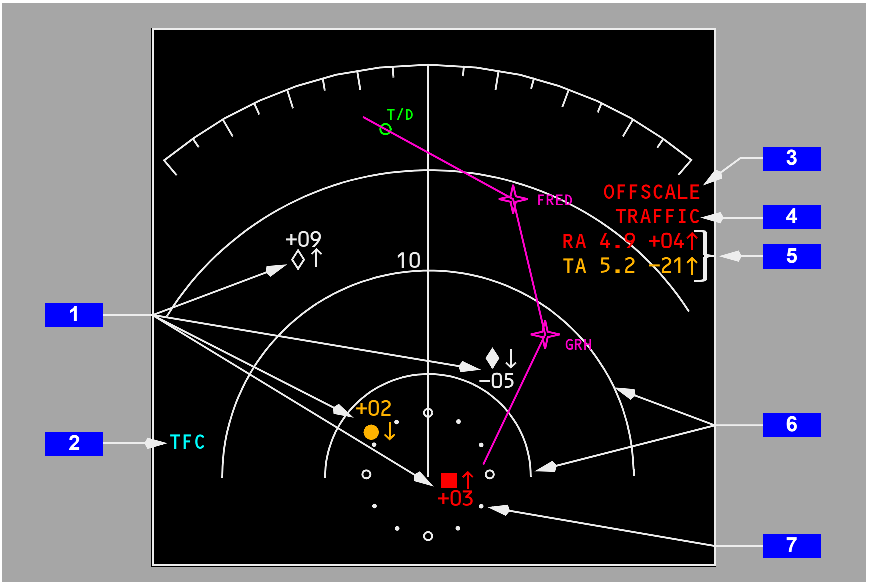
TCAS Traffic and TCAS Alert Message TRAFFIC Display

Displayed when TFC selected and respective ND is in MAP or MAP CTR mode.

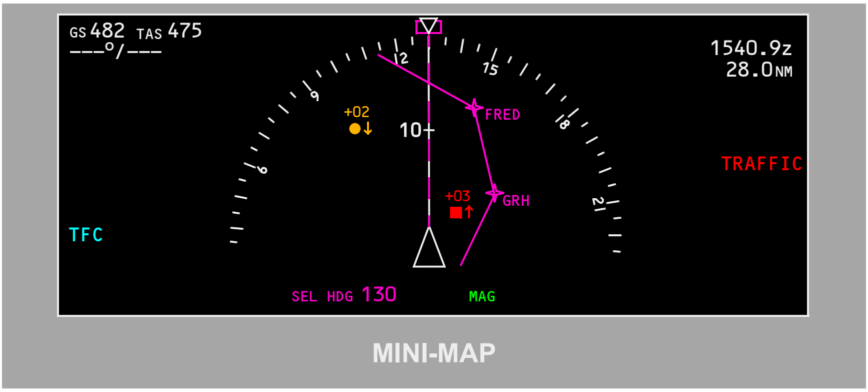
Displayed automatically when:

- a RA or TA is occurring, and
- TFC not selected on either ND, and
- respective ND is in MAP or MAP CTR mode

[Option – TCAS 3 NM range ring, range arcs]



NAVIGATION DISPLAY



1 Traffic Targets

Indicates relative position of traffic.

- filled red square indicates a resolution advisory (RA)
- filled amber circle indicates a traffic advisory (TA)
- filled white diamond indicates proximate traffic
- unfilled white diamond indicates other traffic
- number is relative altitude of traffic in hundreds of feet; not displayed when altitude unknown
- vertical motion arrow indicates traffic climbing or descending at 500 feet per minute or greater; not displayed for vertical motion less than 500 feet per minute

2 TCAS Mode Annunciations

TFC (cyan) –

- TCAS traffic display enabled
- TCAS traffic displayed in MAP or MAP CTR modes

TA ONLY (cyan) –

- TCAS cannot provide RAs
- all traffic that would have been RAs are predicted as TAs

3 OFFSCALE Message

OFFSCALE (red) – RA is beyond selected map range.

OFFSCALE (amber) – TA is beyond selected map range.

4 TRAFFIC Alert Message

Displayed:

- in all ND modes and ranges
- whether TCAS traffic is displayed or not

TRAFFIC (red) – RA is occurring.

TRAFFIC (amber) – TA is occurring, and RA is not occurring.

5 **TCAS No Bearing Messages**

RA (red) – data tag displayed for no-bearing RA.

TA (amber) – data tag displayed for no-bearing TA.

Data tag contains distance, altitude, and vertical motion arrow.

[Option – Range arcs]

6 **TCAS/Weather Radar Range Arcs**

Displayed when TCAS or weather radar selected; replace range scale tics.

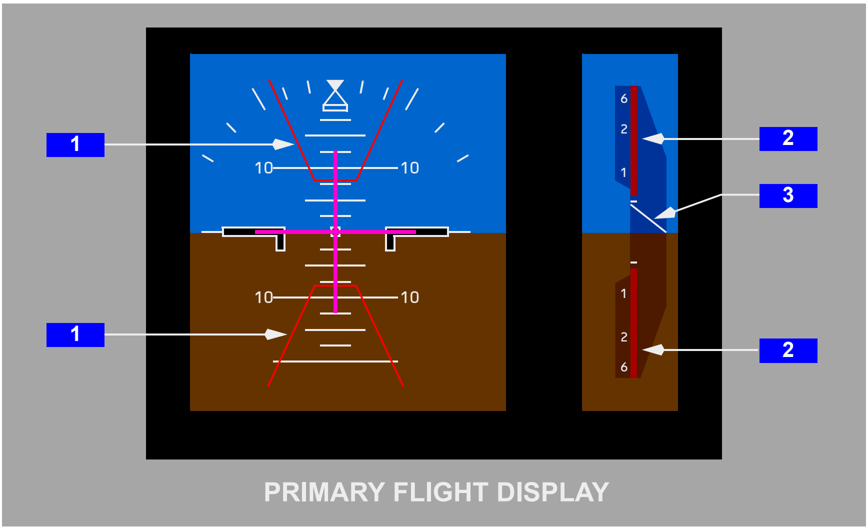
[Option – TCAS 3 NM range ring, range arcs]

7 **TCAS Three Mile Ring**

Displayed when TCAS selected and range selected is less than 80 miles.

TCAS PFD Vertical Guidance

[Option – Split cue]



1 **RA Pitch Region To Avoid (red outlined)**

Displayed: (red) – RA is occurring.

Note: For a single RA, only one red outlined RA pitch region, either above or below, is displayed at a time. For two or more RAs, two red outlined RA pitch regions may be displayed.

To ensure vertical separation, the center of the airplane symbol must be outside the red outlined RA pitch regions to avoid.

2 RA Vertical Speed Region to Avoid (red)

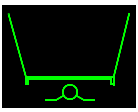
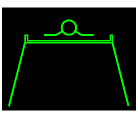
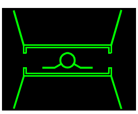
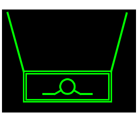
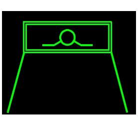
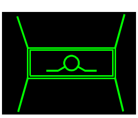
To ensure vertical separation, vertical speed must be outside the red RA vertical speed region to avoid.

3 Vertical Speed Pointer

Red – present vertical speed does not ensure RA traffic is avoided.

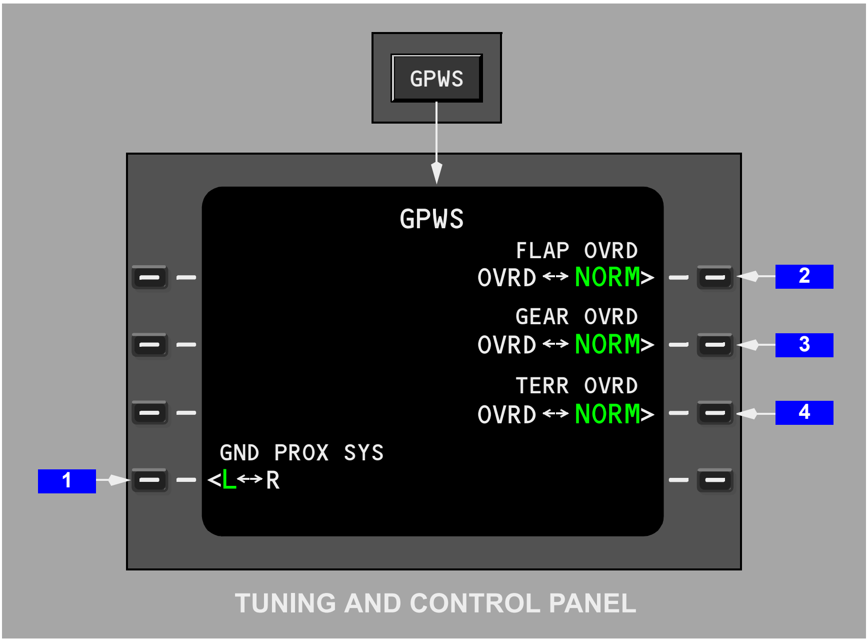
White – present vertical speed ensures RA traffic is avoided.

TCAS HUD Vertical Guidance

SYMBOL	NAME	REMARKS
	Down preventive	Area(s) inside the lines indicate the pitch region(s) to avoid in order to resolve the traffic conflict. The flight path symbol should be positioned outside the pitch command area(s) to ensure traffic avoidance. A double-lined box indicates a corrective action is required, and represents TCAS maneuver guidance to maintain or increase separation from the traffic.
	Up preventive	
	Up and down preventive	
	Descend corrective	
	Climb corrective	
	Combined corrective	

Ground Proximity Warning System (GPWS) Controls

Tuning and Control Panel



1 Ground Proximity System (GND PROX SYS)

Push – toggles the ground proximity warning system between the left (L) and right (R) systems.

Defaults to the left system.

If a fault is detected the system automatically switches to the other side.

Selection is displayed in large green font.

2 Ground Proximity Flap Override (FLAP OVRD)

Push – toggles between normal and override settings.

OVRD –

- inhibits TOO LOW FLAPS alert
- EICAS caution message GND PROX SYS is displayed when airspeed is greater than 250 knots for more than 60 seconds

NORM – all flap inhibits removed.

Selection is displayed in large green font.

3 Ground Proximity Gear Override (GEAR OVRD)

Push – toggles between normal and override settings.

OVRD –

- inhibits TOO LOW GEAR alert
- EICAS caution message GND PROX SYS is displayed when airspeed is greater than 290 knots for more than 60 seconds

NORM – all gear inhibits removed.

Selection is displayed in large green font.

4 Ground Proximity Terrain Override (TERR OVRD)

Push – toggles between normal and override settings.

OVRD –

- inhibits look-ahead terrain alerts and display
- EICAS advisory message GPWS TERR OVRD is displayed

NORM – all terrain inhibits removed.

Selection is displayed in large green font.

Alerting and Transponder Control Panel

1 Ground Proximity Glideslope Inhibit (G/S INHIBIT)

The BELOW G/S light illuminates when the GPWS senses excessive deviation below the ILS or GLS glideslope or the FMC generated flight path angle.

Push (amber BELOW G/S light illuminated) –

- inhibits GLIDESLOPE alert when pushed below 1,500 feet radio altitude
- extinguishes the BELOW G/S light

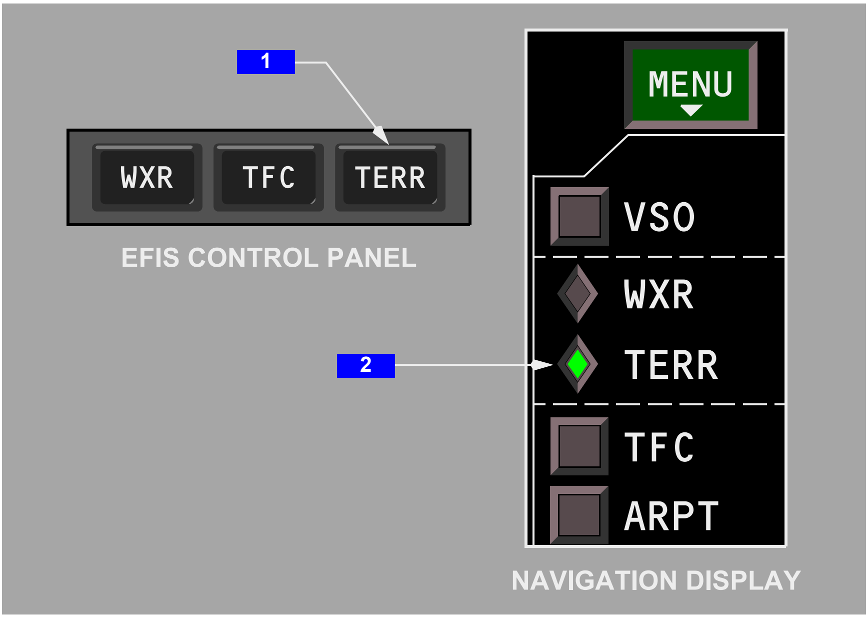
The inhibit function resets when –

- on the ground
- after a touch and go landing

- after a go-around
- when deselected by the flight crew

GPWS Look-Ahead Terrain Alerting Display and Annunciations

GPWS Terrain Display Selection



1 Terrain (TERR) Map Switch

Push –

- selection applied to both the navigation display and the PFD mini-map
- TERR displayed in cyan on the left center of navigation display and mini-map
- terrain data displayed in MAP or MAP CTR modes
- deselects weather radar display regardless of switch position

Second push – deselects terrain map display.

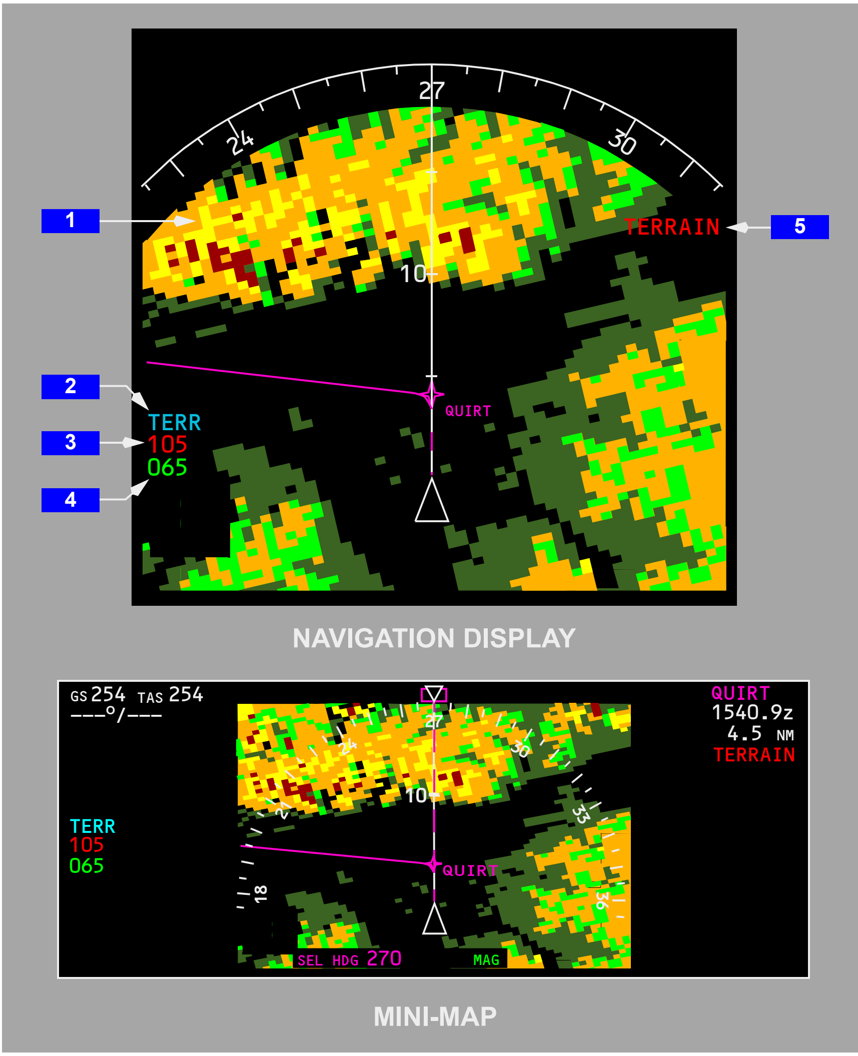
2 Terrain (TERR) Map Menu Selection

Selected –

- selection applied to navigation display only
- TERR displayed in cyan on the left center of display
- terrain data displayed in MAP or MAP CTR modes
- replaces weather radar display

Terrain Display

[Option – Lookahead peaks]



1 Terrain Display

[Option – Lookahead peaks]

When the airplane is higher than 2,000 feet above terrain, density based on obstacle height, peaks height, and airplane altitude:

- solid green – highest obstacles or peaks displayed
- high density green – intermediate height obstacles or terrain peaks displayed
- low density green – lowest obstacles or terrain peaks displayed

When the airplane is lower than 2,000 feet above terrain, color and density based on obstacle height, terrain height, and airplane altitude:

- low density dotted green – terrain from 2,000 feet below to 1000 feet below airplane altitude
- high density dotted green – terrain from 1,000 feet below to 500 feet (250 feet with gear down) below airplane altitude
- low density dotted amber – terrain 500 feet (250 feet with gear down) below to 1,000 feet above airplane altitude
- high density dotted amber – terrain 1000 feet to 2,000 feet above airplane altitude
- dotted red – terrain more than 2,000 feet above airplane altitude
- dotted magenta – no terrain data available
- solid amber – look-ahead terrain caution alert is occurring
- solid red – look-ahead terrain warning alert is occurring

Note: In areas without terrain data, look-ahead terrain alerting and display functions not available. GPWS immediate alerts function normally.

Displayed automatically when:

- a look-ahead terrain alert occurs, and
- TERR not selected on either ND, and
- respective ND is in MAP or MAP CTR mode

Display updates with a display sweep similar to weather radar display.

2 Terrain Mode Annunciation

TERR (cyan) – Terrain display enabled.

[Option – Lookahead peaks]

3 Highest Elevation of Obstacle or Terrain Displayed

Color (amber, green, or red) same as color of corresponding obstacle or terrain displayed.

[Option – Lookahead peaks]

4 **Lowest Elevation of Obstacle or Terrain Displayed**

Color (amber, green, or red) same as color of corresponding obstacle or terrain displayed.

5 **OBSTACLE and TERRAIN Annunciation**

OBSTACLE (amber) – obstacle caution alert is occurring.

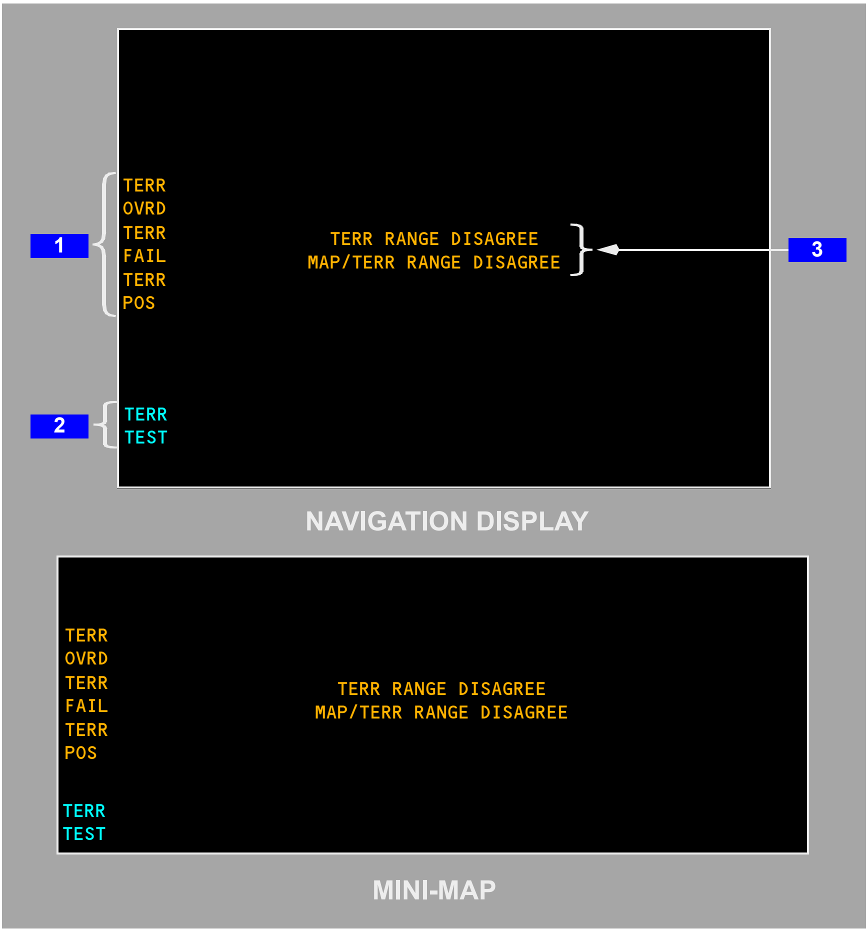
OBSTACLE (red) – obstacle warning alert is occurring.

TERRAIN (amber) – look-ahead terrain caution alert is occurring.

TERRAIN (red) – look-ahead terrain warning alert is occurring.

Displayed in all navigation display modes.

Terrain Navigation Display Annunciations



1 Terrain Status Annunciation

TERR FAIL (amber) – Look-ahead terrain alerting and display failed.

TERR OVRD (amber) – TERR OVRD selected from the GPWS page of the TCP.

TERR POS (amber) – Look-ahead terrain alerting and display unavailable due to GPS position uncertainty. During time between GPS position failure and display of TERR POS message, IRS provides position for look-ahead terrain alerting and display.

2 Terrain Mode Annunciation

TERR TEST (cyan) – GPWS operating in self–test mode.

3 Terrain Range Status Annunciation

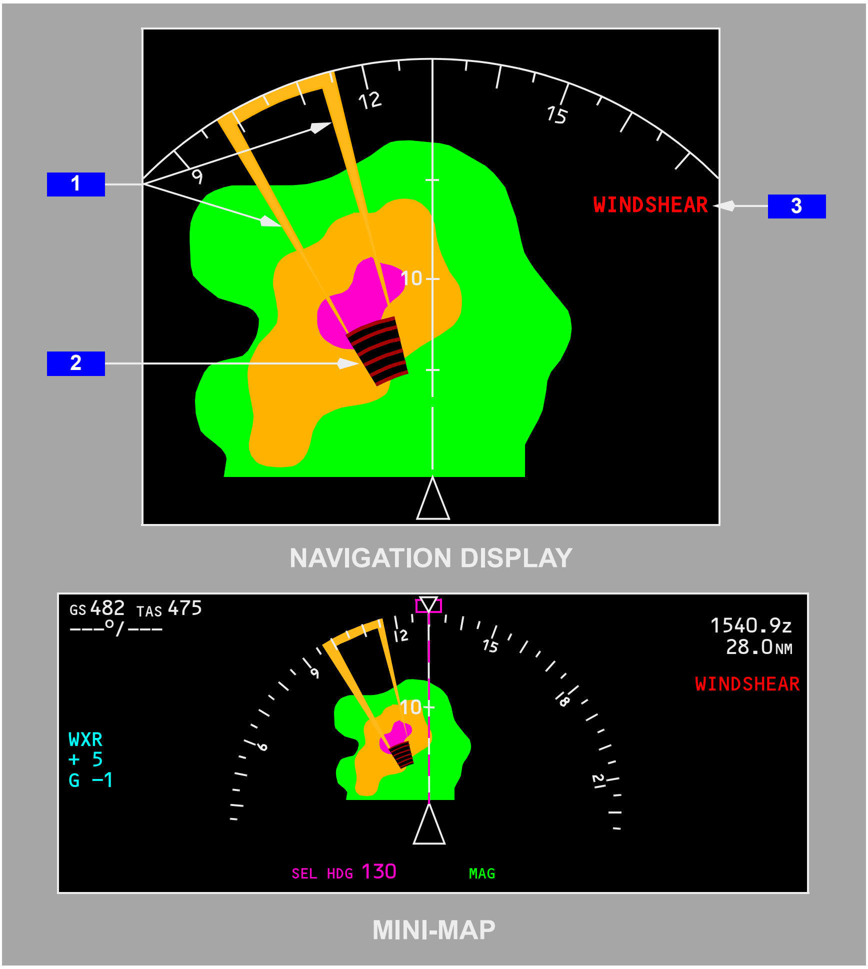
TERR RANGE DISAGREE (amber) –

- terrain display enabled, and
- terrain output range disagrees with range selected by EFIS control panel

MAP/TERR RANGE DISAGREE (amber) –

- terrain display enabled, and
- terrain output range disagrees with range selected by EFIS control panel, and
- map display output range disagrees with range selected by EFIS control panel

Predictive Windshear (PWS) Display and Annunciations



1 PWS Radials

Displayed (amber) –

- PWS alert is occurring
- extend from PWS symbol to help locate windshear event

2 PWS Symbol

Displayed (red and black) –

- PWS alert is occurring
- displays windshear location and approximate geometric size (width and depth).

Symbol, radials, and weather radar returns displayed automatically when:

- PWS alert occurs, and
- WXR is not selected on either ND, and
- respective ND is in MAP or MAP CTR mode

When terrain display is selected and PWS alert occurs, weather radar display replaces terrain display.

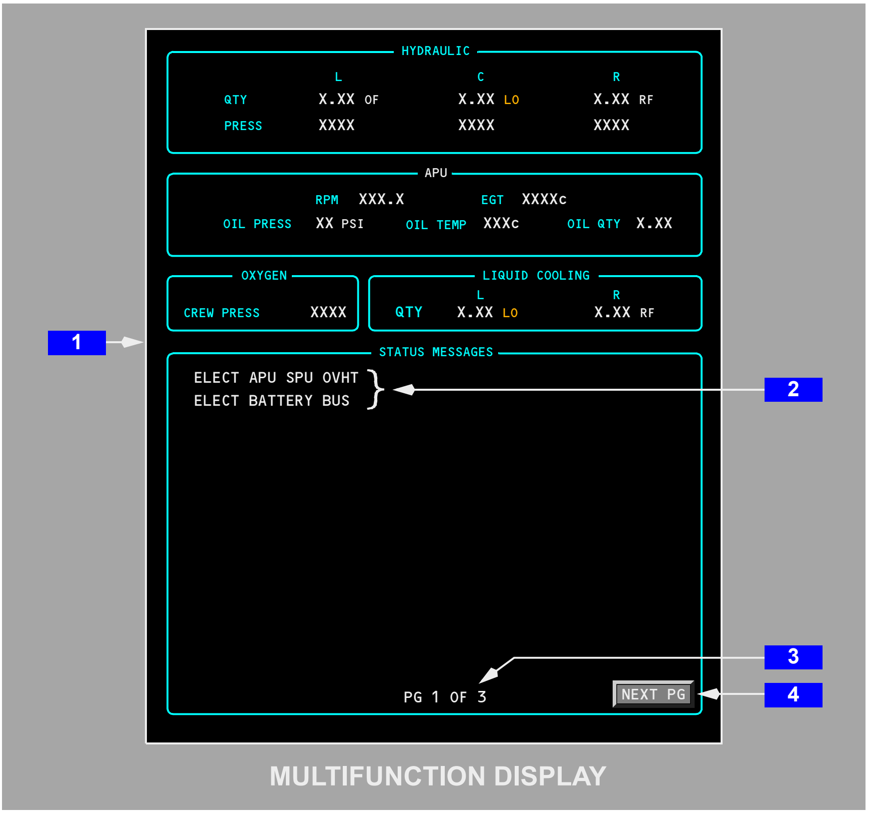
3 **WINDSHEAR Annunciation**

WINDSHEAR (amber) – PWS caution alert is occurring.

WINDSHEAR (red) – PWS warning alert is occurring.

Displayed in all navigation display modes.

Status Display



1 Status Display

Displays hydraulic, APU, oxygen system and cooling liquid indications and status messages.

2 Status Messages

Status messages indicate equipment faults requiring MEL reference for dispatch.

3 Page (PG) Number

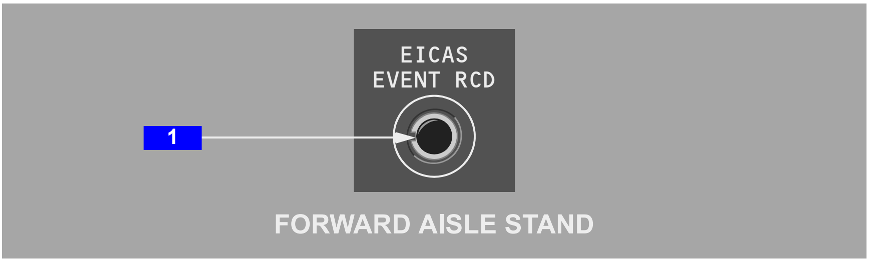
Displayed –

- additional pages of status messages exist
- displays number of page selected

4 Next Page (NEXT PG)

Select – displays the next page of status messages.

EICAS Event Record Switch



1 EICAS EVENT Record (RCD) Switch

Push – records up to five EICAS events into memory.

Intentionally
Blank

Introduction

Warning systems consist of:

- engine indication and crew alerting system (EICAS)
- airspeed alerts
- tail strike detection system
- takeoff and landing configuration warning system
- MCP selected altitude alerts
- crew alertness monitor (as configured by the airline)
- traffic alert and collision avoidance system (TCAS)
- windshear alerts
- ground proximity warning system (GPWS)

Engine Indication and Crew Alerting System (EICAS)

EICAS consolidates engine and airplane system indications and is the primary means of displaying system indications and alerts to the flight crew. EICAS information may be displayed on any MFD as desired by the aircrew.

System Alert Level Definitions

Time Critical Warnings

Time critical warnings alert the crew of a non-normal operational condition requiring immediate crew awareness and corrective action to maintain safe flight. Master warning lights, voice alerts, and ADI indications or stick shakers announce time critical conditions.

Warnings

Warnings alert the crew to a non-normal operational or system condition requiring immediate crew awareness and corrective action.

Cautions

Cautions alert the crew to a non-normal operational or system condition requiring immediate crew awareness. Corrective action may be required.

Advisories

Advisories alert the crew to a non-normal operational or system condition requiring routine crew awareness. Corrective action may be required.

EICAS Messages

Systems conditions and configuration information is provided to the crew by four types of EICAS messages:

- EICAS alert messages are the primary method to alert the crew to non-normal conditions
- EICAS communication messages direct the crew to normal communication conditions and messages
- EICAS memo messages are crew reminders of certain flight crew selected normal conditions
- EICAS status messages indicate equipment faults which may affect airplane dispatch capability

An EICAS alert, communications, or memo message is no longer displayed when the respective condition no longer exists.

EICAS Alert Messages

From after engine start until engine shut down, EICAS alert messages are the primary means to alert the crew to non-normal conditions which may impact other operations during the flight.

There is a non-normal procedure for each EICAS alert message. The procedure for every EICAS alert message is included as a checklist in the QRH. Procedures for some EICAS alert messages have steps to reconfigure airplane systems. A rectangular symbol [] prefaces an alert message that has procedural steps. The rectangular symbol [] also prefaces EICAS alert messages for checklists that have notes or information of which the crew must be made aware.

EICAS alert messages are grouped into three priority levels: warning, caution, and advisory. Prioritization is an aid to flight crew decision making when more than one EICAS alert message is displayed.

EICAS warning messages are displayed red and EICAS caution and advisory messages are displayed amber. Red EICAS alert messages remain displayed and cannot be canceled by pushing the CANC/RCL switch. Amber EICAS alert messages can be canceled and recalled by pushing the CANC/RCL switch.

EICAS Communication Messages

EICAS communication messages direct crew attention to normal communication conditions which may require crew attention. There is a crew action for each EICAS communications message.

EICAS communications messages are grouped into three priority levels: high, medium, and low. Prioritization is an aid to flight crew decision making when more than one message is displayed.

EICAS communications messages are displayed in white below EICAS alert messages. Communication messages can not be cancelled by pushing the CANC/RCL switch.

EICAS Memo Messages

EICAS memo messages are crew reminders of certain flight crew selected normal conditions. They are displayed in white at the bottom of the last page of EICAS alert messages on the primary EICAS display.

Pushing the CANC/RCL switch when the last page of EICAS alert messages is displayed ensures all current memo messages have been displayed.

EICAS Status Messages

All EICAS status messages are listed in the Dispatch Deviation Guide (DDG) or airline equivalent and provide a cross reference to the Minimum Equipment List (MEL) for dispatch capability.

Display and Manipulation of EICAS Messages

If more than one EICAS alert message is displayed, the messages are displayed in a list which is grouped by priority level. EICAS warning messages are displayed in red at the top of the message list.

EICAS caution messages are displayed in amber below the lowest warning message. EICAS advisory messages are displayed in amber below the lowest caution message and are indented one character so they may be distinguished from EICAS caution messages.

The most recent EICAS alert message is displayed at the top of its priority group and all messages move down one display line. If a message is no longer displayed because the respective system non-normal condition no longer exists, all messages previously displayed move up one display line.

If there are more messages in the list than can be displayed on one page, multiple pages are created and numbered sequentially. The page number is normally displayed at the bottom of each list. Multiple pages of EICAS caution and advisory messages can be displayed one page at a time by pushing the CANC/RCL switch. If there are more EICAS warning messages in the list than can be displayed on one page, no page number is displayed and it is not possible to display other pages. In all other cases, pushing the CANC/RCL switch displays the next page of EICAS caution and advisory messages. EICAS warning messages are displayed at the top of each page.

Pushing the CANC/RCL switch when the last page of the list is displayed causes all EICAS caution and advisory messages to be no longer displayed.

EICAS alert messages for new system non-normal conditions are displayed on the page being viewed.

For example, if page three is displayed and an EICAS caution message is displayed because a new system non-normal occurs, the message is displayed immediately below any EICAS warning messages. If the CANC/RCL switch is subsequently pushed to redisplay page one, the message is displayed as the first EICAS caution message on page one.

When no EICAS caution or advisory messages are displayed, pushing the CANC/RCL switch redisplays page one of the EICAS caution and advisory messages for all system non-normal conditions and the RECALL message is displayed briefly.

The most recent EICAS communication message is displayed at the top of its priority group and all messages move down one display line. If a message is no longer displayed because the respective communication condition no longer exists, all messages previously displayed move up one display line.

The most recent EICAS memo message is displayed at the bottom of the memo messages.

The STATUS cue is displayed on primary EICAS when a new EICAS status message is displayed.

Aurals, Master WARNING/CAUTION Switches and Lights

Aurals and two master WARNING and CAUTION lights call attention to the following alerts:

- in the following table, parenthesis ( ) describe crew action to silence the aural or extinguish the light while the alert is occurring
- the AURAL CANCEL switch located on the ATP can be used to inhibit any false or nuisance aural alerts

Aural	Light	Calls Attention To:
Voice annunciation: ADJUST VERTICAL SPEED, ADJUST	None	Red regions to avoid on PFD Red TRAFFIC message and TCAS RA Traffic display on NDs and mini-maps
Voice annunciation: AIRSPEED, AIRSPEED	Master WARNING lights (Extinguish by pushing Master WARNING/CAUTION Reset switch)	TAMS indication on speed tape Airspeed at or below Thrust Asymmetry Minimum Speed

Aural	Light	Calls Attention To:
Altitude voice annunciations	None	Altitude voice annunciations during approach
Bell (Silence by pushing Master WARNING/CAUTION Reset switch)	Master WARNING lights (Extinguish by pushing Master WARNING/CAUTION Reset switch)	EICAS warning message: FIRE APU FIRE CARGO AFT, FWD FIRE ENG L, R FIRE WHEEL WELL
Beeper	Master WARNING lights (Extinguish by pushing Master WARNING/CAUTION Reset switch)	New EICAS caution message, except: ENG SHUTDOWN L ENG SHUTDOWN R
Beeper	None	Altitude deviation from selected MCP altitude New EICAS caution message: ALTITUDE ALERT Amber box surrounds current altitude on PFD
Voice annunciation: CAUTION TERRAIN	Master CAUTION light Amber CAUTION TERRAIN EICAS message	Amber TERRAIN message and terrain display on NDs and mini-maps
Voice annunciation: CAUTION OBSTACLE	Master CAUTION light Amber CAUTION OBSTACLE EICAS message	Amber OBSTACLE on both NDs and mini-maps
Voice annunciation: CLEAR OF CONFLICT	None	Red regions to avoid on PFD, Red TRAFFIC message, and TCAS RA Traffic display on NDs and mini-maps are no longer displayed.

Aural	Light	Calls Attention To:
Voice annunciation: CLIMB, CLIMB	None	Red regions to avoid on PFD Red TRAFFIC message and TCAS RA Traffic display on NDs and mini-maps
Voice annunciation: CLIMB, CLIMB NOW, CLIMB, CLIMB NOW	None	Red regions to avoid on PFD Red TRAFFIC message and TCAS RA Traffic display on NDs and mini-maps
Voice annunciation: CLIMB, CROSSING CLIMB, CLIMB, CROSSING CLIMB	None	Red regions to avoid on PFD Red TRAFFIC message and TCAS RA Traffic display on NDs and mini-maps
Voice annunciation: DESCEND, CROSSING DESCEND, DESCEND, CROSSING DESCEND	None	Red regions to avoid on PFD Red TRAFFIC message and TCAS RA Traffic display on NDs and mini-maps
Voice annunciation: DESCEND, DESCEND	None	Red regions to avoid on PFD Red TRAFFIC message and TCAS RA Traffic display on NDs and mini-maps
Voice annunciation: DESCEND, DESCEND NOW, DESCEND, DESCEND NOW	None	Red regions to avoid on PFD Red TRAFFIC message and TCAS RA Traffic display on NDs and mini-maps

Aural	Light	Calls Attention To:
Voice annunciation: DON’T SINK	Master CAUTION light Amber DON’T SINK EICAS message	GPWS immediate alert
Siren, followed by voice annunciaton: ENGINE FAIL	Master WARNING lights (Extinguish by pushing Master WARNING/CAUTION Reset switch)	Red ENG FAIL on both PFDs ENG FAIL on both HUDs
Voice annunciation: GLIDESLOPE	Master CAUTION light Amber GLIDESLOPE EICAS message Amber BELOW G/S on Alerting and Transponder Control Panel	GPWS immediate alert
High-low chime	None	New EICAS medium level communication message
Voice annunciation: INCREASE CLIMB, INCREASE CLIMB	None	Red regions to avoid on PFD Red TRAFFIC message and TCAS RA Traffic display on NDs and mini-maps
Voice annunciation: INCREASE DESCENT, INCREASE DESCENT	None	Red regions to avoid on PFD Red TRAFFIC message and TCAS RA Traffic display on NDs and mini-maps
Voice annunciation: MAINTAIN VERTICAL SPEED, MAINTAIN	None	Red regions to avoid on PFD Red TRAFFIC message and TCAS RA Traffic display on NDs and mini-maps

Aural	Light	Calls Attention To:
Voice annunciation: MAINTAIN VERTICAL SPEED CROSSING, MAINTAIN	None	Red regions to avoid on PFD Red TRAFFIC message and TCAS RA Traffic display on NDs and mini-maps
Voice annunciation: MONITOR RADAR DISPLAY	Master CAUTION light Amber MONITOR RADAR DISP EICAS message	Amber WINDSHEAR message and PWS display on NDs and mini-maps
Voice annunciation: MONITOR VERTICAL SPEED	None	Red regions to avoid on PFD Red TRAFFIC message and TCAS RA Traffic display on NDs and mini-maps
Voice annunciation: OBSTACLE AHEAD	Master CAUTION light Amber OBSTACLE AHEAD EICAS message	Amber OBSTACLE on NDs and mini-maps
Voice annunciation: OBSTACLE, PULL UP	Master WARNING lights	GPWS immediate alert Red TERRAIN on NDs and mini-maps Red PULL UP on both PFDs PULL UP on both HUDs
Voice annunciation: PULL UP	Master WARNING lights (Extinguish by pushing Master WARNING/CAUTION Reset switch)	Red PULL UP on both PFDs PULL UP on both HUDs
Voice annunciation: SINK RATE	Master CAUTION light Amber SINK RATE EICAS message	GPWS immediate alert

Aural	Light	Calls Attention To:
Voice annunciation: SINK RATE, PULL UP	Master WARNING lights	GPWS immediate alert Red PULL UP on both PFDs PULL UP on both HUDs
Siren	Master WARNING lights (Extinguish by pushing Master WARNING/CAUTION Reset switch)	EICAS warning message CONFIG DOORS CONFIG FLAPS CONFIG PARKING BRAKE CONFIG RUDDER CONFIG SPOILERS CONFIG STABILIZER OVERSPEED
Siren (Silence by pushing Master WARNING/CAUTION Reset switch.	Master WARNING lights (Extinguish by pushing Master WARNING/CAUTION Reset switch)	EICAS warning message: CABIN ALTITUDE PILOT RESPONSE (as configured by the airline)
Siren (If caused by Thrust lever at idle, silence by pushing Master WARNING/CAUTION Reset switch)	Master WARNING lights (If caused by Thrust lever at idle, extinguish by pushing Master WARNING/CAUTION Reset switch)	EICAS warning message CONFIG GEAR for: • Thrust lever at idle, and • radio altitude less than 800 feet, and • gear not down and locked or • flaps set to landing, and • gear not down and locked
Voice annunciation: SPEEDBRAKE, SPEEDBRAKE	Master WARNING light	Red SPEEDBRAKE on both PFDs SPEEDBRAKE on both HUDs

Aural	Light	Calls Attention To:
Voice annunciation: TERRAIN	Master CAUTION light Amber TERRAIN EICAS message	GPWS immediate alert
Voice annunciation: TERRAIN AHEAD	Master CAUTION light Amber TERRAIN AHEAD EICAS message	Amber TERRAIN message and terrain display on NDs and mini-maps
Voice annunciation: TERRAIN, PULL UP	Master WARNING lights	GPWS immediate alert Red PULL UP on both PFDs PULL UP on both HUDs
Voice annunciation: TERRAIN, TERRAIN	None	GPWS immediate alert
Voice annunciation: TERRAIN, TERRAIN, PULL UP	Master WARNING lights (Extinguish by pushing Master WARNING/CAUTION Reset switch)	GPWS immediate alert Red TERRAIN on NDs and mini-maps Red PULL UP on both PFDs PULL UP on both HUDs
Voice annunciation: TOO LOW, FLAPS	Master CAUTION light Amber TOO LOW FLAPS EICAS message	GPWS immediate alert
Voice annunciation: TOO LOW, GEAR	Master CAUTION light Amber TOO LOW GEAR EICAS message	GPWS immediate alert
Voice annunciation: TOO LOW, TERRAIN	Master CAUTION light Amber TOO LOW TERRAIN EICAS message	GPWS immediate alert

Aural	Light	Calls Attention To:
Voice annunciation: TRAFFIC, TRAFFIC	None	Amber TRAFFIC message and TCAS TA Traffic display on NDs and mini-maps

[Option – Aural V1 callout]

Voice annunciation: VEE ONE	None	Airspeed at V1 during takeoff

Voice annunciation: WINDSHEAR AHEAD GO AROUND, WINDSHEAR AHEAD	Master WARNING lights (Extinguish by pushing Master WARNING/CAUTION Reset switch)	Red WINDSHEAR on both PFDs WINDSHEAR on both HUDs Red WINDSHEAR message and PWS display on NDs and mini-maps
Siren, followed by voice annunciaton: WINDSHEAR, WINDSHEAR, WINDSHEAR	Master WARNING lights (Extinguish by pushing Master WARNING/CAUTION Reset switch)	Reactive windshear warning Red WINDSHEAR on both PFDs WINDSHEAR on both HUDs

Flight Deck Panel Annunciator Lights

Flight deck panel annunciator lights are used with EICAS messages to:

- help locate and identify affected systems and controls
- reduce potential for error

Airspeed Alerts

Stall Warning

Warning of an impending stall is provided by left and right stick shakers, which independently vibrate the left and right control columns.

Airspeed Low

The EICAS caution message AIRSPEED LOW is displayed and the box around the current airspeed indication on the PFD is highlighted amber when airspeed is below minimum maneuvering speed.

This indication is accompanied by a beeper and Master WARNING/CAUTION light.

Takeoff V1 Airspeed

[Option – Aural V1 callout]

The voice annunciation VEE ONE sounds when airspeed reaches V1 during takeoff.

Thrust Asymmetry Minimum Speed

TAMS is displayed on the speed tape to provide pilots with situational awareness of the minimum control speed for operation with a large thrust asymmetry.

TAMS varies with weight and CG but will always be at least 10 knots above minimum control speed during takeoff or go-around.

When airspeed decreases to TAMS, the AIRSPEED, AIRSPEED aural sounds and the Master WARNING light illuminates.

Overspeed Warning

The EICAS warning message OVERSPEED is displayed if airspeed is greater than VMO/MMO. The message remains displayed until airspeed is reduced below VMO/MMO.

This indication is accompanied by a siren and Master WARNING light.

Tail Strike Detection System

The tail strike alert system detects ground contact which could damage the airplane pressure hull. A two inch blade target and two proximity sensors are installed on the aft body of the airplane. The EICAS caution message TAIL STRIKE is displayed when a tail strike is detected.

This indication is accompanied by a beeper and Master CAUTION light.

Takeoff And Landing Configuration Warning System

The takeoff and landing configuration warning system alerts the crew that the airplane is not configured for normal takeoff or normal landing.

Takeoff Configuration Warnings

The respective EICAS warning message CONFIG is displayed if:

- airplane is on the ground, and
- FUEL CONTROL switches are in RUN position, and
- either engine thrust is in takeoff range, and
- thrust reversers are not unlocked or deployed, and

- airspeed is less than V1, and
- any of the following configurations exist;
  - any door not closed, latched, and locked, or
  - flaps not in takeoff position, or
  - parking brake set, or
  - rudder trim not centered, or
  - SPEEDBRAKE lever not in DOWN detent, or
  - stabilizer trim not in green band

Takeoff configuration warnings are inhibited at V1.

When the EICAS warning message CONFIG is displayed, pushing either Master WARNING/CAUTION reset switch resets the Master WARNING lights but does not silence the siren. If thrust is decreased below takeoff range and airspeed is less than V1 but the airplane is still not configured for takeoff, the Master WARNING lights are extinguished and the siren is silenced. The CONFIG message remains displayed for 10 seconds after thrust is reduced to aid in identifying the takeoff configuration.

Landing Configuration Warning

The landing configuration warning system alerts the crew the landing gear is not extended for landing. The EICAS warning message CONFIG GEAR is displayed if:

- the airplane is in flight, and
- any landing gear is not down and locked, and
- any of the following configurations exist;
  - either thrust lever closed and radio altitude less than 800 feet, or
  - FLAP lever in landing position

If the message is displayed because a Thrust lever is closed at low radio altitudes, pushing either Master WARNING/CAUTION reset switch silences the siren and extinguishes the Master WARNING lights. The message remains displayed until the Thrust levers are advanced or landing gear is down and locked.

If the message is displayed because the FLAP lever is in landing position, the siren cannot be silenced by pushing a Master WARNING/CAUTION reset switch and the message remains displayed. The siren sounds and the message is displayed until the landing gear is down and locked or GEAR OVRD is selected to OVRD on the GPWS page of the TCP.

Speedbrake Lever Extend Beyond ARM During Climb

In flight, the EICAS warning message CONFIG SPOILERS alerts the crew if:

- the SPEEDBRAKE lever is extended beyond ARMED, and
- climb or higher thrust is set on either thrust levers

When the EICAS warning message CONFIG SPOILERS is displayed in flight, pushing either Master WARNING/CAUTION Reset switch silences the siren and extinguishes the Master WARNING lights. The EICAS message remains displayed until:

- the SPEEDBRAKE lever is DOWN or at ARMED, or
- both thrust levers are set below climb thrust

Speedbrake Warning During Rollout

The SPEEDBRAKE warning alerts the crew that the speedbrake has not deployed during landing or during a rejected takeoff. The warning is displayed on both PFDs and both HUDs and is accompanied by a Master WARNING Light and aural SPEEDBRAKE, SPEEDBRAKE.

The SPEEDBRAKE warning occurs when:

- the aircraft is on the ground, and
- both thrust levers not in the takeoff thrust position, and
- the groundspeed exceeds 85 knots, and
- the speedbrake lever position is less than 35 degrees, and
- all the above occur together for 1 second

The warning is automatically reset when any of the above conditions are no longer true.

Configuration Warning System Non-normal Operation

If the takeoff and landing warning system fails, the EICAS advisory message CONFIG WARNING SYS is displayed. If the takeoff and landing configuration system fails, CONFIG messages may or may not be displayed. If the messages are displayed with the CONFIG WARNING SYS message, the CONFIG messages may not be correct.

MCP Selected Altitude Alert

Altitude alerting is provided when approaching or departing the altitude selected in the MCP altitude window.

Approaching MCP Selected Altitude

At 900 feet prior to reaching the selected altitude a highlighted white box is displayed around the selected altitude and the current altitude on the PFD. The highlights are no longer displayed when within 300 feet of the selected altitude.

Departing MCP Selected Altitude

When departing the selected altitude by 300 feet, the EICAS alert message ALTITUDE ALERT is displayed, and a highlighted amber box is displayed around the current altitude. The message and amber highlight are no longer displayed when:

- subsequently reapproaching to within 300 feet of the selected altitude, or
- a new MCP altitude is selected, or
- departing more than 900 feet from the selected altitude

MCP Selected Altitude Alert Inhibits

MCP selected altitude alerts are inhibited when:

- glideslope captured, or
- landing flaps selected and landing gear down and locked

500 Foot Callout

An aural callout of “FIVE HUNDRED” is announced on approach when radio altitude transitions throught 500 feet, and any of the following conditions are met:

- flight path is not within + or - 2 dots of a valid glideslope beam, or
- flight path is not within + or - 2 dots of a valid localizer beam, or
- no valid localizer signal is received, or
- no valid glideslope signal is received, or
- glideslope inhibit switch is actuated

Crew Alertness Monitor

The Crew Alertness Monitor is configured (enabled/disabled) by the airline. When enabled, the FMC continuously monitors switch action on the MCP, EFIS control panel, display select panel, CDUs, and radio transmitter microphone switches. When a predefined time elapses after the last switch action was detected, the EICAS advisory message PILOT RESPONSE is displayed.

If there is still no switch action after a brief time, the EICAS caution message PILOT RESPONSE is displayed.

If there is still no switch action the EICAS warning message PILOT RESPONSE is displayed.

The PILOT RESPONSE message is no longer displayed after pushing any monitored switch.

The PILOT RESPONSE message is inhibited during climb below 20,000 feet when flaps are not up.

Traffic Alert and Collision Avoidance System (TCAS)

TCAS alerts the crew to possible conflicting traffic. TCAS interrogates operating transponders in other airplanes, tracks the other airplanes by analyzing the transponder replies, and predicts the flight paths and positions. TCAS provides TCAS ND messages, voice annunciations, PFD vertical flight path guidance, and traffic displays of the other airplanes to the flight crew. Neither ND messages, voice annunciations, PFD vertical guidance, nor traffic display is provided for other airplanes that do not have operating transponders. TCAS operation is independent of ground–based air traffic control.

TCAS identifies a three–dimensional airspace around the airplane where a high likelihood of traffic conflict exists. The dimensions of this airspace are contingent upon the closure rate with conflicting traffic.

TCAS provides:

- resolution advisory (RA) and display
- traffic advisory (TA) and display
- proximate traffic display
- other traffic display

TCAS messages and TCAS traffic symbols can be displayed on the ND and mini-map. TCAS messages and TCAS traffic symbols cannot be displayed on the ND in plan mode.

TCAS messages TRAFFIC, TA ONLY, and TCAS TEST may be displayed in all ND modes.

Resolution Advisories (RA) and Display

An RA is a prediction that another airplane will enter the TCAS conflict airspace within approximately 15 to 35 seconds. If altitude data from the other airplane is not available, no RA can be provided.

When TCAS predicts an RA:

- the TCAS red message TRAFFIC is displayed on the ND
- a TCAS voice annunciation sounds
- TCAS PFD vertical guidance is displayed

When the TCAS cyan message TFC is displayed on the ND, and the RA is within the display range of the ND, the TCAS RA Traffic symbol and its accompanying data tag is displayed on the ND.

The TCAS RA Traffic symbol is a filled red square. The RA data tag contains the altitude and the vertical motion arrow.

For no–bearing RAs, the red RA label is displayed below the red message, TRAFFIC, and the RA data tag information is displayed to the right of the label. The RA red data tag contains the distance, altitude, and the vertical motion arrow.

When the RA is further from the airplane than the ND range currently displayed, the TCAS red message OFFSCALE is displayed on the ND.

Traffic Advisories (TA) and Display

A TA is a prediction another aircraft will enter the conflict airspace in 20 to 48 seconds. TAs assist the flight crew in establishing visual contact with the other aircraft.

When TCAS predicts a TA:

- the TCAS amber message TRAFFIC is displayed on the ND
- the TCAS voice annunciation TRAFFIC, TRAFFIC sounds once

When the TCAS cyan message TFC is displayed on the ND and the TA is within the display range of the ND, the TCAS TA Traffic symbol and its accompanying data tag are displayed on the ND.

The TA Traffic symbol is a filled amber circle. The TA data tag contains the altitude and the vertical motion arrow.

For no–bearing TAs, the amber TA label is displayed below the TRAFFIC message, and the TA data tag information is displayed to the right of the label. The TA labels are displayed below the RA labels. The TA data tag contains the distance, altitude, and vertical motion arrow.

When the TA is further from the airplane than the ND range currently displayed, the TCAS amber message OFFSCALE is displayed on the ND.

Proximate Traffic Display

Proximate traffic is another airplane that is neither an RA or a TA but is within:

- six miles
- 1,200 feet vertically

When the TCAS cyan message TFC is displayed on the ND, and the Proximate Traffic is within the ND display range, the TCAS Proximate Traffic symbol is displayed on the ND.

The TCAS Proximate Traffic symbol is a filled white diamond. If the other aircraft is providing altitude data, the Proximate Traffic data tag is displayed on the ND. The proximate traffic data tag contains the altitude and vertical motion arrow.

Other Traffic Display

Other Traffic aircraft is an aircraft that is within the ND display limits but is neither an RA, a TA, or proximate traffic aircraft. When TCAS is not receiving and processing altitude data from the Other Traffic aircraft, the Other Traffic aircraft becomes Proximate Traffic aircraft automatically when within six miles.

When the TCAS cyan message TFC is displayed on the ND and the Other Traffic is within the ND display range, then the TCAS Other Traffic symbol is displayed on the ND.

The TCAS Other Traffic symbol is a hollow white diamond. When TCAS is receiving and processing altitude data from the Other Traffic aircraft, a data tag like that described in Proximate Traffic Display is displayed.

TCAS HUD and PFD Vertical Guidance

When TCAS predicts an RA, TCAS vertical guidance is displayed on both the HUD and PFD for a maneuver to ensure vertical separation. Traffic avoidance is ensured by adjusting or maintaining a pitch attitude and vertical speed outside the displayed RA regions.

If the traffic airplane also has TCAS and a mode S transponder, TCAS vertical guidance is coordinated with the traffic aircraft TCAS.

TCAS ND Messages

ND Message	Color	Description
OFFSCALE	Amber	TA is occurring at range greater than current ND range. Replaced by red OFFSCALE when RA is also occurring at range greater than current ND range.
OFFSCALE	Red	RA is occurring at range greater than current ND range.
TA ONLY	Cyan	TCAS can not provide RAs. All traffic that would have been RAs are predicted as TAs.
TCAS FAIL	Amber	TCAS failed, or TCAS information cannot be displayed on ND.
TCAS OFF	Amber	TFC switch pushed to display traffic but TCAS not selected on transponder panel.
TCAS TEST	Cyan	TCAS in test mode. Message is displayed on all ND modes and ranges.
TFC	Cyan	TCAS traffic display enabled. Inhibited if following TCAS messages are displayed: TCAS FAIL, TCAS OFF, TCAS TEST
TRAFFIC	Amber	TA is occurring.
TRAFFIC	Red	RA is occurring.

TCAS Voice Annunciations

Voice Annunciation	Condition	Response
ADJUST VERTICAL SPEED, ADJUST	Existing RA, minimum vertical speed required to ensure separation has decreased, present pitch attitude and vertical speed are outside the red RA regions, or, new RA, initial voice annunciation. Present pitch attitude and vertical speed are within the red RA regions.	Continue to keep pitch attitude and vertical speed outside the red RA regions. Vertical speed may be decreased, or, change pitch attitude and vertical speed to remain outside the red RA regions.
CLEAR OF CONFLICT	TCAS PFD vertical guidance is no longer displayed and traffic changes to a TA symbol. Separation is increasing and the RA will not occur. However, the voice annunciation does not sound if TCAS can no longer predict the track of the RA aircraft.	Attempt to visually locate the traffic.
CLIMB, CLIMB	New RA, initial voice annunciation. Present pitch attitude and vertical speed are within the red RA regions.	Increase pitch attitude and vertical speed to remain outside the red RA regions.
CLIMB, CLIMB NOW, CLIMB, CLIMB NOW	Existing RA, previous TCAS vertical guidance was to descend. Present pitch attitude and vertical speed are within the red RA regions.	

Voice Annunciation	Condition	Response
CLIMB, CROSSING CLIMB, CLIMB, CROSSING CLIMB	New RA, initial voice annunciation. Present pitch attitude and vertical speed are within the red RA regions. Airplane will climb through the altitude of the traffic.	Increase pitch attitude and vertical speed to remain outside the red RA regions.
DESCEND, CROSSING DESCEND DESCEND, CROSSING DESCEND	New RA, initial voice annunciation. Present pitch attitude and vertical speed are within the red RA regions. Airplane will descend through the altitude of the traffic.	Decrease pitch attitude and vertical speed to remain outside the red RA regions.
DESCEND, DESCEND	New RA, initial voice annunciation. Present pitch attitude and vertical speed are within the red RA regions.	
DESCEND, DESCEND NOW, DESCEND, DESCEND NOW	Existing RA, previous TCAS vertical guidance was to climb. Present pitch attitude and vertical speed are within the red RA regions.	
INCREASE CLIMB, INCREASE CLIMB	Existing RA, TCAS requires change in vertical rate. Present pitch attitude and vertical speed are within the red RA regions.	Adjust pitch attitude and vertical speed to remain outside the red RA regions.
INCREASE DESCENT, INCREASE DESCENT		

Voice Annunciation	Condition	Response
MAINTAIN VERTICAL SPEED CROSSING, MAINTAIN	New RA, initial voice annunciation. Present pitch attitude and vertical speed are outside the red RA regions. Airplane will pass through the altitude of the traffic.	Continue to keep pitch attitude and vertical speed outside the red RA regions.
MAINTAIN VERTICAL SPEED, MAINTAIN	New RA, initial voice annunciation. Present pitch attitude and vertical speed are outside the red RA regions.	
MONITOR VERTICAL SPEED	New RA, initial voice annunciation. Present pitch attitude and vertical speed are outside the red RA regions.	
TRAFFIC, TRAFFIC	New TA, initial voice annunciation.	Attempt to visually locate the traffic.

TCAS Normal Operation

TCAS is controlled from the Alerting and Transponder Control panel (ATP). TA/RA is normally selected. However, it is sometimes necessary to select TA ONLY to prevent nuisance RAs.

TA ONLY is selected during engine out operations to prevent RAs when adequate thrust is not available to follow the RA commands.

TCAS Non–Normal Operation

The EICAS advisory message TCAS OFF is displayed if TCAS is not operating. The message is inhibited below 400 feet radio altitude. No TCAS RA guidance is displayed on the PFDs, no TCAS traffic symbols are displayed on the NDs or mini-maps, and no TCAS voice alerts sound. An amber TCAS OFF message is displayed on the NDs and mini-maps.

The EICAS advisory message TCAS RA (CAPTAIN or F/O) is displayed if TCAS cannot display RA guidance on the respective PFD. The ND and mini-map traffic displays and voice alerts are unaffected.

The EICAS advisory message TCAS is displayed if TCAS cannot display TCAS RA guidance on either PFD, and cannot display TCAS traffic symbols on the NDs or mini-maps. TCAS voice alerts do not occur. An amber TCAS FAIL message is displayed on the NDs and mini-maps.

Ground Proximity Warning System (GPWS)

Introduction

GPWS provides immediate alerts, and look-ahead obstacle and terrain alerts for potentially hazardous flight conditions involving imminent impact with the obstacles and the ground.

GPWS immediate alerts are based on radio altitude, barometric altitude, ADRS, glideslope deviation, and airplane configuration. GPWS alerts are provided for:

- altitude loss after takeoff or go-around
- excessive and severe descent rate
- excessive terrain closing rate
- unsafe terrain clearance when not in the landing configuration
- excessive deviation below ILS glideslope
- windshear

[Option – Bank angle callouts]
GPWS provides bank angle voice annunciations and altitude voice annunciations during approach.

GPWS also provides look-ahead terrain mode alerts by monitoring obstacle and terrain proximity using a world-wide terrain database and an obstacle database. The obstacle database is not yet world wide. Proximate obstacle and terrain data may be displayed on the NDs and mini-maps. If there is a potential obstacle or terrain hazard, GPWS look-ahead alerts are provided based on estimated time to impact.

Altitude used for look-ahead terrain mode alerts are a weighted combination of radio altitude, barometric altitude, GPS, and previous flight path. Weighting is reduced for an altitude source which becomes less reliable.

Estimated time to impact is based on airplane position, barometric altitude, present track, vertical path, and groundspeed. FMC VNAV and LNAV path is not considered in the estimated time to impact.

Note: Obstacles or terrain ahead of the airplane may exceed available climb performance. A GPWS caution or warning does not guarantee obstacle or terrain clearance.

GPWS Look–Ahead Obstacle and Terrain Mode

A GPWS terrain database contains detailed terrain and man made obstacle data. Obstacle and terrain data is not designed to be used as an independent navigation aid.

When the TERR switch is pushed on or TERR is selected from the ND pull down menu, the TERR symbol is displayed on the NDs and mini-maps. Obstacle and terrain contours may also be displayed. When obstacle and terrain contours are displayed, the altitudes of the highest and lowest displayed obstacle or terrain are displayed below the TERR symbol. The color of each altitude corresponds to the altitude of the respective contour.

[Option – Lookahead peaks]

When the airplane is higher than 2,000 feet above the terrain, obstacles and terrain peaks are displayed using solid, high density, and low density contours of green. The highest obstacles or terrain is represented by solid green, and the lowest obstacles or terrain displayed is represented by low density green.

When the airplane is lower than 2,000 feet above the terrain, all obstacles and terrain within 2,000 feet of airplane barometric altitude is displayed on the navigation display.

When a obstacle or terrain alert occurs, the respective message is displayed on the ND. When an OBSTACLE alert occurs while a TERRAIN alert message is displayed, the OBSTACLE alert message replaces the TERRAIN alert message. Both messages are not displayed at the same time.

The terrain display is correlated to GPS position, or to IRS position if GPS position is intermittently unavailable.

Terrain and weather radar cannot be simultaneously displayed on the NDs and mini-maps. When one pilot selects terrain and the other pilot selects weather radar, each display updates on alternating sweeps All other navigation displays can be simultaneously displayed with terrain data.

GPWS Look-Ahead Obstacle and Terrain Alerts

Voice Annunciation	Visual Indications	Description
CAUTION OBSTACLE	Master CAUTION lights Amber CAUTION OBSTACLE EICAS message Amber OBSTACLE on the NDs and mini-maps	40 to 60 seconds from projected impact with obstacle. Toggling the TERR OVRD switch to OVRD on the GPWS page of the TCP inhibits the alert.

Voice Annunciation	Visual Indications	Description
CAUTION TERRAIN	Master CAUTION lights Amber CAUTION TERRAIN EICAS message Amber TERRAIN on the NDs and mini-maps	40 to 60 seconds from projected impact with terrain. Toggling the TERR OVRD switch to OVRD on the GPWS page of the TCP inhibits the alert.
OBSTACLE AHEAD	Master CAUTION lights Amber OBSTACLE AHEAD EICAS message Amber OBSTACLE on the NDs and mini-maps	40 to 60 seconds from projected impact with obstacle. Toggling the TERR OVRD switch to OVRD on the GPWS page of the TCP inhibits the alert.
OBSTACLE, PULL UP	Master WARNING lights Red OBSTACLE on the NDs and mini-maps	20 to 30 seconds from projected impact with obstacle. Toggling the TERR OVRD switch to OVRD on the GPWS page of the TCP inhibits the alert.
TERRAIN AHEAD	Master CAUTION lights Amber TERRAIN AHEAD EICAS message Amber TERRAIN on the NDs and mini-maps	40 to 60 seconds from projected impact with terrain. Toggling the TERR OVRD switch to OVRD on the GPWS page of the TCP inhibits the alert.
TERRAIN TERRAIN (Whoop, Whoop) PULL UP	Master WARNING lights Red PULL UP on both PFDs Red TERRAIN on the NDs and mini-maps	20 to 30 seconds from projected impact with terrain. Toggling the TERR OVRD switch to OVRD on the GPWS page of the TCP inhibits the alert.

Voice Annunciation	Visual Indications	Description
TOO LOW, TERRAIN	Master CAUTION lights Amber TOO LOW TERRAIN EICAS message	Descent below safe altitude while too far from any airport in the terrain database. Toggling the TERR OVRD switch to OVRD on the GPWS page of the TCP inhibits the alert.

GPWS Immediate Alerts

Voice Annunciation	Visual Indications	Description
DON'T SINK	Master CAUTION light Amber DON'T SINK EICAS message	Altitude loss with flaps and/or gear up after takeoff or go-around.
GLIDESLOPE	Master CAUTION light Amber GLIDESLOPE EICAS message Amber BELOW G/S displayed on G/S INHIBIT switch	Excessive deviation below glideslope or glidepath. Volume and repetition rate increase as deviation increases. Pushing the G/S INHIBIT switch on the ATP inhibits the alert when pushed below 1,500 feet radio altitude.
PULL UP	Master WARNING lights Red PULL UP message on both PFDs	Follows SINK RATE alert when descent rate becomes severe, or follows TERRAIN alert with flaps and/or gear not in landing configuration when excessive terrain closing rate continues.
SINK RATE	Master CAUTION light Amber SINK RATE EICAS message	Excessive descent rate.

Voice Annunciation	Visual Indications	Description
TERRAIN	Master CAUTION light Amber TERRAIN EICAS message Amber TERRAIN on the NDs and mini-maps	Excessive terrain closing rate.
TOO LOW, FLAPS	Master CAUTION light Amber TOO LOW FLAPS EICAS message	Unsafe terrain clearance with flaps not in landing configuration at low altitude and airspeed. Toggling the FLAP OVRD switch to OVRD on the GPWS page of the TCP inhibits the alert.
TOO LOW, GEAR	Master CAUTION light Amber TOO LOW GEAR EICAS message	Unsafe terrain clearance with gear not in landing configuration at low altitude and airspeed with gear not down. Toggling the GEAR OVRD switch to OVRD on the GPWS page of the TCP inhibits the alert.
TOO LOW, TERRAIN	Master CAUTION light Amber TOO LOW TERRAIN EICAS message	Follows DON'T SINK alert with gear and/or flaps up after takeoff or go-around for altitude loss at low altitude, or unsafe terrain clearance with gear and/or flaps not in landing configuration at low altitude and airspeed. Toggling the FLAP OVRD switch to OVRD on the GPWS page of the TCP inhibits the alert, when the alert is due to flaps not in landing position. Toggling the GEAR OVRD switch to OVRD on the GPWS page of the TCP inhibits the alert, when the alert is due to gear not down.

Bank Angle Voice Annunciations

[Option – Bank angle callouts]

The voice alert BANK ANGLE sounds if bank angle exceeds 35°, 40°, and 45°.

The voice alert BANK ANGLE also sounds at low altitudes during takeoff and landing for bank angles as small as 10°.

Altitude Voice Annunciations During Approach

GPWS provides the following altitude voice annunciations during approach:

- 500 feet – FIVE HUNDRED (500 Foot Callout, Ch. 15, Sec. 20)
- 50 feet – FIFTY
- 30 feet – THIRTY
- 10 feet – TEN

Approaching Minimums Voice Annunciation

GPWS provides the voice annunciation APPROACHING MINIMUMS at 80 feet above the altitude set by the Captain's MINS selector on the EFIS Control Panel.

Minimums Voice Annunciation

GPWS provides the voice annunciation MINIMUMS at the altitude set by the Captain's MINS selector on the EFIS Control Panel.

GPWS Windshear Alert and PWS

Windshear alerts are enabled during takeoff, approach, and landing:

- GPWS provides an immediate windshear alert when an excessive downdraft or tailwind is occurring
- PWS provides windshear alerts when an excessive windshear condition is detected ahead of the airplane

PWS Alert System

Weather radar uses radar imaging to detect disturbed air ahead of the airplane.

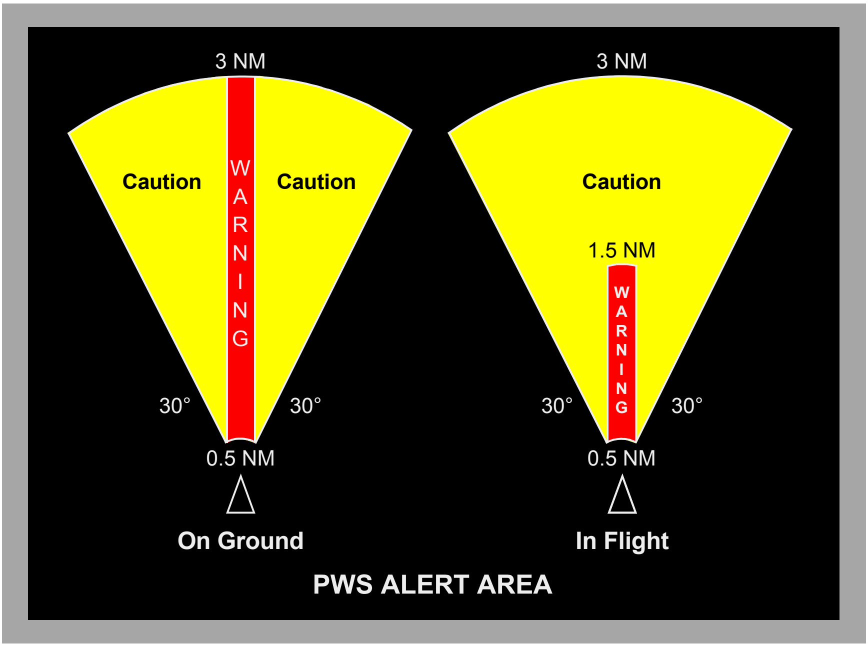
PWS alerts are enabled approximately 12 seconds after weather radar begins scanning for windshear.

When PWS is scanning for windshear, radar antenna scan sweep is reduced.

Prior to takeoff, PWS alerts can be enabled by pushing the WXR switch on the EFIS control panel. On the ground with the WXR switch pushed or not pushed, weather radar begins scanning for windshear when the thrust of either engine is in the takeoff range and thrust reversers are not unlocked or deployed.

In flight with the WXR switch pushed or not pushed, weather radar begins scanning for windshear below 2,300 feet radio altitude and PWS alerts are enabled below 1,200 feet radio altitude.

When windshear is not predicted by PWS, weather radar returns are displayed only when the WXR on the EFIS control panel is pushed.



PWS Alerts

Voice Annunciation	Visual Indications	Description
GO AROUND, WINDSHEAR AHEAD	Master WARNING lights Red WINDSHEAR on both PFDs Red WINDSHEAR message on the NDs and mini-maps RED, BLACK and YELLOW windshear symbol on the NDs and mini-maps WINDSHEAR on both HUDs	Windshear predicted within 1.5 miles and directly ahead of the airplane. Enabled during approach, below 1,200 feet radio altitude. WIndshear position displayed by PWS symbol on the NDs and mini-maps.

Voice Annunciation	Visual Indications	Description
MONITOR RADAR DISPLAY	Amber WINDSHEAR message on the NDs and mini-maps RED, BLACK and YELLOW windshear symbol on the NDs and mini-maps	Windshear predicted within 3 miles and ahead of the airplane. Enabled during takeoff and approach, below 1,200 feet radio altitude. Windshear position displayed by PWS symbol on the NDs and mini-maps.
WINDSHEAR AHEAD	Master WARNING lights Red WINDSHEAR on both PFDs Red WINDSHEAR message on the NDs and mini-maps RED, BLACK and YELLOW windshear symbol on the NDs and mini-maps WINDSHEAR on both HUDs	Windshear predicted close to and directly ahead of airplane. Enabled during takeoff, below 1,200 feet radio altitude. Windshear position displayed by PWS symbol on the NDs and mini-maps.

Note: Weather radar provides windshear alerts for windshear events containing some level of moisture or particulate matter.

Note: Weather radar detects microbursts and other windshears with similar characteristics. Weather radar does not provide alerting for all types of windshear. The flight crew must continue to rely on traditional windshear avoidance methods.

Immediate Windshear Alerts

Voice Annunciation	Visual Indications	Description
(Siren) WINDSHEAR, WINDSHEAR, WINDSHEAR	Master WARNING lights Red WINDSHEAR on both PFDs WINDSHEAR on both HUDs	Excessive windshear detected by GPWS. Enabled below 1,500 feet radio altitude. GPWS windshear detection begins at rotation.

Alert Inhibits

Alerts are inhibited when they are operationally unnecessary or inappropriate. Alerts are inhibited during normal system operation, and during part of the takeoff and landing to prevent distracting the crew.

GPWS immediate windshear alert inhibits all PWS, TCAS, and other GPWS alerts.

When TA/RA is selected on the transponder panel and a GPWS or PWS warning alert occurs, TCAS automatically inhibits RA mode. During the inhibit, all aircraft that would have been predicted as an RA are predicted as a TA. When GPWS and PWS warning alerts are no longer occurring, the RA mode inhibit ends.

Alert Messages Inhibited During Normal System Operation

Certain EICAS alert messages are time delayed, even though related flight deck panel annunciator lights are illuminated. Time delay inhibits prevent normal in–transit indications from being displayed as EICAS alert messages. For example, valves are generally only sensed open or closed, not in–transit. When a valve is in–transit, the message indicating the valve has failed to open or close is inhibited to allow the valve time to move to the commanded position. If the valve is not in the commanded position at the end of the inhibit time delay, the respective EICAS alert message is displayed.

Alert Messages Inhibited By Other Alert Messages

Some EICAS alert messages are inhibited if another related alert message is displayed. For example, individual hydraulic pump pressure messages are inhibited if a hydraulic system pressure message is displayed.

Voice Annunciation Inhibits

Voice annunciations for warning alerts inhibit new voice annunciations for caution alerts.

All voice annunciations are prioritized to aid flight crew decision making when more than one alert could occur.

ND Display Alert Inhibits and Automatic Display

Alert displays on the NDs are prioritized to aid flight crew decision making when more than one alert occurs. The displays are also prioritized when neither ND is in MAP or MAP CTR mode.

Immediate windshear alert inhibits the automatic display of a new TCAS, look-ahead terrain, or PWS alerts.

TCAS traffic can be displayed concurrently with either TERR and WXR display.

New TCAS TRAFFIC TA or RA alerts:

- when both NDs are in MAP or MAP CTR mode and a new TCAS TA or RA alert occurs, TFC is selected automatically for both NDs and TCAS traffic is displayed on both NDs
- when only one ND is in MAP or MAP CTR mode and a new TCAS TA or RA alert occurs, TFC is selected automatically for that ND and TCAS traffic is displayed. The ND not in MAP or MAP CTR mode is armed for TCAS display and TFC will be selected automatically when MAP or MAP CTR mode is selected
- when neither ND is in MAP or MAP CTR mode and a new TCAS TA or RA alert occurs, both NDs are armed for TCAS display and TFC will be selected automatically when MAP or MAP CTR mode is selected

New look-ahead terrain alerts:

- when both NDs are in MAP or MAP CTR mode and a new look-ahead terrain alert occurs, TERR is selected automatically for both NDs
- when only one ND is in MAP or MAP CTR mode and a new look-ahead terrain alert occurs, TERR is selected automatically for that ND. The ND not in MAP or MAP CTR mode is armed for TERR display and TERR will be selected automatically when MAP or MAP CTR mode is selected. TERR is disarmed by selecting WXR prior to selecting MAP or MAP CTR mode
- when neither ND is in MAP or MAP CTR mode and a new look-ahead terrain alert occurs, both NDs are armed for TERR display and TERR will be selected automatically when MAP or MAP CTR mode is selected. TERR is disarmed for either ND by selecting WXR prior to selecting MAP or MAP CTR mode on the respective ND

New PWS alerts:

- when both NDs are in MAP or MAP CTR mode and a new PWS alert occurs, WXR is selected automatically for both NDs
- when only one ND is in MAP or MAP CTR mode and a new PWS alert occurs, WXR is selected automatically for that ND. The ND not in MAP or MAP CTR mode is armed for WXR display and WXR will be selected automatically when MAP or MAP CTR mode is selected. WXR is disarmed by selecting TERR prior to selecting MAP or MAP CTR mode
- when neither ND is in MAP or MAP CTR mode and a new PWS alert occurs, both NDs are armed for WXR display and WXR will be selected automatically when MAP or MAP CTR mode is selected. WXR is disarmed by selecting TERR prior to selecting MAP or MAP CTR mode

Alerts Inhibited Before Engine Start and After Shutdown

Alert Inhibited	For Message	Inhibit Occurs
Master CAUTION lights Beeper	For all EICAS caution messages	On the ground, and both FUEL CONTROL switches in CUTOFF
Respective EICAS messages: ELEC GEN DRIVE L1, L2, R1, R2 ELEC GEN OFF L1, L2, R1, R2 ENG OIL PRESS L, R HYD PRESS PRI L, R	For EICAS caution messages: ENG SHUTDOWN L ENG SHUTDOWN R ENG SHUTDOWN	On the ground, and FUEL CONTROL switch in CUTOFF or FIRE handle pulled

Alerts Inhibited During Engine Start

Alert Inhibited	Inhibit Begins	Inhibit Ends
All new EICAS caution and advisory messages, except: APU LIMIT APU SHUTDOWN ENG AUTOSTART L, R ENG FUEL VALVE L, R ENG SHUTDOWN L, R ENG STARTERS L, R ENG STARTER CUTOUT L, R OVERHEAT ENG L,R	Engine START selector to START	Engine reaches idle RPM, or start is aborted.

Alerts Inhibited During Takeoff

Alert Inhibited	For Message	Inhibit Begins	Inhibit Ends
TCAS TA voice alerts	TCAS TAs	On ground	Approximately 600 feet radio altitude
All TCAS RAs	TCAS RAs are inhibited When RA selected on panel, TCAS switches automatically to TA only mode and TCAS message TA ONLY is displayed on the NDs and mini-maps	On ground	Approximately 1,000 feet radio altitude
TCAS DESCEND RAs	Alerts are inhibited	On ground	Approximately 1,200 feet radio altitude

Alert Inhibited	For Message	Inhibit Begins	Inhibit Ends
Red ENG FAIL on PFD	Engines not producing commanded thrust and rate of thrust increase insufficient; same condition as EICAS messages ENG THRUST L, R	Engine start	65 knots airspeed
EICAS caution message ENG THRUST L, R	Messages are inhibited	Engine start	Six knots before V1

[Option – 30 min inhibit]

STATUS cue	All EICAS status messages	Engine start	30 minutes after lift-off.

[Option – 400 ft / 20 sec inhibit]

All EICAS communication messages except: CABIN ALERT Hi-Lo Chime	Messages are inhibited	Either engine in takeoff thrust range	400 feet radio altitude or 20 seconds after lift-off, whichever occurs first, or on the ground and thrust on both engines reduced below takeoff thrust range.

Alert Inhibited	For Message	Inhibit Begins	Inhibit Ends

[Option – 400 ft / 20 sec inhibit]

Master CAUTION lights Beeper If the Master CAUTION lights illuminate before reaching 80 knots airspeed, they continue to be illuminated when 80 knots airspeed is exceeded and cannot be extinguished until the inhibit ends. If new EICAS caution messages are displayed during the inhibit, the beeper sounds when the inhibit ends.	New EICAS caution messages displayed during inhibit	80 knots airspeed	400 feet radio altitude or 20 seconds after lift-off, whichever occurs first. If rejected takeoff initiated above 80 knots, inhibit continues until airspeed is less than 75 knots.

[Option – 400 ft / 20 sec inhibit]

All EICAS advisory messages	Messages are inhibited	80 knots airspeed	400 feet radio altitude or 20 seconds after lift-off, whichever occurs first, or if takeoff thrust not selected on both engines. If rejected takeoff initiated above 80 knots, inhibit continues until airspeed is less than 75 knots.

New PWS caution alerts	Messages are inhibited	80 knots airspeed	400 feet radio altitude
New PWS warning alerts	Messages are inhibited	100 knots airspeed	50 feet radio altitude
New red ENG FAIL on PFD	EICAS caution message ENG THRUST L, R	Six knots before V1	Landing

Alert Inhibited	For Message	Inhibit Begins	Inhibit Ends
Master WARNING lights Bell If the Master WARNING lights illuminate and fire bell sounds before reaching V1, they continue to be illuminated and sound when V1 is exceeded. If new FIRE messages are displayed during the inhibit, the bell sounds when the inhibit ends.	New EICAS warning messages FIRE displayed during inhibit.	V1 or rotation, which-ever occurs first.	400 feet radio altitude or 25 seconds after inhibit began, whichever occurs first.
Master WARNING lights Siren If the Master WARNING lights illuminate and siren sounds before reaching V1, they continue to be illuminated and sound when V1 is exceeded If new EICAS warning messages are displayed during the inhibit, the siren sounds when the inhibit ends.	New EICAS warning messages displayed during inhibit, except FIRE	V1 or rotation, which-ever occurs first.	400 feet radio altitude or 25 seconds after inhibit began, whichever occurs first.
EICAS warning messages CONFIG for takeoff configuration warnings	Messages are inhibited	V1 or rotation, which-ever occurs first.	Landing
Master WARNING lights Siren	EICAS warning message CONFIG GEAR for landing configuration warnings.	Gear unlock for retraction	800 feet radio altitude or 140 seconds after inhibit began, whichever occurs first.

Alert Inhibited	For Message	Inhibit Begins	Inhibit Ends
All PWS alerts	Messages are inhibited	Above 1,200 feet radio altitude	Below 1,200 feet radio altitude

Alerts Inhibited During Landing

Alert Inhibited	For Message	Inhibit Begins	Inhibit Ends
All PWS alerts	Alerts are inhibited	Above 1,200 feet radio altitude	Below 1,200 feet radio altitude
TCAS INCREASE DESCENT RAs	Alerts are inhibited	Approximately 1,450 feet radio altitude	Go-around at approximately 1,650 feet radio altitude
TCAS DESCEND RAs	Alerts are inhibited	Approximately 1,000 feet radio altitude	Go-around at approximately 1,200 feet radio altitude
All TCAS RAs	Alerts are inhibited When RA selected on panel, TCAS switches automatically to TA only mode and TCAS message TA ONLY is displayed on the NDs and mini-maps	Approximately 1,000 feet radio altitude	Go-around at approximately 1,000 feet radio altitude
All EICAS communication messages, except: CABIN ALERT	Messages are inhibited	800 feet radio altitude	75 knots airspeed
STATUS cue	All EICAS status messages	800 feet radio altitude	75 knots airspeed
TCAS voice alerts	TCAS TAs	Approximately 400 feet radio altitude	Go-around at approximately 600 feet radio altitude

Alert Inhibited	For Message	Inhibit Begins	Inhibit Ends
EICAS alert message WINDSHEAR SYS	Message is inhibited	400 feet radio altitude	80 knots airspeed
New PWS caution alerts	Alerts are inhibited	400 feet radio altitude	80 knots airspeed
Master CAUTION lights Beeper	All EICAS caution messages, except: AUTOPILOT AUTOTHROTTLE DISC NO AUTOLAND SPEEDBRAKE EXTENDED	LAND 2 or LAND 3 displayed on PFD, and 200 feet radio attitude	75 knots airspeed, or 40 seconds elapse, or 800 feet radio altitude
New PWS warning alerts	Alerts are inhibited	50 feet radio altitude	100 knots airspeed

EICAS Event Record

Pushing the EICAS EVENT RCD switch records currently displayed engine indications and additional EICAS maintenance information. Up to five events may be recorded by the first five pushes. The system also records out of limit parameters and related conditions automatically when a system parameter is exceeded.

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Warning Systems — Chapter 15
EICAS Messages — Section 30

Warning System EICAS Messages

The following EICAS messages can be displayed.

Airspeed

Message	Level	Aural	Condition
AIRSPEED LOW	Caution		Airspeed is less than minimum maneuvering speed.
OVERSPEED	Warning	Siren	Airspeed is more than Vmo/Mmo.

Altitude Alert and GPWS

Message	Level	Aural	Condition
ALTITUDE ALERT	Caution	Beeper	A deviation from the MCP set altitude occurs.
ALTITUDE CALLOUTS	Advisory		Altitude voice annunciations during approach are not supplied.
GND PROX SYS	Advisory		A ground proximity warning system fault occurs.
GPWS FLAP OVRD	Advisory		The ground proximity flap override switch is in OVRD.
GPWS GEAR OVRD	Advisory		The ground proximity landing gear override switch is in OVRD.
GPWS TERR OVRD	Advisory		The ground proximity terrain override switch is in OVRD.
G/S ALERT INHIBITED	Memo		The flight crew has inhibited the Glideslope aural warning.
MONITOR RADAR DISP	Caution		Monitor the radar display for windshear information.
TERR POS	Advisory		Terrain position data is lost.
WINDSHEAR SYS	Advisory		A windshear system fault occurs.

Configuration

Message	Level	Aural	Condition
CONFIG DOORS	Warning	Siren	An entry, forward cargo, or aft cargo door is not closed and latched and locked during takeoff.
CONFIG FLAPS	Warning	Siren	The flaps are not in a takeoff position during takeoff.
CONFIG GEAR	Warning	Siren	A landing gear is not down and locked and one of these occurs: • A thrust lever is at idle below 800 feet radio altitude • The flaps are in a landing position
CONFIG PARKING BRAKE	Warning	Siren	The parking brake is set during takeoff.
CONFIG RUDDER	Warning	Siren	Rudder trim is not centered during takeoff.
CONFIG SPOILERS	Warning	Siren	The speedbrake lever is not down during takeoff.
CONFIG STABILIZER	Warning	Siren	The stabilizer is not in the greenband during takeoff.
CONFIG WARNING SYS	Advisory		A configuration warning system fault occurs.

Pilot Response

Message	Level	Aural	Condition
AURAL CANCELED	Advisory		The crew canceled the aural alert.
PILOT RESPONSE	Advisory		Pilot action is not detected during a specified time.

Tailstrike

Message	Level	Aural	Condition
TAIL STRIKE	Caution		The tail hits the runway on takeoff.

TCAS

Message	Level	Aural	Condition
TCAS	Advisory		TCAS is failed.
TCAS OFF	Advisory		TCAS modes TA or TA/RA are not selected.
TCAS RA CAPTAIN, F/O	Advisory		TCAS cannot show RA guidance on the PFD.

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