# BOEING 767

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DOCUMENT TITLE
**Boeing 767**

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# CHAPTER 7

## AUTOMATIC FLIGHT

FLIGHT DIRECTOR SWITCH (2)

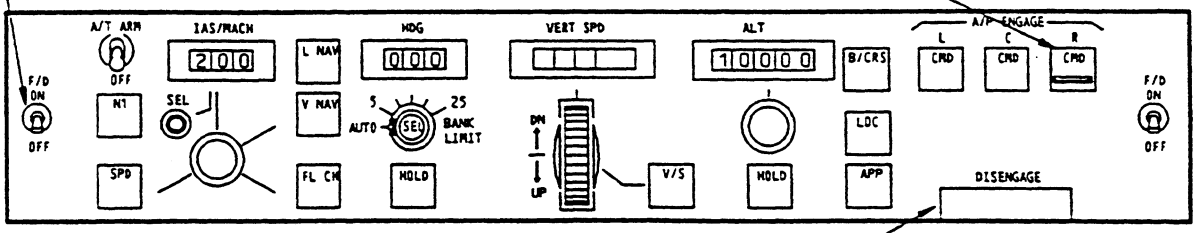
- on the ground with no A/P engaged and FD OFF, the first FD switch turned ON activates FD in TO mode
- in flight with no A/P engaged and FD OFF, turning the first FD switch ON engages the FD in V/S and HDG HOLD modes, or on some airplanes V/S and ATT if bank angle greater than 5°

[1] ON - respective pilots command bars appear and are positioned by FCC selected with Flight Director Source Selector Switch providing the selected FCC is not operating in CMD (see Flight Instruments chapter)
- command bars operate in current AFDS mode

OFF - command bars disappear

COMMAND SWITCH

PUSH - (bar in view) engages respective A/P in CMD in active FD mode(s), except TO and GA, if either FD switch is ON. If both FD switches are OFF, A/P engages in V/S and HDG HOLD modes
- CMD appears on both ADIs




GLARESHIELD

AUTOPILOT DISENGAGE BAR

PUSH DOWN - (exposes amber stripe) disconnects all three A/Ps from flight control servos
- prevents A/P engagement

LIFT UP - (conceals amber stripe)
- permits A/P engagement

[1] Command bars always in view on some airplanes.

AFDS MODE CONTROL PANEL (MCP)

AUTOTHROTTLE ARM SWITCH

A/T ARM - arms A/T system. Engaged when any one of the following modes initially selected; N1, SPD, VNAV, FLCH, GA

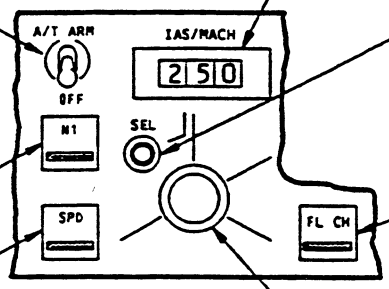
OFF - disconnects A/T
- prevents A/T engagement

SPEED WINDOW

- displays selected speed when IAS/MACH Selector is controlling command airspeed bugs
- blank when FMC is controlling command airspeed bugs
- displays 200 knots when first powered on the ground
- display range is: 100-399 kts, 0.40-0.95 mach
- in climb changes from IAS to MACH at approximately .80 IMN
- in descent changes from MACH to IAS at approximately 300 KIAS

IAS/MACH SELECT SWITCH

PUSH - alternately changes Speed Window between present IAS and Mach if within indicator range




GLARESHIELD

FLIGHT LEVEL CHANGE SWITCH

PUSH - (bar in view) selects FLCH mode and sets Speed Window and command airspeed bugs to current speed
- FLCH and SPD appears on ADI
- AFDS pitch holds selected speed and A/T sets thrust for climb or descent. When selected altitude is reached, pitch mode changes to ALT HOLD and A/T changes to SPD mode
- with FLCH mode displayed, pushing switch resets Speed Window and command airspeed bugs to current speed
- changes thrust reference from TO to CLB if above 400 feet RA

SPEED SWITCH

PUSH - (bar in view) selects A/T SPD mode
- SPD appears on each ADI
- A/T controls thrust to maintain the IAS or MACH displayed in the Speed Window subject to minimum and maximum speed limits
- changes thrust reference from TO to CLB if above 400 feet RA

N1 SWITCH

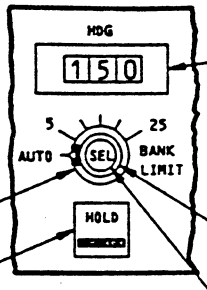
PUSH - (bar in view) selects A/T N1 mode
- N1 appears on each ADI
- A/T holds reference thrust value displayed on EICAS subject to maximum speed limits
- changes thrust reference from TO to CLB if above 400 feet RA

IAS/MACH SELECTOR

PUSH - alternately changes Speed Window between current IAS or MACH and a blank display
- Speed Window does not blank if SPD, FLCH, TO or GA mode is active

ROTATE - sets speed in Speed Window and positions command airspeed bugs
- not operative if Speed Window is blank

AFDS MODE CONTROL PANEL (MCP)




GLARESHIELD

HEADING WINDOW

- displays selected heading
- HSI Selected Heading Markers are positioned to this value
- indicator and markers initialize at 000 when power is first applied
- automatically changes to selected ILS front course heading at LOC capture

HEADING SELECTOR

ROTATE - sets heading in Heading Window
- positions selected Heading Marker on both HSIs

HEADING HOLD SWITCH

PUSH - (bar in view) selects HDG HOLD mode
- HDG HOLD appears on each ADI
- AFDS commands wings level, then holds heading

HEADING SELECT SWITCH

PUSH - engages HDG SEL mode
- HDG SEL appears on each ADI
- AFDS controls roll to acquire and hold heading shown in Heading Window and on HSI Heading Markers
- bank is limited by Bank Limit Selector

BANK LIMIT SELECTOR

ROTATE - sets AFDS commanded bank limit when in HDG SEL mode as follows:

AUTO - varies from 25 to 15 degrees as true airspeed varies. As true airspeed increases, angle of bank decreases

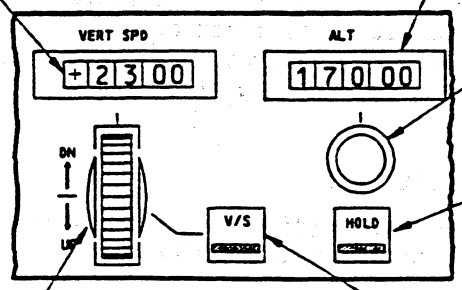
5, 10, 15, 20, 25 - selected value is maximum regardless of airspeed

VERTICAL SPEED WINDOW

- displays selected vertical speed
- blank when V/S mode not engaged
- range is: -8000 to +6000 fpm in 100 fpm increments

ALTITUDE WINDOW

- displays altitude in 100 feet increments. Range 0 to 50,000 feet
- displayed altitude is reference altitude for altitude alerting and level off
- indicator reads 10,000 feet when power is first applied




GLARESHIELD

ALTITUDE SELECTOR

ROTATE - sets altitude in Altitude Window

ALTITUDE HOLD SWITCH

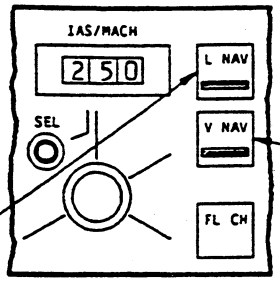
PUSH - (bar in view) engages ALT HOLD mode
- ALT HOLD appears on each ADI
- AFDS commands altitude existing when switch is pushed

VERTICAL SPEED SWITCH

PUSH - (bar in view) engages V/S mode
- V/S appears on each ADI
- causes existing vertical speed to be displayed in Vertical Speed Window
- when a selected altitude is reached, pitch mode changes to ALT HOLD
- AFDS pitch commands vertical speed displayed in MCP Vertical Speed Window
- if AFDS is engaged in V/S from FLCH or from VNAV, A/T automatically engages in SPD mode, if armed

VERTICAL SPEED SELECTOR

UP/DN - sets vertical speed in Vertical Speed Window




GLARESHIELD

LATERAL NAVIGATION SWITCH

PUSH – (bar in view) arms or engages AFDS in LNAV as follows:
- if the active route leg is beyond the turning radius of the airplane, LNAV annunciates white (armed) on each ADI. Previously engaged roll modes remain active. With LNAV armed and airplane not on a heading which will intercept the active leg the FMC MSG lights illuminate and "NOT ON INTERCEPT HEADING" appears in the scratch pad of both CDUs.
- if the active route leg is within the turning radius of the airplane, LNAV annunciates green (engaged) on each ADI. AFDS then follows active route.
- LNAV mode is disengaged by selecting HDG HOLD or HDG SEL mode, or when localizer capture occurs

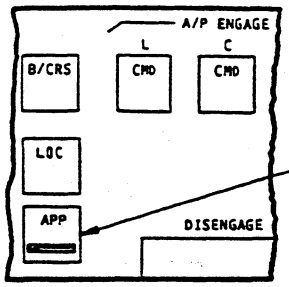
VERTICAL NAVIGATION SWITCH

PUSH – (bar in view) changes thrust reference from TO to CLB if above 400 feet RA
- VNAV PTH or VNAV SPD appears on each ADI
- AFDS and A/T follow vertical path and thrust guidance from FMC

During climbs or descents, AFDS captures and holds altitude displayed in Altitude Window or FMC target altitude, whichever is reached first.

When in VNAV mode, pushing IAS/MACH Selector permits manual speed selection. FMC's then use manually selected speeds for speed control.

VNAV mode is disengaged by any one of the following:
- selecting V/S
- selecting ALT HOLD
- selecting SPD or N1 mode
- selecting FLCH mode
- in climb or descent, reaching altitude displayed in Altitude Window prior to reaching FMCs target altitude
- passing top of descent point if the MCP is not set to an altitude below cruise altitude
- G/S engagement
- selecting GA mode

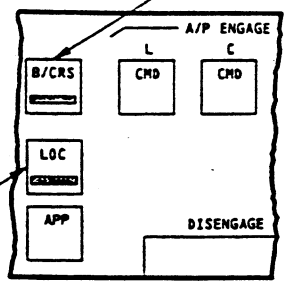



GLARESHIELD

APPROACH SWITCH

PUSH - (bar in view) arms or engages AFDS in APP mode as follows:
- LOC and G/S appear white (armed) in each ADI prior to localizer and glideslope capture
- LOC and G/S appear green (engaged) in each ADI after each one is captured
- AFDS captures and tracks localizer as in LOC mode and captures glide slope upon interception; either localizer or glideslope can be captured first
- LOC capture can occur when intercept track angle is within 120 degrees of localizer course
- G/S capture can occur when intercept track angle is within 80 degrees of localizer course
- arms the other A/P systems (CMD switch bars in view) for subsequent automatic engagement which occurs when localizer and glideslope are captured, and radio altitude is below 1500 feet
- A/P systems connected to separate power sources

APP mode may be disengaged under the following conditions and actions:
- before LOC or G/S capture:
  push APP second time or select other pitch or roll mode
- with LOC captured and G/S armed:
  select other roll mode
- with G/S captured and LOC armed:
  select other pitch mode
- after LOC and G/S captured:
  engage GA mode or, disengage A/P and turn both FDs OFF




GLARESHIELD

BACKCOURSE (B/CRS) SWITCH (as installed) (Must be used concurrently with LOC switch)

PUSH - (bar in view) arms or engages AFDS in B/CRS mode as follows:

- B/CRS appears white (armed) in each ADI prior to localizer capture. AFDS is armed to capture and track inbound on backcourse of localizer.

  Capture point varies based on range and intercept angle.

  Initial roll modes; LNAV, HDG SEL or HDG HOLD remain engaged until B/CRS capture.

  Before localizer capture, pushing the LOC switch a second time disarms both the LOC and B/CRS modes. Pushing only the B/CRS switch a second time, disarms the B/CRS mode but the LOC mode remains armed.

- B/CRS appears green (engaged) in each ADI after localizer capture. AFDS tracks inbound on backcourse

  If the LOC switch is selected and localizer is captured before B/CRS switch is pushed, AFDS will track the localizer Front Course (outbound) and B/CRS cannot be selected.

- G/S, FLARE and ROLLOUT functions are not available.

LOCALIZER SWITCH

PUSH - (bar in view) arms or engages AFDS in LOC mode as follows:

- LOC appears white (armed) in each ADI prior to capture.

  AFDS is armed to capture and track inbound on the front course. Capture point varies based on range and intercept angle.

  Initial roll modes; LNAV, HDG SEL or HDG HOLD remain engaged until LOC capture.

  Pushing LOC switch a second time prior to localizer capture disarms the LOC mode.

- LOC appears green (engaged) in each ADI after localizer capture. AFDS tracks inbound front course.

  LOC capture will not occur if intercept track angle exceeds 120 degrees.

- G/S, FLARE and ROLLOUT functions are not available.

NOTE: LOC and B/CRS modes are single autopilot functions only. Multiple autopilots cannot be engaged with these modes.

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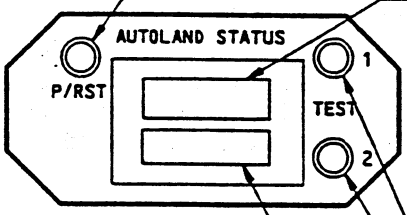



CENTER PANEL (2)

PUSH/RESET (P/RST) SWITCH

PUSH - resets both pilots annunciators as follows:
Before APP mode selected:
- changes NO AUTOLND or NO LAND 3 to blank
- if condition is still present when switch released, annunciation returns

After APP mode selected:
- if NO LAND 3 displayed, becomes blank. Remains blank until after landing and A/Ps disengaged
- if NO AUTOLND displayed, remains displayed until A/Ps are disengaged

AUTOLAND STATUS ANNUNCIATOR (upper-green)

(blank) - normal

LAND 3 - indicates all three A/P systems, with their airplane system inputs, are operating normally
- appears below 1500 feet RA with LOC and G/S captured

LAND 2 - indicates a minimum of two A/P systems, with their airplane system inputs, are operating normally
- appears below 1500 feet RA with LOC and G/S captured

TEST SWITCH
(push to test)

1 - LAND 3 and NO LAND 3 appear in upper and lower ASA respectively

2 - LAND 2 and NO AUTOLND appear in upper and lower ASA respectively

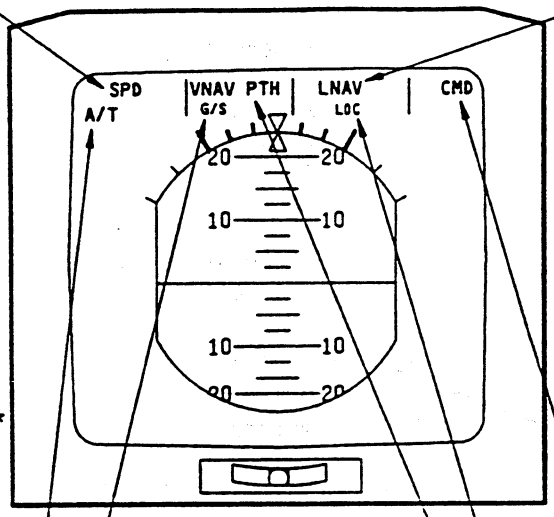
AUTOLAND STATUS ANNUNCIATOR (lower-amber)

(blank) - normal

NO AUTOLND - indicates fault conditions exist which preclude the use of the A/Ps for an automatic landing

NO LAND 3 - indicates a fault condition exists which results in a LAND 2 condition

AUTOLAND STATUS ANNUNCIATORS




AUTOTHROTTLE MODES***
ENGAGED (green)

- N1
- SPD
- FLCH
- GA
- IDLE
- TEST
- THR HOLD

AUTOTHROTTLE LIMITS*
(green)

- FLAP LIM
- ALPHA
- SPD LIM

AUTOTHROTTLE STATUS****
(green)

- A/T
- F/S

AFDS PITCH MODES
ARMED (white)

- G/S
- FLARE
- VNAV

AFDS PITCH MODES**
ENGAGED (green)

- TO
- ALT HOLD
- V/S
- VNAV PTH
- VNAV SPD
- SPD
- G/S
- FLARE
- ALT CAP
- GA

AFDS PITCH LIMITS*
(green)

- FLAP LIM
- SPD LIM

AFDS ROLL MODES**
ENGAGED (green)

- HDG HOLD
- HDG SEL
- LNAV
- LOC
- B/CRS
  (as installed)
- ATT
  (as installed)
- ROLLOUT
- TO
- GA

AFDS ENGAGED STATUS
(green)

- CMD
- FD
- TEST

AFDS ROLL MODES
ARMED (white)

- LOC
- B/CRS
  (as installed)
- ROLLOUT
- LNAV

NOTE: On some installations the Flight Mode Displays are oriented as shown on page 14.10.02.

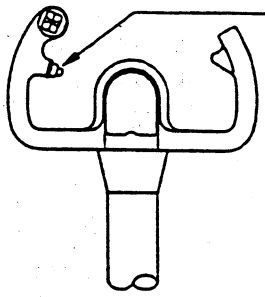
* Mode is operating with angle of attack (alpha) or airspeed limit. Limit mode annunciation replaces engaged mode annunciation.

** An amber horizontal line is drawn through the appropriate A/P pitch or roll mode annunciation when a flight mode fault is detected.

*** AFDS/Autothrottle mode changes are emphasized for 10 seconds by a box (green) drawn around the annunciated mode.

**** F/S appears only when autothrottle is disengaged, AFDS is not operating in a speed mode (FLCH or GA) and the present airspeed exceeds either a SPD LIM, ALPHA or FLAP LIM.

FLIGHT MODE DISPLAYS



CONTROL WHEEL

AUTOPILOT DISENGAGE SWITCH

PUSH - disengages all A/Ps. A/P Disconnect and Master Warning Lights illuminate, EICAS message displayed and aural warning sounds on disengagement. Second push extinguishes A/P Disconnect Light and silences aural warning.
- extinguishes A/P Disconnect Light and silences aural warning if A/P automatically disengaged


AUTOPILOT DISCONNECT LIGHT (red)

ILLUMINATED - an A/P has been automatically or manually disengaged
- extinguished by pushing either A/P Disengage Switch

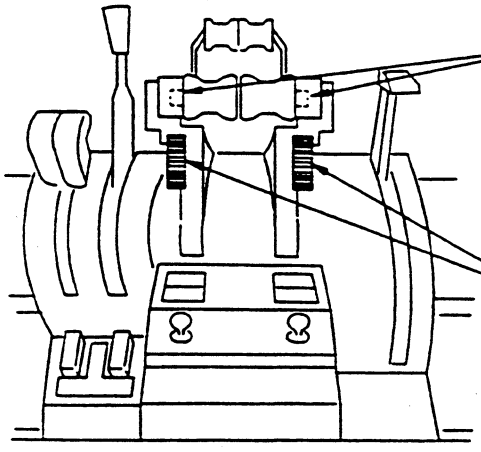

AUTOPILOT LIGHT (amber)

ILLUMINATED - a degraded operating condition exists in engaged A/P
- extinguished when condition is corrected or an alternate A/P is selected provided fault is not common to alternate A/P


CENTER PANEL

AUTOTHROTTLE DISCONNECT LIGHT (amber)

ILLUMINATED - A/T is disengaged
- extinguished by pushing either A/T Disconnect Switch



CONTROL STAND

AUTOTHROTTLE DISCONNECT SWITCH

PUSH - disengages A/T
- A/T remains armed and A/T Disconnect Light illuminates
- subsequent push or reengaging A/T extinguishes light

GO-AROUND SWITCH

PUSH - engages AFDS and A/T in GA mode if previously armed. Automatic arming occurs with GS pitch mode engagement or with flap extension
- if flight director off, activates flight director in go-around mode
- cancels all thrust derates if selected after takeoff
- provides windshear guidance during GA if windshear detected

MISCELLANEOUS CONTROLS AND INDICATORS

## SYSTEM DESCRIPTION

### AUTOFLIGHT SYSTEM

The Autoflight System (AFS) consists of the Autopilot Flight Director System (AFDS) and the Autothrottle System (A/T). The Flight Management Computers (FMCs) automatically manage pitch, roll and thrust through simultaneous control of the AFDS and A/T.

Control of the AFDS is accomplished through the AFDS Mode Control Panel (MCP). The A/T is controlled through the MCP and the Thrust Mode Select Panel (TMSP).

Normally, the AFDS and A/T are controlled automatically by the FMCs to perform optimized lateral and vertical flight path guidance through climb, cruise and descent.

### AUTOPILOT FLIGHT DIRECTOR SYSTEM

The AFDS is a triple system consisting of three individual Flight Control Computers (FCCs) and a single Mode Control Panel (MCP). The MCP provides coordinated control of autopilot, flight director, altitude alert and autothrottle functions.

The three FCCs, identified as left, center and right, send control signals to their respective A/P control servos which operate the flight controls through the three separate hydraulic systems. The A/P controls the ailerons and elevator and adds rudder only during a multi-A/P approach. Nose wheel steering is also added during rollout from an automatic landing. During an ILS approach with all three A/Ps engaged, the three FCCs are powered from separate electrical sources.

On some airplanes, autopilot engagement requires at least two operable FCCs. Commands from the two FCCs are compared to reduce the possibility of an autopilot hardover. On later airplanes, autopilot engagement requires only one FCC. However, if two or more FCC's are operable, commands from the FCC's are compared. The left AC bus normally powers the left and center FCCs except during autoland operations after bus isolation occurs. When the electrical busses are isolated for an automatic landing, the center FCC receives power from the hot battery bus and standby inverter (REF 10.20.08). If left AC bus power is lost inflight, the left and center FCCs will be unpowered. With only the right FCC powered, no autopilots can be engaged. The right flight director, however, will operate with only the right FCC powered.

The FCCs also provide inputs for AFDS operating mode displays and FD commands on the ADI.

#### MCP Mode Selector Switches

MCP mode selector switches are pushed to select a mode. A light bar in the lower half of each switch illuminates to indicate that the mode has been requested. Mode engagement is indicated by flight mode displays on the ADIs.

In general, all modes can be disengaged by selecting another mode, or disengaging the A/P and turning both FDs OFF. The exception is APP mode after LOC and G/S capture. In this situation APP mode can only be disengaged by disengaging the A/P and turning both FD's OFF, or engaging GA. VNAV, LNAV, LOC, B/CRS (As installed), and APP modes when only armed can be disarmed by pushing the mode switch a second time.

AFDS Failures

During single A/P operation, failures affecting the engaged mode are annunciated on the ADI. If the failure affects only the operating mode, the A/P remains engaged in an attitude stabilizing mode, an amber line is drawn through the mode and an A/P caution condition is annunciated. Failures degrading all A/P operational modes result in an A/P disconnect.

An FD failure in either pitch or roll causes the respective command bar to disappear. If both axes become unusable, both command bars disappear.

AUTOLAND STATUS ANNUNCIATORS (ASA)

Autoland Status Annunciators provide information relative to the status of the A/P systems for CAT II and III approaches with automatic landing and rollout. An ASA is located on each pilot's panel to display this information. Each ASA has an upper and lower display which shows one of three indications. Except during test, both ASAs show the same indication.

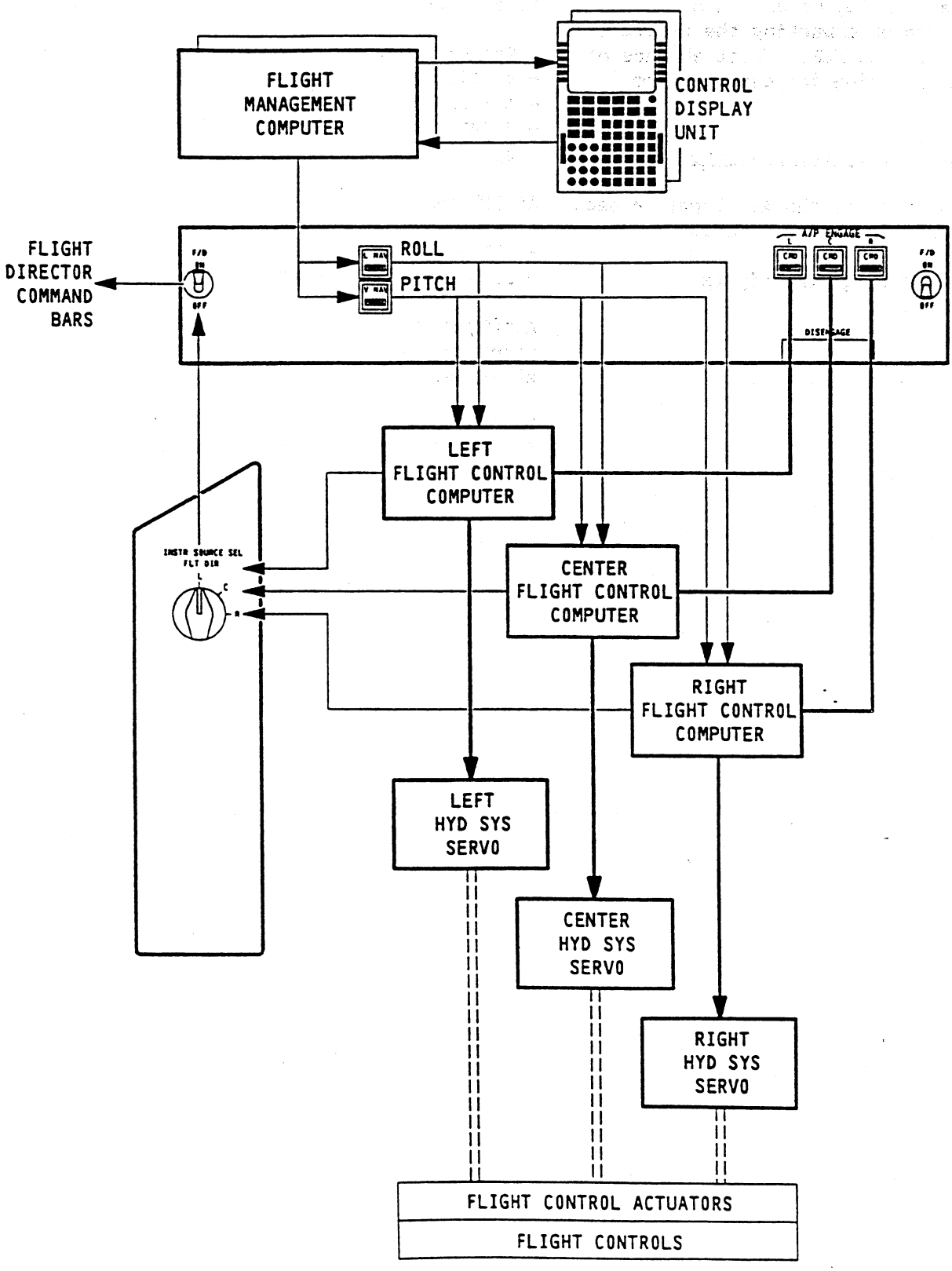
Monitoring of the A/P systems is initiated by the autoland status system when the electrical system is powered. A fault which limits the A/P system is shown as NO LAND 3 or NO AUTOLND on the ASAs. Should the limiting fault(s) clear prior to the selection of APP mode, the ASA will blank when APP mode is selected. Faults that do not require immediate crew action or cognizance are annunciated after touchdown.

With a LAND 3 indication the level of redundancy of the A/P system is such that the occurrence of any single fault would not prevent the A/P system from making an automatic landing (fail operational). With a LAND 2 indication the level of redundancy is such that any single fault does not cause a significant deviation from the flight path (fail passive).

During autoland operations, the FCC detects ILS system anomalies. LAND 3 and LAND 2 annunciations do not necessarily mean that the localizer and glide slope signals are being received. If the ILS station fails or goes off the air, the airplane continues on an inertial track. After a short delay, an amber line is drawn through the affected ADI mode annunciation (G/S or LOC) and the affected flight director commands are removed from view. Also, the AUTOPILOT and master CAUTION lights illuminate, and the caution beeper sounds. The ASA annunciation may or may not change.

Below 200 feet RA the ASA display cannot change except to indicate a NO AUTOLND condition.

The ASA system does not monitor the status of all ground and airborne equipment required for CAT II and III operations. It is primarily an autopilot and autopilot support system monitor.




AUTOPILOT FLIGHT DIRECTOR SYSTEM DIAGRAM

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## ALTITUDE ALERT

Altitude alerting occurs when approaching or departing the altitude selected on the MCP. Total absence of altitude alerting indicates system failure.

### Approaching a Selected Altitude

At 900 feet to go the ALT light on each pilot's altimeter illuminates.

At 300 feet to go the lights extinguish.

### Deviating From a Selected Altitude

At 300 feet from the altitude:

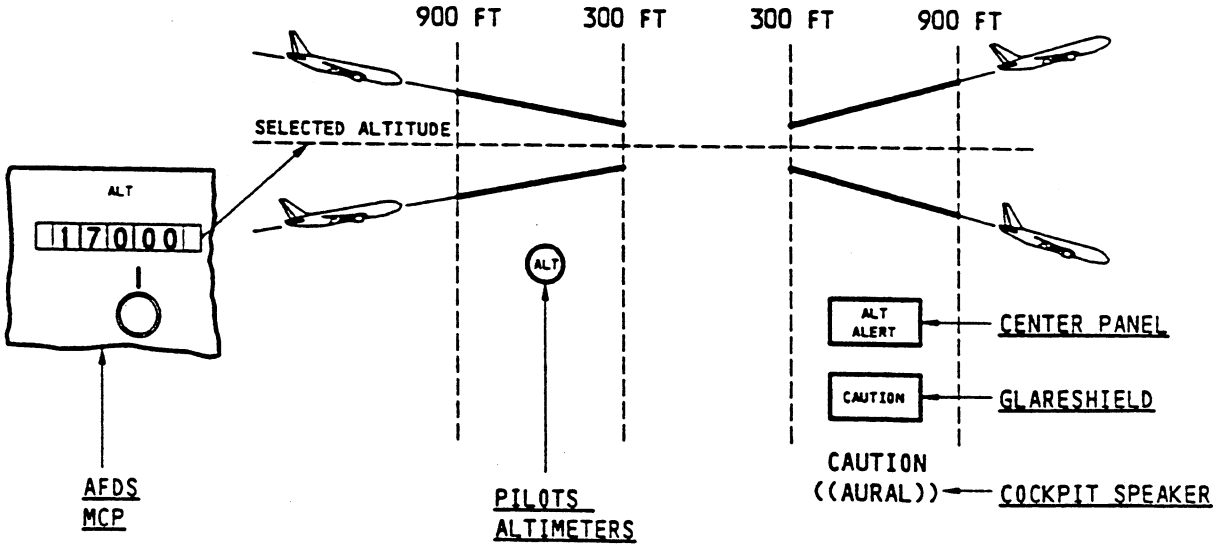
- Master Caution lights illuminate
- caution aural sounds
- ALT ALERT light illuminates
- EICAS message ALTITUDE ALERT appears

At 900 feet from the altitude:

- ALT ALERT light extinguishes
- EICAS message disappears

Altitude deviation alerting can be reset by changing the selected altitude.

Deviation alerting is inhibited in flight with the landing gear down and locked.

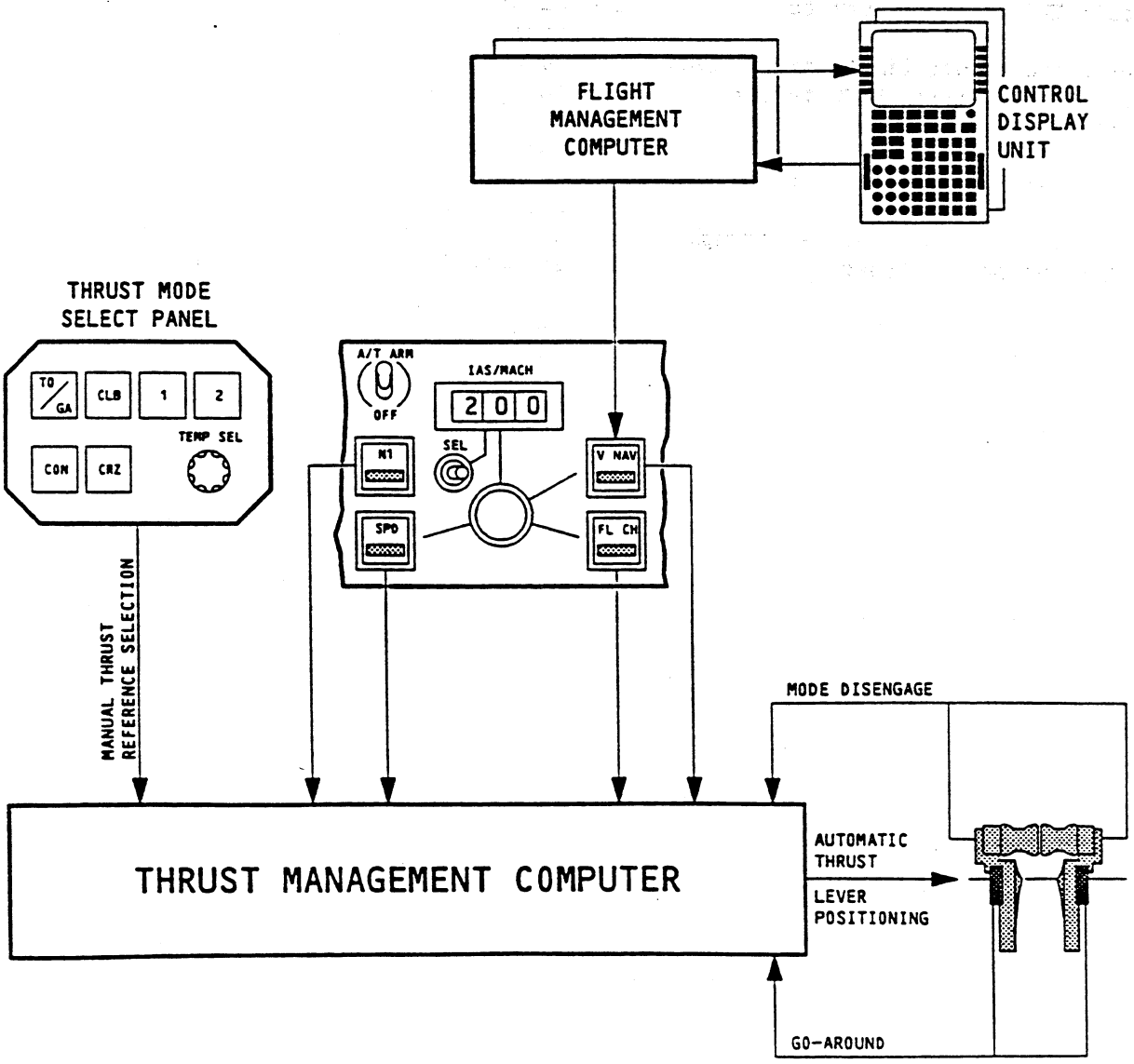


## AUTOTHROTTLE SYSTEM

The autothrottle (A/T) is a full time system which provides automatic thrust control from start of takeoff through climb, cruise, descent, approach and go-around or landing. The A/T system consists of the thrust management computer (TMC), the thrust mode select panel (TMSP), a portion of the controls and indicators on the AFDS MCP and the electric servo system which actuates the thrust levers.

A/T operation is controlled through mode and speed selection from the MCP and thrust limits selection from the TMSP. When in VNAV, the FMC selects A/T modes and target thrust values.

The A/T can be manually overridden at anytime, or disconnected by using either A/T Disconnect Switch.




AUTOTHROTTLE SYSTEM

## Thrust Management Computer

The thrust management computer (TMC) exercises primary control of the A/T system. It operates the A/T in response to manual mode requests from the pilots or to automatic mode requests from the FMCs. Manual A/T mode requests are made from the MCP. The Thrust Mode Select Panel provides for the selection reference thrust. Automatic A/T mode requests are made from the FMCs while the VNAV mode is engaged.

The basic TMC functions are to:

1. Calculate thrust limits and thrust settings or follow FMCS thrust settings.
2. Detect and transmit A/T failures.
3. Actuate the thrust levers through the servo and clutches.
4. Adjust flight idle with engine anti-ice operation.

## Thrust Mode Select Panel

The thrust mode select panel (TMSP) (see Power Plant chapter) provides the following functions:

1. Selection of reference thrust modes (TO/GA, CLB, CON, CRZ).
2. Selection of fixed and assumed temperature derated reference thrust values.

## ADI A/T Mode Annunciations

Once armed, the A/T can be engaged in one of the following modes. Each ADI displays the engaged mode.

1. N1: A/T controlling to the selected N1 reference thrust.
2. SPD: A/T controlling thrust to maintain speed selected in Speed Window or, if VNAV mode engaged, the speed as programmed by the FMC.
3. FL CH: A/T controlling to a maximum of the selected mode reference thrust during climb, and to a minimum N1 during descent.
4. GA: A/T controlling to a maximum of GA reference thrust to maintain a climb rate of at least 2000 fpm with GA displayed as pitch mode. If both FDs and the A/P are off, A/T controls to GA reference thrust subject to flap and VMO limit speeds.
5. IDLE: A/T is reducing or has reduced thrust to flight idle. It may engage in a VNAV descent. It will engage when FLARE is engaged.
6. THR HOLD: A/T servo(s) de-energized. Thrust Levers remain in existing position or where manually placed.

Thrust Lever Operation

The A/T system moves both thrust levers together, maintaining their relative positions. The first thrust lever reaching a forward or aft limit, causes both thrust levers to stop moving. If necessary, thrust may be equalized by manually repositioning the lagging thrust lever.

Manually positioning the Thrust Levers does not disengage the A/T. Following manual positioning the A/T system may reposition the Thrust Levers to comply with computed thrust requirements, except in THR HOLD mode.

A/T Disengagement

The A/T can be disengaged manually by positioning the A/T Arm Switch to OFF or by pushing either A/T Disconnect Switch. Disengagement occurs automatically when a fault in the operating mode is detected or when either reverse thrust lever is moved to the reverse position.

AUTOFLIGHT OPERATION

Takeoff Operation (FD and A/T only)

Takeoff (TO) is a FD only mode which displays pitch and roll commands for climb out while A/T maintains takeoff thrust.

The FD TO mode can only be engaged while on the ground. With all A/Ps disengaged and both FDs OFF, engagement occurs when the first FD is turned on. The associated ADI then displays FD as the AFDS engaged status and TO as the pitch and roll modes. The command bars come into view.

A/Ps are not used during the takeoff roll.

On takeoff, prior to 80 knots IAS:

- pitch commands a fixed attitude (about 8° up)
- roll commands wings level
- A/T is engaged in N1 mode by pushing the N1 Switch
- Thrust Levers advance until an engine reaches takeoff N1
- ADIs annunciate N1 for A/T and TO for both pitch and roll until a mode change is made.

At 80 knots IAS:

- A/T annunciates THR HOLD.

At liftoff:

- pitch commands greater of V2 + 15 or liftoff speed + 15. If engine failure occurs, pitch commands:

    1) V2 if airspeed below this value
    2) existing speed if between V2 and V2 + 15
    3) V2 + 15 if airspeed above this value

- roll commands bank to maintain ground track

After liftoff:

- A/T remains in THR HOLD mode at takeoff thrust until a pitch mode, A/T mode, or thrust reference mode switch is pushed. The A/T then sets climb thrust, or the selected reference thrust.

- FD TO modes are terminated by engaging an A/P in CMD, or selecting any other pitch or roll mode

- Fast/Slow Pointer appears on ADIs following selection of a FD mode other than TO. (As Installed)

Enroute

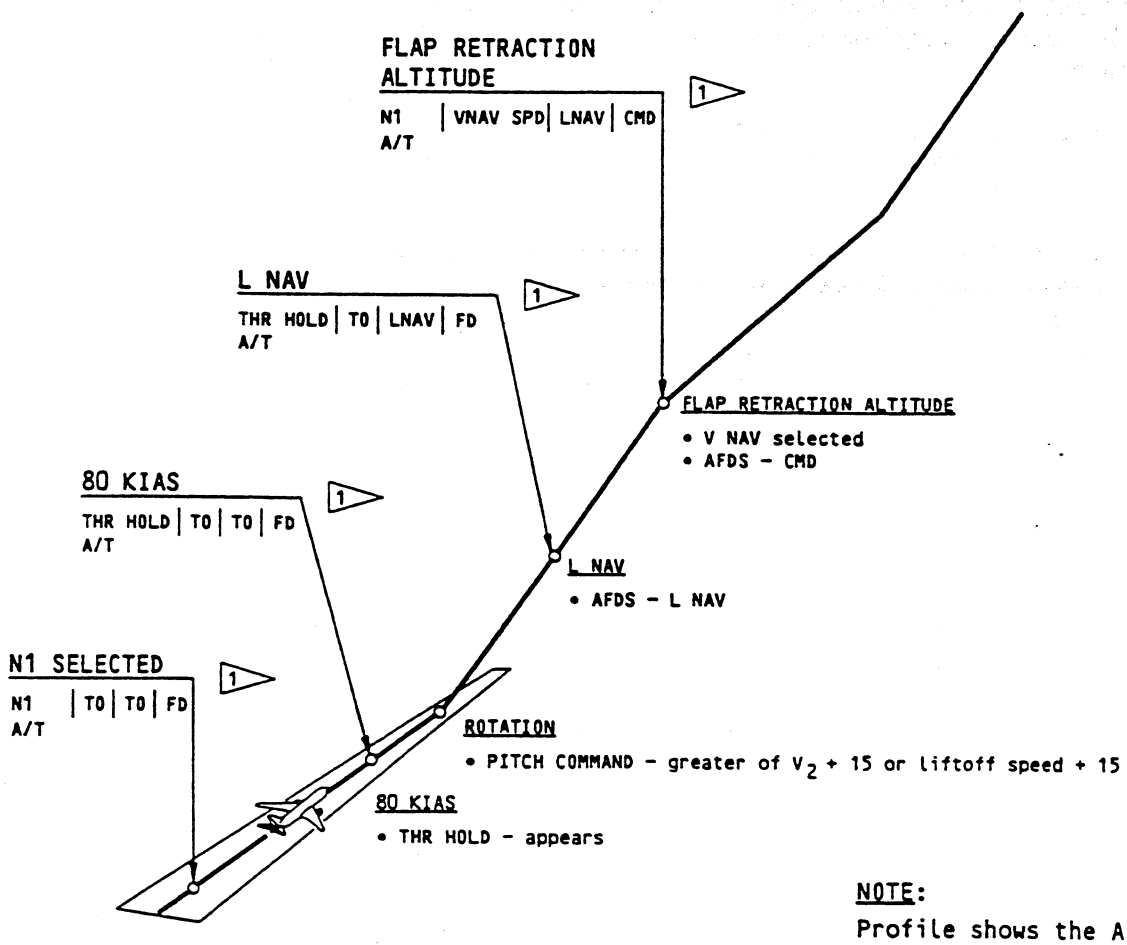
The A/T can be operated independently of the A/P or FD in either N1 or SPD mode. See Supplementary Normal Procedures for operational information.

An A/P and or a FD can be used after takeoff to fly the lateral track (LNAV) and a vertical track (VNAV) as provided by the respective FMC. Maximizing the autoflight use of LNAV and VNAV ensures operations for best economy.

Other pilot selected control modes are available for guidance:

- Flight Level Change (FLCH)
- Heading Select (HDG SEL)
- Heading Hold (HDG HOLD)
- Vertical Speed (V/S)
- Altitude Hold (ALT HOLD)
- Localizer only approach (LOC)
- Backcourse LOC approach (B/CRS) (as installed)
- ILS approach (APP)

Use of the above modes are covered in the controls and indicators section of this chapter and Supplementary Normal Procedures.




CONDITIONS:

BRAKE RELEASE

- A/T - ARM
- FD - ON
- Pitch Command - 8 Degrees
- Roll Command - Wings Level

NOTE:

Profile shows the ADI Flight Mode Displays at the appropriate takeoff condition.

1 On some installations the Flight Mode Displays are oriented as shown on page 14.10.02.

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AUTOFLIGHT TAKEOFF OPERATIONS

Approach

The A/P provides automatic flying of precision approaches to ILS CAT I, II, IIIA and IIIB weather minimums, or non-precision approaches: R NAV (via L NAV and V NAV mode), LOC, or B/CRS (As installed).

Flight Director provides steering commands for manual precision approaches to CAT I and II weather minimums or non-precision approaches: R NAV, LOC, B/CRS.

Procedures for autoflight operations are found in Normal and Supplementary Normal Procedures.

ADI flight mode displays for Autoflight Approach Operation are shown on the opposite page.

NOTE: During a LAND 2 multi-A/P approach and below 330 feet RA (100 feet RA for -300 airplanes), an increment of nose up trim is automatically applied for flare. If the A/Ps are subsequently disengaged in the approach, a forward control column force of 20-30 lbs may be required to counter the automatic trim condition.

If an automatic multi-autopilot go-around is performed, the increment of automatic trim is removed.

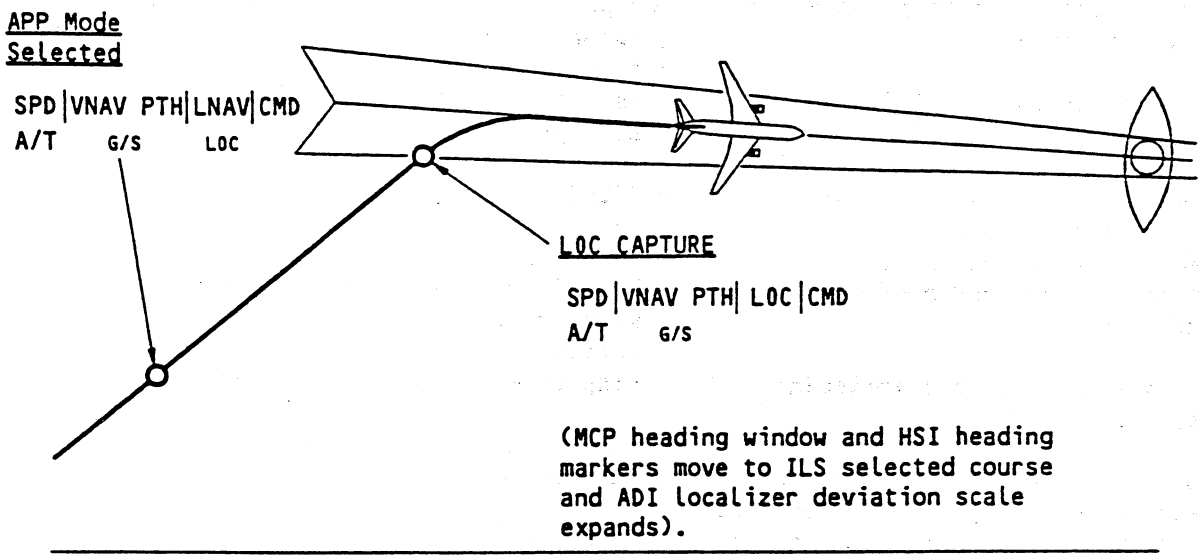
Rudder Control and Runway Align Submode Operation

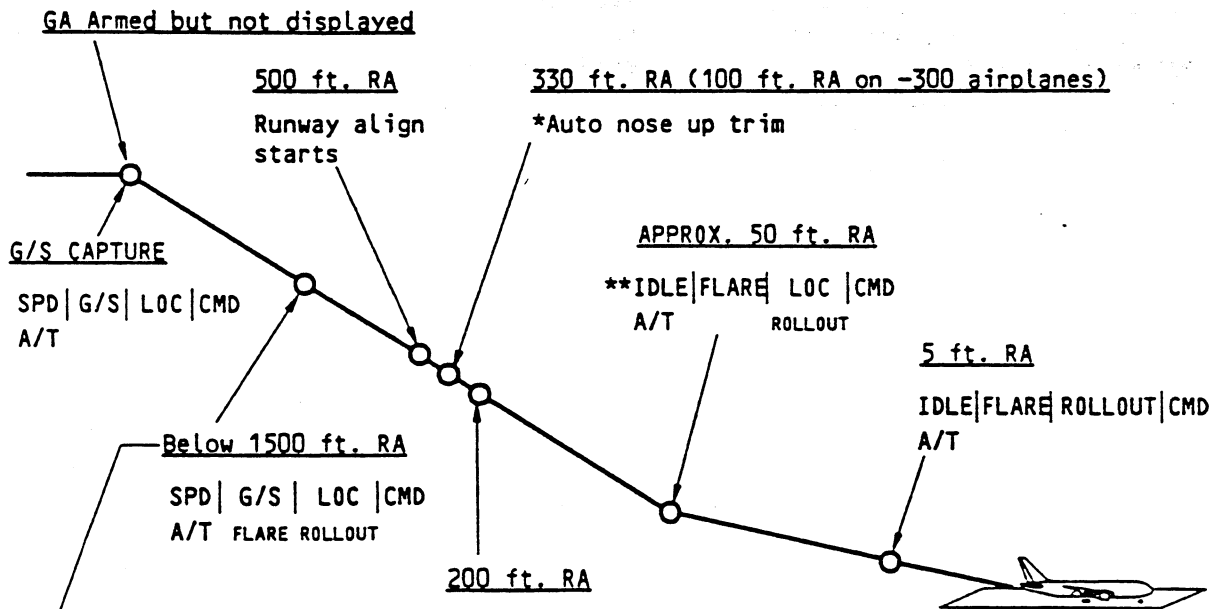
Rudder control is accomplished by the A/P systems during a multi-A/P ILS approach. The purpose is to provide automatic rudder compensation for an asymmetric thrust condition resulting from an engine failure during an ILS approach. Thus, when LAND 3 or LAND 2 is annunciated, A/P control of the rudder is active.

NOTE: If the A/Ps are disconnected or disconnect in an asymmetric thrust condition with rudder control active, the rudder will return to the trimmed position unless the pilot exerts the rudder pedal force required to maintain the rudder position.

The runway align submode is also operative during a multi-A/P ILS approach. Its purpose is to reduce the crab angle established during a crosswind condition on an ILS approach prior to an automatic landing. The submode operates as follows:

- actuated at 500 feet RA with LAND 3 or LAND 2 annunciated
- activation not displayed
- A/P systems initiate a slip with a maximum bank angle of 2 degrees when the crab angle exceeds 5 degrees
- wing leveling from the slip is initiated when the ROLLOUT mode is engaged.




* Applied during LAND 2 multi-A/P approach only

** IDLE occurs at 15 ft. RA on -300 airplanes

NOTE:
On some installations the Flight Mode Displays are oriented as shown on page 14.10.02.

## Flare

The FLARE submode is a multi-A/P mode. It is not intended for single A/P, or FD only operation and:

- FLARE is armed when LAND 3/LAND 2 is annunciated on the ASAs
- FLARE engages at approximately 45 feet RA and the A/Ps start the landing flare maneuver
- the FLARE engaged annunciation replaces G/S captured annunciation on the ADIs

During flare maneuver the following also occurs.

- at 45 feet RA* or 15 feet RA** the A/T starts retarding Thrust Levers to idle and the A/T annunciation changes from SPD to IDLE
- if slip exists due to runway align submode, wings are levelled when ROLLOUT mode engaged
- A/Ps start lowering nose wheel to runway at 5 feet RA plus 2 seconds with pitch attitude less than 2 degrees
- FLARE annunciation disappears at touchdown

*767-200
**767-300
***On some installations, the roll command bar will not be displayed during a multi - A/P approach

## Rollout

ROLLOUT is a multi-A/P approach submode and provides runway centerline rollout guidance and:

- ROLLOUT is armed when LAND 3/LAND 2 is annunciated on the ASAs.
- at approximately 5 feet RA ROLLOUT engages
- ROLLOUT replaces the LOC captured annunciation
- localizer centerline is maintained by A/P control of rudder and nose wheel steering ***
- rollout guidance continues to a full stop or until A/Ps are disengaged

During rollout the following also occurs relative to the A/T.

- IDLE mode remains engaged until A/T is disengaged
- reversing thrust disengages A/T with the A/T DISC Light remaining extinguished

Go-Around (GA)

A fully automatic go-around is normally performed with multi-A/P operation, however, a single A/P or a FD only go-around can also be made. With GA mode engaged, the AFDS controls pitch and roll while the A/T increases thrust as required to establish a 2000 fpm climb with GA reference thrust the maximum.

The GA mode is armed when the flaps are not up or G/S is captured. Arming is not annunciated. GA remains armed until 2 seconds after 5 feet RA. Pushing either GA Switch during this period of the approach engages the GA mode. The mode will remain engaged even though the airplane touches down in executing the go-around. If the airplane is floating within 5 feet RA for more than 2 seconds when the GA switch is pushed, the A/P pitch mode will remain in FLARE and the A/T GA mode will engage. If the airplane is on the ground but has been below 5 feet RA for less than 2 seconds when the GA switch is pushed, the A/P GA pitch mode will engage but the A/T mode will remain in IDLE. The GA switches are interlocked with the thrust reversers to prevent GA mode engagement during reverse thrust operation.

During GA mode operation:

- GA mode shows engaged on ADI in A/T, pitch and roll modes
- A/T increases thrust for go-around
- Roll commands bank to maintain ground track
- AFDS increases pitch to hold existing speed or the selected MCP speed, whichever is higher, as thrust increases.
- A/T controls thrust to a maximum of GA reference thrust to maintain climb rate of at least 2000 fpm.
- If flap setting is 20 or less, a thrust mode other than GA can be selected using the TMSP
- At selected altitude, AFDS pitch mode changes to ALT HOLD and A/T mode changes to SPD with thrust decreasing to maintain selected speed
- GA remains the engaged roll mode until another roll mode is selected
- landing gear and wing flaps must be operated manually

GA Mode Termination

Below 400 feet RA:

- if flap setting is 25 or 30 A/T remains in GA mode unless disengaged
- AFDS remains in GA mode unless A/P disengaged and FDs turned OFF

Above 400 feet RA:

- a different pitch or roll mode can be selected using the MCP. Concurrent with new pitch or roll mode engagement, all A/Ps except first in CMD automatically disengage
- A/T SPD mode can be selected

NOTE: If the A/P systems are compensating for an asymmetric thrust condition when they revert to a single A/P in CMD configuration, the rudder will return to the trimmed position unless the pilot exerts the rudder pedal force required to maintain the rudder position.

## AUTOFLIGHT LIMIT MODES

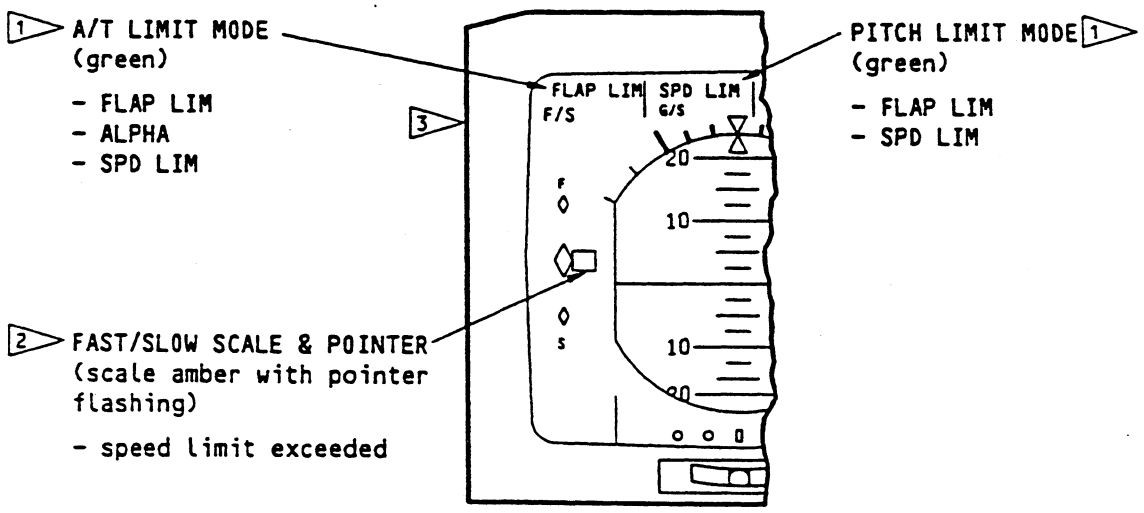
Flap placard speeds, airplane maximum angle of attack and maximum speed limit are automatically monitored by the AFDS and TMC. The appropriate speed limit mode annunciation of FLAP LIM, ALPHA, or SPD LIM is displayed when a speed limit is exceeded and the MCP selected speed or FMC target speed is set to exceed a limit. When the limit mode is displayed, the limit speed becomes the reference speed for the A/T and AFDS.

When the AFDS is engaged in a speed mode (FLCH, GA), the speed limit monitoring is accomplished by the AFDS. When approaching a speed limit, the appropriate limit mode annunciation, except ALPHA, replaces the existing pitch mode. The AFDS will not annunciate ALPHA when approaching maximum angle of attack speed, however the alpha safe speed will be maintained by AFDS pitch.

When the AFDS is not controlling speed, speed limit monitoring is accomplished by the TMC. When a speed limit is exceeded, the appropriate autothrottle limit mode annunciation is displayed. The speed limit mode annunciation may appear only when autothrottles are engaged. On airplanes with fast/slow indications*, the speed limit mode annunciations may appear even when the autothrottles are not engaged.

The fast/slow scale* changes color to amber and the pointer flashes when a speed limit is exceeded.

*As installed




1 Only one limit mode can be displayed at a time.

2 Not applicable on airplanes equipped with speed tape

3 On some installations the Flight Mode Displays are oriented as shown on page 14.10.02.

AUTOFLIGHT LIMIT MODES

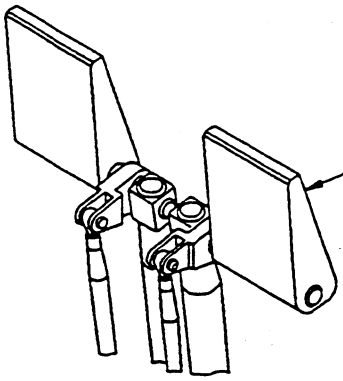
Windshear Recovery Guidance

The AFDS provides windshear recovery guidance by means of the normal takeoff and go-around pitch and roll modes. The AFDS commands a pitch of 15 degrees or slightly below the Pitch Limit Indicator (PLI), whichever is lower.

If the autopilot is not engaged at the time go-around is initiated, the pilot must fly the windshear recovery following flight director commands. If the autothrottle is not armed or engaged, the thrust levers must be advanced manually.

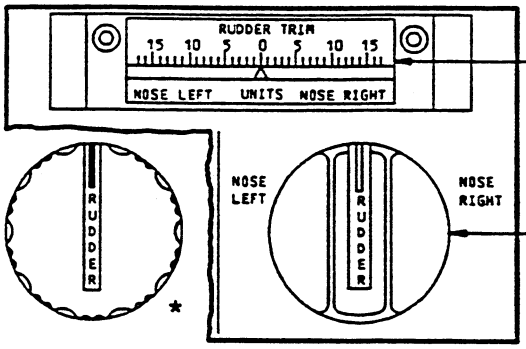
CHAPTER 13

FLIGHT CONTROLS



RUDDER PEDALS

PUSH - deflects rudder in desired direction




AFT ELECTRONICS PANEL

RUDDER TRIM INDICATOR

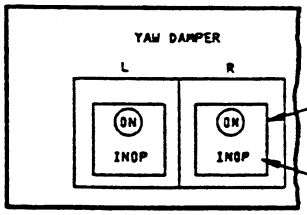
- indicates units of rudder trim

RUDDER TRIM CONTROL
(spring loaded to neutral)

ROTATE - trims rudder in desired direction


RUDDER RATIO LIGHT (amber)

ILLUMINATED - rudder ratio system failed
- pilot inputs to rudder may be increased or decreased in sensitivity



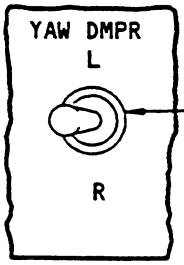

OVERHEAD PANEL

YAW DAMPER SWITCH
(alternate action)

ON - yaw damper signaled on

YAW DAMPER INOPERATIVE LIGHT (amber)

ILLUMINATED - yaw damper switch off
- yaw damper inoperative




ACCESSORY PANEL

YAW DAMPER TEST SWITCH
(spring loaded to neutral)

L - illuminates yaw damper INOP lights during left system test

R - illuminates yaw damper INOP lights during right system test

* As installed

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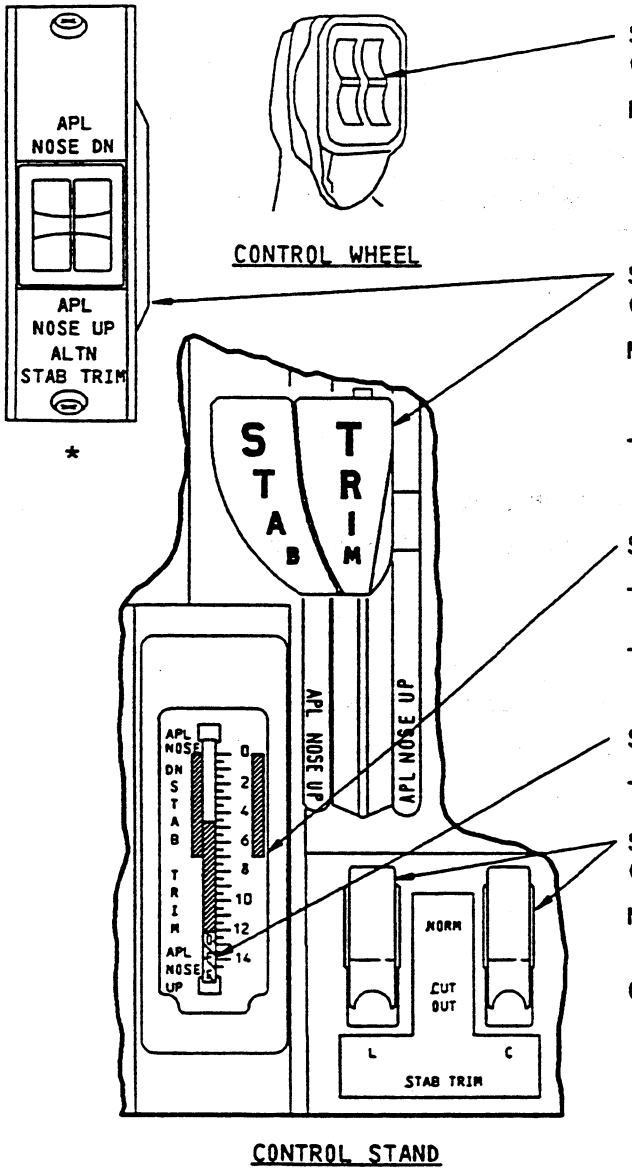
RUDDER AND YAW DAMPER




STABILIZER TRIM SWITCHES
(spring loaded to neutral)

PUSH (both halves) - electrically signals stabilizer trim in desired direction

STABILIZER TRIM LEVERS (SWITCHES*)
(spring loaded to neutral)

MOVE (both halves) - mechanically (electrically*) signals stabilizer trim in desired direction
- overrides (neutralizes*) all other stabilizer trim signals

STABILIZER TRIM INDICATOR

- indicates stabilizer position in units of trim
- green bands indicate allowable range for takeoff

STABILIZER TRIM OFF FLAG

- trim indicator inoperative

STABILIZER TRIM CUTOUT SWITCH
(toggle, guarded)

NORM - supplies hydraulic power for stabilizer trim

CUTOUT - shuts off respective hydraulic system power to stabilizer trim

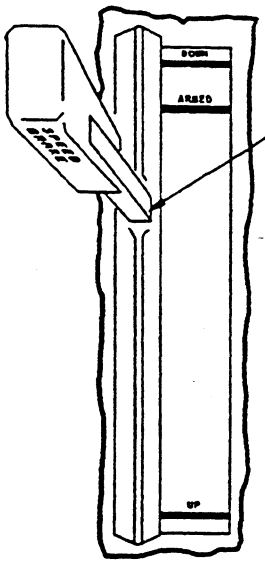

UNSCHEDULED STABILIZER TRIM LIGHT (amber)

ILLUMINATED - uncommanded stabilizer movement
- (autopilot engaged) stabilizer moving opposite the direction signaled

STABILIZER TRIM LIGHT (amber)

ILLUMINATED - stabilizer trimming at half the rate signaled by the electric trim switches

* As installed




CONTROL STAND

SPEEDBRAKE LEVER

DOWN (detent) – all spoiler panels retracted
– on the ground, speedbrake lever moves to DOWN and spoiler panels retract if either thrust lever is advanced

ARMED – auto speedbrake system armed
– after landing, speedbrake lever moves to UP and spoiler panels extend

UP – required spoiler panels extend to their maximum in flight or on ground positions
– on the ground, speedbrake lever moves to UP and all spoiler panels extend when either Reverse Thrust Lever is raised to its respective interlock stop


CENTER INSTRUMENT PANEL

SPEEDBRAKES LIGHT (amber)

ILLUMINATED – speedbrake lever beyond ARMED detent with radio altitude between 800' and 15'
– speedbrake lever beyond ARMED detent with landing flaps extended and radio altitude above 15'


OVERHEAD PANEL

AUTO SPEEDBRAKE LIGHT (amber)

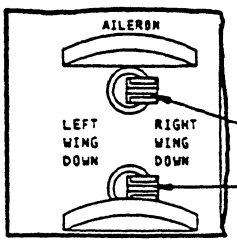
ILLUMINATED – if speedbrake lever is ARMED or DOWN, speedbrakes will not extend automatically after landing
– if speedbrake lever is ARMED, speedbrakes may extend in flight if additional faults occur

SPOILERS LIGHT (amber)

ILLUMINATED – one or more spoiler system faults have been detected

AILERON LOCKOUT LIGHT (amber)

ILLUMINATED – aileron lockout actuator not in signaled position

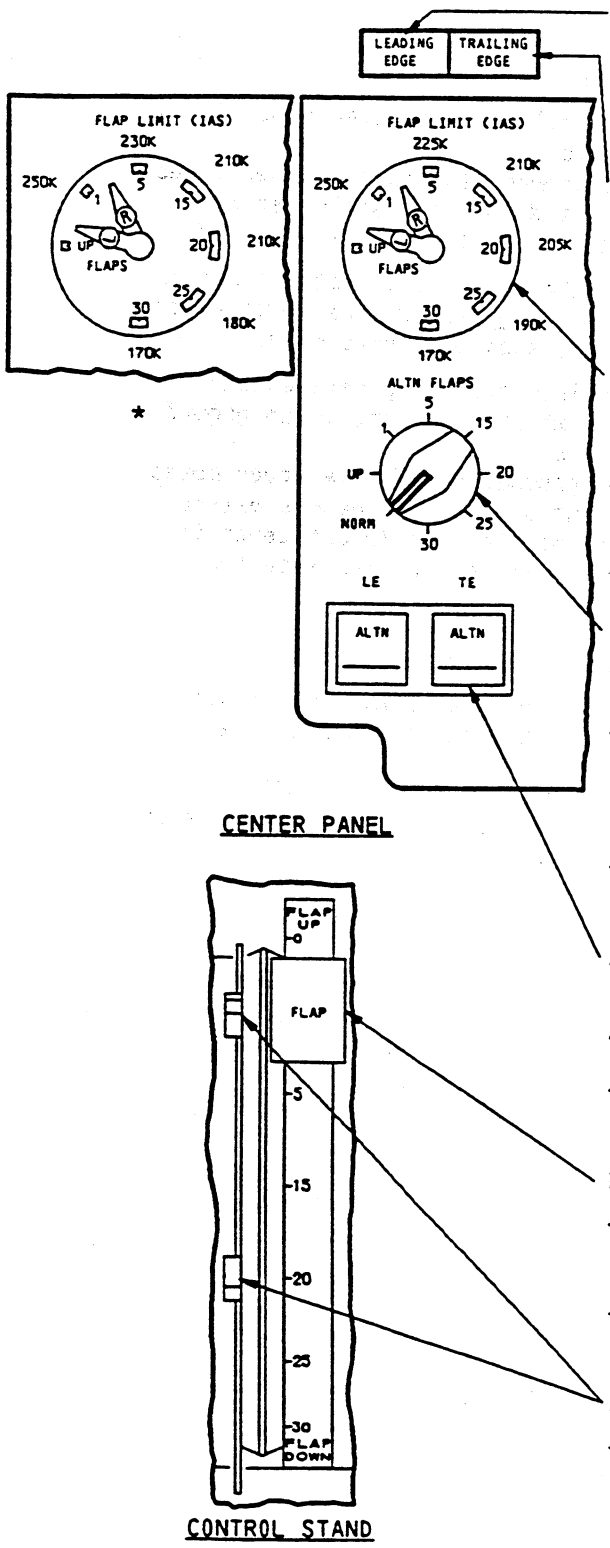



AFT ELECTRONICS PANEL

AILERON TRIM SWITCH
(spring loaded to neutral)

PUSH (both switches) – trims the ailerons in desired direction

SPEEDBRAKE AND AILERON




LEADING EDGE LIGHT (amber)

ILLUMINATED - slat position disagrees with the position selected
- slat asymmetry exists

TRAILING EDGE LIGHT (amber)

ILLUMINATED - flap position disagrees with the position selected
- flap asymmetry exists
- flap load relief failure

FLAP POSITION INDICATOR

- indicates flap positions as follows:

UP - all flaps/slats retracted

Between UP and 1 - slats between retracted and flaps 1 position
1 to 30 - actual flap position

ALTERNATE FLAPS SELECTOR

NORM - selector position during normal operations
- alternate flap/slat command inactive

UP to 30 - signals alternate drive unit(s) to position flaps/slats to selected position
- Respective Alternate Flaps Switch must be in ALTN for flaps/slats to move

ALTERNATE FLAPS SWITCH
(alternate action)

ALTN - arms the selected TE flap/LE slat alternate drive unit(s)
- shuts off hydraulic power to the selected flap or slat drive unit(s)

FLAP LEVER

- signals hydraulic drive units to move flaps/slats to selected detent position
- selecting position 25* or 30 arms the flap load relief system

FLAP GATE

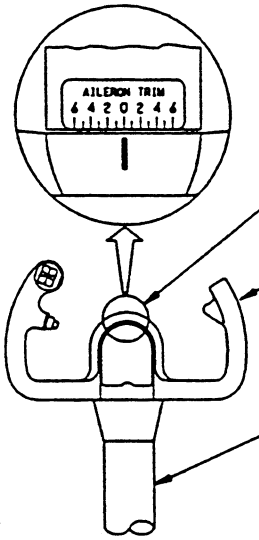
- prevents inadvertent flap lever movement past gate positions:

  1 - prevents inadvertent high lift system retraction

  20 - two engine go-around flap position

* -300 Airplanes

FLAPS




AILERON TRIM INDICATOR

- indicates units of trim

CONTROL WHEEL

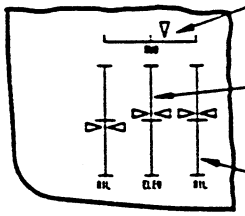
ROTATE - operates ailerons and roll spoilers in desired direction

CONTROL COLUMN

PUSH/PULL - operates elevators in desired direction

- movement opposing stabilizer trim stops trimming

EICAS STATUS DISPLAY



RUDDER POSITION

- indicates rudder deflection

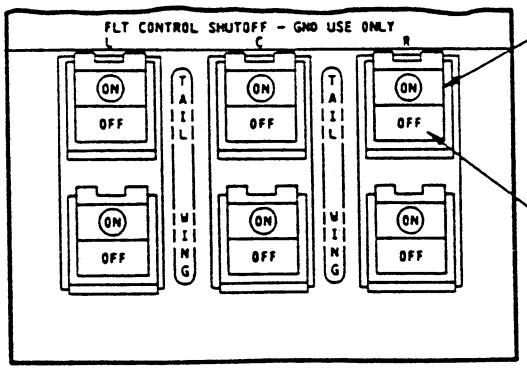
ELEVATOR POSITION

- indicates left and right elevator deflection

AILERON POSITION

- indicates corresponding inboard and outboard aileron deflection

CENTER PANEL




FLIGHT CONTROL SHUTOFF SWITCH (alternate action, guarded)

ON - respective hydraulic shutoff valve signaled open

FLIGHT CONTROL SHUTOFF OFF LIGHT (amber)

ILLUMINATED - respective hydraulic shutoff valve closed

ACCESSORY PANEL

239752

MISCELLANEOUS CONTROLS AND INDICATORS

## SYSTEMS DESCRIPTION

### GENERAL

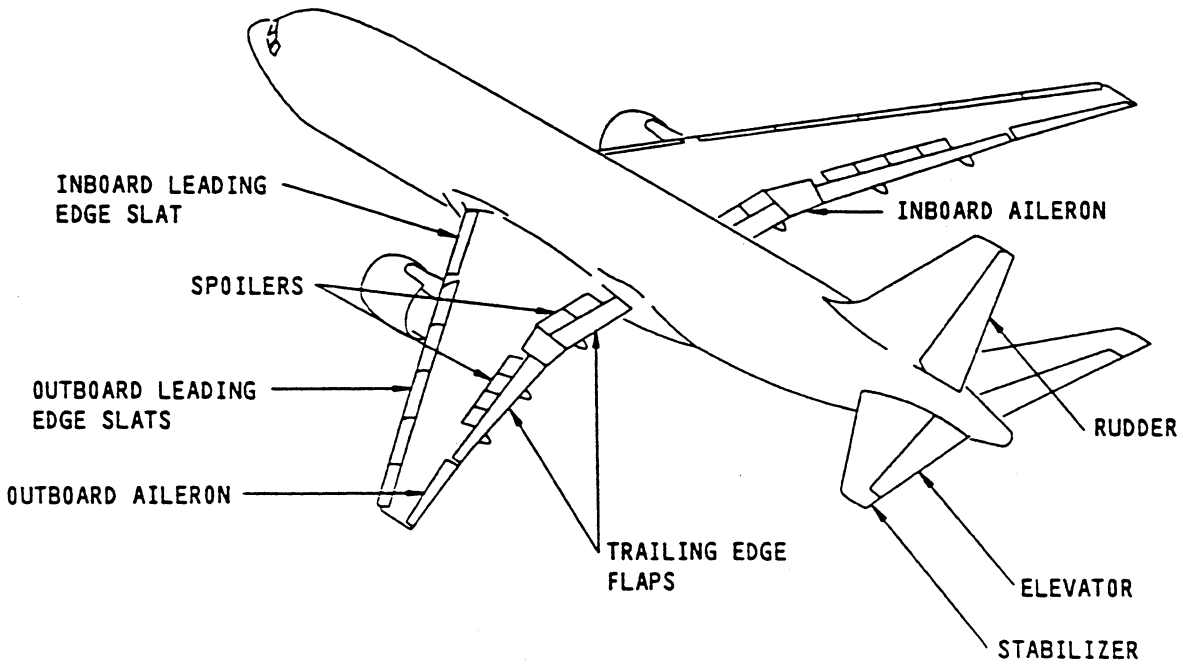
The primary flight controls are the ailerons, elevators and rudder. Flight controls are powered from the three airplane hydraulic systems. There is no manual reversion.

Spoilers assist the ailerons in providing roll control and also operate as speedbrakes. A variable pitch horizontal stabilizer assists the elevators in providing pitch control. High lift for takeoff and landing is provided by trailing edge flaps and leading edge slats. The flaps and slats can also be operated by an alternate electric system.

There are six guarded Flight Control Shutoff Switches. The tail switches control hydraulic power to the elevators and rudder. The wing switches control hydraulic power to the ailerons and spoilers. When the switches are ON, hydraulic power is available for the flight controls when the hydraulic systems are pressurized. When a Flight Control Shutoff Light is illuminated, hydraulic power from that system is not available to the indicated flight controls. When an OFF light illuminates a L, C or R WING HYD VAL or a L, C or R TAIL HYD VAL advisory message appears on EICAS. If two or more OFF lights illuminate the advisory message changes to FLT CONT VALS.

### JAMMED OR RESTRICTED FLIGHT CONTROLS

Flight control system overrides protect against control column or flight control jams. Overrides bypass the restricted portion of the control system when higher than normal control forces are applied. There is protection against system damage when applying high control forces. When a restricted portion of the flight controls are bypassed, some control effectiveness may be lost.




FLIGHT CONTROL SURFACES LOCATION

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YAW CONTROL

Directional control about the yaw axis is provided by the rudder control system. The rudder is hydraulically powered and controlled through displacement of either pilots rudder pedals. Two yaw dampers operate through the rudder control system to improve directional stability.

Rudder Control System

Displacement of either set of rudder pedals sends a signal to the three rudder hydraulic actuators.

The position of the rudder is shown on the EICAS status display. On the ground, pushing a rudder pedal to its stop causes a full scale deflection of the pointer from the neutral mark.

Rudder trim is available by rotating the Rudder Trim Control in the desired direction. The control provides signals to an electric motor that repositions the rudder neutral point. The Rudder Trim Indicator shows the units of rudder trim that are signaled.

The control signals from the rudder pedals and trim control are modified by a rudder ratio changer. As airspeed increases the ratio changer desensitizes these inputs from the pilot to reduce the rudder deflection.

The ratio changer receives air data computer airspeed inputs and provides control signals to an actuator powered by the left hydraulic system. The actuator then dampens the pilots inputs to the rudder.

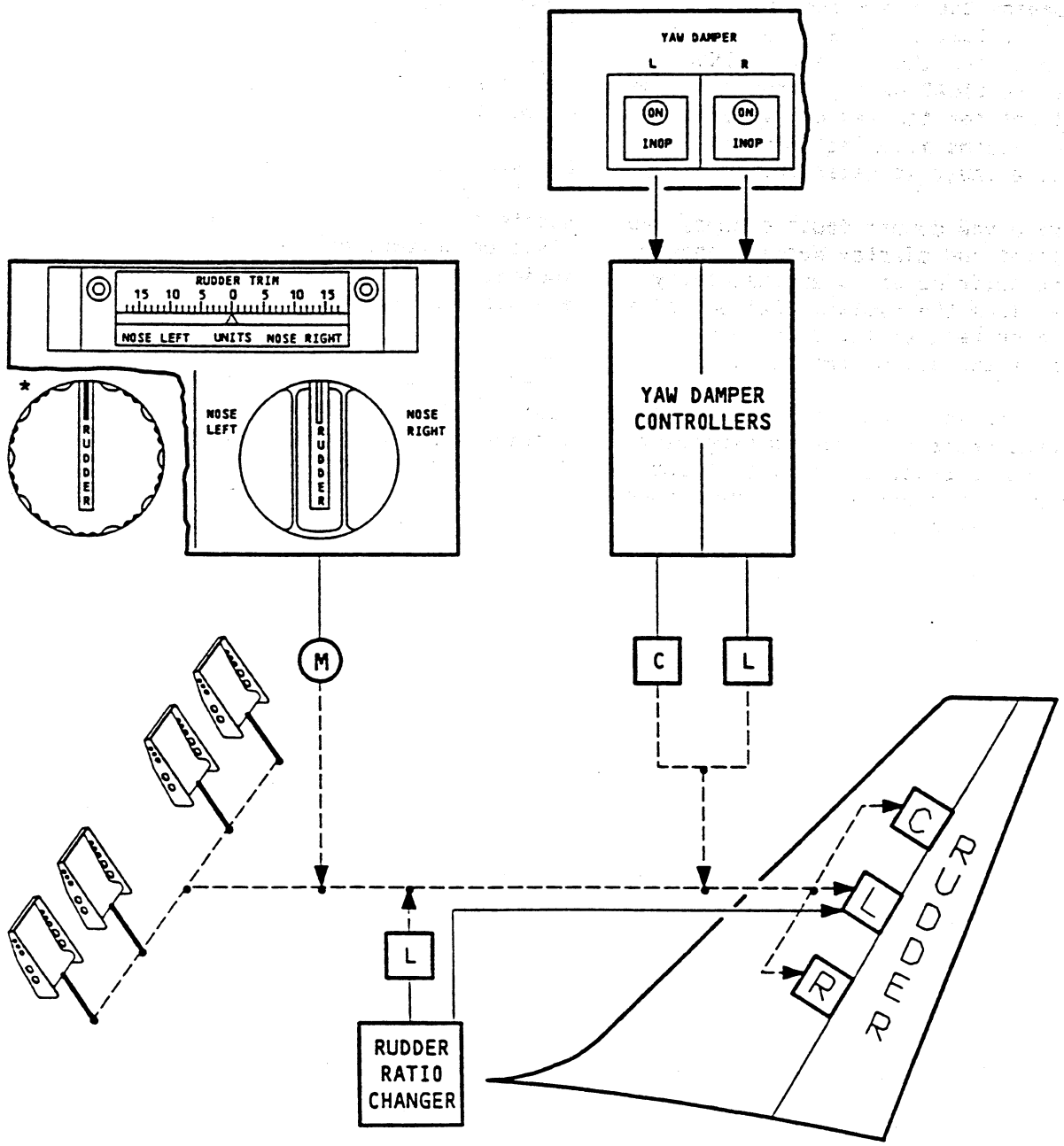
A RUDDER RATIO advisory message appears on EICAS and the Rudder Ratio Light illuminates to indicate control inputs to the rudder are not being correctly modified. Rudder structural protection is provided by automatic depressurization of the left hydraulic system rudder actuator which limits rudder displacement at high airspeeds. However, abrupt rudder pedal input should be avoided at high airspeeds. At low airspeeds the two remaining rudder actuators provide sufficient control for full rudder displacement.

If the left hydraulic system is providing normal pressure to the ratio changer, a fault may result in limited displacement of the rudder at all airspeeds. This requires that crosswind and autoland limitations be observed.

Two independent yaw damper systems operate continuously in flight to improve the airplanes directional stability and turn coordination. Each system has a yaw damper controller. The controller provides signals to operate a yaw damper actuator which in turn generates rudder control inputs. The left and right yaw damper actuators are powered by the center and left hydraulic systems respectively.

When the Yaw Damper Switches are ON and the Yaw Damper Inoperative Lights are extinguished, the systems are powered and no faults exist.

When yaw damper system electrical power is initially established an electrical self-test occurs.




* As installed

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RUDDER CONTROL DIAGRAM

Rudder Control System (Cont)

The entire yaw damper system can be tested on the ground with the Yaw Damper Test Switch. The test requires one aligned IRS and hydraulic power for the yaw damper system to be tested. Momentarily moving the test switch to L or R begins the ten second test. During the test all IRS panel lights illuminate and the yaw damper INOP lights and EICAS messages appear. The INOP light for the yaw damper being tested remains illuminated after the test if a fault is detected.

Anytime a yaw damper fault occurs, the INOP light and display message appear and hydraulic power is automatically removed from the system. Failure of a yaw damper reduces the total yaw damping authority by one half.

Pushing the Yaw Damper Switch OFF is a redundant means of removing hydraulic power from a system. The INOP light and display message always appear when the switch is off.

PITCH CONTROL

The pitch control surfaces consist of two hydraulically powered elevators and a hydraulically powered stabilizer.

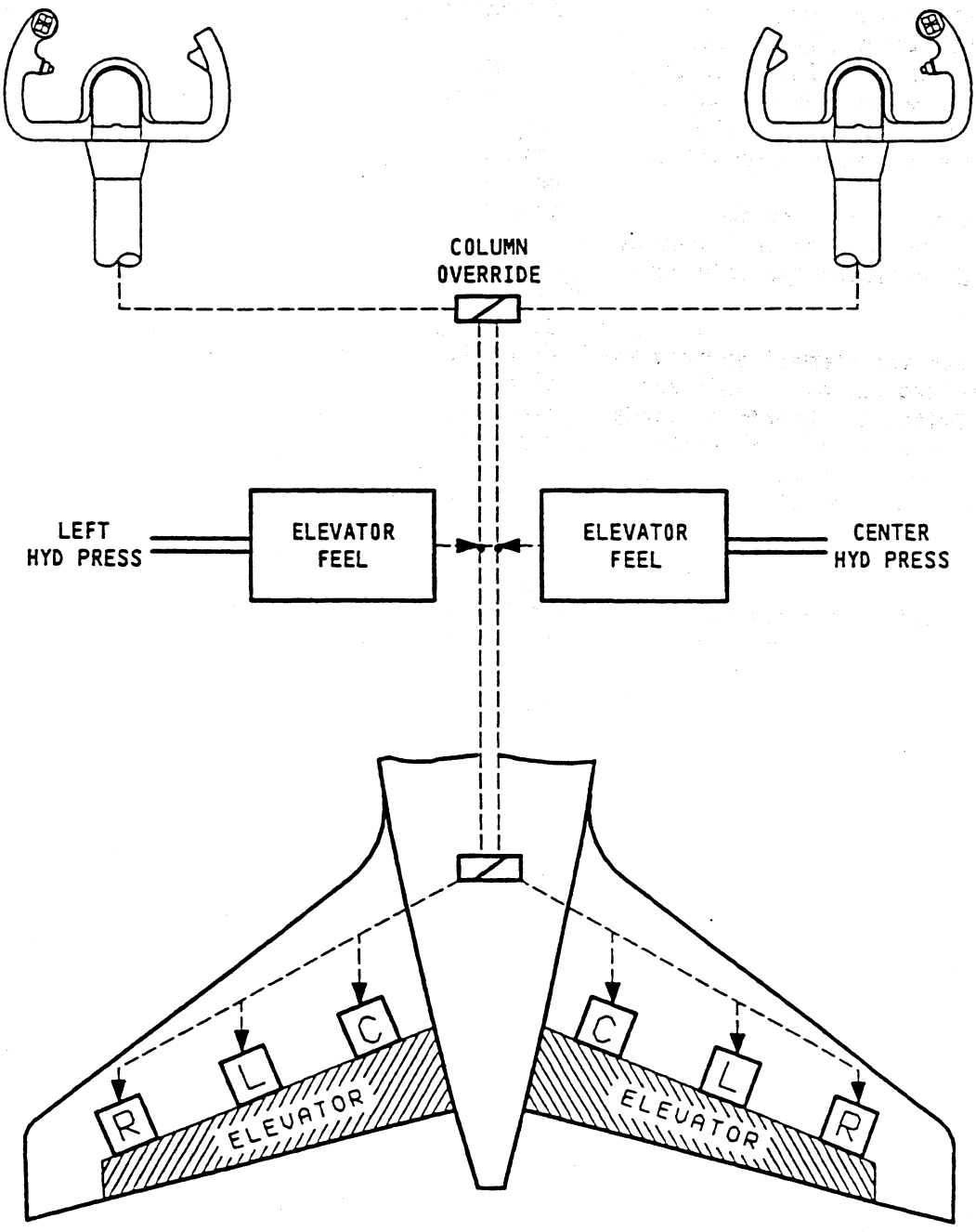
Elevator

Moving either control column sends signals to the hydraulic actuators on the elevators. There are three actuators for each elevator.

If one control column should jam, applying significant forward or aft force to the other causes the two columns to override. Pitch control is then available using the free control column path.

Elevator positions are shown on the EICAS status display. Separate pointers indicate the left and right elevator deflection. A full scale indication corresponds to the maximum elevator deflection.

Two elevator feel systems provide artificial feel forces to the pilots control columns. Mechanical springs provide feel following a loss of L and C hydraulic systems.




ELEVATOR CONTROL DIAGRAM

## Stabilizer

### General

The stabilizer trim control system provides pitch trim by varying the horizontal stabilizer angle. The stabilizer is positioned by dual trim control modules which use hydraulic power to reposition the stabilizer through a motor and brake mechanism.

The rate of trim varies and is controlled by the trim control modules. When airspeed increases the trim rate decreases.

Hydraulic power for stabilizer trim is controlled by two guarded Stabilizer Trim Cutout Switches. When the guards are closed, the switches are in the NORM position and hydraulic power is available for trim when the left and center hydraulic systems are pressurized.

Stabilizer position is shown on indicators located on either side of the control stand. The indicators show the stabilizer position in units of trim. Green bands indicate the normal trim settings for takeoff.

There are three modes of stabilizer trim control: electric, manual/alternate and automatic.

### Electric Trim

Dual Electric Trim Switches are located on each Control Wheel. Actuating both switches provides electrical arming and direction signals to the two trim control modules.

### Manual/Alternate* Trim

The Stabilizer Trim Levers (or Alternate Stabilizer Trim Switches*) provide backup trim control. Moving both levers (switches) provides mechanical (electrical) arming and direction signals to both trim control modules. The signals from the manual trim levers override all other trim inputs. The signals from the electrical trim switches neutralize any other conflicting trim inputs.

### Automatic Trim

The stabilizer is controlled automatically by the autopilots. Automatic stabilizer trim uses only one trim control module and trims at one-half the electric or manual/alternate trim rate.

### Non-normal Operation

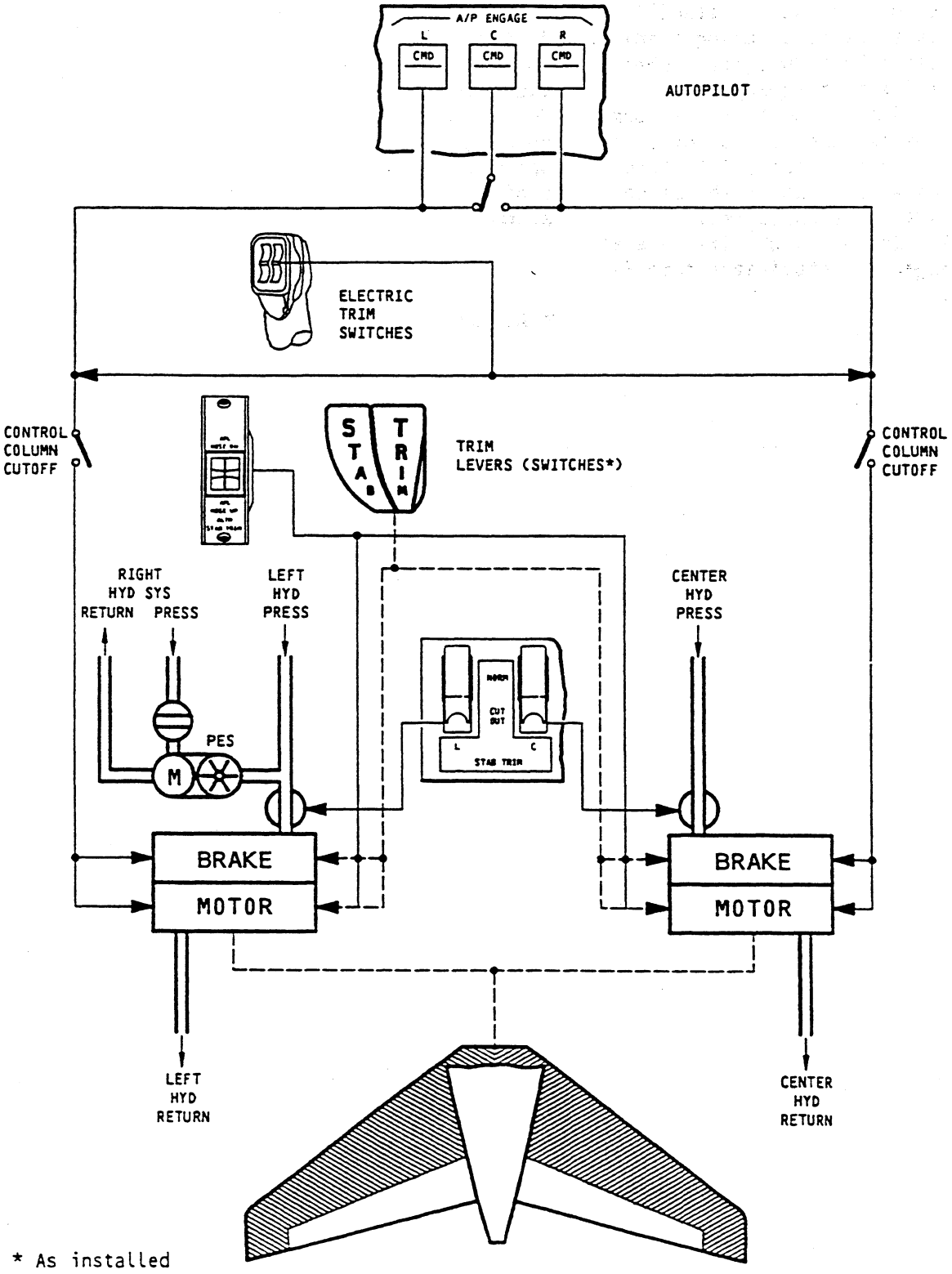
If a single autopilot is engaged, electric trimming causes the autopilot to disengage. If multiple autopilots are engaged, the Electric Trim Switches are inhibited. Manual/alternate trimming does not cause disengagement of the autopilot(s).

An unscheduled stabilizer trim condition is detected anytime the stabilizer moves without receiving a trim signal. Unscheduled trim is also detected if the stabilizer is moving in the opposite direction signaled by the autopilot. The Unscheduled Stabilizer Trim Light illuminates and the UNSCHD STAB TRIM caution message appears when either condition occurs. The light and message also occur if manual/alternate trim is used with an autopilot engaged.

A Control Column operated trim cutoff enables either pilot to stop stabilizer movement. Moving the Control Column in the direction opposing stabilizer trim cuts off electric and automatic trim signals to the trim control modules.

Moving the Stabilizer Trim Cutout Switches to CUTOUT shuts off hydraulic power to the trim control modules.

*As installed




* As installed

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STABILIZER CONTROL DIAGRAM

Stabilizer (Cont)

The Stabilizer Trim Light illuminates and the STAB TRIM advisory message appears when one of the two stabilizer brakes fails to release during trimming by the Electric Trim Switches. When one brake fails to release, the stabilizer trims at one-half the normal rate. If the malfunction is unique to the electric trim control, full trim rate is available by using the manual trim levers (or alternate trim switches*). If both stabilizer brakes remain engaged, no stabilizer trim is available.

Loss of both the left and center hydraulic systems inflight opens a shutoff valve to automatically activate the Pitch Enhancement System (PES). The PES consists of a hydraulic motor in the right system driving a pump which uses trapped left trim system fluid to operate the stabilizer. The PES trims at approximately 1/4 the normal rate. When the PES is operating, only electric trim is available; manual/alternate and automatic trim will be inoperative.

* As installed

BOEING 767
OPERATIONS MANUAL

(INTENTIONALLY LEFT BLANK)

ROLL CONTROL

The roll control surfaces consist of hydraulically powered ailerons and spoilers that are controlled by rotating either Control Wheel.

The Control Wheels are connected so that, if one Control Wheel jams, using significant force causes the Control Wheels to override. Roll control is then available using the free Control Wheel.

The inboard ailerons droop in conjunction with trailing edge flap extension.

Ailerons

Two ailerons are located on each wing on either side of the outboard trailing edge flap. Rotating either Control Wheel sends a signal to the aileron hydraulic actuators. Two actuators are used for each aileron.

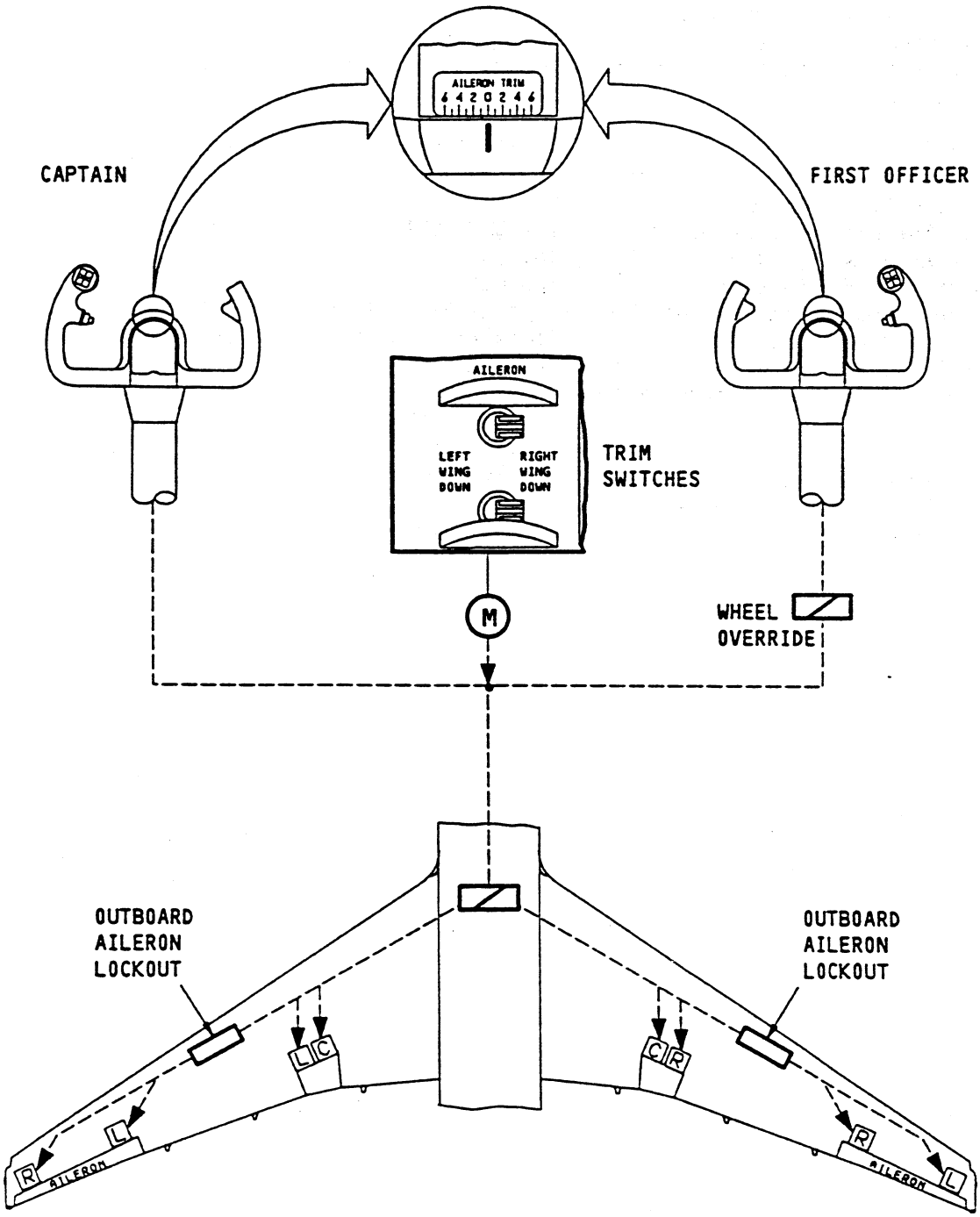
Aileron positions are shown on the EICAS status display. Separate pointers indicate the inboard and outboard aileron positions on each wing. A full scale deflection of the position indicator corresponds to maximum aileron travel.

Aileron trim is accomplished by pushing both Aileron Trim Switches in the desired direction. The switches provide arming and direction signals to an electric motor that repositions the aileron neutral (trimmed) point. Hydraulic power from one of the three hydraulic systems is necessary to accurately set aileron trim. An Aileron Trim Indicator is located on each Control Column and indicates in units of trim.

NOTE: If the flight crew inadvertently activates aileron trim while an autopilot is engaged, the repositioning of the aileron neutral point is not apparent to the crew. When the autopilot is disengaged, the Control Wheels and ailerons move to the new (possibly undesired) neutral point and the airplane will roll proportional to the amount of trim input.

An aileron lockout control system permits full travel of the outboard ailerons at low airplane speeds and locks out the outboard ailerons at high airplane speeds. This provides the required roll authority at low airspeeds and prevents overcontrolling at high airspeeds.

An AILERON LOCKOUT advisory message appears and the Aileron Lockout Light illuminates to indicate a fault in the aileron lockout system. At high airspeeds (around cruise speeds) it may indicate that one or both of the outboard ailerons failed to lockout. When the message and light appear at low airspeeds (around approach speeds) it may indicate that one or both of the outboard ailerons failed to unlock.




AILERON CONTROL DIAGRAM

SPOILERS/SPEEDBRAKES

There are six spoiler panels located on each upper wing surface just forward of the trailing edge flaps. Specific spoiler panels on each wing operate with the ailerons to provide roll control and operate as inflight speedbrakes. All six spoiler panels on each wing function as ground speedbrakes.

The Control Wheels and the Speedbrake Lever send signals to the spoiler controller. The spoiler controller combines the signals from the Control Wheels and the Speedbrake Lever, determines the required spoiler panel deflection, and then signals the spoiler panel actuators to operate. A separate hydraulic actuator powers each spoiler panel.

The roll spoilers are signaled to operate by rotating either Control Wheel.

The speedbrakes are controlled by using the Speedbrake Lever. The speedbrakes also operate automatically when the airplane is on the ground. Placing the lever in the DOWN detent signals all spoiler panels to the full down (retracted) position. Moving the Speedbrake Lever to the UP position signals spoiler panels to extend to the full up position. The speedbrakes extend to a greater maximum angle on the ground than in flight.

Moving the Speedbrake Lever to the ARMED position signals the spoiler panels to extend automatically after landing. The Speedbrake Lever moves to the UP position and the spoiler panels extend when all of the following conditions occur:

- there is hydraulic pressure to both landing gear truck tilt actuators
- both truck tilt sensors detect a no-tilt condition (airplane on the ground)
- both Thrust Levers are at idle

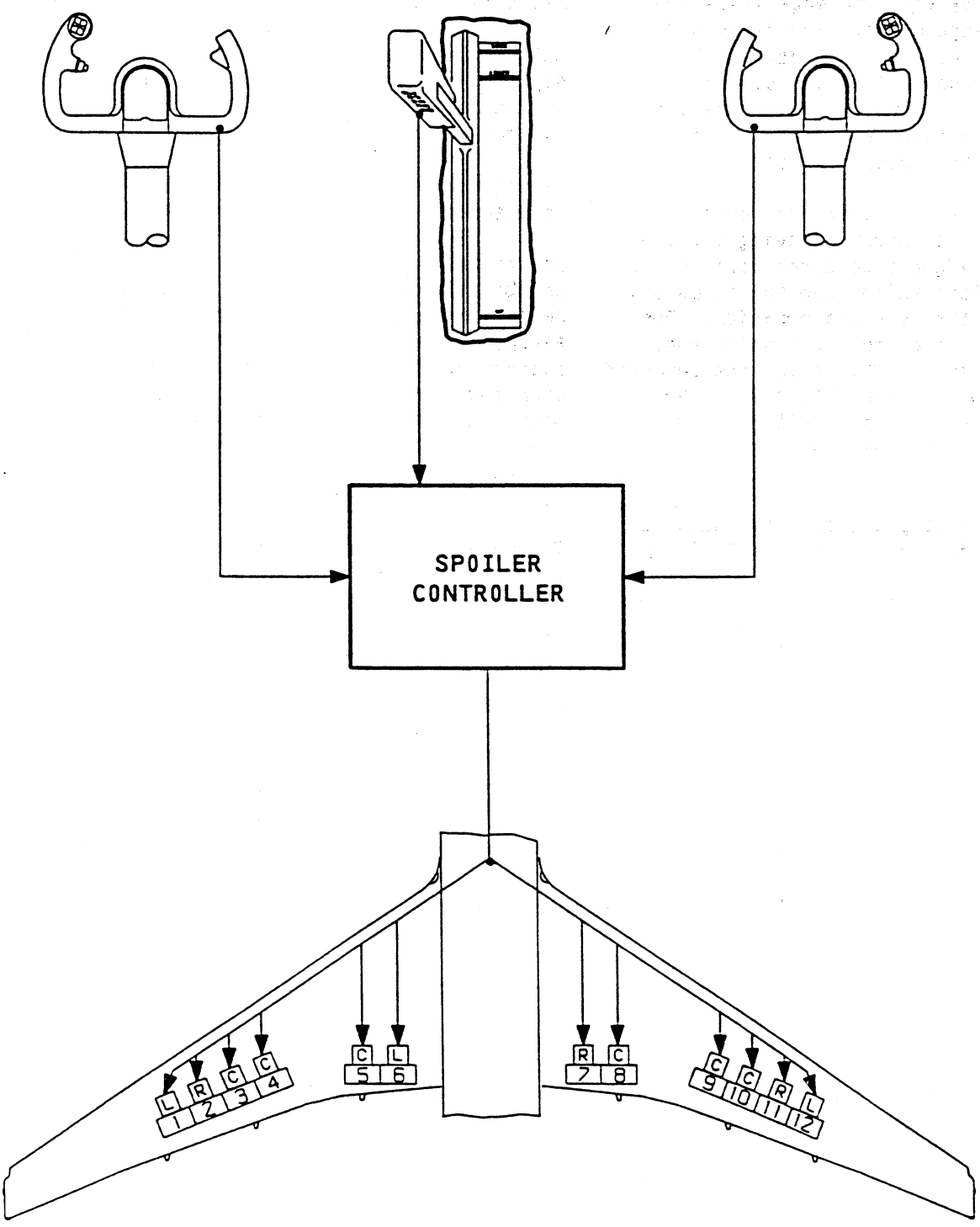
Following automatic speedbrake extension, if any of the three conditions are no longer met, the Speedbrake Lever moves to the DOWN position and the spoiler panels retract.

The speedbrakes also extend automatically anytime the above three conditions occur and either Reverse Thrust Lever is raised to its interlock stop. The Speedbrake Lever does not need to be in the ARMED position.

The SPEEDBRAKES EXT message appears and the Speedbrakes Light illuminates to indicate that the Speedbrake Lever is beyond the ARMED detent with the Captain's radio altitude between 800 feet and 15 feet. The same message and light occur when the Speedbrake Lever is beyond the ARMED detent with landing flaps extended and the Captain's radio altitude above 15 ft.

The AUTO SPEEDBRAKE advisory message appears and the Auto Speedbrake Light illuminates to indicate a fault in the system which may result in the loss of automatic speedbrake extension. If the Speedbrake Lever is armed, the message and light indicate a fault which may result in an inadvertent speedbrake extension inflight. The Speedbrake Lever should be returned to the DOWN position. The speedbrakes can still be operated manually. If the speedbrakes are extended manually inflight, they must also be retracted manually.

The SPOILERS advisory message appears and the Spoilers Light illuminates to indicate that one or more spoiler system faults have been detected and spoiler/speedbrake capability is reduced.




SPOILER CONTROL DIAGRAM

FLAP/SLAT CONTROL SYSTEM

General

High lift for takeoff and landing is provided by trailing edge flaps and leading edge slats. The flaps and slats are normally operated with hydraulic power from the center hydraulic system. An alternate system allows the flaps and slats to be operated by electric motors.

Flap and slat position is controlled with the Flap Lever. Moving the lever provides signals to three Power Drive Units (PDUs) which move the flaps and slats to the selected position. One PDU drives the inboard leading edge slats, a second PDU drives the outboard slats and the third PDU drives the trailing edge flaps. All three PDUs are powered by the center hydrauilc system.

Flap and slat positions are indicated by two pointers in the Flap Position Indicator. There are L and R pointers for the left and right wing flaps and slats. The right pointer is normally hidden from view by the left pointer.

Normal Operation

When the Flap Lever is in the UP detent all flaps and slats are retracted and the flap position indicator points to UP.

Moving the flap lever to position 1 signals the slats to extend to their takeoff position. The trailing edge flaps remain retracted. The position indicator pointers move mid-way between UP and 1 when the slats are in-transit. The pointers move to the 1 mark when the slats are in the takeoff position.

Placing the flap lever in positions 5, 15 or 20 signals the flaps to extend to the selected position. The inboard ailerons droop in conjunction with flap extension. The slats remain in the takeoff position. The position indicator provides only trailing edge flap position indications for all flap settings greater than 1.

Moving the flap lever to position 25 signals the slats to extend to their landing position and the flaps to extend to the selected setting.

Selecting position 30 signals the flaps to extend to the full down position.

Selecting position 25 (-300 airplanes) or 30 (all airplanes) arms a flap load relief system. If the selected flaps airspeed limit is exceeded the flaps automatically retract to the 20 (-300 airplanes) or 25 (-200 airplanes) position. The flap lever does not move. The flaps extend back to the selected position when the airspeed is sufficiently reduced.

The maximum flap extension speeds are placarded around the flap position indicator.

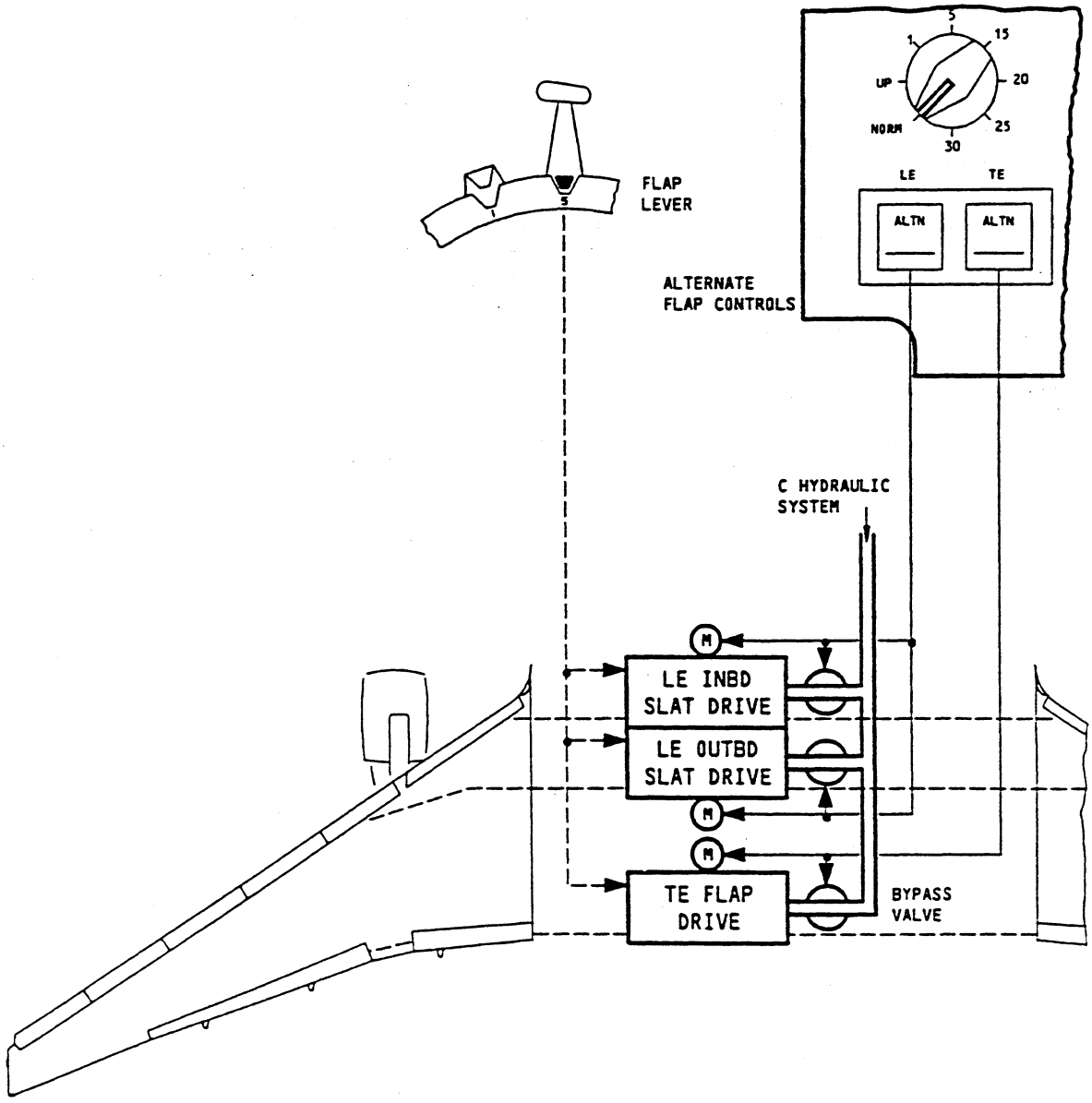
The flap maneuvering speeds allow a normal 25 degree bank for maneuvering plus an additional 15 degree bank safety factor before initial buffet is encountered. Flap maneuvering speeds are based on the flaps 30 VREF as follows:

| | |
|---|---|
| Flaps 0 | at VREF +80 kts |
| Flaps 1 | at VREF +60 kts |
| Flaps 5 | at VREF +40 kts |
| Flaps 15/20 | at VREF +20 kts |

Non-normal Operation

Alternate Flap Operation

An alternate flap drive system allows the PDUs to be driven by electric motors rather than hydraulic power.

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FLAP/SLAT CONTROL DIAGRAM

During normal operations the Alternate Flaps Selector is in the NORM (normal) position.

There are two Alternate Flap Switches, one for the leading edge drive system and one for the trailing edge drive system. When the switches are blank, the alternate flap system is deactivated.

When an Alternate Flaps Switch is pushed on, ALTN appears in the switch. Hydraulic pressure is then bypassed and electrical power is made available to the selected flap or slat PDUs.

Rotating the Alternate Flap Selector signals the flaps and slats to move to the selected position. Extension of the flaps and slats from UP to position 20 with the alternate system requires approximately 3 minutes. Asymmetry and flap load relief protection are not provided during alternate flap operation.

Leading Edge Disagreement

When the inboard or outboard slats are not in their commanded position, or not driving toward their commanded position, an LE SLAT DISAGREE caution message appears and the Leading Edge Light illuminates. The light and message do not appear as long as the slats are driving toward their commanded position. If a disagree occurs, the slats can be positioned using the alternate system.

An LE SLAT DISAGREE may also occur if the Flap Lever is not in a detent for an extended period of time. In this case, the light and message can be removed by moving the Flap Lever to the desired detent.

Leading Edge Asymmetry

When a leading edge slat asymmetry is detected the affected slats can no longer be positioned by the hydraulic system. The Leading Edge Light illuminates and a LE SLAT ASYM caution message appears on EICAS. When a LE SLAT ASYM message appears the ASYMMETRY procedure is used.

Trailing edge flap extension is inhibited until the slats extend to position 1. Therefore, if a slat asymmetry occurs between the UP and 1 positions, the trailing edge flaps are extended by the alternate system. The slats should not be operated by the alternate system due to the lack of asymmetry protection.

Trailing Edge Disagreement

When the flaps are not in their commanded position, or not driving toward their commanded position, a TE FLAP DISAGREE caution message appears and the Trailing Edge Light illuminates. The light and message do not appear as long as the flaps are driving toward their commanded position. If a DISAGREE occurs, the flaps can be positioned by the alternate system.

A TE FLAP DISAGREE may also occur if the Flap Lever is not in a detent for an extended period of time. In this case, the light and message may be removed by moving the Flap Lever to the desired detent.

Trailing Edge Asymmetry

When a trailing edge flap asymmetry is detected, hydraulic power to the trailing edge flap PDU is automatically shutoff. The TRAILING EDGE Light illuminates and a TE FLAP ASYM caution message appears. When a TE FLAP ASYM message appears, the ASYMMETRY procedure is used. Alternate trailing edge flap operation is not used due to the lack of asymmetry protection.

Load Relief Inoperative

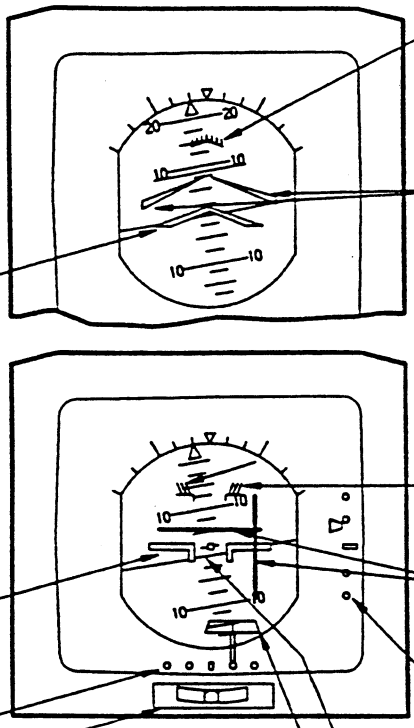
The FLAP LD RELIEF advisory message is displayed and the Trailing Edge Light illuminates when the flap load relief system fails to operate when required.

Hydraulic Driven Generator

When the Hydraulic Driven Generator is supplying electical power, hydraulic flow to the flap/slat mechanism is mechanically reduced, resulting in increased flap/slat operating time.

# CHAPTER 14

## FLIGHT INSTRUMENTS



PILOTS PANEL (2)
(As installed)

PITCH LIMIT INDICATOR

- appears when flaps are extended
- displays the pitch attitude at which stick shaker occurs

FLIGHT DIRECTOR COMMAND BARS

- appear when respective FD switch on, valid command steering is available, and the selected FD and A/P (in CMD) are not the same*
- disappear when the respective FD switch is off, command steering becomes unreliable or when the same FD and A/P (in CMD) are selected*

PITCH LIMIT INDICATOR
(see description above)

FLIGHT DIRECTOR COMMAND BARS
(see description above)

GLIDE SLOPE POINTER AND DEVIATION SCALE

- pointer indicates glideslope position
- scale indicates deviation
- pointer is not displayed when a no computed data condition exists or when track and the front course on the ILS panel differ by more than 90°
- scale and pointer removed when ILS frequency is not selected
- scale and pointer can display ILS deviation monitoring (as installed)

HORIZON LINE AND PITCH ANGLE SCALE

RISING RUNWAY (as installed)

- appears when localizer pointer is in view and radio altitude below 2500 ft AGL
- rises when below 200 feet AGL
- stem can display ILS Deviation monitoring (as installed)

SLIP INDICATOR

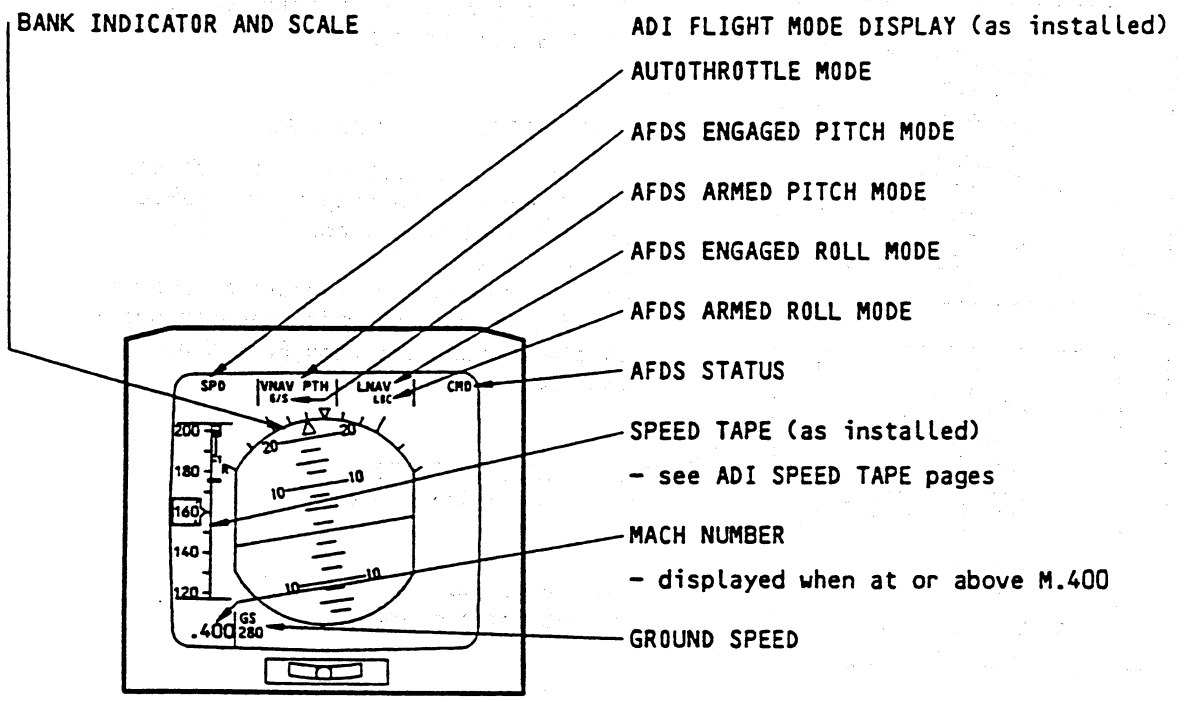
LOCALIZER POINTER AND DEVIATION SCALE

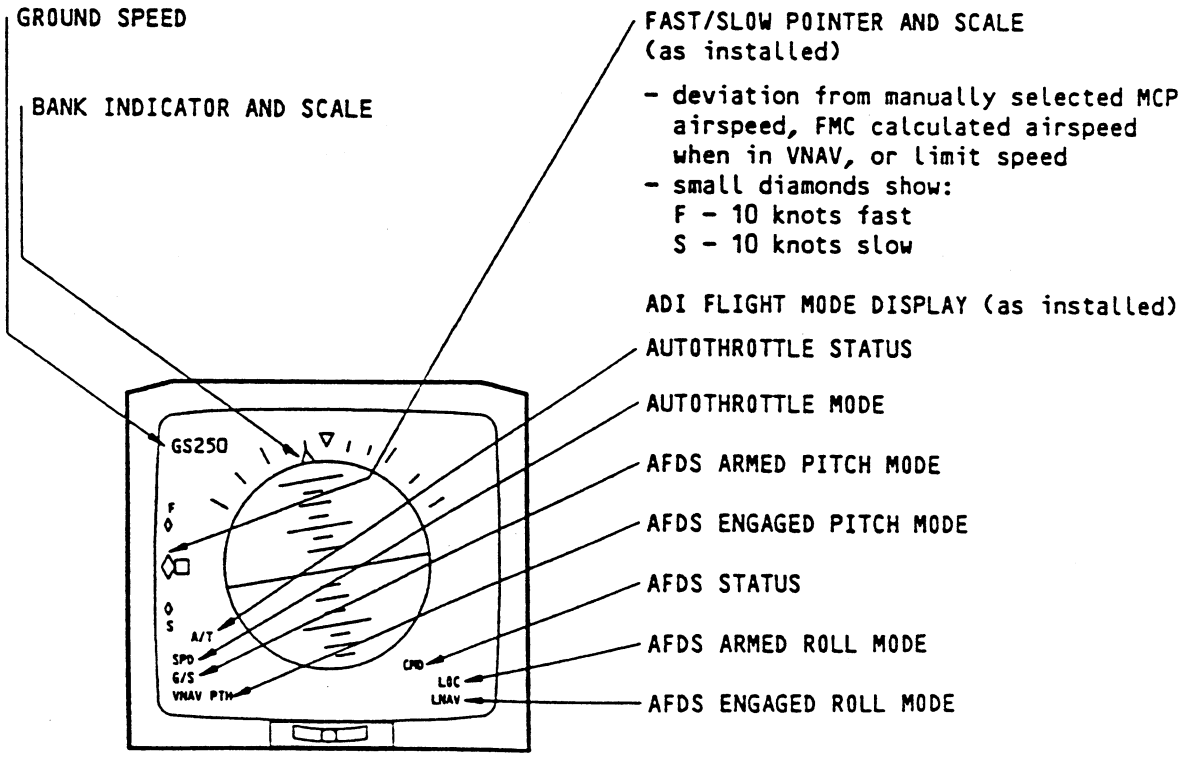
- pointer indicates localizer position
- scale indicates deviation
- when LOC is engaged and deviation slightly more than one half dot, scale expands (not shown here)
- pointer is not displayed when a no computed data condition exists
- scale and pointer removed when ILS frequency is not selected
- scale and pointer can display ILS deviation monitoring (as installed)

AIRPLANE SYMBOL

* On some installations, FD command bars are in view at all times regardless of autopilot/flight director FCC selection.

ATTITUDE DIRECTOR INDICATOR (ADI) DISPLAY




ATTITUDE DIRECTOR INDICATOR (ADI) DISPLAY

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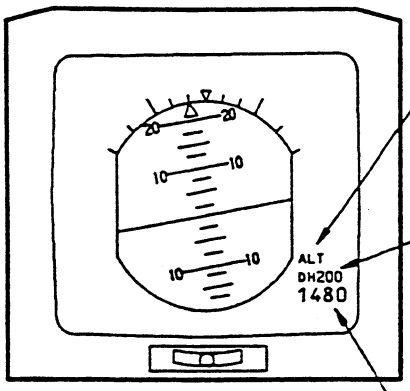



HEIGHT ALERT (As installed)

- appears when between 2500 feet to 500 feet RA and on some airplanes from 1000 feet to 500 feet RA.
- blanked by pushing RST switch on ADI Control Panel

DECISION HEIGHT (As Installed)

- blank when negative DH is selected
- displays selected decision height as set on the ADI control panel
- alert indicated at the selected DH during descent by changing color, size and momentarily flashing 'DH'
- reset automatically to selected decision height for missed approach after 75 feet above set DH or pushing RST switch on ADI control panel

RADIO ALTITUDE (As Installed)

- blank above 2500 feet RA
- presents radio altitude when below 2500 feet RA
- presents the circular ring and scale with 100 foot increments and digital radio altitude at and below 1000 feet RA. As the airplane descends, segments of the ring erase indicating radio altitude
- descending through DH causes the remaining ring, scale and digital readout to change from white to amber and flash momentarily
- changes to white after touchdown

RADIO ALTITUDE (As Installed)

- blank above 2500 feet AGL
- displays radio altitude below 2500 feet AGL
- changes color from white to amber when below selected DH on descent
- changes to white when passing selected DH plus 75 feet during go-around, after touchdown, or after pushing RST switch on ADI control panel

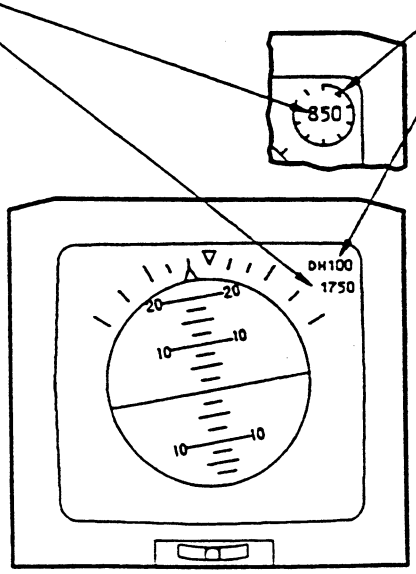
DECISION HEIGHT (As Installed)

Above 1000 feet RA:

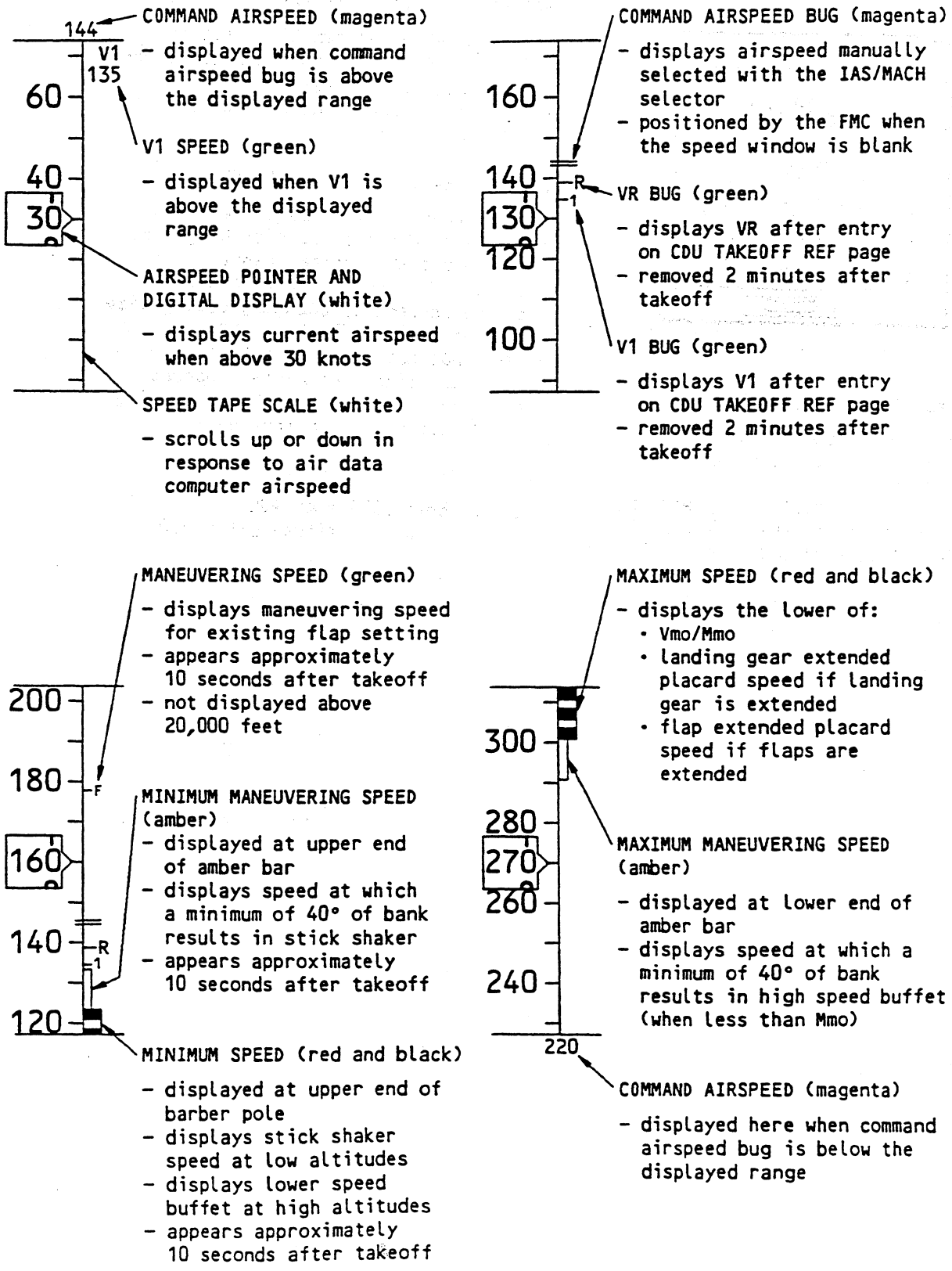
- presents DH letters and selected decision height as set on ADI control panel
- blank when a negative value is selected

Below 1000 feet RA:

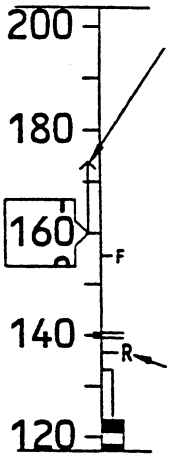
- presents a DH marker corresponding to selected value. During descent at decision height plus 50 feet, an alert tone sounds. At decision height the DH marker changes from magenta to amber and flashes momentarily
- blank when a negative DH value is selected




ATTITUDE DIRECTOR INDICATOR (ADI) DISPLAY




ADI SPEED TAPE




AIRSPEED TREND ARROW (green)

- tip of arrow depicts predicted airspeed within the next 10 seconds based on present airspeed and acceleration
- arrow points upward during acceleration and downward during deceleration

VREF BUG (green)

- displays VREF after selection on the CDU APPROACH REF page
- entry on CDU permissible only after V1 and VR are no longer displayed

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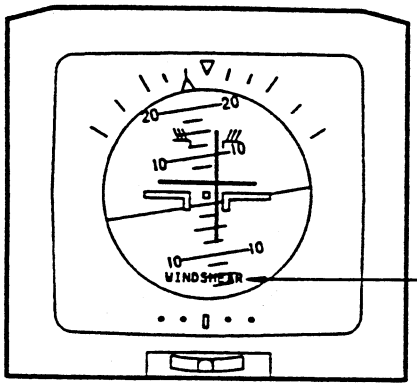
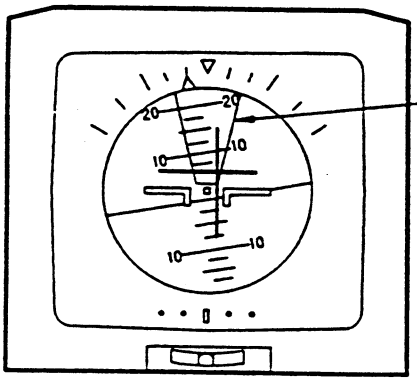
ADI SPEED TAPE



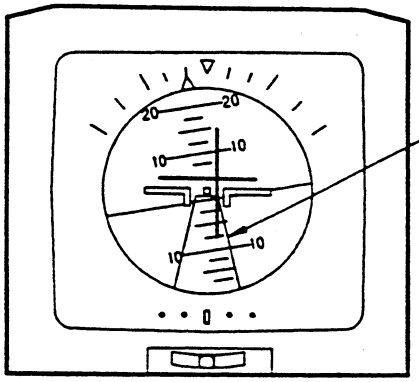

WINDSHEAR WARNING (red)

- displayed on the ADI at the same time the WINDSHEAR light is illuminated (see Chapter 22)




TCAS* RA PITCH COMMAND (red)
(Down Advisory)

- displayed during a RA condition
- indicates pitch attitude to be avoided for traffic separation (see Chapter 22)




TCAS* RA PITCH COMMAND (red)
(Up Advisory)

- displayed during a RA condition
- indicates pitch attitude to be avoided for traffic separation (see Chapter 22)

* As installed

ATTITUDE DIRECTOR INDICATOR (ADI) DISPLAY

SPEED FLAG

- Speed Tape display is inoperative [1]
- removes SEL SPD, $V_1$ INOP and SPD LIM messages [1]
- Speed deviation data has failed [2]

$V_1$ INOPERATIVE MESSAGE [1]

- $V_1$ display is inoperative

SELECTED SPEED MESSAGE [1]

- command airspeed bug is inoperative

DECISION HEIGHT FLAG (As installed)

- selected decision height data has failed while below 1000' AGL

RADIO ALTITUDE FLAG (As installed)

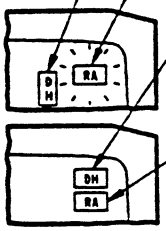
- radio altimeter has failed while below 1000' AGL

DECISION HEIGHT FLAG (As installed)

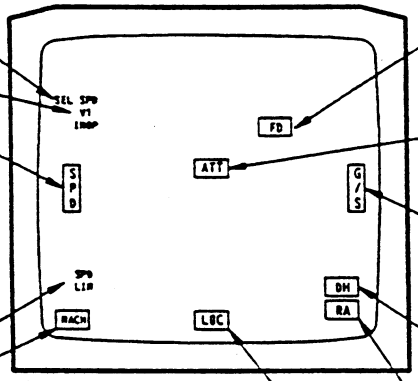
- selected decision height data has failed while above 1000' AGL

RADIO ALTITUDE FLAG (As installed)

- radio altimeter has failed while at or above 1000' AGL




ADI FAILURE FLAGS/MESSAGES




FLIGHT DIRECTOR FLAG

- selected flight director has failed

ATTITUDE FLAG

- selected IRS attitude has failed

GLIDESLOPE FLAG

- glideslope has failed

DECISION HEIGHT FLAG (As installed)

- selected decision height data has failed

RADIO ALTITUDE FLAG (As installed)

- radio altimeter has failed

LOCALIZER FLAG

- localizer receiver has failed

MACH FLAG

- mach display has failed

SPEED LIMIT MESSAGE [1]

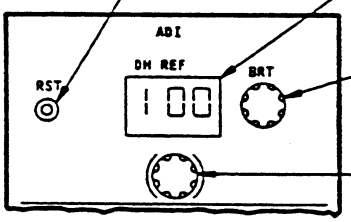
- minimum and/or maximum speed displays have failed

[1] Only on ADIs with Speed Tape Display

[2] Only on ADIs with Fast/Slow Display

NOTE: All flags and annunciations are amber.

ADI FAILURE FLAGS




CONTROL STAND (2)

**DECISION HEIGHT RESET SWITCH**

PUSH - resets a DH alert to selected decision height
- changes RA display from amber to white
- automatic reset occurs on touchdown or on climbing more than 75 feet above DH during go-around

**DECISION HEIGHT REFERENCE INDICATOR**

- selected decision height
- also displayed on ADI

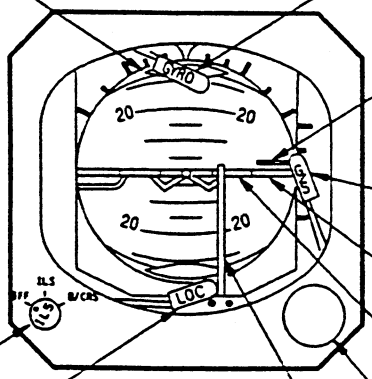
**ADI BRIGHTNESS CONTROL**

- selects a minimum to maximum brightness range

**DECISION HEIGHT SELECTOR**

- selects decision height for Reference Indicator

ATTITUDE DIRECTOR INDICATOR (ADI) DISPLAY/CONTROL PANEL




CENTER PANEL

BANK INDICATOR AND SCALE

GYRO FLAG
- attitude is unreliable

GLIDESLOPE POINTER AND DEVIATION SCALE
- pointer indicates glideslope position
- pointer not displayed when ILS selector is OFF or no computed data exists
- scale indicates deviation

GLIDESLOPE FLAG
- glideslope receiver has failed

HORIZON LINE AND PITCH ANGLE SCALE

AIRPLANE SYMBOL

CAGING CONTROL

PULL - levels horizon with airplane symbol

RELEASE - control retracts

LOCALIZER FLAG
- localizer receiver has failed

ILS SELECTOR

OFF - pointers and failure flags retracted from view

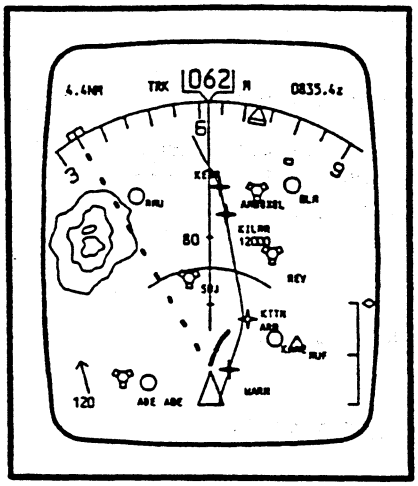
ILS - pointers indicate position from localizer and glideslope
- ILS signals are provided by C-ILS receiver

B/CRS* - reverses sensing for localizer pointer
- used during backcourse approach

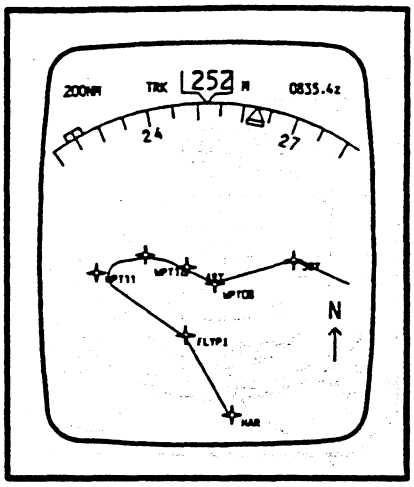
LOCALIZER POINTER AND DEVIATION SCALE
- pointer indicates localizer position
- pointer not displayed when ILS selector is OFF or no computed data exists
- scale indicates deviation
- expanded localizer scale not available

* Placarded INOP on some airplanes

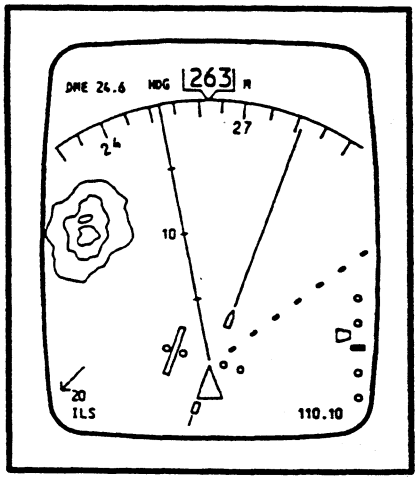
MAP MODE



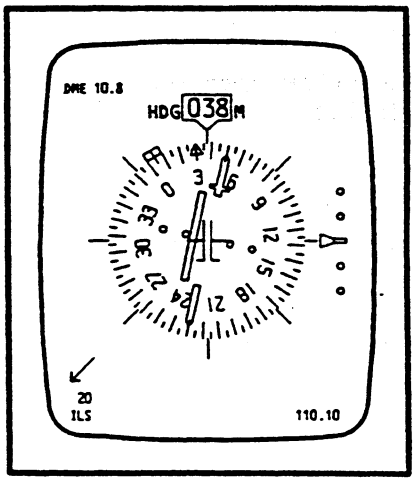

PLAN MODE



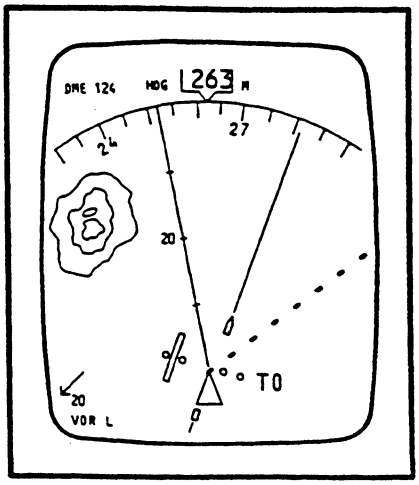

EXPANDED ILS MODE




FULL ILS MODE

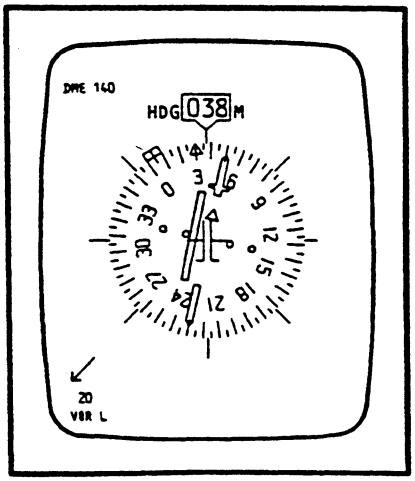



EXPANDED VOR MODE




NOTE: For detailed explanation, consult HSI symbology starting on next page.

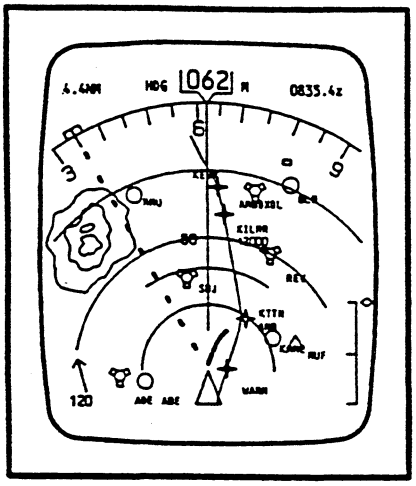
FULL VOR MODE




PILOTS PANEL (2)

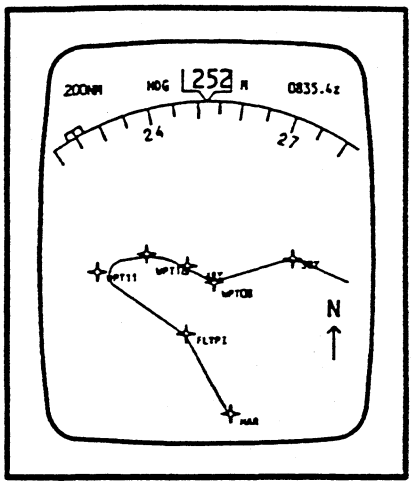
HORIZONTAL SITUATION INDICATOR (HSI) DISPLAY MODES
(TYPICAL)

MAP MODE*

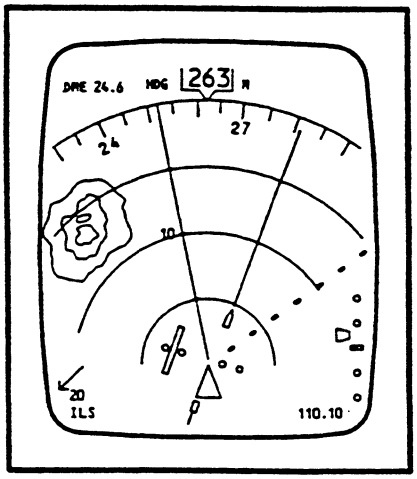



* MAP/PLAN Mode Heading Up orientation and Range Arcs as installed

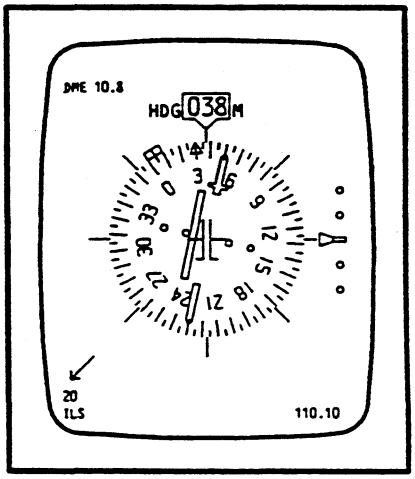
PLAN MODE*



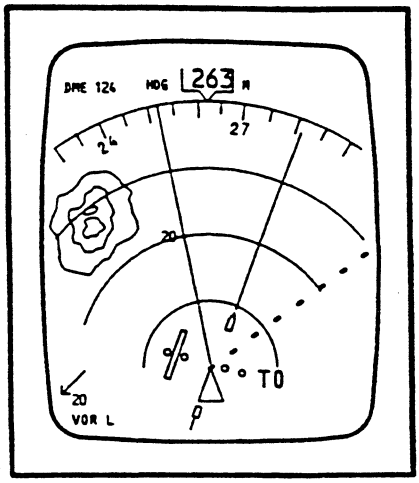

EXPANDED ILS MODE



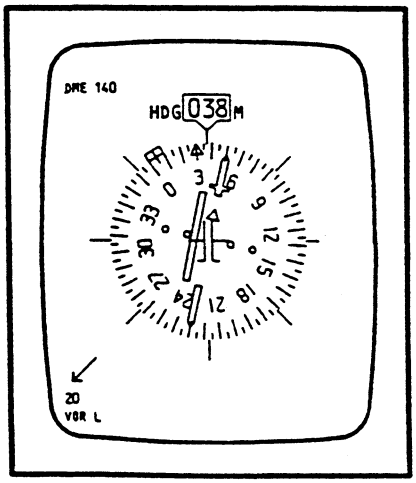

FULL ILS MODE




EXPANDED VOR MODE




FULL VOR MODE




NOTE: For detailed explanation, consult HSI symbology starting on next page.

PILOTS PANEL (2)

HORIZONTAL SITUATION INDICATOR (HSI) DISPLAY MODES (TYPICAL)

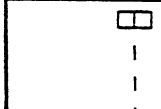
B42821

(INTENTIONALLY LEFT BLANK)

## HSI Symbology

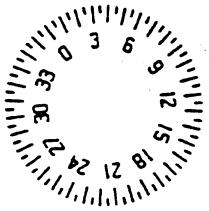
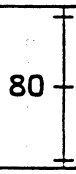
The following symbols can be displayed on each HSI depending on HSI control panel switch selection. Symbols can be displayed with different colors. General color presentation is as follows:

GREEN (G) - indicates engaged flight mode displays, dynamic conditions
WHITE (W) - indicates present status situation, scales, armed flight mode displays
MAGENTA (M)(pink) - indicates command information, pointers, symbols, fly-to condition
CYAN (C)(blue) -indicates non-active and background information
RED (R) - indicates warning
AMBER (A) - indicates cautionary information, faults, flags
BLACK (B) - indicates blank areas, off condition

| SYMBOL | NAME | APPLICABLE MODE(S) | REMARKS |
|---|---|---|---|
| 200NM / 4.4NM OR DME 124 / DME 24.6 | DISTANCE DISPLAY (W) | PLAN, MAP OR VOR, ILS | Distance is displayed to next FMC waypoint (nm) or tuned navaid (DME). |
| TRK 062 M | TRACK - orientation (G), indicator (W) and reference (G)* | MAP, PLAN | Indicates number under pointer is a track.Box displays actual track. See System Description. |
| HDG 263 M | HEADING - orientation (G), indicator (W) and reference (G)* | MAP, PLAN, VOR, ILS | Indicates number under pointer is a heading. Box displays actual heading. See System Description. |
| 0835.4z | ETA DISPLAY (W) | MAP, PLAN | Indicates FMC calculated ETA for the active waypoint based on present groundspeed. |
|  | Selected Heading Marker (M) | MAP, ILS, VOR, PLAN | Indicates the heading set in the MCP. A dashed line (M) extends from the marker to the airplane symbol for ease in tracking the marker when it is out of view (except Plan mode). |
|   | Expanded Compass Rose (W) | MAP, EXP ILS, EXP VOR, PLAN | 360° are available but approximately 70° are displayed. |

* Airplanes may have TRK or HDG indicator installed for MAP and PLAN modes

HSI SYMBOLOGY CHART

| SYMBOL | NAME | APPLICABLE MODE(S) | REMARKS |
|---|---|---|---|
|  | FULL COMPASS ROSE (W) | FULL VOR, FULL ILS | Compass data is provided by the selected IRS. |
|  | Heading Pointer (W)* | MAP, PLAN | Indicates airplane heading when selected mode has track orientation. |
|  80 | PRESENT TRACK LINE and (W) RANGE SCALE | MAP, EXP VOR, EXP ILS | Predicts ground track which will result with present heading and winds. Displayed range mark is one -half the actual selected range. |
|  | AIRPLANE SYMBOL (W) | MAP, EXP VOR, EXP ILS | Represents the airplane and indicates its position at the apex of the triangle. |
|  | AIRPLANE SYMBOL (W) | FULL VOR, FULL ILS | Represents the airplane and indicates its position at the center of the symbol. |
|  AMBOY | WAYPOINT: ACTIVE (M) INACTIVE (W) | MAP, PLAN | Active - Represents the waypoint the airplane is currently navigating to.<br>Inactive - Represents a navigation point making up the selected active route. |
|  | ALTITUDE RANGE ARC (G) | MAP | When intersected with the track line, it predicts the point where the reference altitude will be reached. |
|  | TREND VECTOR (W) | MAP | Predicts airplane directional trend at the end of 30, 60, and 90 second intervals. Based on bank angle and ground speed. 3 segments are displayed when selected range is greater than 20 nm. 2 segments are displayed on the 20 nm scale and one segment on 10nm scale. |

* Not displayed for HDG UP MAP orientation installations

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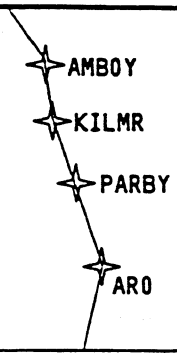
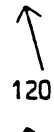
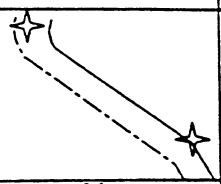
HSI SYMBOLOGY CHART

| SYMBOL | NAME | APPLICABLE MODE(S) | REMARKS |
|---|---|---|---|
|  | ACTIVE ROUTE (M)<br>ACTIVE ROUTE MODIFICATIONS(W)<br>INACTIVE ROUTES (C) | MAP, PLAN | The active route is displayed with continuous lines (M) between waypoints. Active route modifications are displayed with short dashes (W) between waypoints. When a change is activated in the FMC, the short dashes are replaced with a continuous line. Inactive routes are displayed with long dashes (C) between waypoints. |
|  | VERTICAL POINTER (M)<br>DEVIATION SCALE (W) | MAP | Displayed only during descent. Displays vertical deviation from FMC descent profile. Scale range is ± 400 feet deviation. Pointer represents path. Center of scale represents airplane position. |
|  | GLIDESLOPE POINTER (M) AND DEVIATION SCALE (W) | ILS | Displays glideslope position and deviation in ILS mode. The pointer is not displayed when track and the front course on the ILS panel differ by more then 90° |
|  | DRIFT ANGLE POINTER (W) | FULL VOR, ILS | Displays difference between FMC track angle and IRS heading. |
|  <br>  <br>120°/20<br>(As installed) | WIND SPEED (W) AND DIRECTION (W) | MAP, VOR, ILS | Indicates wind speed in knots and wind direction with respect to the map display orientation and compass reference.<br><br>Digital wind direction and speed. |
|  | OFFSET PATH (M) | MAP, PLAN | Presents a dot-dash line parallel to and offset from the active route after execution on the FMC CDU. |
|  | NORTH POINTER (G) | PLAN | Indicates map background is oriented and referenced to true north. |

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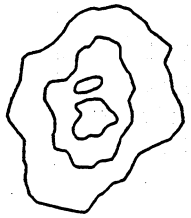
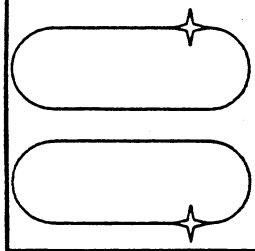
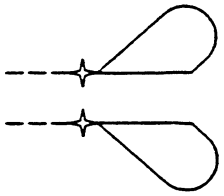
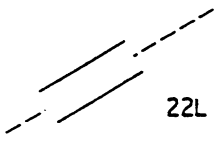
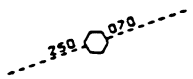
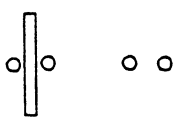
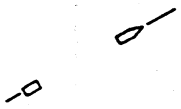
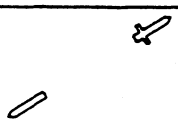
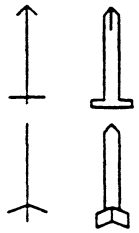
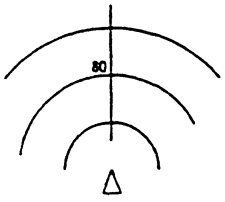
HSI SYMBOLOGY CHART

| SYMBOL | NAME | APPLICABLE MODE(S) | REMARKS |
|---|---|---|---|
| ○ T/D | VERTICAL ALTITUDE PROFILE POINT AND IDENTIFIER (G) | MAP, PLAN | Represents an FMC calculated point and is labeled on the flight plan path as T/C (top-of-climb), T/D (top-of-descent), S/C (step climb), and E/D (end of descent). Deceleration points have no identifier. |
|  | WEATHER RADAR RETURNS (G, A, R, M) | MAP, EXP VOR, EXP ILS | Multicolored returns are presented when either WXR ON switch is pushed. Most intense areas are displayed in red. Lesser intensity amber, and lowest intensity green. Magenta indicates turbulence. |
|  | HOLDING PATTERN ACTIVE (M) MODIFICATION (W) INACTIVE (C) | MAP, PLAN | A fixed size holding pattern appears when it is part of the displayed FMC route. When the holding waypoint is active and the HSI range is 80 or less, the displayed holding pattern changes to the correct scale size. |
|  | PROCEDURE TURN ACTIVE (M) MODIFICATION (W) INACTIVE (C) | MAP, PLAN | A fixed size procedure turn appears when it is part of the displayed route. When the procedure turn waypoint is active and the HSI range is 40 or less, the procedure turn changes to the correct scale size. |
|  | AIRPORT IDENT-IFIER AND RUNWAY (W) | MAP, PLAN | Appears when selected on FMC CDU. Available when HSI range is 80, 160 or 320 nm. |
|  | AIRPORT AND RUNWAY (W) | MAP, PLAN | Appears when selected on FMC CDU. Available when HSI range is 10, 20 or 40 nm. Dashed centerlines extend outward 14.2 nm. |

| SYMBOL | NAME | APPLICABLE MODE(S) | REMARKS |
|---|---|---|---|
|  ABC | SELECTED FIX CIRCLE (G) SYMBOL AND IDENTIFIER (C or G) | MAP, PLAN | Presents a selected reference point (fix) via the FMC CDU FIX key. Can appear with special map symbols (i.e., VOR, VORTAC, airport or waypoint, etc.) if contained in the existing data base. |
|  | VOR (C)<br>DME/TACAN (C)<br>VORTAC (C) | MAP | When NAVAID switch is ON, all appropriate navaids in range appear in addition to those navaids which are standard or active. Tuned navaids are displayed regardless of the NAVAID switch and appear green. When HSI is 80, 160, or 320 only high altitude navaids are displayed. Otherwise, both high and low altitude navaids are displayed. |
|  | MANUALLY TUNED NAVAID (G) | MAP | When a navaid is manually tuned the selected course and reciprocal are displayed. |
|  KTEB | AIRPORT (C) | MAP | When the ARPT switch is ON, airports within the map area are displayed. Origin and destination airports are always displayed independant of ARPT switch. |
|  KILMR<br>12000<br>0835Z | ROUTE DATA (M,W) | MAP, PLAN | When the RTE DATA switch is ON, altitude and ETA for route waypoints can be displayed. |
|  MLF | OFF ROUTE WAYPOINT (C) | MAP | When WPT switch is ON, data base waypoints not on the selected route are displayed when using HSI ranges 10, 20, or 40. |
|  | COURSE INDICATOR (M) AND DEVIATION SCALE (W) | VOR, ILS | Displays ILS course when ILS mode is selected and valid signals are present. VOR course is displayed when VOR mode is selected and valid signals are present. |

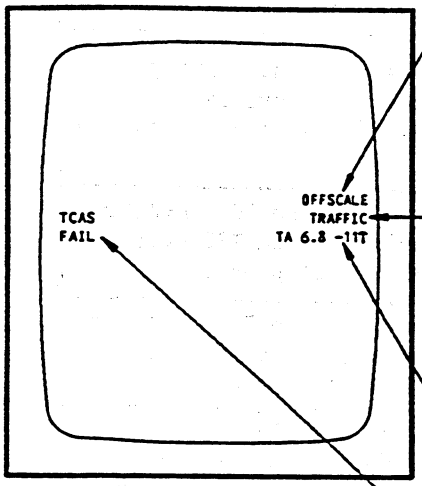
| SYMBOL | NAME | APPLICABLE MODE(S) | REMARKS |
|---|---|---|---|
| TO<br>FROM | TO/FROM DISPLAY (W) | EXP VOR | Display logic is the same as on non-EFI HSI's. |
| △ | TO/FROM POINTER (W) | FULL VOR | Display logic is the same as non-EFI HSI's. |
| VOR L/R<br>ILS | SOURCE NAV DATA (G) | VOR<br>ILS | Displays source of nav radio data based on HSI control selection. |
|  | SELECTED COURSE POINTER (W) and LINE (M) | EXP VOR<br>EXP ILS | Displays selected course as appropriately set by the VOR course selector or ILS Course Selector. |
|  | SELECTED COURSE POINTER (W) | FULL VOR<br>FULL ILS | Displays selected course as set by the VOR course selector or ILS course selector. |
| 110.10 | ILS FREQUENCY DISPLAY (G) | ILS | Displays ILS frequency. |
|  | ADF DISPLAYS (G) | ALL | Appear when valid ADF signals are being received. The narrow displays are the head and tail of the left ADF pointer and the wide displays are the head and tail of the right ADF pointer. |
| VAR/WX+T<br>+12<br><br>(as installed) | WEATHER RADAR ANNUNCIATION<br>GAIN (C)/MODE (C)<br>TILT (C) | MAP<br>EXP VOR<br>EXP ILS | GAIN - VAR indicates gain control on weather radar control panel is not being controlled automatically<br>MODE - displays MAP, WX, WX+T or TEST<br>TILT - displays antenna tilt |
|  <br>(as installed) | PRESENT TRACK LINE (W) and RANGE ARCS (W) | MAP<br>EXP VOR*<br>EXP ILS* | Predicts ground track which will result with present heading and winds<br>3 range arcs appear in any range when in MAP mode.<br>* 3 range arcs appear in EXP VOR and EXP ILS only when WXR is ON.<br>Displayed range value is one-half the selected range. |

HSI SYMBOLOGY CHART

| SYMBOL | NAME | APPLICABLE MODE(S) | REMARKS |
|---|---|---|---|
| ↑ | VERTICAL MOTION ARROW (R,A,W)* | MAP<br>EXP VOR<br>EXP ILS | Displayed when traffic vertical speed is greater than 500 feet per minute and TFC selected on HSI control panel. |
| TA 6.8 -11<br>RA 3.6 +04 | NO BEARING DATA*<br>(Red for RA)<br>(Amber for TA) | MAP<br>EXP VOR<br>EXP ILS | Displayed when no bearing information is available. Displays distance and altitude. |
| ■ | RA TRAFFIC SYMBOL (R)* | MAP<br>EXP VOR<br>EXP ILS | Displayed during TCAS Resolution Advisory when TFC selected on HSI control panel. |
| ● | TA TRAFFIC SYMBOL (A)* | MAP<br>EXP VOR<br>EXP ILS | Displayed during TCAS Traffic Advisory when TFC selected on HSI control panel. |
| ◆ | PROXIMATE TRAFFIC SYMBOL (W)* | MAP<br>EXP VOR<br>EXP ILS | Displayed when TFC selected on HSI control panel and traffic is within 1200 feet vertical and 6 miles lateral from present position. |
| ◇ | OTHER TRAFFIC SYMBOL (W/OUTLINED)* | MAP<br>EXP VOR<br>EXP ILS | Displayed when TFC selected on HSI control panel and traffic is greater than 1200 feet vertical or 6 miles lateral from present position. |
| + 05<br>- 05 | RELATIVE ALTITUDE (R,A,W)* | MAP<br>EXP VOR<br>EXP ILS | With TFC selected on HSI control panel, displays relative traffic altitude in hundreds of feet. |

* TCAS as installed
(refer to Chapter 22)

HSI TCAS MESSAGES




PILOTS PANELS

OFFSCALE (red or amber)

- TA (amber) or RA (red) traffic beyond HSI display range with TFC selected on and a TCAS capable mode displayed

TRAFFIC (red or amber)

- displayed during a TA (amber) or RA (red) condition
- displayed in all HSI modes whether TFC is selected or not

NO BEARING MESSAGES (red or amber)

- displayed when no bearing information available for traffic (see HSI symbology chart for display)

TCAS MODE DISPLAY

TFC (green) - TFC selected on HSI control panel with a TCAS capable mode displayed

TCAS TEST (white) - TCAS in test mode
- displayed in all HSI modes whether TFC is selected or not

TCAS FAIL (amber) - TCAS failed
- displayed in all HSI modes whether TFC is selected or not

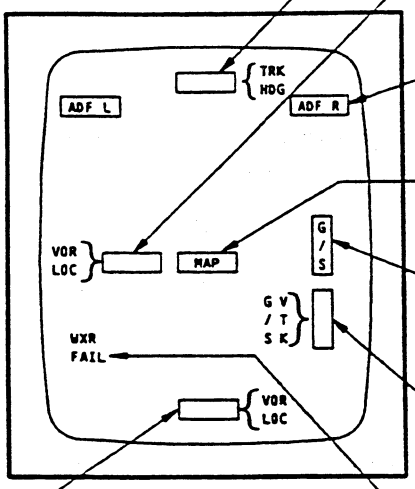
TA ONLY (green) - TCAS TA only mode is selected
- displayed in all HSI modes whether TFC is selected or not

TCAS OFF (white) - TCAS is selected off
- displayed in all HSI modes whether TFC is selected on or not

TCAS (refer to Chapter 22)

HSI TCAS MESSAGES
(As installed)

HSI FAILURE FLAGS




PILOTS PANELS

TRK/HDG FLAG

- track or heading data has failed (TRK flag not displayed for HDG UP Map orientation installations)

VOR/LOCALIZER FLAG

- indicates VOR or localizer receiver has failed
- location only for full compass rose presentations

ADF FLAG (2)

- indicates associated ADF receiver has failed

MAP FLAG

- indicates failure of associated FMC generated map display

GLIDESLOPE FLAG

- glideslope receiver has failed
- location only for full compass rose presentations

G/S-VTK FLAG

- glideslope receiver has failed
- vertical track data has failed or an FMC resynchronization is in progress

VOR/LOC FLAG

- indicates VOR or localizer receiver has failed

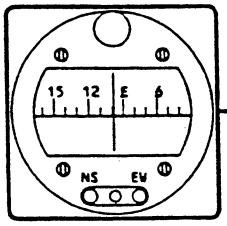
WEATHER RADAR MESSAGES

WXR FAIL - indicates associated weather radar has failed (no weather displayed)

WXR WEAK - indicates weather radar receiver malfunction

WXR DISY - indicates weather raster CRT has failed (no weather displayed)

WXR ATT - indicates loss of attitude stabilization for antenna

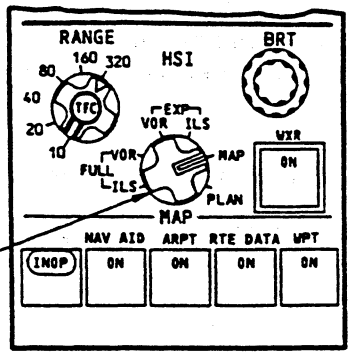



STANDBY MAGNETIC COMPASS

CENTERPOST ABOVE GLARESHIELD

797381

HSI FAILURE FLAGS/STANDBY MAGNETIC COMPASS




CONTROL STAND (2)

HSI MODE SELECTOR

FULL ILS - displays heading up, full, conventional, compass rose, and ILS navigation information
- displays ILS in lower left corner and and frequency in the lower right corner of the HSI
- selects manual VOR and DME tuning
- DME tuned by ILS panel
- WXR displays inhibited

FULL VOR - displays heading up, full, conventional, compass rose and VOR navigation information
- displays VOR (L or R) in the lower left corner of the HSI
- selects manual VOR and DME tuning
- DME tuned by VOR/DME panel
- WXR displays inhibited

EXP VOR - displays heading up, expanded compase rose, and VOR navigation information
- displays VOR (L or R) in the lower left corner of the HSI
- selects manual VOR and DME tuning
- DME tuned by VOR/DME panel
- displays WXR returns when weather radar is on
- displays TCAS information on HSI when TFC is selected on

EXP ILS - displays heading up, expanded compass rose, and ILS navigation information
- displays ILS in the lower left corner and the frequency in the lower right corner of the HSI
- selects manual VOR and DME tuning
- DME tuned by ILS panel
- displays WXR returns when weather radar is on
- displays TCAS information on HSI when TFC is selected on

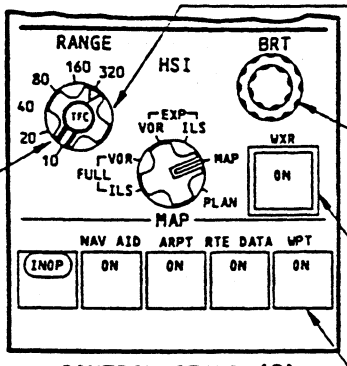
MAP - displays track up, expanded compass rose, and dynamic FMC generated map information including aeronautical chart information, flight route information, airplane position and heading
- allows automatic tuning of VOR and DME by FMC
- remote VOR/DME tuning is available via the CDU
- displays WXR returns when weather radar is on
- displays TCAS information on HSI when TFC is selected on

PLAN - displays a static, true north up map in the lower portion of HSI, top portion remains the same as in the MAP mode
- allows automatic tuning of VOR and DME by FMC
- remote VOR/DME tuning is available via the CDU
- permits pilot action via the CDU LEGS Page to step through a selected route
- WXR displays inhibited

1 HSI Range Selector with TFC as installed

991383

HSI CONTROL PANEL




CONTROL STAND (2)

HSI RANGE SELECTOR

- selects desired nautical miles range for HSI MAP, PLAN and weather radar displays

HSI BRIGHTNESS CONTROLS (2)

OUTER CONTROL - adjusts brightness for HSI display

INNER CONTROL - adjusts brightness for weather radar display

WEATHER RADAR SWITCH
(see NAVIGATION chapter)

TRAFFIC SWITCH [1]
(momentary action)

PUSH - if TFC not displayed on HSI, displays TCAS information on HSI
- if TFC displayed on HSI, removes TCAS information from HSI
- with TCAS FAIL displayed on HSI, cancels TCAS FAIL message

MAP SWITCHES (alternate action)

- adds data to HSI display when selected
- multiple switches can be selected simultaneously
- illuminated ON (white) when selected

NAVAID - adds information to the HSI Map mode
- displays high altitude navigation aids if on high map scales (80, 160, 320)
- displays all navigation aids if on low map scales (10, 20, 40)

AIRPORT - adds information to the HSI Map mode
- displays all data base airports within the map area of the HSI

ROUTE DATA - adds information to the HSI Map and Plan modes
- displays altitude and estimated time of arrival at each waypoint on the displayed route of flight

WAYPOINT - adds information to the HSI Map and Plan modes
- displays waypoints in data base not on the displayed route of flight if 40nm or less is selected for HSI range
- waypoints not displayed above 40nm selected HSI range

BLANK - spare

[1] HSI Range Selector with TFC as installed

991387

HSI CONTROL PANEL

LEFT DME INDICATOR

- displays distance to left VOR tuned station (VORTAC or VOR/DME) except when ILS is selected on the L-HSI Control Panel
- displays distance to left ILS tuned station when ILS is selected on the L-HSI Control Panel ("L" is displayed when valid ILS/DME is available)
- displays dashes to indicate no computed data is available
- displays blank when airplane DME is inoperative

RIGHT DME INDICATOR

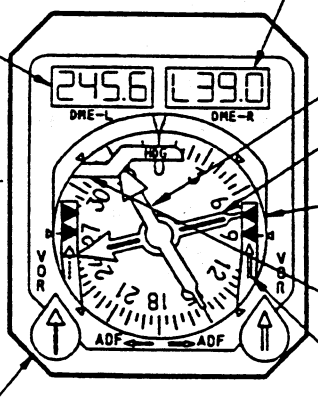
- displays same as DME-L indicator, but with right data inputs (R-HSI CP, VOR-R, ILS-R)

WIDE POINTER

- indicates right VOR/ADF magnetic bearing to selected stations
- indicates last bearing on loss of right VOR/ADF signal

NARROW POINTER

- indicates left VOR/ADF magnetic bearing to selected stations
- indicates last bearing on loss of left VOR/ADF signal




CAPTAINS PANEL
CENTER PANEL

COMPASS CARD

- positioned by IRS as selected on the opposite side Instrument Source select panel (see EFI/IRS diagram)
- indicates airplane heading under lubber line

HEADING FLAG

- indicates selected IRS heading source has failed or no computed data is available
- instrument failure

ADF/VOR SELECTOR (LEFT/RIGHT)

VOR - VOR bearing to the tuned station is supplied to the selected pointer when a valid signal is available

ADF - ADF bearing is supplied to the selected pointer when a valid signal is available

BEARING POINTER FAILURE FLAG (LEFT/RIGHT)

- indicates selected VOR/ADF receiver has failed or no computed data is available
- may be in view with heading flag
- instrument failure

71528

RADIO DISTANCE MAGNETIC INDICATOR (RDMI)

AIRSPEED POINTER

- indicates air data computer generated airspeed in knots
- indicates zero if associated ADC has failed

VMO FLAG

IN VIEW - VMO pointer is inoperative

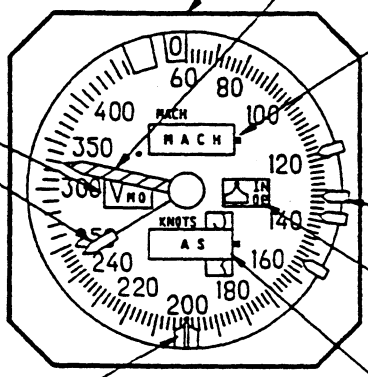
MACH/AIRSPEED INDICATOR (electric)

VMO POINTER

- indicates maximum operating airspeed in knots
- positioned to 260 knots when data from air data computer is unreliable

MACH INDICATOR AND FLAG

- shows air data computer generated mach number from .400 to .999 in digital form
- masked below .400 mach
- digits covered by flag when associated ADC has failed




CAPTAINS PANEL
CENTER PANEL

REFERENCE AIRSPEED BUGS

- set at reference airspeeds

COMMAND AIRSPEED INOPERATIVE FLAG

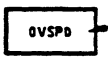
IN VIEW - command airspeed bug is inoperative

AIRSPEED INDICATOR AND FLAG

- shows air data computer generated airspeed in digital form when above 30 knots
- digits covered when associated ADC has failed

COMMAND AIRSPEED BUG

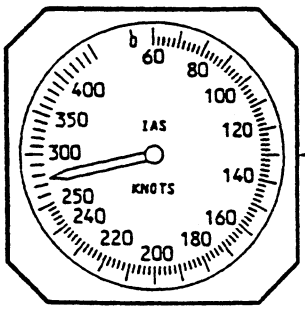
- indicates airspeed as manually selected with the IAS/MACH Selector
- positioned by FMC when IAS/MACH indicator is blank
- removed from view when inoperative




OVERSPEED WARNING LIGHT (red)

ILLUMINATED - airplane is exceeding Mmo or Vmo

- master WARNIING lights illuminate, aural warning sounds, EICAS message OVERSPEED appears




STANDBY AIRSPEED INDICATOR (pneumatic)

CENTER PANEL

71529

AIRSPEED/OVERSPEED INDICATORS

ALTITUDE INDICATOR

- displays air data computer generated altitude in increments of twenty feet
- a NEG flag appears when altitudes below zero feet is displayed
- an OFF flag appears when associated ADC has failed, no computed data available, or an internal failure has occured

PRIMARY ALTIMETER (electric)

ALTIMETER ALTITUDE LIGHT (white)

ILLUMINATED - within 900' of the altitude selected with the altitude selector

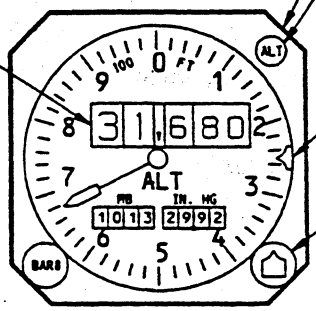
EXTINGUISHES - within 300' of the selected altitude

REFERENCE ALTITUDE MARKER

- indicates reference altitude

REFERENCE ALTITUDE CONTROL

- positions reference altitude marker




CENTER PANEL
FIRST OFFICER PANEL

ALTITUDE ALERT LIGHT (amber)

ILLUMINATED - 300 foot deviation from selected altitude

- master caution lights illuminate, caution aural sounds, EICAS message ALTITUDE ALERT appears
- light extinguishes 900 feet from the selected altitude

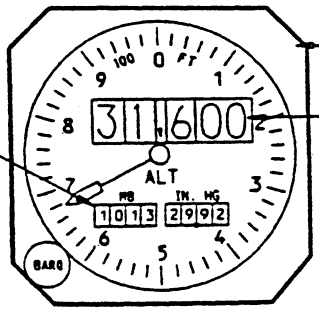

PILOTS CENTER INSTRUMENT PANEL

BARO INDICATOR (2)

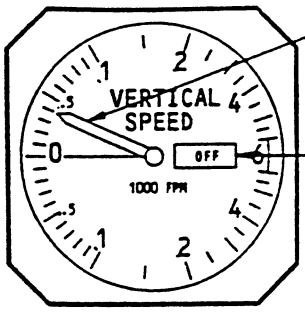
STANDBY ALTIMETER (pneumatic)

ALTITUDE INDICATOR

- displays alternate static source altitude




CENTER PANEL



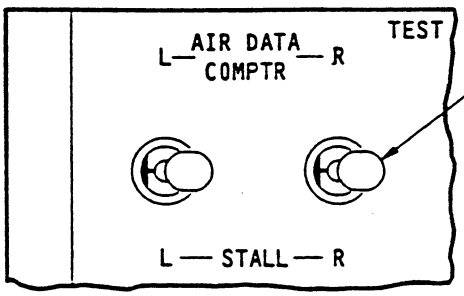

CENTER PANEL
FIRST OFFICER PANEL

VERTICAL SPEED INDICATOR POINTER

- indicates zero value when IRS vertical speed is unreliable

OFF FLAG

IN VIEW - selected IRS vertical speed data is unreliable
- respective VSI and/or ADC has failed

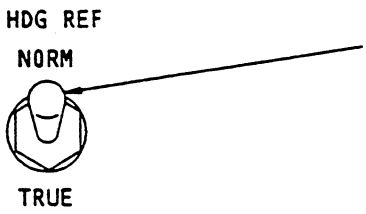



ACCESSORY PANEL

AIR DATA COMPUTER TEST SWITCH
(spring loaded to neutral)

L or R - initiates 3 phase test of selected air data computer
- test data is displayed on associated flight instruments
- must be held for 7 seconds or more to complete all test phases

RELEASE - cancels test




CENTER PANEL

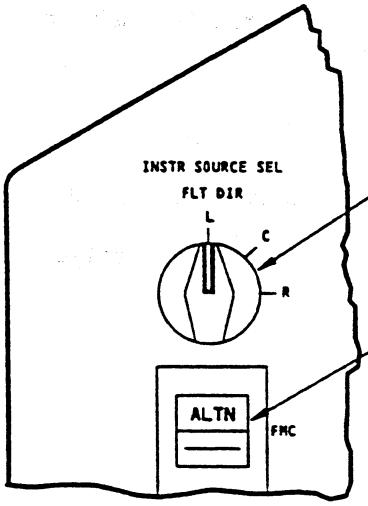
HEADING REFERENCE SWITCH *

NORM - references each compass card to magnetic north when between 73°N and 60°S latitude
- references each HSI to true north and causes each RDMI heading flag to appear when north of 73°N or south of 60°S latitude

TRUE - references each compass card to true north regardless of latitude

* As installed

VERTICAL SPEED INDICATOR/AIR DATA COMPUTER TEST SWITCH
HEADING REFERENCE SWITCH




CAPTAIN PANEL
FIRST OFFICER PANEL

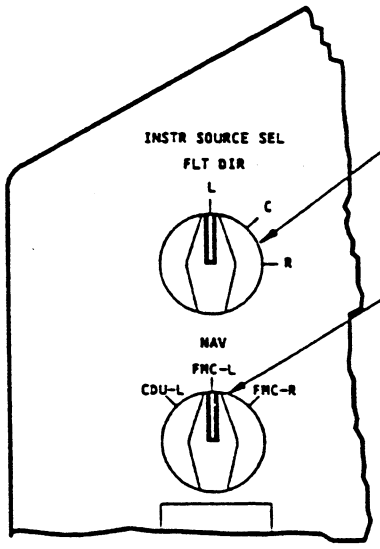
FLIGHT DIRECTOR SOURCE SELECTOR

- selects the flight control computer (L, C or R) for command bar operation

FMC SWITCH (as installed)
(alternate action)

BLANK - selects normal configuration:
L FMC supplies L and C EFIS SG
R FMC supplies R EFIS SG

ALTN - selects opposite (L or R) FMC for the EFIS SG above




CAPTAIN PANEL
FIRST OFFICER PANEL

FLIGHT DIRECTOR SOURCE SELECTOR

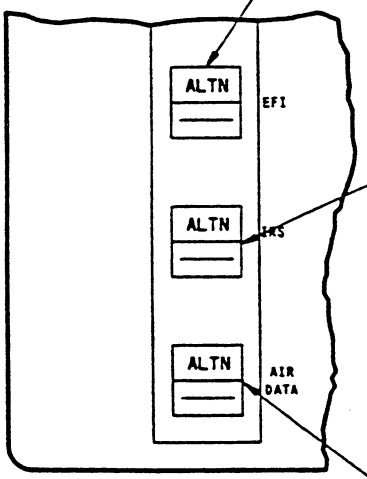
- (see above description)

NAV INSTRUMENT SOURCE SELECTOR
(as installed)

- selects source supplying FMS information to Symbol Generators and flight control computers

Captain's side:
FMC-L - supplies L and C EFIS SG, and L and C FCC
FMC-R - supplies L and C EFIS SG, and L and C FCC
CDU-L - supplies L and C EFIS SG

First Officer's side:
FMC-R - supplies R EFIS SG and R FCC
FMC-L - supplies R EFIS SG and R FCC
CDU-R - supplies R EFIS SG




CAPTAIN PANEL
FIRST OFFICER PANEL

EFI SWITCH
(alternate action)

BLANK - selects normal configuration:
L EFIS SG supplies CAPT ADI and HSI
R EFIS SG supplies FO ADI and HSI
C EFIS SG is available as the alternate SG

ALTN - selects center EFIS SG for ADI and HSI display
- CAPT has display control if each pilot has selected ALTN (C-SG)
- causes EICAS message of INSTR SWITCH if each pilot has selected ALTN

IRS SWITCH
(alternate action)

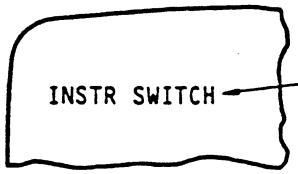
BLANK - selects normal configuration:
L IRS supplies L & C EFIS SG, CAPT VSI, and FO RDMI
R IRS supplies R & C EFIS SG, FO VSI and CAPT RDMI
C IRS is available as the alternate IRS source

ALTN - selects center IRS for attitude, heading and track data for the appropriate systems above

AIR DATA SWITCH
(alternate action)

BLANK - selects normal configuration:
L ADC supplies CAPT MACH/AIRSPEED and main altimeter
R ADC supplies F/O MACH/AIRSPEED and main altimeter

ALTN - selects opposite air data computer to supply above instruments




CENTER PANEL

INSTR SWITCH MESSAGE

- indicates each pilot has selected ALTN with EFI switch

729247

INSTRUMENT SWITCHING

CHRONOGRAPH SECOND HAND

- indicates chronograph seconds

CHRONOGRAPH SWITCH

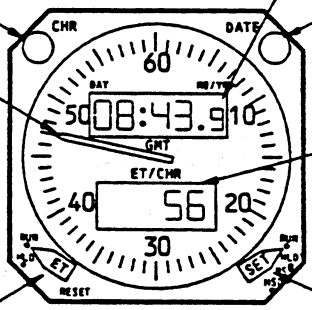
- controls start, stop and reset of CHR display and second hand with successive "push" operations
- overrides existing ET displays

GMT/DATE INDICATOR

- displays time in 24 hour format (hours and minutes) or date
- tenths of minutes shown on some installations
- date display alternates between day, month (XX:XX) and year ( :XX) every 1.5 seconds

DATE SWITCH

PUSH - alternately changes display between GMT and DATE




CENTER PANEL
FIRST OFFICERS PANEL

ET/CHR INDICATOR

- displays ET/CHR time

ET display range: zero to 99 hrs 59 min.

CHR display range: zero to 99 min.

GMT/DATE SET SELECTOR

- sets GMT and Date for clock reference

HS D (Hours Slew, Day) - advances GMT hours or days as selected by Date Switch

MS M (Minutes Slew, Month) - advances GMT minutes or month as selected by Date switch

HLD Y (Hold, Year) - stops GMT indicator time and sets seconds to zero, or advances year as selected by Date switch

RUN - starts GMT indicator counting

ELAPSED TIME SELECTOR

RESET - returns ET display to zero time
- spring loaded to HOLD position

HLD - stops ET display at indicated time

RUN - starts ET display counting time
- continues to count from HLD time when selected back to RUN

D19612

CLOCK
(As installed)

CHRONOGRAPH SECOND HAND

- indicates chronograph seconds

CHRONOGRAPH SWITCH

- controls start, stop and reset of CHR display and second hand with successive "push" operations
- overrides existing ET displays

GMT INDICATOR

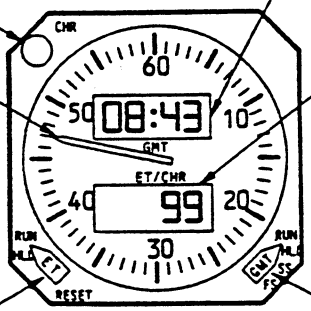
- displays time in 24 hour format

ET/CHR INDICATOR

- displays ET/CHR time

ET display range: zero to 99 hrs 59 min.

CHR display range: zero to 99 min.




CENTER PANEL
FIRST OFFICERS PANEL

ELAPSED TIME SELECTOR

RESET - returns ET display to zero time
- spring loaded to HOLD position

HLD - stops ET display at indicated time

RUN - starts ET display counting time
- continues to count from HLD time when selected back to RUN

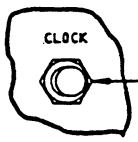
GMT SELECTOR

RUN - starts GMT indicator counting in hours and minutes

HLD (Hold) - stops GMT indicator time and sets seconds to zero

SS (Slow Slew) - advances GMT minutes

FS (Fast Slew) - advances GMT hours



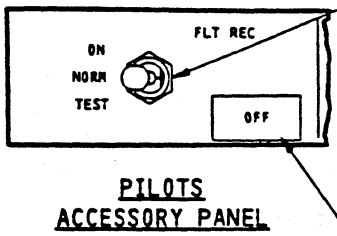

CLOCK SWITCH

- functions same as chronograph switch

SIDE GLARESHIELD (2)

991388

CLOCK
(As installed)




PILOTS
ACCESSORY PANEL

FLIGHT RECORDER SWITCH

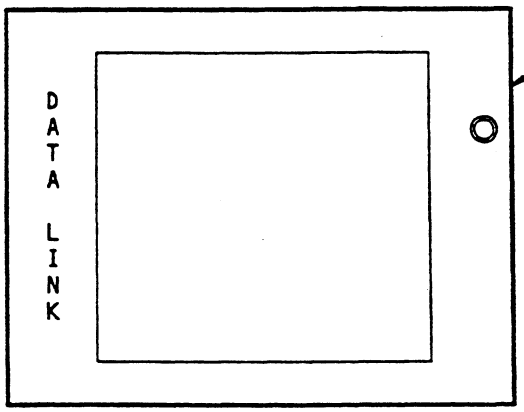
ON - applies power to flight recorder

NORM - applies power automatically to the flight recorder when:
- one or two engines operating
- inflight as long as electrical power is available

TEST - applies power to flight recorder
- spring loaded to NORM
- when held in TEST, the OFF light will extinguish if test is satisfactory

FLIGHT RECORDER OFF LIGHT (white)

ILLUMINATED - recorder is not operating



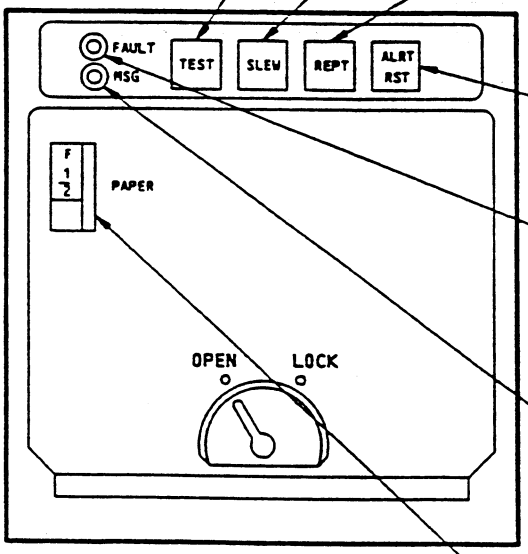

AFT ELECTRONICS PANEL

MULTIPURPOSE INTERACTIVE DISPLAY UNIT

- provides interface with Digital Flight Data Acquisition Unit (DFDAU) for entering or retreiving airplane systems data
- screen is touch sensitive
- displays vary according to the software controlling program

d20017

MULTIPURPOSE INTERACTIVE DISPLAY UNIT
(As installed)




ACCESSORY PANEL

FUNCTION SWITCHES

TEST SWITCH

PUSH - produces character test pattern and Input Port Status report of active/inactive ports
- illuminates FAULT and MSG lights during test

SLEW SWITCH

PUSH - advances printer paper as long as switch is depressed

REPT SWITCH

PUSH - reprints last message received
- subsequent pushes provide additional copies

ALRT RST SWITCH

PUSH - resets printer MSG light

FAULT LIGHT

ILLUMINATED - indicates printer failure, out of paper, door open or test in progress

MSG LIGHT

ILLUMINATED - incoming message to printer or test in progress
- remains illuminated until ALRT RST switch pushed or test completed

PAPER QUANTITY INDICATOR

- indicates quantity of paper remaining

ACMS PRINTER
(As installed)

SYSTEMS DESCRIPTION

ELECTRONIC FLIGHT INSTRUMENTS

The Electronic Flight Instruments (EFI) consist of three (L, C, R) Symbol Generators (SG), and two control Panels (CP), two Attitude Director Indicators (ADI), and two Horizontal Situation Indicators (HSI). These instruments depend on the Flight Management Computer for flight progress and map background data, the Inertial Reference System for attitude and heading data.

EFI Symbol Generator

The central part of the EFI is the symbol generator. It receives input from many avionics systems. It processes data and generates the proper output for presentation on the ADI and HSI. When each of the three SG's are powered, the displays are provided on the appropriate ADI and HSI. When not powered the displays are blank. When a Lights TEST switch on the overhead panel is pushed, the ADI and HSI will display a maintenance test pattern. A message stating TEST OK or TEST FAIL, and the name of the failed component, appears at the end of the test. This test is inhibited in flight.

Various failure conditions may be displayed on each ADI or HSI. A blank screen results when a power failure or overtemperature condition exists. Partial loss of color capability may cause an odd color presentation. When information is not reliable or radio signals are not received, the display is removed. Numeric indications are replaced with dashes. If airplane equipment fails a failure flag is displayed. (Note: Some symbol generator installations cannot display the LOC and/or GS flags on the ADI.)

On some airplane installations, ADI data fault detection and comparison monitoring is accomplished by an Attitude Comparator feature. The system monitors the following ADI data for cross cockpit agreement.

- Attitude (pitch and roll)

When conditions are detected outside parameters, the appropriate Master caution light illuminates, an aural signal sounds, and a message ATT DISAGREE appears on EICAS.

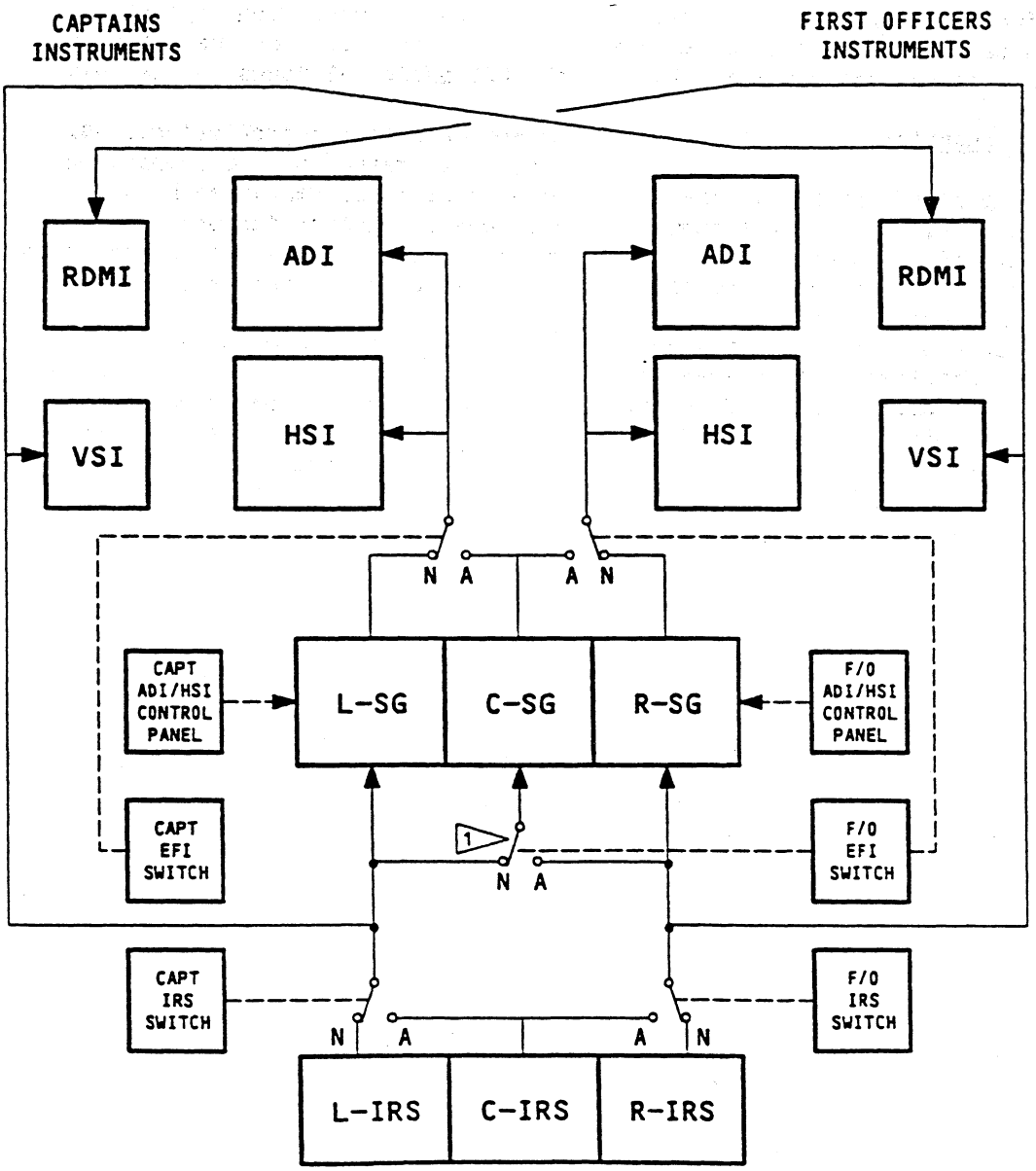
Attitude comparison monitoring is inhibited when both pilots are using the center symbol generator.

EFI Control

The ADI and HSI Control Panels provide control of symbology options, modes, ranges and brightness for the respective ADI and HSI displays.

## EFI/IRS INTERFACE

The diagram below shows the normal EFI/IRS interface. EFI switching determines the C-SG input and output. Normally, left system instrument sources supply the C-SG. When the F/O EFI switch is in ALTN, right system instrument sources supply the C-SG. When both pilots select ALTN with their EFI switches, the left system instrument sources supply data to the C-SG. However, the C-SG always uses the center ILS and center radio altimeter. Each ADI and HSI Control Panel is connected to the symbol generator selected with the EFI switch. Each IRS switch permits pilot selection of the alternate data source for heading, attitude and vertical speed.




1 This switch remains in the N position if the Capt EFI switch is selected to ALTN.

EFI/IRS INTERFACE DIAGRAM

Attitude Director Indicator

The ADI presents conventional airplane attitude indications, flight director commands and deviation from localizer, glide slope, selected airspeed and pitch limit. Flight Mode displays (AFDS operating modes), height alert, airspeed information on a tape display (As installed), ground speed, radio altitude, decision height, and TCAS* RA pitch commands are also displayed. Attitude information is provided by the respective IRS (Capt ADI-L IRS, F/O ADI - R IRS). The center IRS is an alternate source.

During preflight attitude data is unavailable until the associated IRS has completed alignment and entered the navigation mode. The ATT (attitude) flag does not appear in this case. IRS alignment must be completed before flight director commands can be displayed. A flight director failure in either axis causes the respective command bar to disappear. If both axes become unreliable, both command bars disappear and the FD flag appears. For single cue flight directors, failure in either axis causes the command bars to disappear.

The speed tape displays (As installed) current airspeed, bug speeds, minimum and maximum maneuvering speeds, and minimum and maximum speeds.

When the normal data sources for the ADI are not desired the Instrument Source Selector Panel provides alternate data.

The selected decision height is displayed digitally when the airplane is above 1000 feet radio altitude. Below 1000 feet the selected decision height is displayed as a decision height marker on the circular radio altitude display.

When between 2500 feet and 1000 feet RA, digital radio altitude is displayed. Below 1000 feet RA, a radio altitude ring and scale* encircle the digital radio altitude readout.

As the airplane descends, segments of the ring erase indicating radio altitude. The ring is calibrated in increments of 100 feet. At DH the ring, scale and digital RA display change from white to amber, the DH marker changes from magenta to amber and ring, scale, digital RA display and DH marker, flash for several seconds.

Pressing the Reset Switch on the ADI Control Panel stops the flashing, changes the amber DH marker back to magenta and changes the amber RA display back to white. The DH alert and RA display are automatically reset to a magenta DH display and white RA display upon touchdown or climbing above selected DH +75 feet. Climbing above 1000 feet RA during go-around returns the DH to a digital display. Selecting a negative DH blanks DH display, but does not affect the RA display.

ILS Deviation Monitoring alerts the crew of ILS deviations during an approach. With APP selected on the MCP, below 500 feet AGL, if more than one dot for one second in glide slope deviation or more than one fifth dot for one second in localizer deviation occurs, the respective localizer or glide slope scales change color from white to amber and the pointer flashes. This alert condition ceases when localizer and/or glide slope parameters return to within their normal limits. The Glideslope alert is inhibited below 100 feet AGL.

The Height Alert is displayed as ALT in the lower right corner of the ADI. It appears while descending from 2500' AGL (1000' in some installations) to 500' AGL. It can be removed from the display by pushing the Reset Switch on the ADI Control Panel.

*As installed (TCAAS - Chapter 22).

Horizontal Situation Indicator

The HSI presents a selectable, dynamic color display of flight progress and plan view orientation. Various display modes presented include MAP, PLAN, ILS and VOR.

Heading is supplied by the respective IRS (CAPT HSI - L IRS, F/O HSI - R IRS). The center IRS provides that data as an alternate source. The HSI compass rose is automatically referenced to magnetic north when between 73° N and 60° S latitude and to true north when above those latitudes. For airplanes with a Heading Reference Switch installed, this occurs while in the NORM position. Additionally, the compass rose may be referenced to true north by manually selecting TRUE with the Heading Reference Switch (as installed) regardless of the latitude. TRU is displayed at the top of the HSI enclosed by a white box when the HSI is referenced to true north. When the HSI is referenced to true north and the airplane descends 2000 feet at more than 800 feet per minute, the box changes from white to amber, flashes for 10 seconds, then remains amber. The box returns to white when the airplane climbs 2000 feet at more than 500 feet per minute. A green box is displayed around the M for 10 seconds when the HSI is returned to magnetic referencing.

Track is supplied by the FMC (CAPT HSI - L FMC, F/O HSI - R FMC). The opposite FMC is available as an alternate source. If track information from the FMC is unreliable, it is automatically supplied by the IRS.

The MAP mode presents information against a moving map background. Displayed information includes track, heading, routes, curved trend vector, range to altitude, wind, distance, estimated time of arrival and selected navigation data points programmed into the Flight Management computer and *TCAS. MAP mode is the recommended mode of display for most phases of flight.

The PLAN mode presents on the bottom part of the HSI a static map background with route data oriented to true north. Pilot action on the FMC CDU LEGS Page is required to sequence through the active route for viewing. The top part of the HSI maintains a display of track and heading information as in the MAP mode.

The EXP VOR and EXP ILS modes present an expanded compass rose with heading orientation. Selected range, wind information, *TCAS information, and system source annunciation is provided with conventional VOR/ILS navigation information. A conventional full compass rose VOR and ILS mode is also available.

The HSI displays weather radar data in green, amber, red and magenta. Red is used for areas of greatest intensity. Reductions in intensity are indicated by a change of color from red to amber to green. Magenta indicates turbulence. Cyan and amber are also used for message displays. Weather radar data can only be displayed when the radar system is on and the respective HSI is in EXP VOR, EXP ILS or MAP mode.

During preflight, heading/track data is unavailable until the associated IRS has completed alignnment and entered the navigation mode. HDG (heading) or TRK (track) flags do not appear in this case. The TRK flag does not appear on installations with heading up MAP orientation.

*As Installed (refer to Chapter 22 for TCAS)

Horizontal Situation Indicator (Cont)

If an FMC FAIL message is observed on a CDU, a map flag will appear on the associated HSI when viewing the MAP mode. Selecting ALTN with the associated FMC switch causes the map display to reappear. With ALTN selected, the other pilot has control of the HSI range. A MAP RANGE DISAGREE message is displayed on the HSI when the range selections differ .

In addition to previously mentioned EFIS failure indications, other discrepancy messages can be displayed on the HSI. For example WXR/MAP RANGE DISAGREE, indicates the associated Flight Management Computer and weather radar range disagree with the control panel range data.

The Instrument Source Selector Panel provides alternate source data for the HSI when the normal sources are not usable.

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STANDBY ATTITUDE INDICATOR

A self-contained Standby Attitude Indicator incorporating an ILS display is installed on the center main panel. In the event that all generator power is lost, the Standby Attitude Indicator will be supplied with electrical power from the standby DC bus for approximately 30 minutes. ILS information is provided from the C-ILS receiver.

STANDBY MAGNETIC COMPASS

A direct reading compass is installed on the center post above the pilots glareshield. A deviation correction card is placed nearby.

RADIO DISTANCE MAGNETIC INDICATOR (RDMI)

A Radio Distance Magnetic Indicator is installed on each pilots panel. It displays magnetic heading or true heading depending on the position of the Heading Reference Switch*, VOR or ADF bearing and (VOR/ILS/DME, VORTAC) distance. The RDMI receives primary heading signals from the opposite side IRS and alternate heading signals from the C-IRS. The RDMI is inoperative until the associated IRS has completed alignment and entered the navigation mode.

When the Heading Reference Switch* is in NORM, magnetic heading is displayed if the airplane is between 73-N and 60-S. Outside this latitude range, a heading flag is in view. When the switch is in TRUE, true heading is displayed regardless of latitude. When the RDMI is referenced to true north, positioning an ADF/VOR Selector to VOR causes the associated pointer failure flag to appear. When operating on standby power and referenced to true north, no VOR radio navigation capability exists.

HEADING REFERENCE SWITCH*

A Heading Reference Switch is installed on the center instrument panel and permits selection of a magnetic or true heading reference for each HSI, each RDMI, the AFDS and each FMC.

The AFDS uses true heading only when the switch is in TRUE. If the AFDS is in the HDG SEL mode and the Heading Reference Switch position is changed, the AFDS mode changes to HDG HOLD.

AIR DATA SYSTEM

General

The air data system consists of a pitot static system (See Pitot Static Schematic), one temperature and two angle of attack probes, two air data computers and electric flight instruments. Standby airspeed and altimeter indicators are also provided.

*As Installed

AIR DATA SYSTEM (Cont)

Sensed air data is provided to the air data computers. Processed pressure and temperature information from each computer provide input signals to certain flight instruments (Electric Mach/Airspeed Indicator, ADI speed tape, Electric Altimeter) and other using systems (IRS, AFCS, FMC, FDR, EEC, TMC, GPWS, ATC and others). The Captain's instruments use the L ADC and the F/O's instruments use the R ADC. The opposite ADC is available as an alternate source.

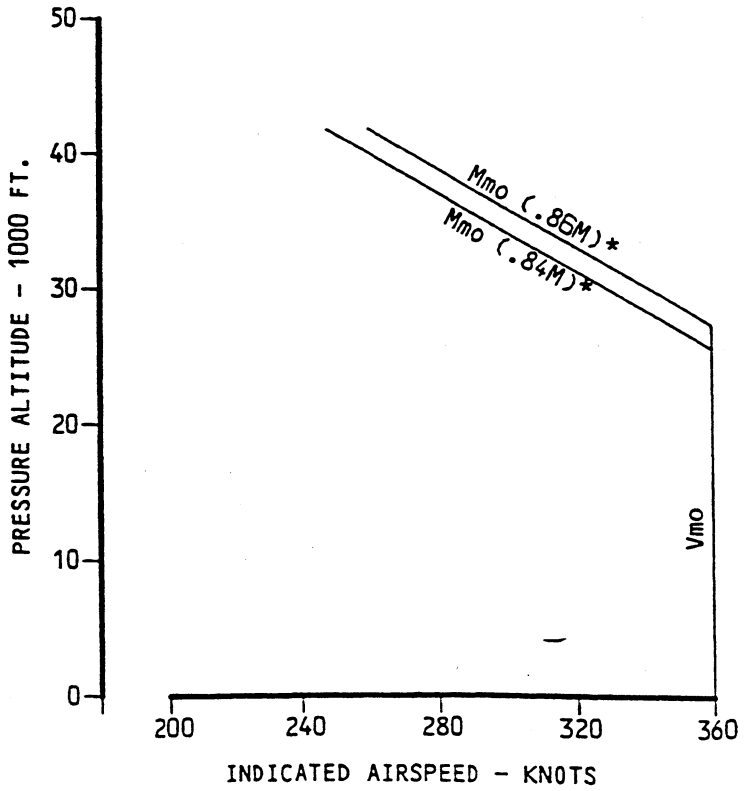
Unreliable air data signals cause warning flags to appear on the air data instruments. When a malfunction occurs in instruments with failure monitors warning flags will appear. On some airplanes the IAS/ALT DIFF advisory message appears on EICAS when there is a significant difference between the Captain's and F/O's air data sources. This message is inhibited at low altitude or when both pilots have the same air data source selected.

Two test switches on the accessory panel are provided for ground air data computer testing. They are inoperative inflight. For further information on this test, see Supplementary Normal Procedures.

Mach/Airspeed Indicator

Each Mach/Airspeed Indicator displays airspeed, mach and Vmo from the selected air data computer. The command airspeed bug on each Mach/Airspeed Indicator can be automatically positioned from the FMC CDU or manually from the MCP IAS/MACH Selector.

The following chart depicts Vmo pointer operation. M.86 limit is for United States FAA certified airplanes.




* As installed

$V_{MO}$ POINTER OPERATION

AIR DATA SYSTEM (Cont)

Standby Airspeed Indicator

A Standby Airspeed Indicator is installed on the center panel. The instrument is connected directly to the L AUX pitot and the alternate static ports.

Altimeter

Each pilot is provided with a Primary Altimeter (electric) that receives altitude signals from the selected air data computer. An altimeter Altitude Light and an Altitude Alert Light are provided for altitude alerting. The Automatic Flight chapter describes altitude alerting in greater detail.

Standby Altimeter

The Standby Altimeter (pneumatic) provides standby altitude information. Input for the indicator is from the alternate static ports.

VERTICAL SPEED INDICATOR

An electrically driven Vertical Speed Indicator (VSI) is installed on each pilot panel. Vertical speed indications are in feet per minute. The Captains VSI is connected to the left IRS and ADC and the F/O's VSI is connected to the right IRS and ADC. The center IRS provides backup vertical speed data for either crewmember when ALTN is selected with the respective IRS Switch. The opposite ADC provides backup vertical speed data for either crewmember when ALTN is selected with the respective ADC Switch.

The VSI is inoperative until the associated IRS has completed alignment and entered the navigation mode.

FLIGHT RECORDER

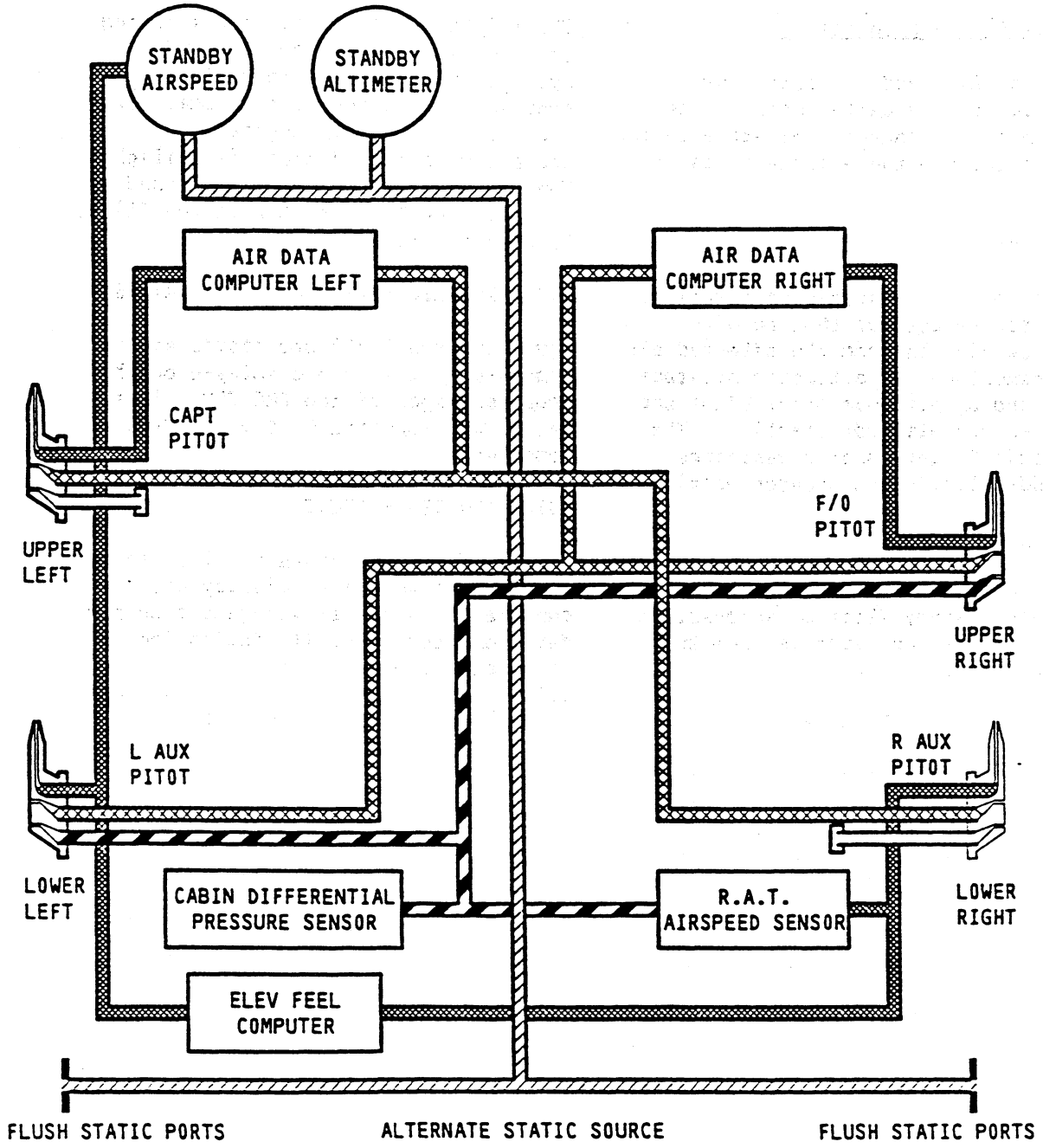
The flight recorder provides a record of operational data from selected systems in a sealed fire resistant container. The recorder automatically turns on when either engine is operating or the airplane is inflight. The recorder can be manually turned on by selecting TEST or ON with the Flight Recorder Switch.

TRUE AIRSPEED/STATIC AIR TEMPERATURE

True airspeed (TAS) and static air temperture (SAT) are displayed on the progress pages of the FMC CDU. These values are supplied by the air data computer.

TOTAL AIR TEMPERATURE

A total air temperature (TAT) appears on EICAS above the N1 display and is supplied by a thrust management or air data computer. The TAT indication is comprised of outside air temperature (OAT) plus ram rise. TAT indication on the ground will approximate OAT.




CAPPED STATIC SOURCE
PITOT
STATIC
AUXILIARY STATIC
ALTERNATE STATIC

PITOT STATIC SCHEMATIC

## ACCEPTABLE ALTIMETER DIFFERENCES

The following chart depicts the maximum acceptable difference between altimeters.

| Altitude (feet) | Airspeed/Mach (knots) | Maximum Difference: Captain and First Officer (feet) | Maximum Difference: C or F/O and Standby (feet) -200 airplanes | Maximum Difference: C or F/O and Standby [1] (feet) -300 airplanes |
|---|---|---|---|---|
| Sea Level | 0 | 40 | 40 | 40 |
| 10,000 | 250 | 60 | + 25 to -195 | - 5 to -225 |
| 20,000 | 300/0.651 | 115 | + 5 to -295 | -105 to -405 |
| 30,000 | 283/0.750<br>304/0.800 | 135<br>135 | + 45 to -375<br>+ 65 to -435 | -100 to -520<br>-115 to -615 |
| 35,000 | 253/0.750<br>272/0.800 | 145<br>145 | + 5 to -415<br>+ 25 to -465 | -135 to -555<br>-155 to -645 |
| 40,000 | 225/0.750<br>242/0.800 | 160<br>160 | - 55 to -495<br>- 40 to -540 | -190 to -630<br>-215 to -715 |

[1] Negative sign means Standby Altimeter reads higher than Captain or First Officer Altimeter.

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## CLOCK

The clock provides GMT in hours and minutes on the GMT indicator. On some installations, a Date Switch can display Date (day, month, year) on the GMT display. The clock receives power from the hot battery bus. However, when main DC power is not available the GMT display is blank. When power is restored, the clock displays the correct indications. The GMT indicator can be set by slecting Fast Slew and Slow Slew (Hours Slew and Minutes Slew (as installed) on the GMT selector. On some installations, a date can be set by selecting Day, Month, and Year using the Date Set Selector. Selecting HLD stops the time, RUN starts the time. The bottom display is shared by the elapsed timer (ET) and the chronograph (CHR). The chronograph has priority on the display and must be zeroed to read the elapsed time.

The CHR can be controlled by either a push-button switch on the clock or by remote switch on the glareshield. The clock accepts a signal from either switch with equal priority. The first switch actuation starts the CHR display after resetting the ET display to zero. The second switch actuation holds the CHR time and the sweep second hand. A third actuation of the switch resets the CHR time to zero, displays the current ET if running, and returns the sweep-second hand to zero.

Clock GMT is provided to other systems such as the FMC and Flight Recorder. Normally the Captain's clock provides time to the FMCs. If the Captain's clock fails, the First Officer's clock provides time to the FMCs.

AIRCRAFT CONDITION MONITORING SYSTEM (ACMS) (As installed)

The Aircraft Condition Monitoring System (ACMS) provides a record of selected airplane systems performance and flight conditions. The system consists of a Digital Flight Data Acquisition Unit (DFDAU), a Digital Flight Data Recorder (DFDR), a printer, and an Multipurpose Interactive Display Unit (MIDU).

The DFDAU receives signals representing certain flight conditions and airplane systems' operating performance and converts them to a digital form for recording on the DFDR.

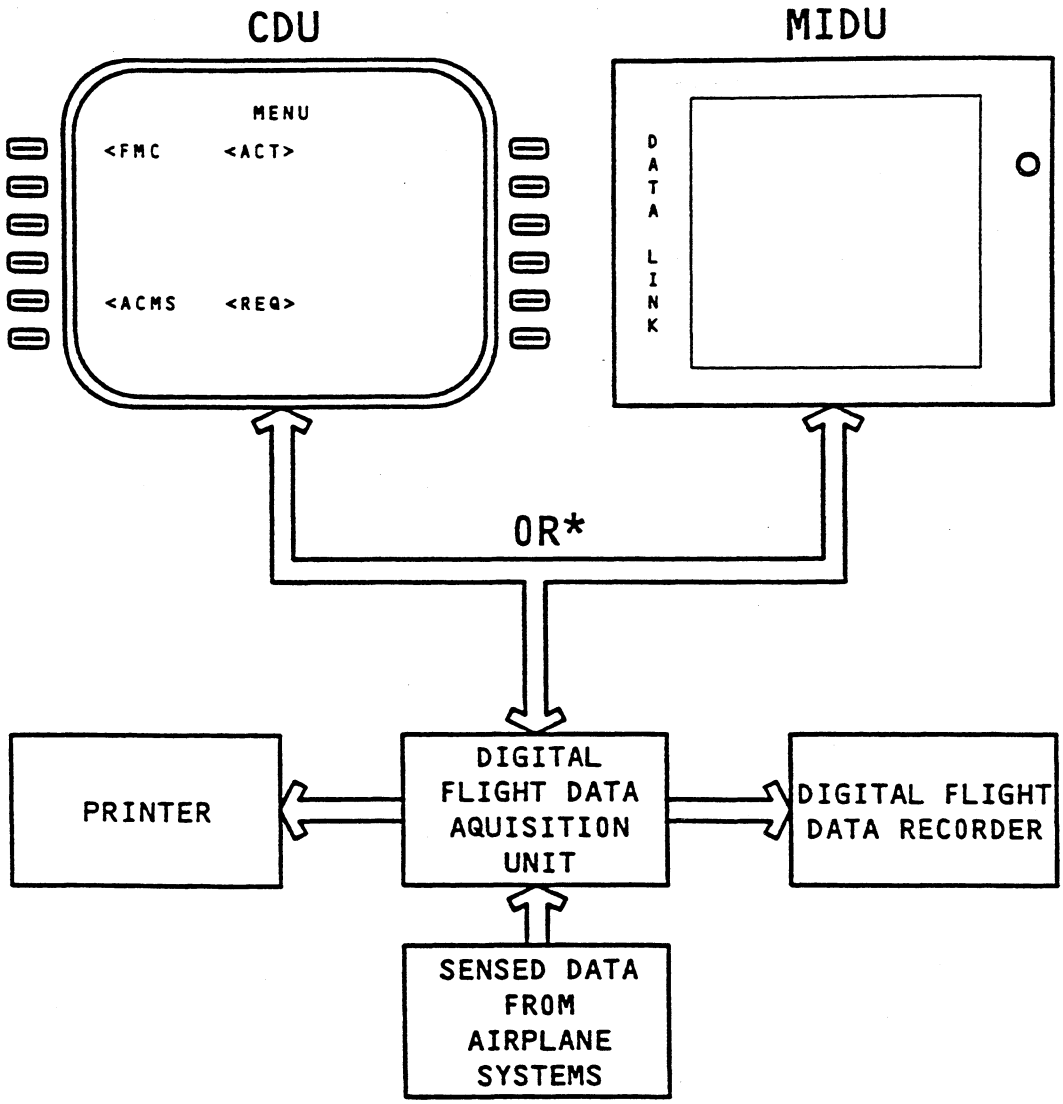
The DFDR records airplane system and flight data. The DFDR is located in the aft fuselage area.

The recorder can be manually tested by selecting TEST with the Flight Recorder Switch.

Access to the ACMS is provided by the MIDU. The CDU menu key can also be used to access the ACMS.

The printer allows data to be printed as required.

When the airplane busses are powered, all of the system operates except the DFDR. The DFDR begins to operate as either engine starts (on the ground). In the air the DFDR is powered with either engine generator or the APU generator powering busses.

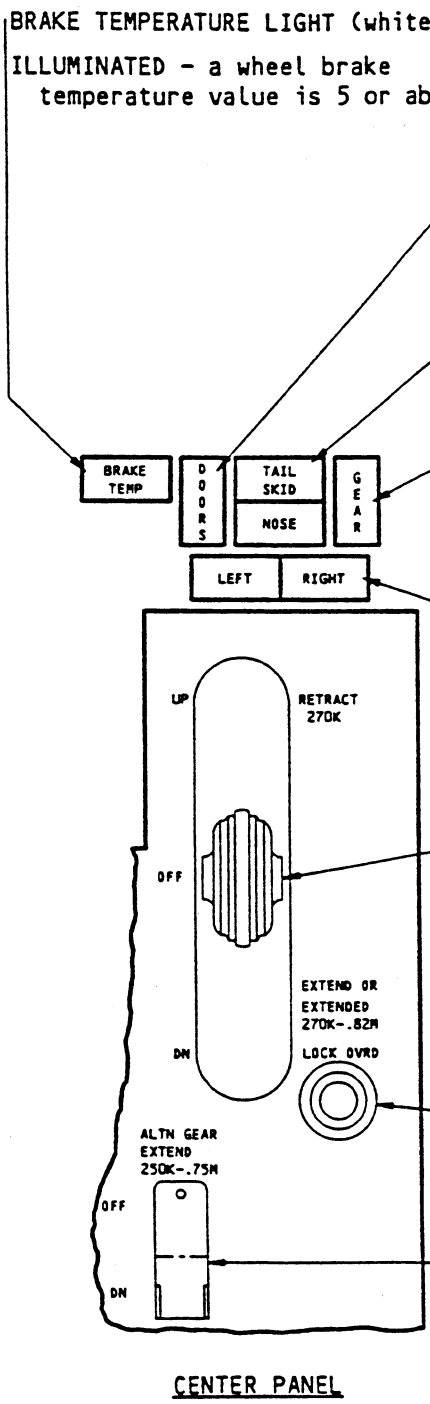



* Access though the CDU or IDU

ACMS DIAGRAM
(As installed)

CHAPTER 18

LANDING GEAR




CENTER PANEL

BRAKE TEMPERATURE LIGHT (white) 1

ILLUMINATED - a wheel brake temperature value is 5 or above

DOORS LIGHT (amber)

ILLUMINATED - either main gear door open, or nose gear door open when the nose gear is not extended

TAIL SKID LIGHT (amber) 2

ILLUMINATED - tail skid disagrees with lever position

GEAR LIGHT (amber)

ILLUMINATED - gear disagrees with lever position
- any main gear door open with gear lever in OFF or UP position
- gever lever not properly seated in detent

GEAR DOWN LIGHT (green)

ILLUMINATED - respective gear down and locked

LANDING GEAR LEVER

UP - releases downlocks
- pressurizes UP side of gear actuator

OFF - depressurizes landing gear hydraulic system

DN - releases uplocks
- pressurizes down side of gear actuator

LEVER LOCK OVERRIDE SWITCH

PUSH - manually releases lever lock

ALTERNATE GEAR EXTENSION SWITCH (toggle, guarded)

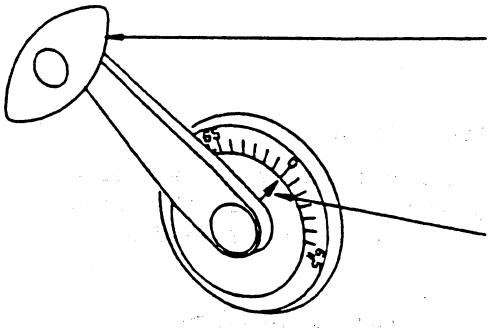
OFF - resets alternate gear extension system

DOWN - releases all gear uplocks

1 As installed

2 -300 only

C41359



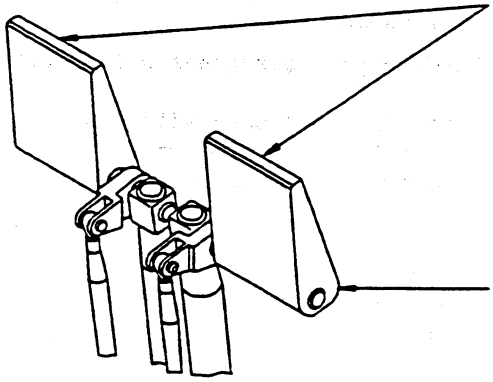

NOSE WHEEL STEERING TILLER

ROTATE - turns nose wheel up to 65° in desired direction
- overrides rudder pedal steering

NOSE WHEEL INDICATOR

- shows direction and angle of nose wheel steering signal

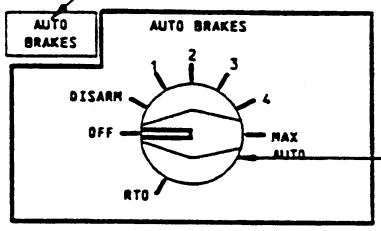
PILOTS SIDEWALL (2)*



RUDDER PEDAL TOE BRAKE

RUDDER PEDAL STEERING

PUSH - turns nose wheel up to 6° in desired direction




AUTO BRAKES INOPERATIVE LIGHT (amber)

ILLUMINATED - auto brakes system disarmed

AUTO BRAKES SELECTOR

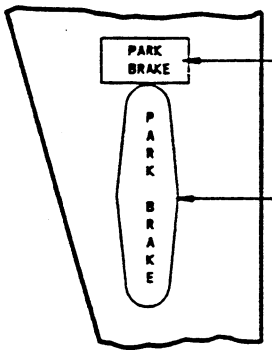
1, 2, 3, 4, MAX AUTO - selects increasing auto brakes deceleration rates

DISARM - auto brakes disengaged, brake pressure released

RTO - automatic rejected takeoff braking

CENTER PANEL

* As installed for First Officer



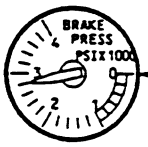

CONTROL STAND

PARK BRAKE LIGHT (amber)

ILLUMINATED - parking brake valve not open

PARK BRAKE HANDLE

PULL - sets parking brake if brake pedal pressure is applied




CENTER PANEL

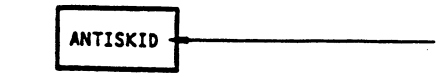
BRAKE/ACCUMULATOR PRESSURE INDICATOR

- hydraulic pressure available to normal brake system
- amber band shows accumulator precharge


CENTER INSTRUMENT PANEL

BRAKE SOURCE LIGHT (amber)

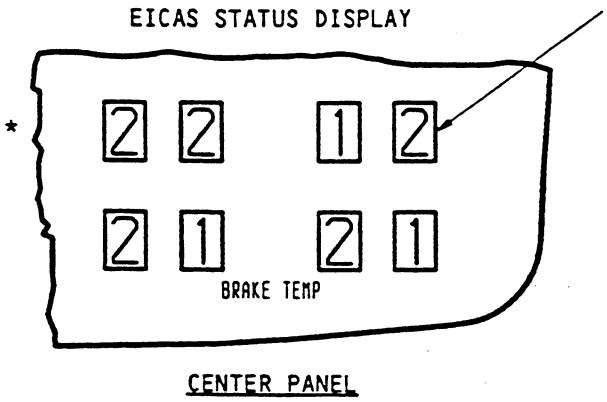
ILLUMINATED - normal and alternate brake system pressure low
- accumulator is power source to brakes




OVERHEAD PANEL

ANTISKID LIGHT (amber)

ILLUMINATED - antiskid fault detected in the active brake system (normal or alternate)




BRAKE TEMPERATURE

- indicates a value relative to wheel brake temperature
- values range from 0 to 9

0 to 2 - initial range
- box and number are cyan

3 to 4 - normal range
- box is white, number cyan

5 to 9 - high temperature range
- box and number are white

(Refer to Chapter 23 Section 10 for brake cooling schedule associated with each indication.)

* As installed

SYSTEM DESCRIPTION

GENERAL

The 767 has two main gear and a steerable nose gear. A tailskid is installed* which extends and retracts with the gear. Each main gear has four wheels per truck while the nose gear has two wheels. Landing gear actuation is powered by the center hydraulic system. An alternate extension system is provided as a back up. A nose wheel steering system is installed to provide ground handling capability.

Normal and alternate braking systems are installed in the airplane. Normal brakes are powered by the right hydraulic system and alternate brakes by the center hydraulic system. Automatic braking is available through the normal brake system. Antiskid protection is provided in both brake systems. Reserve brake and steering power is available if required.

GEAR OPERATION AND INDICATION

The landing gear system is controlled by the landing gear lever which has three positions; UP, OFF, and DN. On the ground, the Landing Gear Lever is prevented from being moved to UP by the lever lock. The lever lock is controlled by main gear tilt sensors. When the gear is not tilted (airplane on the ground), the lock is engaged. The lever lock can be manually overridden by pushing the Lever Lock Override Switch if retraction is desired.

*-300 only

Main gear down locking is provided by a side brace and a drag brace. The LEFT and RIGHT Gear Down Lights illuminate when both side braces and drag braces for each gear are locked. The NOSE Gear Down Light illuminates when the nose gear is down and locked.

Retraction

After takeoff, both main gear tilt, releasing the lever lock. The gear and tail skid retraction sequence is initiated when the Landing Gear Lever is pulled out and positioned to the UP position. The GEAR disagree light illuminates, indicating the Landing Gear Lever disagrees with the gear position.

The main gear doors are sequenced to open and allow the gear to retract into the wheel wells. The gear DOORS light illuminates when any gear door opens. After the main gear retracts, the doors close. Automatic braking occurs during gear retraction.

The nose gear doors are mechanically linked to the nose gear, and open, then close as the gear retracts. The nose gear and doors are held in the retracted position by a lock on the gear structure. When all the gear doors are closed, the DOORS and GEAR disagree lights extinguish.

After the retraction sequence is complete, the Landing Gear Lever is placed in the OFF position. This depressurizes the landing gear system. The main gear are then held in the retracted position by the locked door structure.

Extension

Pulling the landing gear lever out and placing it to the DN position initiates the landing gear and tail skid (-300 only) extension sequence. The main gear doors unlock, releasing the gear. When the main gear have extended, the doors close. The nose gear uplock releases and the doors mechanically open then close as the nose gear extends. After the extension cycle is complete, the GEAR and DOORS Lights extinguish and the Gear Down Lights illuminate. Non-normal landing gear conditions are displayed on EICAS after a time delay. Possible message(s) are shown below.

Alternate Extension

Alternate landing gear extension is accomplished by selecting the Alternate Gear Extension switch. An electric motor trips the locking mechanism for each gear. Gravity and airloads force the gear to the down and locked position. The LEFT, NOSE AND RIGHT Gear Down Lights illuminate when the respective gear is down and locked. The main gear doors remain open following alternate extension if no center hydraulic power is available. There is adequate ground clearance if a gear door is left open for landing.

The tailskid does not extend when the alternate system is used to extend the landing gear.

| CONDITION | MESSAGE |
|---|---|
| RETRACTION: | |
| • Nose, Left or Right Gear not locked | GEAR DISAGREE |
| • Nose, Left or Right Door not closed | GEAR DOORS |
| • Tail Skid not retracted | TAIL SKID * |
| EXTENSION: | |
| • Nose Gear not locked | GEAR DISAGREE |
| • Either Side Brace and associated Drag Brace not locked | GEAR DISAGREE |
| • Left Side Brace not locked | L SIDE BRACE |
| • Right Side Brace not locked | R SIDE BRACE |
| • Left Drag Brace not locked | L DRAG BRACE |
| • Right Drag Brace not locked | R DRAG BRACE |
| • Left or Right Door not closed | GEAR DOORS |
| • Tail Skid not extended | TAIL SKID * |

* -300 only

EICAS GEAR MESSAGES

## AIR/GROUND LOGIC

Inflight and ground operation of various airplane equipment is controlled by an air/ground sensing system and a nose gear compressed sensing system.

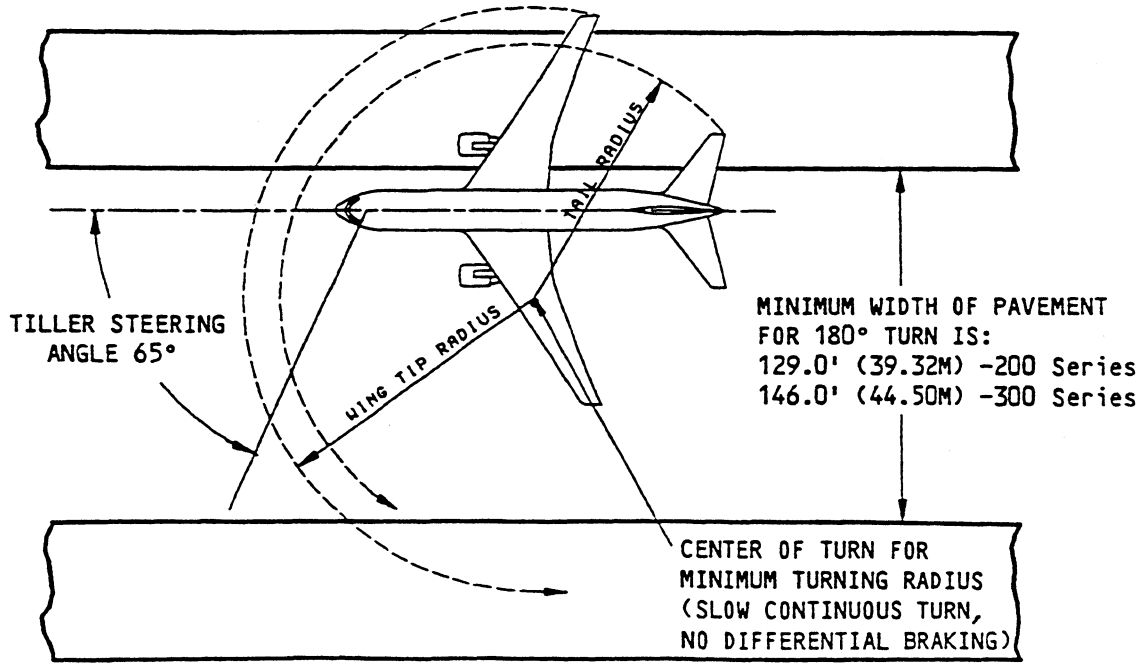
The air/ground sensing system obtains air/ground logic from gear tilt sensors located on each main gear. The system provides logic to relays which control various equipment operations.

A nose gear compressed sensing system provides logic to relays controlling stall warning and portions of the caution and warning system.

On some airplanes, when on the ground, an EICAS advisory message for AIR/GND SYS or NOSE A/G SYS indicates that some portion of the sensing system has failed in the air position. Affected equipment and systems will not operate normally.

## NOSE WHEEL STEERING

Ground handling of the 767 is provided by the center hydraulic powered nose wheel steering system. Primary control of the system is through use of a nose wheel tiller with limited control available through the rudder pedals. The nose wheel can be turned 65° from center by rotating the tiller 360° in the desired turn direction. A nose wheel indicator shows nose wheel direction and angle signaled. The rudder pedals provide a maximum nose wheel steering angle of 6° in either direction. The nose wheel tiller overrides rudder pedal steering inputs. A 180° turn can be made in a minimum 129 feet (39.32 m) of pavement width for the -200 airplane and 146 feet (44.50m) for the -300 airplane. Taxi speed, gross weight, center of gravity, runway conditions and nose wheel steering angle will affect the turn radius and location of the turn center. Wing tip radius is greater than tail radius.




MINIMUM TURNING RADIUS

R44085

NOSE WHEEL STEERING (Cont)

In the event of a center hydraulic leak, a reserve brakes and steering system can power the nose wheel steering.

NORMAL BRAKE SYSTEM

General

The normal brake system is powered by the right hydraulic system. The pilots left and right brake pedals provide independent control of pressure to the left and right main gear brakes. Pushing a brake pedal opens the respective brake metering valve allowing pressure to pass through antiskid valves provided for each wheel.

The antiskid controller regulates pressure through each valve based on eight separate wheel speed transducer inputs.

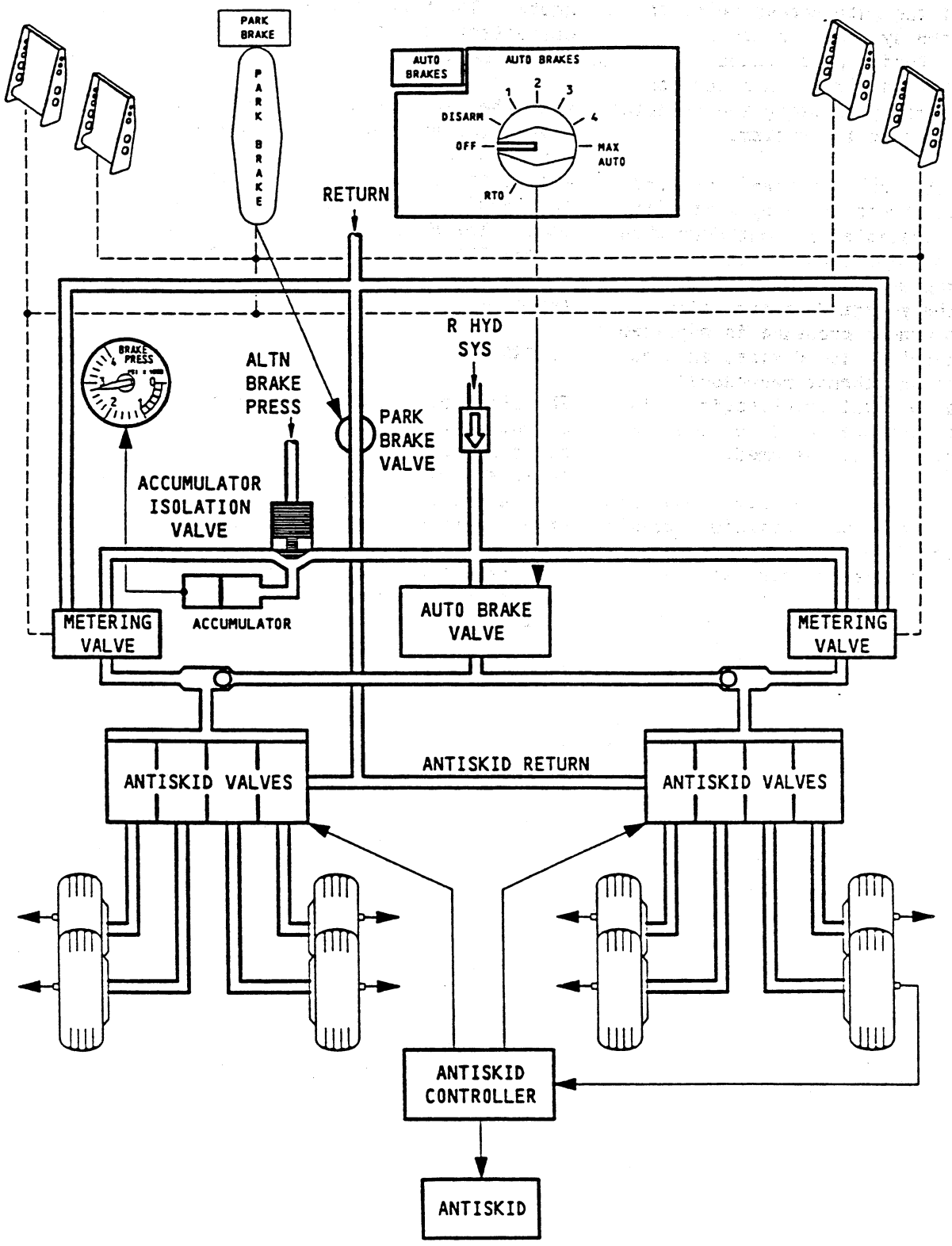
When a potential skid is detected, the controller signals the appropriate valve to reduce brake pressure. This prevents the wheels from skidding when maximum braking efficiency is required. In addition to skid protection, locked wheel, hydroplane and touchdown protection are provided by the antiskid system.

The ANTISKID Light and EICAS message indicate a power loss or system malfunction. The ANTISKID OFF message, and the ANTISKID Light indicate the antiskid system is inoperative. The parking brake is set by applying brake pedal pressure, pulling the Park Brake Handle up and releasing the brake pedals. The handle action holds the pedals down and the brake metering valves open. A brake accumulator in the normal brake system can supply brake pressure when no active hydraulic power exists in the R or C system. To prevent the antiskid system from bleeding off accumulator pressure, a parking brake valve in the antiskid return line is closed when the Park Brake Handle is set. A PARK BRAKE Light indicates the parking brake valve is not open. To release the parking brake, push on the brake pedals. The brake pressure indicator shows the pressure in the brake accumulator. An initial precharge is shown by the amber band on the indicator. A reading at or below the amber band indicates no accumulator brake pressure is available.

The brake accumulator can also provide another source of brake pressure. When the alternate brake system is pressurized, brake accumulator pressure is maintained by closing an accumulator isolation valve. This preserves the accumulator pressure for use if the alternate brake system should also fail. In the event of a total active hydraulic brake source loss, the accumulator isolation valve opens to provide several applications of brake power through the normal brake lines.

Auto Brakes

The auto brakes system permits automatic braking at a pre-selected deceleration rate following touchdown. Various deceleration rates can be selected, however, the maximum autobrakes deceleration rate is less than that produced by full manual braking. Antiskid protection is provided during auto brakes operation.




NORMAL BRAKE SYSTEM SCHEMATIC

Auto Brakes (Cont)

The auto brakes system is armed by selecting a deceleration rate. Latching of the Auto Brakes Selector indicates the system is armed and operative. During auto brakes operation the deceleration selection can be changed by rotating the selector without disarming the system.

With the auto brakes system armed and both Thrust Levers at idle, automatic braking is initiated at touchdown when main landing gear truck untilt and wheel spinup occur. In order to maintain the selected deceleration rate, auto brakes pressure is adjusted as other deceleration devices such as speedbrakes and thrust reversers contribute to total deceleration. The system provides braking to a complete stop or until it is disarmed.

The system disarms immediately when an auto brakes or normal antiskid system fault occurs. Disarming also occurs if the following pilot actions are taken during auto brakes operation:

- manual braking
- advancing either Thrust Lever after landing
- moving the Speedbrake Lever to the DOWN detent after speedbrakes have been extended on the ground
- selecting the DISARM or OFF
- position

When the system disarms, the selector moves to the DISARM position, terminating auto brakes operation. Illumination of the Auto Brakes Inoperative Light indicates that the system has disarmed. Rotating the Auto Brakes Selector to OFF removes power from the system and extinguishes the light.

The RTO (rejected takeoff) mode can only be selected on the ground. Latching of the selector indicates the RTO mode is armed. With the RTO mode armed, the auto brakes system applies maximum brake pressure if both Thrust Levers are retarded to idle above 85 knots. The brake pressure applied is equivalent to that provided by full manual braking.

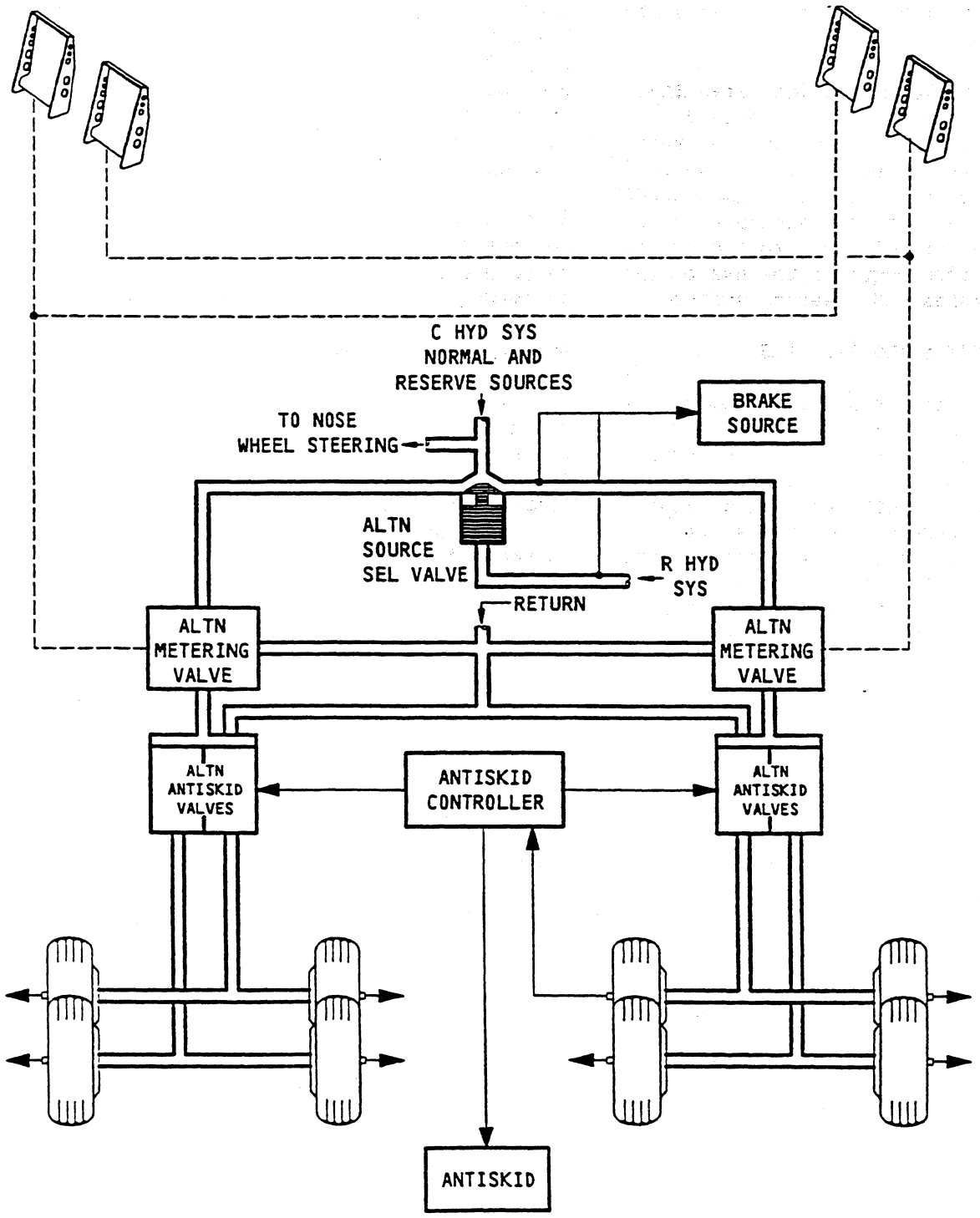
When the RTO mode disarms, the Auto Brakes Inoperative Light illuminates. During a rejected takeoff, after 85 knots, the same conditions which disarm the landing mode also disarm the RTO mode. The Auto Brakes Selector remains in the RTO position after system disarming. At liftoff, the selector trips OFF.

ALTERNATE BRAKE SYSTEM

The alternate brake system is powered by the center hydraulic system. When right hydraulic pressure to the normal brake system is low, an alternate source selector valve automatically opens to supply center hydraulic system pressure to the alternate brake system. Pushing a brake pedal opens the respective alternate brake metering valve, allowing pressure to pass through the alternate antiskid valves to the brakes.

The same antiskid controller and light are used by both the normal and alternate brake systems. The controller regulates pressure through each alternate antiskid valve to a set of laterally paired wheels based on eight separate wheel speed transducer inputs.

When a potential skid is detected, the controller signals the appropriate valve to reduce brake pressure. Since each valve controls pressure for two wheels, brake pressure is reduced to both wheels. In addition to skid protection, locked wheel, hydroplane and touchdown protection are provided by antiskid in the alternate brake system.

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ALTERNATE/RESERVE BRAKES AND STEERING SCHEMATIC

ALTERNATE BRAKE SYSTEM (Cont)

When the alternate brake system is powered, the ANTISKID Light monitors the alternate brake system. The light illuminates with a power loss or system malfunction.

The BRAKE SOURCE Light indicates that both normal brake system pressure (right hydraulic system) and alternate brake system pressure (center hydraulic system) are low. With the BRAKE SOURCE Light illuminated, the accumulator is the only source of power to the brakes. This condition requires the use of the reserve brakes and steering system.

RESERVE BRAKES AND STEERING

The reserve brakes and steering system provides nose wheel steering power with a loss of center hydraulic pressure, or brakes and nose wheel steering power with a loss of both center and right hydraulic pressures. The reserve system pressurizes the alternate brake system. A detailed description of system operation is included in the Hydraulic Power chapter.

The BRAKE SOURCE Light illuminates when both center and right hydraulic system pressures are low. The BRAKE SOURCE Light extinguishes if the reserve system is selected and pressure is available.

BRAKE TEMPERATURE*

Wheel brake temperature conditions are displayed on the EICAS Status page. Numerical values relative to wheel brake temperature are displayed in boxes for each main gear brake, and range from 0 to 9. Temperature values are not instantaneous readings of wheel brake conditions and tend to build for 10 to 15 minutes after brakes are applied.

A temperature value of 0 to 2 represents the initial temperature range and both number and box are cyan in color. Values in the normal range of 3 to 4 are indicated by a white box around a cyan number. If two brake values are within the normal range, only the brake with the highest value, or the first brake to reach the highest value, is surrounded by the white box. All brake values in the high temperature range of 5 to 9 are indicated by a white box and a white number. A BRAKE TEMP light illuminates when any temperature value is 5 or above.

*As installed

# CHAPTER 19

## NAVIGATION/GENERAL



## NAVIGATION/FLIGHT MANAGEMENT

## NAVIGATION/FLIGHT MANAGEMENT (Cont)



## NAVIGATION/STANDBY

TEST SWITCH

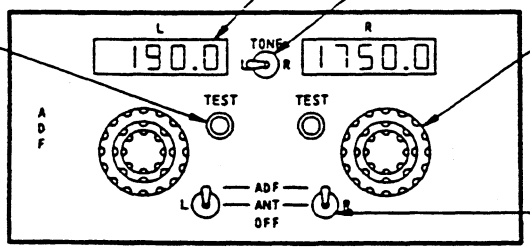
- initiates ADF receiver test
- displays appropriate bearing pointer flag on each RDMI, the flag disappears and pointer positions to 135° relative
- flags remain in view if test fails

ADF FREQUENCY INDICATOR

- displays frequency set by related selector

TONE SWITCH

L or R - activates tone generator required for receiving code from unmodulated (A1) stations



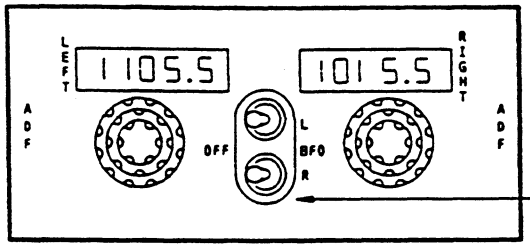

ADF FREQUENCY SELECTOR

- sets frequency in related indicator
- tunes related ADF in frequency range of 190 - 1750 KHz

ADF MODE SWITCH

ANT - audio reception optimized
- no ADF bearing sent to each RDMIs

ADF - ADF bearing sent to RDMIs
- audio reception also possible




AFT ELECTRONIC PANEL

BFO SWITCH [1]

BFO - activates tone generator (beat frequency oscillator) for receiving code from unmodulated (A1) stations

OFF - deactivates tone generator

[1] BFO switch on some airplanes

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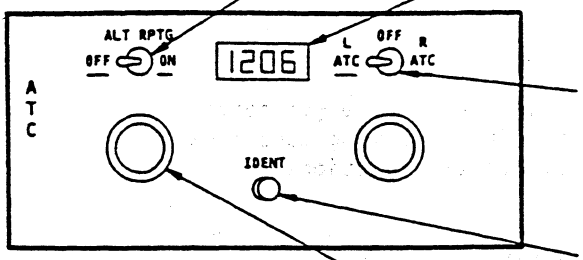
ADF CONTROL PANEL (as installed)




AFT ELECTRONIC PANEL

ALTITUDE REPORTING SWITCH

ON - enables altitude reporting

ATC CODE INDICATOR

- displays code set by ATC Code Selector

TRANSPONDER SWITCH

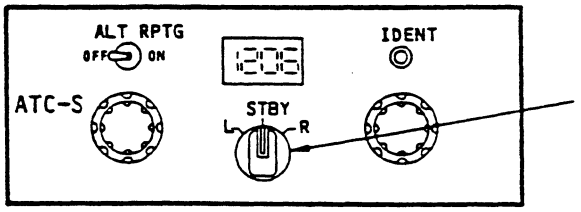
ATC L or ATC R - activates selected transponder

ATC IDENT SWITCH

PUSH - transmits ident signal

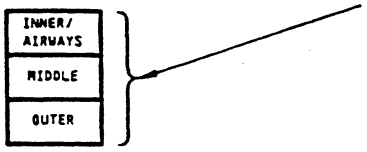
ATC CODE SELECTORS

ROTATE - sets code in ATC Code Indicator and both transponders




TRANSPONDER SELECTOR

L or R - activates selected transponder modes A and C if altitude reporting is ON and airplane is inflight




CENTER PANEL

FIRST OFFICER'S PANEL

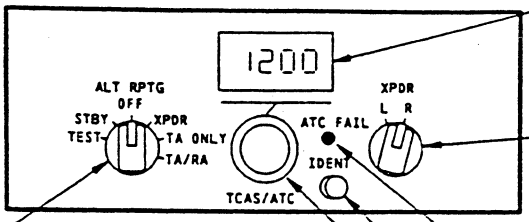
MARKER BEACON LIGHTS

INNER/AIRWAYS - (white) illuminates over an inner or airways marker beacon

MIDDLE - (amber) illuminates over a middle marker beacon

OUTER - (blue) illuminates over an outer marker beacon

TRANSPONDER PANEL(As installed)/MARKER BEACON LIGHTS




AFT ELECTRONIC PANEL

ATC CODE INDICATOR

- displays code set by ATC Code Selector

TRANSPONDER SELECTOR

- selects transponder for operation

ATC FAIL LIGHT (amber)

- illuminates when a transponder malfunction has been detected

ATC IDENT SWITCH

PUSH - transmits ident signal

ATC CODE SELECTOR

ROTATE - sets code in ATC Code indicator and both transponders

TRANSPONDER MODE SELECTOR

TEST - activates test

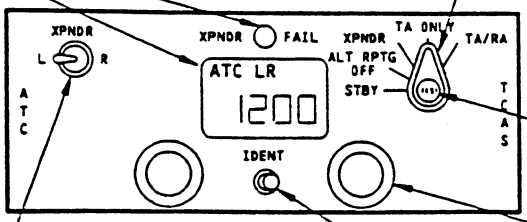
STBY - deactivates transponder

ALT RPDG OFF - activates transponder without altitude reporting if airplane is inflight

XPDR - activates transponder with altitude reporting if airplane is inflight

TA ONLY - activates XPDR and TCAS Traffic Advisory mode

TA/RA - activates XPDR, TCAS TA and Resolution Advisory modes




AFT ELECTRONIC PANEL

ATC INDICATOR

- displays code set by ATC Code Selectors
- displays operating transponder (L or R)

TRANSPONDER FAIL LIGHT (amber)

- illuminates when a transponder malfunction has been detected

TRANSPONDER SWITCH

- selects transponder for operation

TRANSPONDER MODE SELECTOR

STBY - deactivates transponder

ALT RPTG OFF - activates transponder without altitude reporting if airplane is inflight

XPNDR - activates transponder with altitude reporting if airplane is inflight

TA ONLY - activates XPDR and TCAS Traffic Advisory mode

TA/RA - activates XPDR, TCAS TA and Resolution Advisory modes

TCAS TEST SWITCH

PUSH - activates test

ATC CODE SELECTORS

ROTATE - sets code in ATC Indicator and both transponders

IDENT SWITCH

PUSH - transmits ident signal

TRANSPONDER PANEL
(As installed)

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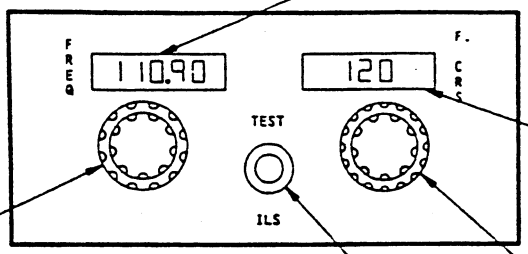
(INTENTIONALLY LEFT BLANK)




AFT ELECTRONIC PANEL

ILS FREQUENCY INDICATOR

- displays frequency sent to center ILS or -----
- dashes indicate frequency selector in standby position and ILS deviation data removed from cockpit displays

ILS FRONT COURSE INDICATOR

- displays course set by ILS Front Course Selector

ILS FRONT COURSE SELECTOR

ROTATE - sets ILS course in ILS Front Course Indicator, ILS receiver, EFIS and AFDS

ILS TEST SWITCH

PUSH - sends test signal to all ILS receivers except during multiple autopilot approaches after LOC or GS capture

ILS FREQUENCY SELECTOR

ROTATE (ILS frequency) - tunes all ILS receivers
- displays received ILS data on ADI
- if HSI Mode Selector in ILS position, ILS data displayed on related HSI and related DME tunes to selected ILS frequency
- VOR frequencies not available
- frequency change inhibited during multiple autopilot approaches after LOC or GS capture

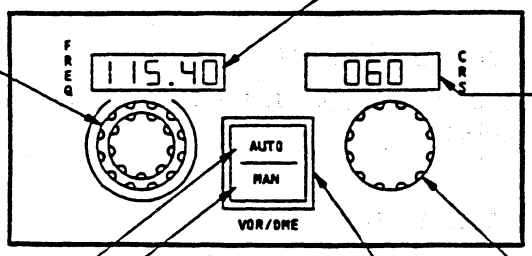
ROTATE (-----) - removes ILS scales and pointers from ADIs

VOR FREQUENCY SELECTOR

ROTATE - when MAN light illuminated tunes related VOR and also tunes DME if HSI Mode Selector not in ILS position
- ILS frequencies not manually available

VOR FREQUENCY INDICATOR

- displays frequency tuned on related VOR
- displays ——— during automatic tuning if no IRS in NAV mode
- during automatic tuning may display ILS frequency




GLARESHIELD (2)

VOR COURSE INDICATOR

- displays course set by VOR Course Selector

VOR COURSE SELECTOR

ROTATE - sets course in VOR Course Indicator and EFIS

VOR/DME MANUAL LIGHT (white)

ILLUMINATED - indicates VOR Frequency Selector tuning VOR
- if HSI ILS mode not selected, VOR Frequency Selector tunes DME
- if HSI Mode Selector in ILS position, ILS Frequency Selector tunes DME

VOR/DME SWITCH
(momentary action)

PUSH - alternates VOR and DME tuning between FMC and VOR Frequency Selector when HSI Mode Selector in MAP or PLAN. Only MAN available when HSI in VOR or ILS mode

VOR/DME AUTO LIGHT (white)

ILLUMINATED - indicates FMC tuning related VOR and DME. HSI Selector must be in MAP or PLAN position

VOR/DME PANEL

M/S SWITCH

- inoperative mode
- removes radar returns from display

MARKER CONTROL

ROTATE - adjusts the brightness of range arcs and azimuth lines

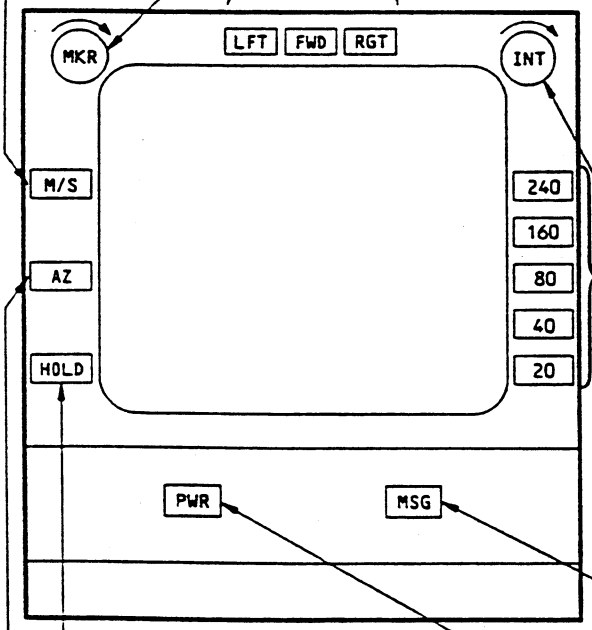
DISPLAY SELECT SWITCHES
(momentary action)

- selects desired area for radar scanning

LFT - shifts origin to right
- displays 90° sector forward and to left of airplane

FWD - shifts origin to center
- displays area ±60° of airplane heading
- displayed automatically when initial power is applied

RGT - shifts origin to left
- displays 90° sector forward and to right of airplane




ELECTRONICS PANEL

INTENSITY CONTROL

ROTATE - adjusts brightness of display

RANGE SELECT SWITCHES
(momentary action)

PUSH - selects desired nautical mile range for radar display
- displays 80nm range when initial power is applied

MSG SWITCH

- inoperative

POWER SWITCH
(alternate action)

ON - (in) activates radar and indicator

OFF - (out) deactivates radar if both HSI Control Panel WXR Switches are OFF

HOLD SWITCH
(alternate action)

PUSH - freezes the displayed image

AZIMUTH SWITCH
(alternate action)

PUSH - displays azimuth marks

GAIN CONTROL

CAL - activates automatic gain control

ROTATE - manually sets receiver sensitivity

MODE SWITCHES

- pushing activates selected mode

TEST - activates radar
- displays maintenance test pattern

WX/T - activates radar
- displays weather and turbulence returns

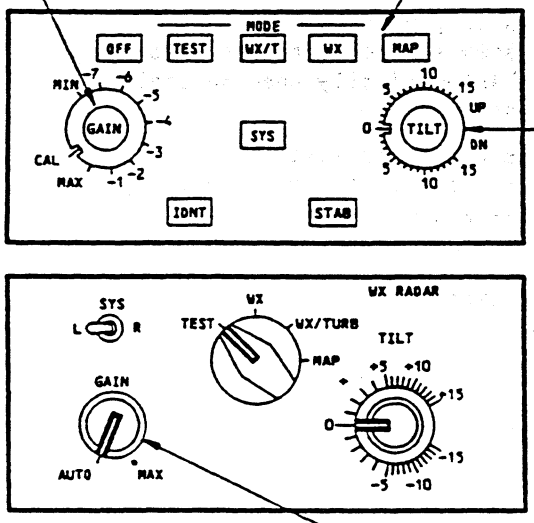
WX - activates radar
- activates display of detected precipitation

MAP - activates radar
- activates display of detected ground returns

SYS - selects left or right system (transmitter/receiver) for operation when radar is on

IDNT - activates ground return suppression. Normal operation position would be off

STAB - activates antenna stabilization




AFT ELECTRONIC PANEL

TILT CONTROL

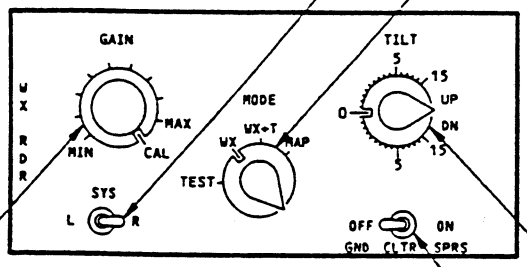
- controls antenna tilt angle with reference to horizon

GAIN CONTROL

AUTO (detent only) - presets an optimum receiver sensitivity for best weather radar display

ROTATE - manually sets receiver gain

WEATHER RADAR
(As installed)




AFT ELECTRONIC PANEL

RADAR SYSTEM SWITCH

- selects left or right system (transmitter/reciever) for operation when radar is on

RADAR MODE SELECTOR

TEST - displays maintenance test pattern

WX - displays weather radar returns

WX + T - display weather and turbulence returns

MAP - displays ground returns

ANTENNA TILT CONTROL

- controls antenna tilt angle with reference to horizon

GROUND CLUTTER SUPPRESSION SWITCH

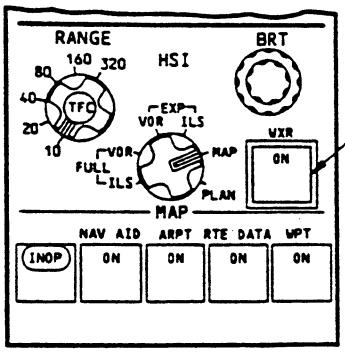
ON - activates ground returrn clutter suppressiion mode
- reduces intensity of ground returns
- reduces intensity of precipitation returns

OFF - radar operates normally

GAIN CONTROL

CAL (detent only) - presets an optimum receiver sensitivity for best weather radar display

ROTATE - manually sets receiver gain



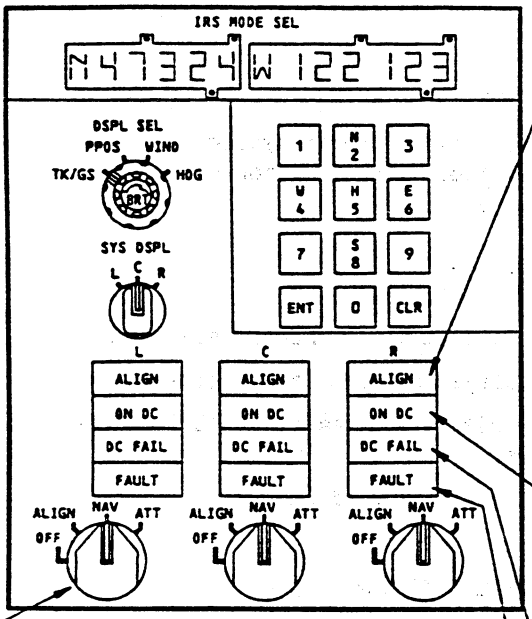

CONTROL STAND (2)

WEATHER RADAR SWITCH
(alternate action)

ON - (ON illuminated white) activates radar on airplanes without radar control panel OFF switch
- displays radar data on related HSI if radar control panel not in OFF

OFF - (blank) removes radar data from related HSI
- deactivates radar if radar indicator and other pilots WXR switch are OFF on airplanes without radar control panel OFF switch

WEATHER RADAR (as installed)




OVERHEAD PANEL

IRS MODE SELECTOR

- controls operating mode of related IRS
- must be pulled out to move from NAV positions

OFF - alignment is lost
- ALIGN light illuminates for 30 seconds as system goes through shutdown sequence
- realignment requires about 10 minutes parking and present position (latitude and longitude) entry

ALIGN - initiates alignment when parked
- initiates a quick alignment if selected when the system is in the navigation mode

NAV - permits system to enter NAV mode after completing alignment
- initiates a 10 minute alignment if selected from OFF

ATT - initiates attitude mode operation
- present position and true heading lost until system realigned on ground
- must be cycled through OFF position to re-enter align or nav mode
- magnetic heading input required to initialize heading output

IRS ALIGN LIGHT (white)

ILLUMINATED (STEADY) - IRS is operating normally in align mode, initial attitude mode selection or powering down

ILLUMINATED (FLASHING) - position entry required
- 10 minute alignment complete except for position entry
- position entry error (previous IRS position being significantly different from entered position)
- IRS error detected

EXTINGUISHED - IRS not in align mode

IRS ON DC LIGHT (amber)

ILLUMINATED - IRS operating on airplane battery (DC) power
- illuminates for a few seconds during initial alignment power test
- on ground, if AC power fails horn sounds in nose wheel well

IRS DC FAIL LIGHT (amber)

ILLUMINATED - IRS DC power voltage level below normal
- system operating on AC power

IRS FAULT LIGHT (amber)

ILLUMINATED - system has detected a fault requiring maintenance

IRS MODE SELECTOR PANEL

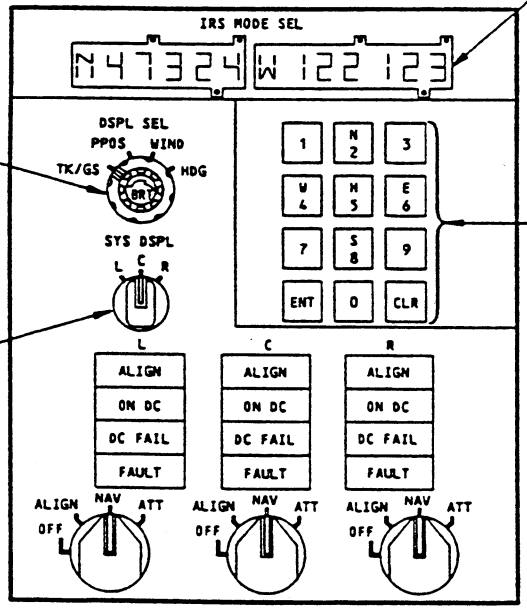
IRS DISPLAY SELECTOR

- selects data for display when keyboard not in control

TK/GS - displays present true track and groundspeed
PPOS - displays present position

WIND - displays present true wind when inflight

HDG - displays present true heading




OVERHEAD PANEL

IRS SYSTEM DISPLAY SELECTOR

- selects system to display data when keyboard not in control

IRS DISPLAY

- displays track, groundspeed, present position, wind and heading
- controlled by display selectors or keyboard

IRS KEYBOARD

- pushing N or S allows keyboard to control display and key latitude into display
- pushing E or W allows keyboard to control display and key longitude into display
- pushing H allows keyboard to control display and key heading into display

ENT KEY - enters data keyed into display in all inertial systems
- restores display selectors control of display

CLR KEY - clears data keyed into display
- restores display selectors control of display

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IRS MODE SELECTOR PANEL

## GENERAL SYSTEMS DESCRIPTION

### GENERAL

Navigation includes information on the ADF, ATC transponder, DME, ILS, VOR, marker beacon, weather radar and inertial reference system (IRS). (See Flight Instruments chapter for systems displays)

### ADF

A dual ADF system is installed. The control panel is located on the aft electronics panel. The ADF bearing signals are sent to the pointers and flags on the RDMI and HSI.

### TRANSPONDER

Two ATC transponders are installed and are controlled by a single control panel. TCAS is also controlled from the transponder panel. The TCAS system is described in Chapter 22.

### DME

Two DME systems are installed. Each can be automatically tuned by the FMC or manually tuned by the VOR or ILS control panel. When the HSI Mode Selector is in the VOR or ILS position, the related panel tunes the DME. When the HSI selector is in the MAP or PLAN position automatic FMC tuning or manual VOR panel tuning can be selected with the VOR/DME switch.

DME distance can be displayed on the RDMI or HSI.

When the related HSI Mode Selector is NOT in the ILS position, DME audio is heard by using the VOR Receiver Control on an audio selector panel. In the ILS position, DME audio is heard by using the ILS Receiver Control.

### ILS

Three ILS receivers are installed. They are controlled by a single control panel. Frequency changes are inhibited after localizer or glide slope capture if three autopilots are in CMD mode. The ADIs display localizer and glide slope deviation. The standby attitude indicator can also display localizer and glide slope deviation.

When an HSI is in ILS mode, the related HSI displays localizer and glideslope deviation along with the selected course.

### MARKER BEACON

Each pilot has a set of marker beacon lights that show outer, middle and inner/airways beacon passage. Both sets are operated by the marker beacon receiver that is part of the left VOR receiver.

### VOR

Two VOR receivers and control panels are installed. The panel is used to tune the related VOR/DME when the associated HSI Mode Selector is in the VOR position. The VOR and DME are automatically tuned by the FMC when the related HSI Mode Selector is in MAP or PLAN and VOR/DME panel is in AUTO.

The VOR bearing can be displayed on the RDMI. The HSI displays the selected course and course deviation when operating in VOR mode.

WEATHER RADAR

The weather radar system consists of two receiver/transmitter (R/T) units, an antenna, a control panel and a dedicated indicator. The control panel selects which R/T unit is used. Returns are displayed on the HSI in all modes except PLAN, FULL VOR and FULL ILS. The range covered by the display is selected on the related pilot's HSI control panel or radar indicator.

INERTIAL REFERENCE SYSTEM

General

Three Inertial Reference Systems (IRSs) are installed. All are controlled from the same control panel. When operating in the navigation mode, the IRSs provide attitude, acceleration, ground speed and track, true and magnetic heading, present latitude and longitude, and wind speed and direction to any system requiring this inertial information. (Magnetic heading is only provided between latitudes N73° and S60°). An IRS must be aligned before it can enter nav mode and supply all the data listed above.

Normal Alignment

The airplane must be on the ground and stationary to align an IRS. Motion caused by wind and loading does not prevent alignment.

Alignment is started by moving the IRS Mode Selector from the OFF position to the NAV position. The system first goes through about a ten-second test, then starts aligning. During the test, the ON DC Light momentarily illuminates as the system tests the DC power source, then extinguishes when it starts operating on the normal AC power source. About ten seconds after system activation the ALIGN Light illuminates to indicate the start of alignment.

Alignment requires about ten minutes while the IRS calculates attitude and true heading. Present position (latitude and longitude) must be entered during alignment. This entry is normally made on the CDU POS INIT page and becomes the navigation starting point. Present position entry is also possible from the IRS Mode Selector Panel.

The system automatically enters the nav mode and the ALIGN Lights extinguish when the selector is in NAV, alignment is complete and present position has been entered.

High Latitude Alignment

High latitude (between 70° 12.0' and 78° 15.0') alignments requires an extended alignment time. This extended alignment is accomplished by rotating the Mode Selector from OFF to the ALIGN position and allowing the IRS to align for a minimum of 17 minutes. Present position is entered while in the align mode. After the extended alignment, nav mode is entered by rotating the Mode Selector to the NAV position.

INERTIAL REFERENCE SYSTEM (Cont)

Fast Realignment

Some accumulated IRS errors can be removed by a 30-second realignment. It is accomplished by selecting ALIGN and entering latitude and longitude. Then, the selector is repositioned to NAV. Fast realignments DO NOT eliminate the requirement to periodically accomplish normal alignments.

Movement During Alignment

The airplane should not be moved while any ALIGN Light is illuminated. If the airplane is moved during alignment, the alignment must be restarted. When the motion stops, some units automatically restart the alignment. Other units flash the ALIGN Light until the alignment is manually restarted.

Manual restarts are accomplished by moving the IRS Mode Selector to OFF. Then, when the ALIGN Light extinguishes, reselect NAV.

Electrical Power

Normally the IRSs operate on AC power from the left and right electrical systems. The main airplane battery is used as an alternate power source. The ON DC Light illuminates when AC power is lost and DC power is being used. The DC FAIL Light illuminates when DC power is lost and AC power is being used. Both lights extinguish if both AC and DC power are on or off.

When powering the standby power system from the main battery for more than 5 minutes, DC power to the right IRS is removed to conserve battery power. If power is also lost on the right AC Bus, the right IRS will shut down. IRS DC power will not be removed if the electrical system is isolated when three autopilots are armed for approach.

Loss of Alignment

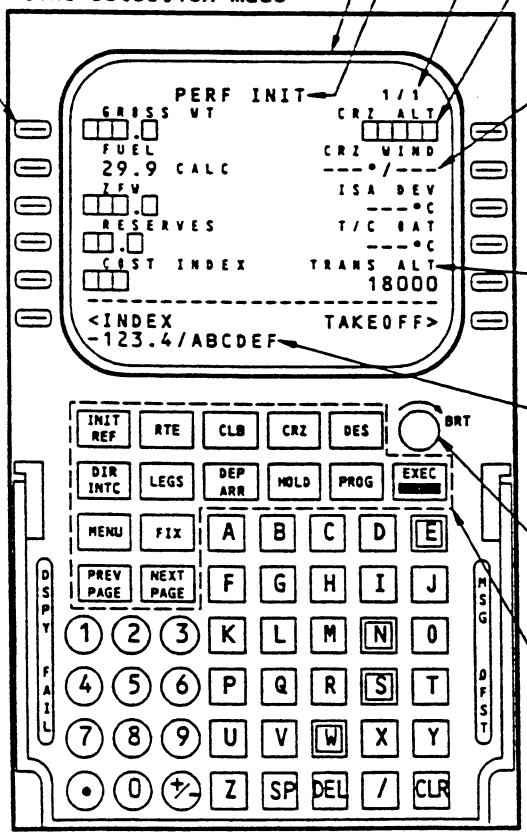
If an IRS loses both AC and DC power, alignment is lost. Alignment can also be lost if the selector is moved out of the NAV position.

If alignment is lost inflight, the nav mode is inoperative for the remainder of the flight and the inertial information mentioned above is not provided. However, attitude information may be available by moving the selector to ATT. This relevels the system and after about 30 seconds provides an attitude display on the ADI. Some attitude errors may occur during acceleration. After acceleration, errors are slowly removed.

In the attitude mode an IRS may also provide magnetic heading, but a magnetic heading input is required for initialization. This heading entry is made on the CDU POS INIT page or IRS Mode Selector Panel and must be updated periodically.

LINE SELECT KEY
(momentary action)

PUSH- selects or enters data on adjacent line
- selects page, procedure, data or function identified on adjacent line
- if scratch pad blank, copies adjacent data in scratch pad
- if scratch pad contains data, transfers scratch pad data to adjacent line, replacing previous data on selected line. This is normal method for entering data
- scratch pad data cannot be moved to blank line
- some data cannot be moved or changed
- scratch pad displays message if inappropriate line selection made




FORWARD ELECTRONIC PANEL (2)

CDU DISPLAY

- displays pages of data as selected with Function and Mode Keys or Line Select Keys

PAGE TITLE

- indicates type of data displayed
- ACT or MOD may be displayed to indicate whether page is active or modified data

PAGE NUMBERS

- first digit indicates page number
- second digit indicates total number of related pages

BOXES

- indicates data entry required for full LNAV and VNAV capability
- data entered by transfering data from scratch pad using Line Select Key

DASHES

- indicates data entry is requested by system and should be made, if data known
- data entered by transfering data from scratch pad using Line Select Key

LINE TITLE

- identifies type of data on line below
- data line blanks when data unknown to FMC

SCRATCH PAD LINE

- bottom line of display
- displays system generated messages for crew, keyboard entries and data being moved from one line to another
- may be blanked by pushing CLR Key

BRIGHTNESS CONTROL

ROTATE - controls intensity of display

FUNCTION AND MODE KEYS
(Momentary action)

PUSH - selects data for display or executes changes
- provides rapid access to data most often used

CONTROL DISPLAY UNIT (CDU)

INITIALIZATION/REFERENCE KEY

PUSH - selects page for initializing the navigation systems or various categories of reference data

ROUTE KEY

PUSH - selects page for entering or changing origin, destination or route

CLIMB KEY

PUSH - selects page for evaluating and changing climb schedule

CRUISE KEY

PUSH - selects page for evaluating and changing cruise schedule

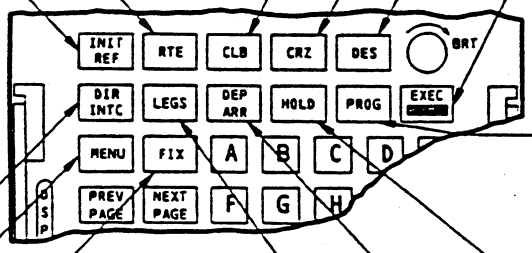
DESCENT KEY

PUSH - selects page for evaluating and changing descent schedule

EXECUTE KEY

ILLUMINATED - (white) indicates modification to active route or vertical profile armed

PUSH - activates the modification and extinguishes the light in key




PROGRESS KEY

PUSH - selects current dynamic flight and navigation data, including ETAs for next two waypoints and destination

HOLD KEY

PUSH - selects page for entering or exiting holding pattern

FIX KEY

PUSH - selects page for creation of intersections using bearing from an offroute waypoint (Fix) stored in the data base

DEPARTURE/ARRIVAL KEY

PUSH - selects page for entering or changing departure and arrival procedures for route one or route two

MENU KEY

PUSH - selects page for changing sub-system control function

LEGS KEY

PUSH - selects page showing lateral and vertical details of each leg of route
- selects page for modifying lateral or vertical waypoints
- selects page for controling HSI PLAN mode map

DIRECT/INTERCEPT KEY

PUSH - selects page with box prompts required for entering route from present position direct to waypoint, or to intercept designated course to waypoint

CDU FUNCTION AND MODE KEYS

FMC FAIL LIGHT (amber)

ILLUMINATED - fault detected in related CDU or FMC

DISPLAY LIGHT (white)

ILLUMINATED - displayed data is not related to active route leg or climb/cruise/ descent schedule

PREVIOUS PAGE KEY

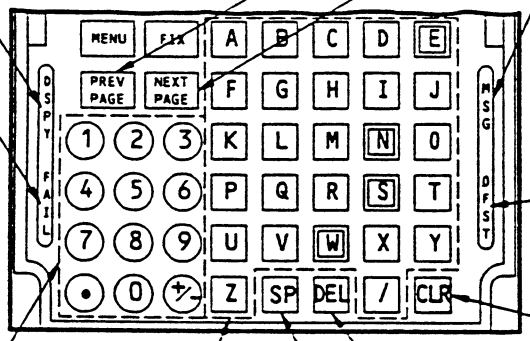
PUSH (momentary) - selects next lower page number in multiple page displays

NEXT PAGE KEY

PUSH (momentary) - selects next higher page number in multiple page displays

MESSAGE LIGHT (white)

ILLUMINATED - indicates system contains message for pilot
- if non-message data is displayed on scratch pad pushing CLR key displays message
- pushing CLR Key again extinguishes light and clears message




OFFSET LIGHT (white)

ILLUMINATED - LNAV based on lateral offset course

CLEAR KEY
(momentary action)

PUSH - clears scratch pad line
- momentary push clears last character of data
- holding down clears all data
- with message displayed on scratch pad, momentary push clears message, extinguishes MSG light and FMC light

ALPHA KEYS
(momentary action)

PUSH - enters alpha characters on scratch pad. / key used to separate speed/ altitude, wind direction/speed, bearing/distance and similar type entries

DELETE KEY
(momentary action)

PUSH - enters DELETE in scratch pad when scratch pad is blank. Subsequent line selection deletes data on adjacent line if the data is deleteable

NUMERIC KEYS
(momentary action)

PUSH - enters numeric characters on scratch pad. First push of +/- key enters - sign. Subsequent push changes sign to +

SPACE KEY
(momentary action)

PUSH - enters blank space in scratch pad when CDU is used to control non-FMC subsystem

FMC LIGHT (amber)

ILLUMINATED - CDU is displaying an operationally significant message on scratch pad
- pushing CLR Key extinguishes light and clears message

FMC

CENTER PANEL

CDU/FMC LIGHTS

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## FLIGHT MANAGEMENT SYSTEMS DESCRIPTION

### FMS INTRODUCTION

The Flight Management System (FMS) is an integration of sub-systems which aids the pilot in controlling (managing) the airplane lateral and vertical flight path. This is commonly called LNAV and VNAV. The sub-systems are designed to allow the pilot to select the level of automation desired during all phases of flight. The sub-systems reduce workload by eliminating the need for many routine tasks and computations.

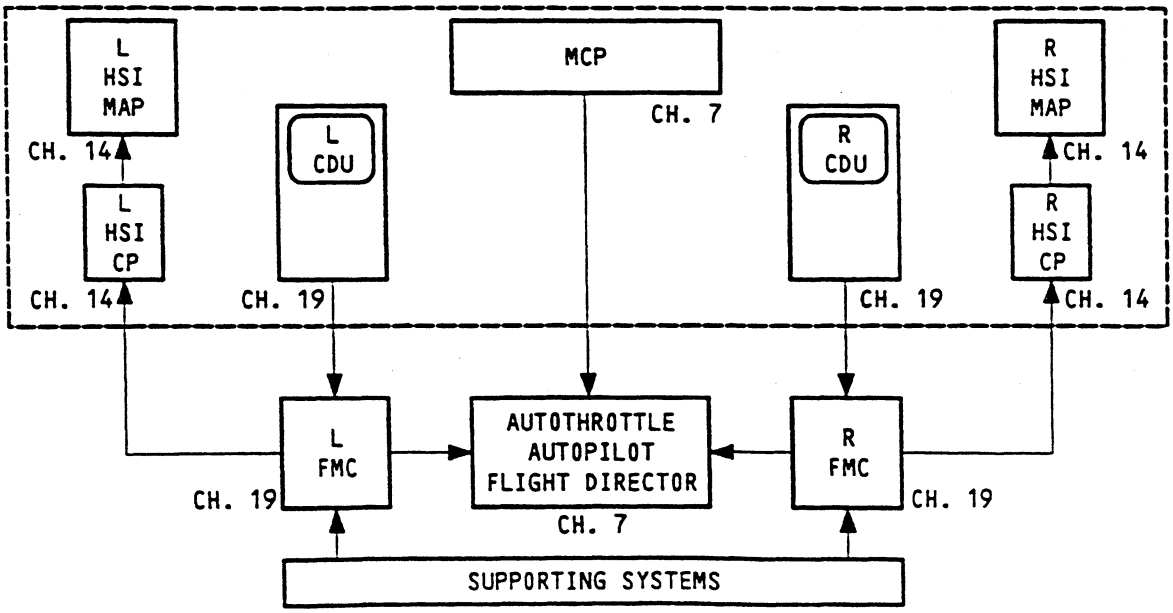
The primary functions of the FMS are to provide automatic navigation, inflight performance optimization and automatic fuel monitoring. A secondary function is to provide cockpit displays to assist the pilot during manual flight. The displays include a map for orientation and bugs on the airspeed and N1 indicators that assist in manually flying precise profiles.

The primary cockpit controls are the Autopilot Flight Director System Mode Control Panel (MCP), two Control Display Units (CDU) and two Horizontal Situation Indicator (HSI) Control Panels. The primary cockpit displays are the two CDU and two HSI displays.

Each CDU contains a display on the top half and a keyboard on the bottom half. The CDU is used to enter the desired lateral and vertical flight plan into the Flight Management Computers (FMC).

The FMC combines the flight plan information entered by the pilot, information received from supporting systems and information stored in its memory. From this information the computer calculates the airplane present position along with the pitch, roll and thrust commands required to fly an optimum flight profile. The computers send commands to the autothrottle, autopilot and flight director, and send map information to the HSI. The HSI Control Panels are used to select the desired information for display on the multicolor maps. The MCP is used to select the operating modes for the autothrottle, autopilot and flight director.

The following diagram presents an overview of the primary function of the Flight Management System components and a reference to the Operations Manual Chapter where more detail may be found.

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## CDU AND FMC OVERVIEW

Refer to the next page for a diagram showing an overview of the system.

Entries made from either CDU are sent to both computers. Because of this interconnection, to prevent confusion it is recommended that only one CDU at a time be used for entering information. The second CDU is best used as a monitor to check information being entered on the other CDU.

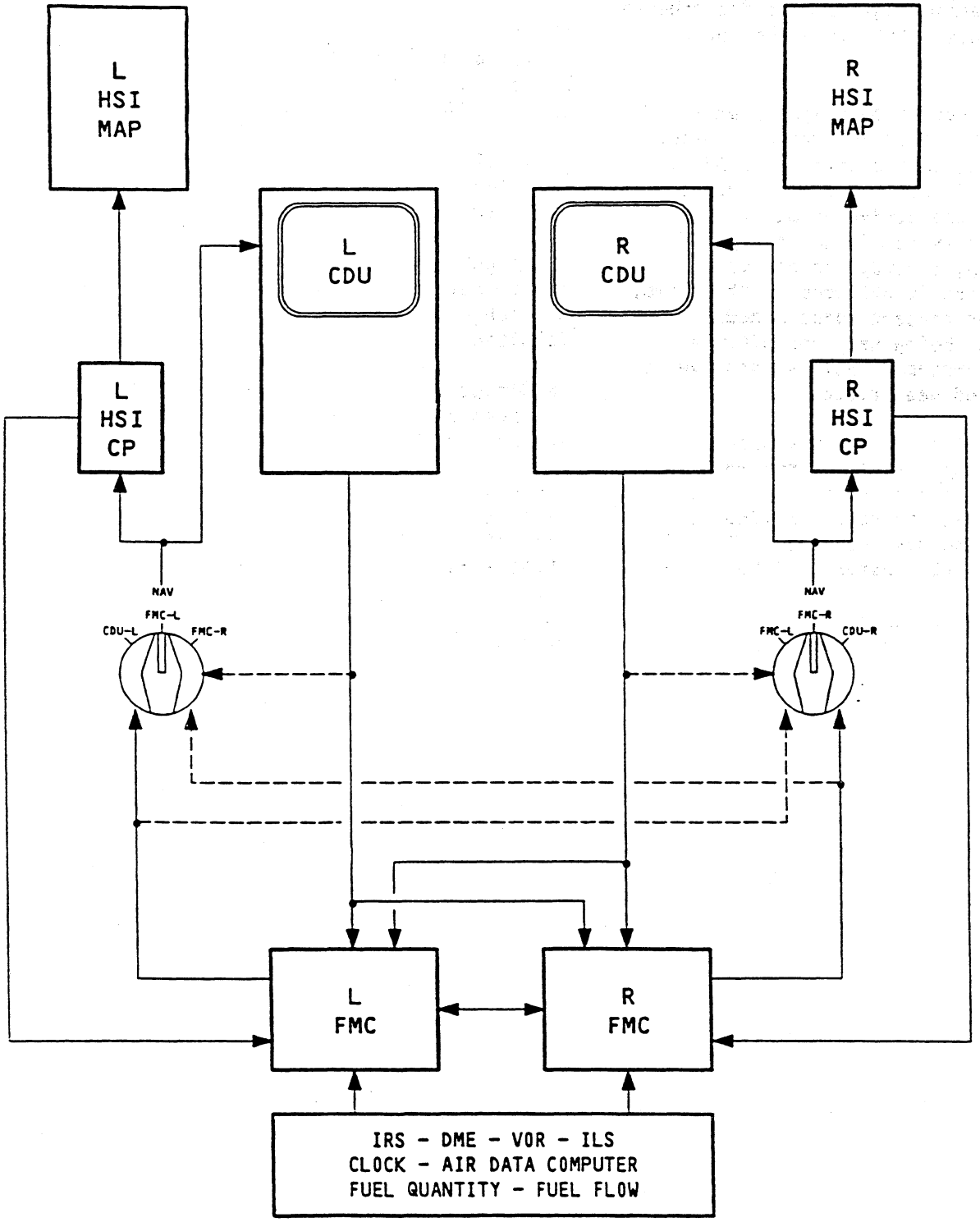
The supporting systems supplying inputs to the FMC include the IRS, DME, VOR, ILS, clocks, air data computers, fuel quantity and fuel flow systems. Normally, each CDU and HSI map displays data from the related computer. However, FMC switch (or the NAV selector) can be used to connect the related HSI and CDU displays to the other sides computer. This level of interconnection makes all flight management functions available as long as either CDU and either FMC is operating. When a pilot selects the other pilots FMC the related HSI control panel must be set to the same map mode (MAP or PLAN) and range as the panel sending signals into the FMC being used. This is required to display a map on both sides of the cockpit because a FMC can only generate one map. However, the same FMC generated map can be displayed on both HSI. The use of the selectors CDU position is covered in the STANDBY NAVIGATION SECTION.

If both FMCs are operating, they operate independently but occasionally compare data. If the comparison fails to meet established tolerances, or an FMC detects a potential fault, a resynchronization is initiated. (Actual faults may result in multiple resynchronizations followed by one FMC shutting down.)

With the NAV selectors in the vertical positions, one FMC is designated the master and the other is the slave. The left FMC is the master except when one of the following two conditions exist:
- the right autopilot is in command;
- all autopilots are disengaged, the left flight director is OFF and the right flight director is ON. (When operating in LNAV and/or VNAV mode the master FMC provides commands to the AFDS and autothrottle.) In most cases the master FMC resynchronizes the slave FMC. However, if the master detects a potential fault the slave resynchronizes the master. During a resynchronization one FMC stops supplying data while the other FMC loads it with new data. Resynchronizations normally take about 15 seconds, but can take longer if a CDU key is pressed.

Any of the following flight deck indications may appear during a resynchronization: The FMC light illuminates and EICAS displays FMC MESSAGE and perhaps FMC FAIL. One CDU displays the RESYNCING OTHER FMC message while the other CDU display is frozen, or displays the FMC FAIL indications. The SINGLE FMC OPERATION message may appear. The HSI on the side being resynchronized displays the VTK flag. If the slave resynchronizes the master while in LNAV and VNAV mode, the autothrottle disengages and the AFDS indicates a mode failure (amber line through mode annunciation, F/D bar removed and an autopilot caution).

The FMC with CDU meets regulatory requirements for an Area Navigation System when used with radio updating. In this configuration, and in conjunction with the map display of the HSI, the FMC and CDU may be used for enroute and terminal area navigation and RNAV approaches and as a supplement to primary navigation means when conducting other types of non-precision approaches. In a dual FMC, dual CDU configuration and in conjunction with two or three IRS, the systems are approved for use as sole means of navigation in areas without radio coverage.

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## CDU AND FMC TERMINOLOGY

The following information describes the unique terminology used to describe the pilots interaction with the CDU and FMC.

"Active" refers to flight plan information that is currently being used to calculate lateral (LNAV) or vertical (VNAV) guidance commands. For example; the active waypoint is the point the system is currently navigating toward; the active performance (VNAV) mode is the climb, cruise or descent speed schedule currently being used for pitch and thrust commands. ACT is displayed in associated page titles.

"Activate" refers to the process of designating one of the two routes as active. It's a two step process. First, push the ACTIVATE line select key for the desired route. Second, push the illuminated EXEC key.

"Altitude Constraint" refers to a crossing restriction at a waypoint.

"Econ" refers to a speed schedule that is calculated to minimize the operating cost of the airplane. The economy speed is based on a cost index that is entered into the CDU during preflight. The index is determined by dividing the operating cost of the airplane by the cost of fuel. If fuel costs are high the number is low. A cost index of zero results in a econ speed equal to the maximum range speed.

"Enter" refers to the process of typing or line selecting characters into the CDU scratch pad line and then line selecting the desired location for the data.

"Erase" refers to removing modified data from the system by pushing the line select key adjacent to the word ERASE.

"Execute" refers to making entered data part of the active flight plan by pushing the illuminated EXEC key.

"Inactive" refers to route, climb cruise or descent information that is not currently being used to calculate LNAV or VNAV commands.

"Initialize" refers to the process of entering data into the CDU that is required to make the system operative.

"Message" refers to information the system automatically writes in the scratch pad to inform the pilot of some condition.

"Modified" refers to active data that has been changed. When a modification is made to the active route or performance mode, MOD is displayed in associated page title, ERASE appears next to one of the line select keys and the EXEC key illuminates. Pushing the ERASE line select key removes the modification. Pushing the EXEC key changes the modified data to the active status.

"Prompt' refers to something displayed on the CDU to aid the pilot in accomplishing a task. It may be some boxes or dashes to remind the pilot to enter information on the associated line, or perhaps a word to indicate what action is required next.

"Resyncronization" is the automatic process of one FMC loading data in the other when a significant difference between the two FMCs is detected.

"Select" refers to pushing a key to obtain the desired data or action.

"Speed Restriction" refers to a pilot entered airspeed limit below a specified altitude.

CDU AND FMC TERMINOLOGY (Cont)

"Speed Transition" refers to an automatically entered airspeed limit below a specified altitude.

"Waypoint" refers to a point in the route. It may be a fixed point such as a latitude and longitude, VOR or NDB station, intersection on an airway, etc., or a conditional point. An example of a conditional point is "when reaching 1000 feet."

FMC DATA BASE

The information stored in the FMC is called its data base. The data base is divided into two major sections. One contains performance related information and the other contains information dealing with navigation.

The purpose of the performance data base is to eliminate the need for the pilot to refer to a performance manual during flight and provide the FMC data required to calculate pitch and thrust commands. All reference data normally required can be displayed on the CDU. The data stored in the data base includes airplane drag and engine characteristics, both maximum and optimum altitudes, and both maximum and minimum speeds. Maintenance can refine the data base for each airplane by entering correction factors for drag and fuel flow.

The FMC navigation data base includes most information that the pilot would normally determine by refering to navigation charts. This information can be displayed on the CDU or HSI map and eliminate most of the cockpit chart reading required in airplanes without FMC. The geographic area covered includes all areas where the airplane is normally flown. The stored data includes the location of VHF navigation aids, airports, runways and other airline selected information such as SID, STARS, approaches and company routes. The content of the data base can be changed by the airline by contacting the navigation data base supplier.

The FMC contains two sets of navigation data, each valid for 28 days. Each set corresponds to the normal revision cycle for navigation charts. During preflight the pilot can select which set is active. The FMC uses the active set for navigation calculations. The contents of the navigation data base is usually updated by maintenance every 28 days. When the navigation chart revision date arrives the new data is already in the FMC and ready for activation.

## CDU OPERATION

### General Rules

To avoid errors, work in a slow deliberate manner while operating the CDU. Avoid pushing more than one key at a time. Avoid entering data in both CDUs at the same time. Do not push CDU keys when the system is going through a resynchronization. Resynchronizations take about 15 seconds to complete. During this time one map and CDU shows a failed condition while the other CDU displays the RESYNCING OTHER FMC message.

When selecting a CDU page read the page title to ensure the correct page appears.

Check that the scratch pad line is blank before trying to enter data on the line. Use the CLR key as required to blank the scratch pad.

When entering data on the scratch pad line ensure that it is correct before continuing with the procedure.

Use care when pushing line select keys to ensure the correct key is being pushed.

Confirm that data displayed on the CDU is correct before pushing the EXEC key. If an error has been made, correct the erroneous data or push the ERASE line select key and then restart the procedure. Data cannot be entered on a blank line.

Messages that commonly indicate an error has been made are NOT IN DATA BASE, INVALID ENTRY and INVALID DELETE.

### Preflight

During preflight, information from the flight plan and load sheet are entered into the CDU. This information defines the starting point of the flight for initialization of the inertial reference systems, the desired route to the destination to initialize LNAV, and performance information to initialize VNAV. If necessary, the CDU may be used to modify the flight plan while enroute.

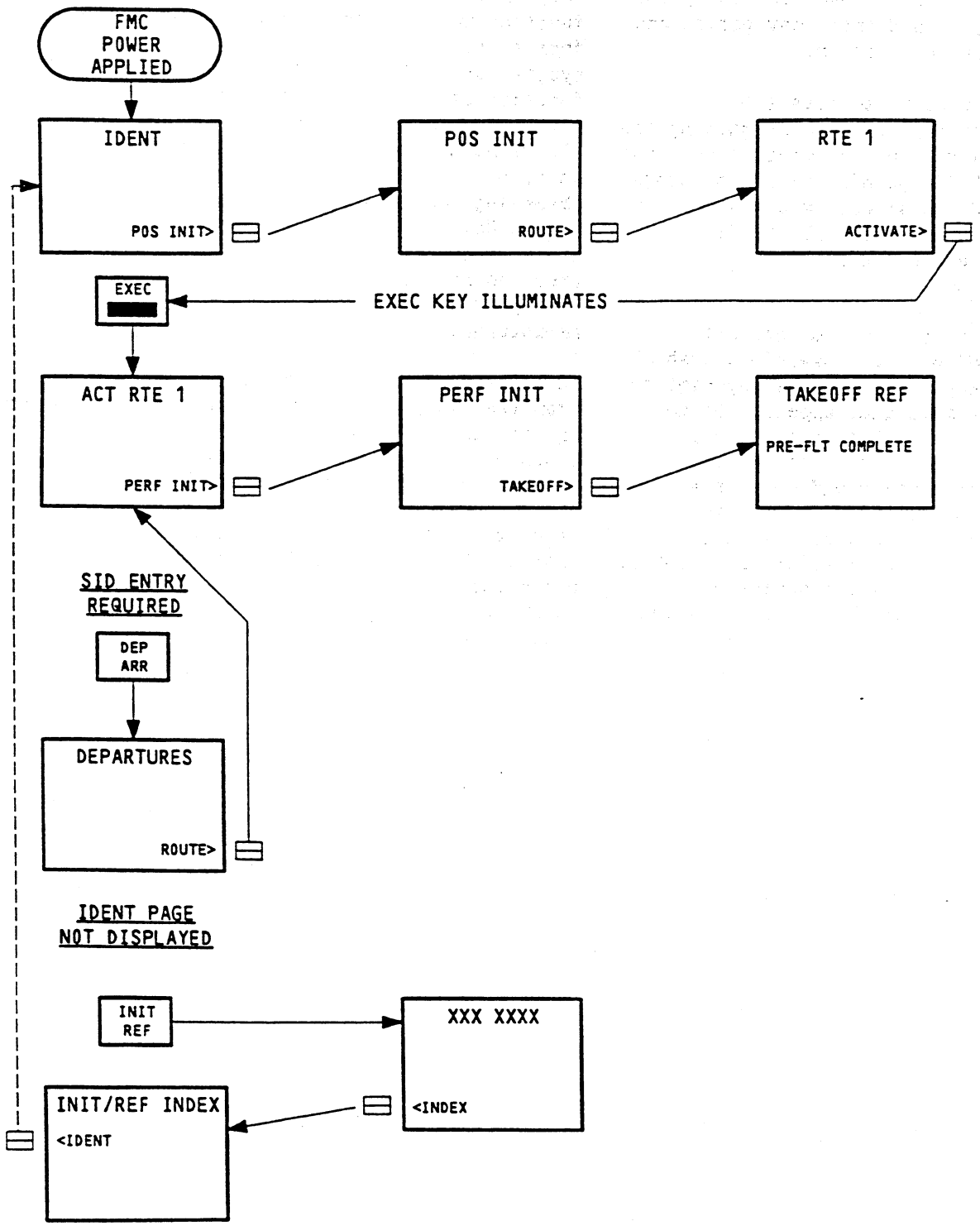
Although the CDU may display many pages of information, proper page selection is not difficult. Automatic display of some pages as well as visual prompts on the CDU provide assistance in selecting the appropriate page for most tasks. For example, the diagram on the next page illustrates how at initial electrical power application the CDU displays the appropriate page for starting the preflight.

After checking and entering the necessary data on each preflight page, the lower right line select key is pushed to select the next page. When ACTIVATE is selected on the route page the EXEC key illuminates. The EXEC key should then be pushed to complete the task of making the route active before continuing the sequence.

If a Standard Instrument Departure (SID) must be entered into the route the DEP/ARR key is pushed. After selecting the desired SID the lower right line select key is again used to proceed with the preflight sequence.

When the TAKEOFF REF page is reached it confirms that all required preflight entries have been made by displaying PRE-FLT COMPLETE.

If the IDENT page is not displayed at the beginning of the preflight, such as during a through flight, the lower part of the diagram shows how the IDENT page can be selected by starting with the INIT REF (initialization) key.



Inflight

Inflight the CDU is used to modify the flight plan and display navigation and performance information.

The first step is to select the appropriate page of data by pushing the key that says what you want to do. For example, DIR = go direct; CLB = change climb conditions; HOLD = enter or exit holding pattern, etc. Then, if required, enter the desired modification.

For example, to fly from present position direct to a waypoint, push the DIR/INTC key and enter the waypoint in the box prompts that appear. Or to answer a "what if" type question, select the page that displays the desired information and enter the modified conditions. The CDU then displays predictions of what will happen if the modification is executed. The pilot then has the option of erasing or executing the modification.

LATERAL NAVIGATION

Position Determination

The FMC determines present position by using inputs from the IRS, DME, VOR and localizer receivers. The FMC uses its calculated present position to generate lateral steering commands along the active le; to the active waypoint.

While the airplane is on the ground the FMC calculates present position based only on data received from the IRS. To function the FMC requires valid data from at least one IRS. Since inertial systems accumulate position errors as a function of time, the position information being used by the FMC is slowly accumulating errors. These position errors can be detected by observing the position of the airplane on the HSI map. If an extended ground delay occurs and a significant map error is noticed the IRS should be realigned and present position re-entered.

The baseline FMC position is derived from the IRS positions received. While the airplane is inflight the FMC computes corrections to this baseline position by using data received from the DME, VOR, and ILS. These position corrections are derived from the data from two DME stations, if available, or one colocated VOR/DME station. During an ILS approach, localizer data can be used to calculate an across track correction to the FMC position.

Normally the FMC automatically tunes the VOR and DME that provides the best available signals for updating the FMC calculated present position. However, the pilot can select frequencies manually or remotely, and if the FMC can continue to use the signals for position updating it will do so.

Manually or remotely tuning both DMEs, precludes the FMC from automatically tuning other frequencies for position updating.

LNAV Guidance

General

LNAV guidance outputs from the FMC are normally great circle courses between the waypoints making up the active route. If the active route contains a holding pattern, guidance is provided to enter and remain in the holding pattern. When a procedure stored in the FMC data base is entered into the active route, the FMC may supply commands to fly procedure turns, constant headings or tracks, or follow a DME arc, as required to comply with the procedure.

Holding Patterns

The FMC computes holding patterns with constant radius turns based on the current wind and the FMC command speed (displayed on the command airspeed bug in VNAV mode). The computed pattern displayed on the HSI map is limited so as not to exceed the size of the FAA or ICAO protected airspace. In LNAV mode, the AFDS tracks the displayed holding pattern using up to a 30° bank angle. However, if airspeed or wind speed is in excess of the FAA and ICAO assumed speeds, the airplane may leave the protected airspace. This can be seen on the map by observing the airplane symbol or trend vector outside the magenta holding pattern.

The holding pattern entry method is not displayed on the HSI map. If LNAV mode is engaged before passing the holding fix, standard holding pattern entry methods (parallel, teardrop or direct entry) are used with the following differences:

1. The entry method used (parallel, teardrop or direct entry) is a function of actual airplane track as the holding fix is crossed, not a function of airplane heading or the direction from which the active route approaches the holding pattern.

2. The initial outbound leg is maintained until a distance from the fix is reached, rather than maintained for a specific time. This distance is a function of the command airspeed and wind speed as the holding pattern becomes active.

3. Teardrop entries use a 40° angle.

4. Parallel and teardrop entries may take the airplane slightly beyond the outside end of the pattern shown on the map. However, the airplane will remain in protected airspace if the airspeed is within FAA or ICAO limits.

If LNAV mode is not engaged until after passing the holding fix, standard holding pattern entries are not used. Rather, the initial turn is in the shortest direction toward a track equivalent to the holding pattern inbound course. If this is in other than the desired direction, Heading Select mode should be used to complete the desired entry procedure.

Heading Hold Submode

A submode of LNAV exists which is designed to maintain the airplane on current heading during the following conditions:

1. When flying into a route discontinuity.

   - The CDU message DISCONTINUITY is displayed.

2. When flying past the end of a lateral offset.

   - Approaching the end of an offset, the CDU message END OF OFFSET is displayed.

3. When flying past the last route waypoint.

   - The CDU message END OF ROUTE is displayed.

4. When executing an INTERCEPT LEG/COURSE TO procedure while the airplane is outside the LNAV capture band of the active leg.

   - If current airplane heading intercepts the active leg, LNAV maintains heading pending leg capture.

   - If current airplane heading does not intercept the active leg, LNAV maintains heading and the CDU message NOT ON INTERCEPT HEADING is displayed.

5. When the AFDS approach or localizer mode is armed and sequencing occurs to a leg aligned with the runway centerline, if at a waypoint that is between the runway and the end of the extended runway centerline on the HSI map.

   - Airplane maintains current heading until localizer capture rather than following the magenta line.

# CHAPTER 7

## AUTOMATIC FLIGHT

VERTICAL NAVIGATION

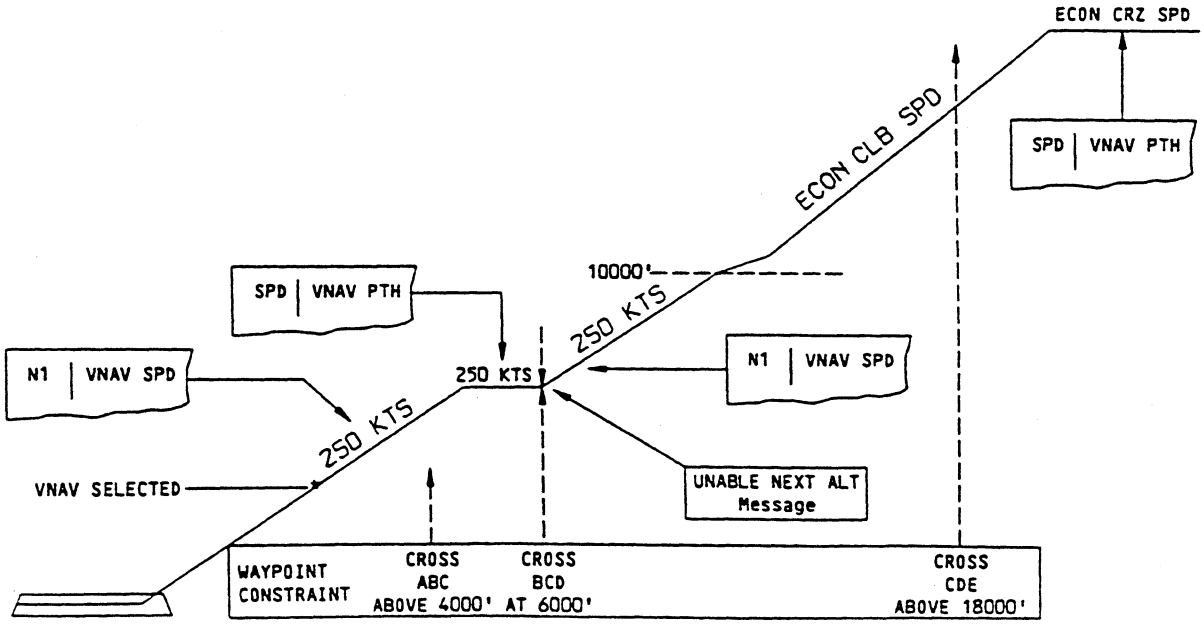
Climb and Cruise

Above 400 feet RA VNAV mode can be engaged if the MCP Altitude Window is set to an altitude above the airplane. VNAV mode disengages if the MCP altitude is intercepted before reaching the FMC cruise altitude. After VNAV engagement, the MCP may be reset to an altitude below the airplane without causing a VNAV disengagement or climb interruption.

The VNAV profile that the FMC commands if not modified by the pilot is a climb with climb thrust at the airspeed limit associated with the origin airport until above the limit altitude, then climb at economy speed to the entered cruise altitude. During climb, remain within all altitude constraints that are part of a SID entered into the active route. Cruise at economy speed until reaching the top of descent point. Thrust is limited to maximum cruise thrust.

If flying the climb speed profile would cause a violation of an altitude constraint the UNABLE NEXT ALT message appears. The pilot must manually select a different speed on the MCP that provides a steeper climb angle.

The following diagram shows a climb profile containing waypoint altitude constraints and a speed transition with a limit of 250 kts below 10000 feet. The diagram also shows normal mode annunciations that appear on the ADI.

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Descent

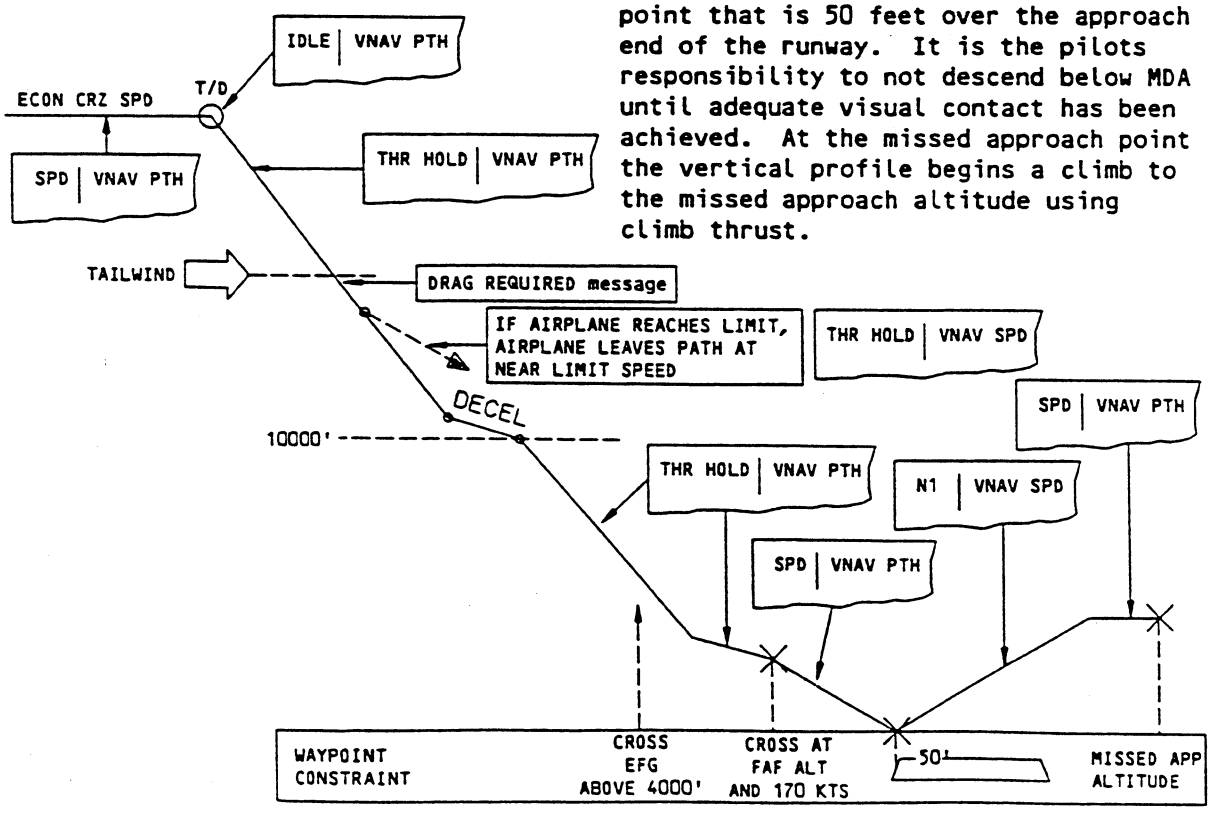
When an (E/D) point is entered the FMC calculates a descent path. (An E/D is a waypoint altitude constraint that requires a descent from cruise altitude. The E/D normally is entered on the legs page as a result of selecting a STAR or APPROACH.)

The descent path begins at the calculated T/D and passes over waypoints so as to comply with altitude constraints. The path to the first constraint assumes the use of idle thrust, speed brakes retracted, a wind speed that decreases with altitude and the appropriate target speed. Normally, the target speed is economy above 10,000 feet and 240 kts below 10,000 feet until necessary to begin a deceleration to reach the final approach fix (FAF) inbound at 170 kts. Target speeds may be changed by entries on the legs or descent page. Wind and thrust assumptions may be changed on the descent forecast page.

If the MCP is set to an altitude below the airplane, when the T/D point is reached the FMC commands idle thrust and pitch to track the descent path. VNAV disengages if MCP altitude is reached before the lowest altitude constraint. During descent the MCP may be set to an altitude above the airplane without VNAV disengaging or stopping the descent.

If an unexpected (not entered on descent forecast page) headwind is encountered, that causes a significant decrease in airspeed, thrust increases to regain the target speed. If the autothrottle is not engaged, a THRUST REQUIRED message is displayed. If an unexpected tailwind is encountered, that causes a significant increase in airspeed, the DRAG REQUIRED message is displayed. If airspeed reaches a limit the airplane flies the limit speed even if it must leave the path.

For VFR and non-precision approaches, the FMC computed path is built to a point that is 50 feet over the approach end of the runway. It is the pilots responsibility to not descend below MDA until adequate visual contact has been achieved. At the missed approach point the vertical profile begins a climb to the missed approach altitude using climb thrust.



OPERATIONAL NOTES

1. When operating in LNAV and VNAV modes monitor system operation for undesired pitch, roll or thrust commands. If undesired operation is noticed switch over to the heading select and flight level change modes.

2. The system should be carefully monitored for errors following activation of a new data base, resynchronization, power interruption or IRS failure.

3. During two IRS operation each FMC uses a different IRS for position calculations. The IRS positions are not averaged as during normal operation. This can result in a difference between the two HSI maps and descent paths when radio updating is not available.

4. When operating significantly off the active route, the active waypoint may not change as it is passed. When the LNAV mode is armed it can only capture the active leg. It will not capture an inactive leg in the active route. The DIRECT TO or INTERCEPT LEG/COURSE TO procedures may be used to make the desired leg active.

5. When the same waypoint is used more than once in the route, certain route modifications (such as DIRECT TO and HOLD) use the first waypoint.

6. Some standard instrument departures and arrivals contain a heading vector leg. These show on the CDU LEGS page as a VECTORS waypoint and on the map as a magenta line leading away from a waypoint or the airplane. When VECTORS becomes the active waypoint, sequencing of waypoints stops. Sequencing restarts when LNAV mode is disengaged, or a DIRECT/INTERCEPT is accomplished.

7. When entering airways into a route page the beginning and ending waypoints must be in the data base. Otherwise the route segment must be entered as a DIRECT leg.

8. Occasionally a procedure in the data base contains a hidden discontinuity that appears on the LEGS page as --- for the inbound course.

9. If an ILS procedure is entered into the active route, and it contains a leg to intercept the inbound course, LNAV mode will maintain intercept heading until LOC mode engages.

10. If engines are not shut down on landing, a cruise altitude entry must be made prior to the next flight to ensure that the vertical profile is rebuilt.

    If in descent and a diversion to another airport is entered, a cruise altitude entry must be made to rebuild the vertical profile

11. When operating outside the FMC navigation data base area the following operating characteristics will be noticed:

    A. The actual origin, destination and runways can not be entered into the route. However, any origin that is in the data base may be entered. An origin entry is required for VNAV operation.
    B. All waypoints must be entered as latitudes and longitudes.
    C. The FMC will not use radio signals to update its calculated position and will not tune the VOR or DME.
    D. The HSI map can not display airports navaids or waypoints that are not in route.

FUEL MONITORING

The FMC receives fuel data from the fuel quantity system and EICAS.

The fuel quantity system provides a totalizer value that is displayed on Progress Page 2. When this value is displayed on the Performance Initialization Page it is labeled SENSED.

The FMC also calculates a fuel quantity. With the engines shutdown, or during fuel jettison, the calculated value is set to agree and track the totalizer value unless the pilot makes a manual fuel quantity entry. When the FMC receives a positive fuel flow signal (engine start) the calculated value is disconnected from the fuel quantity system. After start the calculated value decreases at the rate the fuel flow signals indicate. The calculated value is displayed on Progress Page 2. The calculated value is also displayed on the Performance Initialization page where it is labeled CALC unless a manual entry of fuel quantity is made. In that case it's labeled MANUAL.

If fuel is loaded with the engines running the calculated value will not include the new fuel loaded. (On older FMC programs this also occurs if an engine is started and shutdown without completing a flight.) Normal operation can be restored by making a manual fuel quantity entry on the Performance Initialization page followed by deletion of the manual entry.

The fuel flow signals are also used for calculating the fuel used by the engines. FUEL USED is displayed on Progress Page 2 and is retained through flight completion. FUEL USED resets to zero when an engine is started or electrical power is removed.

Beginning with engine start, the FMC monitors the fuel load on board as detected by the fuel quantity system totalizer and as calculated by the FMC using fuel flow inputs. If the FMC determines a significant difference between the totalizer and calculated values the FUEL DISAGREE - PROG 2/2 message is displayed on the CDU scratch pad. (The message is FUEL QTY ERROR - PROG 2/2 with older FMC programs.) The pilot may then select which value the FMC should use for fuel calculations for the remainder of the flight.

The FMC also continually estimates the amount of fuel that will remain when the destination airport is reached if the active route is flown. If the estimate is less than the fuel reserve value entered on the Performance Initialization Page the INSUFFICIENT FUEL message is displayed.

CDU MESSAGES

Messages are generated by the FMC when a condition exists which degrades the operation of the system. Certain messages have a higher priority than others. Higher priority messages appear in the scratchpad regardless of the prior contents on the line. As messages are activated, they are displayed in the scratch pad if no high priority message is displayed; otherwise they are inserted below the stack of higher priority messages. As the CLR key is pushed, the stack is displayed sequentially from the top to the bottom. Only higher priority messages cause the EICAS to display FMC MESSAGE. All messages illuminate the CDU Message (MSG) annunciator light. Clearing the message or correcting the condition cancels the message.

The following list contains messages which cause FMC MESSAGE to appear on EICAS and illuminates the FMC and MSG lights.

| MESSAGE | CAUSE |
|---|---|
| CHECK ALT TGT | VNAV is engaged when the airplane is between the MCP and FMC target altitudes. VNAV holds level flight. |
| CYCLE IRS OFF - NAV | IRS requires a shutdown and realignment prior to entering nav mode. |
| DESCENT PATH DELETED | VNAV engaged and all waypoint altitude constraint defining descent path are deleted. |
| DISCONTINUITY | LNAV engaged and airplane entered route discontinuity. |
| DRAG REQUIRED | VNAV engaged during descent and additional drag or less thrust required to track target speed. |
| END OF OFFSET | LNAV engaged and approaching end of route offset. |
| END OF ROUTE | LNAV engaged and end of active route overflown. |
| ENTER IRS POSITION | IRS requires a position entry prior to entering nav mode. |

CDU MESSAGES (CONT)

| MESSAGE | CAUSE |
|---|---|
| FUEL DISAGREE-PROG 2/2 | Fuel totalizer and calculated values disagree. |
| FUEL QTY ERROR-PROG 2/2 | Fuel totalizer and calculated values disagree. |
| INSUFFICIENT FUEL | Estimated fuel at destination is less than entered RESERVES value. |
| IRS MOTION | IRS sensed excessive airplane motion. |
| IRS NAV ONLY | FMC is navigating without radio updating. (Not acceptable for instrument approaches) |
| LIMIT ALT FLNNN | VNAV engaged and cruise altitude greater than VNAV limit altitude. |
| NAV INVALID - TUNE AAA<br>(AAA = Required navaid) | Signals not being received from navaid required for approach procedure. |
| NO ACTIVE ROUTE | LNAV selected, but no route is activated. |
| PERF/VNAV UNAVAILABLE | VNAV selected without origin, gross weight, cost index and cruise altitude entry. |
| RESET MCP ALT | Approaching T/D point with MCP not set to altitude below cruise altitude. |
| RESYNC FAIL - SINGLE FMC | Resynchronization was unsuccessful and one FMC shutdown. |
| RESYNCING OTHER FMC | FMC synchronization in progress. |
| SINGLE FMC OPERATION | One FMC is inoperative. |
| THRUST REQUIRED | VNAV engaged, A/T disengaged and additional thrust required to track descent path and maintain speed. |
| UNABLE NEXT ALT | VNAV engaged and climb gradient not great enough to comply with waypoint altitude constraint. |
| VERIFY POSITION | Computed radio and FMC positions or left and right FMC positions differ. |

CDU MESSAGES (CONT)

The following list contains messages which illuminate the MSG light, but does not illuminate the FMC light or display an EICAS message.

| MESSAGE | CAUSE |
|---|---|
| ARR N/A FOR RUNWAY | Selected arrival and runway not compatible. |
| CRS REVERSAL AT FA FIX | Entered route contains a course reversal at final approach fix. |
| DELETE | DEL key pushed. |
| INVALID DELETE | Delete function attempted where not allowed. |
| INVALID ENTRY | The entry has an incorrect format and/or range. |
| INVALID TUNE REQUEST | Remote tune attempted to override a procedure specified navaid on Progress Page 1. |
| MANUALLY TUNED | Remote tuning attempted while manual tuning selected. |
| MAX ALT FLNNN | Entered cruise altitude greater than performance maximum altitude. |
| NNNNN (Altitude set in MCP) | VNAV engaged, climb or cruise page displayed, and new cruise altitude set in MCP. |
| NO ACTIVE ROUTE | DIR/INTC key pushed without active route. |
| NOT IN DATA BASE | Data not in system. |
| NOT ON INTERCEPT HEADING | LNAV selected and airplane outside active leg capture criteria and current heading will not intercept leg. |
| RE-ENTER IRS POSITION | Disagreement between SET IRS POS and IRS feedback position. |

CDU MESSAGES (CONT)

| MESSAGE | CAUSE |
|---|---|
| ROUTE FULL | Total number of waypoints in Route 1 plus Route 2 has filled FMC to its waypoint capacity. Last selection not entered in route. |
| RUNWAY N/A FOR SID | Runway not compatible with SID. |
| RW/ILS FREQ ERROR | Selected ILS frequency does not match frequency for runway in active route. |
| STANDBY ONE | The FMC requires more than 6 seconds to display data. |
| UNABLE CRZ ALT | Entered cruise altitude results in a zero cruise time prediction. |
| VOR AAA INVALID<br>(where AAA is the VOR ident) | Inflight and remote CDU tuned VOR signal input is lost. |

## WAYPOINT IDENTIFIERS

### General

This section is provided as background information to improve understanding of waypoint (navigation fix) identifiers used by the FMC and displayed on the CDU and HSI. Much of the information only applies to a few areas of the world.

The CDU message NOT IN DATA BASE is displayed if an attempt is made to enter a waypoint identification that is not stored in the data base. The waypoint may still be entered as a latitude and longitude, place bearing/distance or place bearing/place bearing. An INVALID ENTRY message indicates the format of the entry is incorrect (wrong number of characters).

Place Bearing/Distance and Place Bearing/Place Bearing entries are not recommended at high latitudes where an intermix of true and magnetic bearings may occur.

Waypoints are identified by a maximum of five characters that are assigned according to the following rules.

### Airport Reference Points

Airport reference points are identified by the ICAO identifier.

Examples: KSEA, CYVR, EGLL, RJNT

### Navigation Aids

Waypoints located at navaids (VOR/DME/LOC/NDB) are identified by a one, two, three or four character facility identifier.

Examples: SEA, IBFI, SZ, YXO

On some airplanes, waypoints located at NDBs are identified by use of the station identifier followed by the letters "NB".

Examples: SZNB, YXONB

### Fixes With Name and Identifier

If the fix is named and has an identifier the identifier should be used.

Example: CARP(CRP) = CRP

### Fixes With One-Word Name

Waypoints located at fixes with names containing five or fewer characters are identified by the name.

Examples: VAMPS, DOT

Names with more than five characters are abbreviated using the following rules sequentially until five characters remain.

Delete double letters.

Example: KIMMEL = KIMEL

Keep the first letter, first vowel and last letter. Delete other vowels starting from right to left.

Example: BAILEY = BAILY

Keep the last letter, then delete consonants from right to left.

Example: KIHLANKI = KIHLI

### Fixes with Multi-Word Name

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.

Example: RAS-SUDR = RSUDR

Fixes With One Letter Name

If the fix is named with only one letter, use the ICAO Phonetic Word reduced to five letters using the above rules.

Examples: A = ALPHA, C = CHARE

Un-Named Fixes

Fixes without a name or identifier on charts may be assigned an identifier by the controlling government agency, ATC authority, data base supplier or FMC. Because each of these sources may use different standards for assigning identifiers, there are inconsistencies in the types of identifiers stored in the FMC and displayed on the CDU.

The pilot should use the HSI and CDU LEGS page to insure routing is consistent with the clearance. In addition to the waypoint identifiers shown on the LEGS page, the Leg Direction and Length should be used to insure the route agrees with the chart and clearance.

Typical Identification Methods

If the un-named fix is collocated with a navaid or a named fix, the navaid identifier or fix name should be used.

If the un-named fix is not collocated with a navaid or a named fix, construct the identifier using a navaid identifier, radial, and/or distance from the navaid.

Examples: SEA101, SEA18, 04YYN, D006T, F340P, 139D

If the un-named fix is a FIR, UIR or Controlled Airspace reporting point, construct the identifer using the three letter airspace identifier and a two digit sequence number.

Examples: FIR05, UIR05, TMA05, CTA05

If the un-named fix is defined by coordinates, construct the identifier using the degrees of latitude and longitude.

Positions in the northern hemisphere use the letters "N" and "E", while positions 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° = 5040N
N75° W170° = 75N70
N50° E020° = 5020E
N06° E110° = 06E10
S52° W075° = 5275W
S07° W120° = 07W20
S50° E020° = 5020S
S06° E110° = 06S10

FMC Identification Method

Waypoints at a fixed latitude and longitude, but not identified in the data base, are assigned a waypoint identifier using the rules for a pilot defined latitude and longitude waypoint.

Examples:
Route 1 = WPT01, WPT02, WPT03
Route 2 = WPT51, WPT52, WPT53

Un-Named Terminal Area Fixes

DME Arc Procedures

Un-named fixes along a DME Arc are identified by a five character designation. The first character is "D".

Characters two through four indicate the radial on which the fix lies.

The last character indicates the arc radius by a letter as follows: A = 1 NM, B = 2 NM, C = 3 NM, etc.

Examples: EPH252°/24 = D252X
GEG006°/20 = D006T

Un-named fixes along a DME arc with a radius greater than 26 NM are identified by the station identifier and the DME radius.

Example: TOE021°/43 = TOE43

When there are multiple un-named fixes along a DME arc with a radius greater than 26 NM, the station identifier is reduced to two characters, followed by the radius, and then a sequence character.

Examples: CPR134°/29 = CP29A
CPR190°/29 = CP29B
CPR201°/29 = CP29C

DME Fixes

DME step down fixes are identified by the distance and a "D".

Examples: 138D, 106D, 56D, 3D

Runway-Related Fixes

Un-named runway-related fixes are identified by adding a two letter prefix to the runway number.

The following prefixes indicate runway-related fixes:

| | |
|---|---|
| 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 | (+ a Letter) Step Down Fix |
| RW | Runway Threshold |
| MA | Missed App Point other than RW |
| RC | Runway Centerline Intercept |
| TD | Touchdown point inboard of RW |

Examples: OM09, MM09, IM23, RW04

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 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 | Backcourse ILS |
| ( )D | VOR/DME |
| ( )V | VOR Only |
| ( )S | VOR with DME Points |
| ( )N | NDB |
| ( )Q | NDB with DME Points |
| ( )M | MLS |
| ( )T | Tacan |
| ( )R | RNAV |

Examples: CI32R, PV15, FN24L

Pilot Defined Waypoints - Identifier assigned by FMC

Waypoints entered as a latitude and longitude are identified as "WPT" followed by a two digit sequence number. 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. For full degrees only degree digits are required.

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.

Duplicate Identifiers

Should application of these rules result in more than one waypoint having the same identifier, when an attempt is made to enter the identifier a CDU page change occurs. The page title is SELECT DESIRED WPT. The page lists the latitude and longitude of the duplicate waypoints. Line selecting the latitude/longitude of the desired waypoint enters the correct waypoint on the original page.

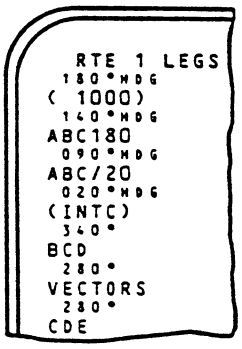
If more than one waypoint with duplicate identifiers must be entered in a route, the second and following waypoints must be entered as a place bearing/distance, place bearing/place bearing, or latitude and longitude.

Conditional Waypoints

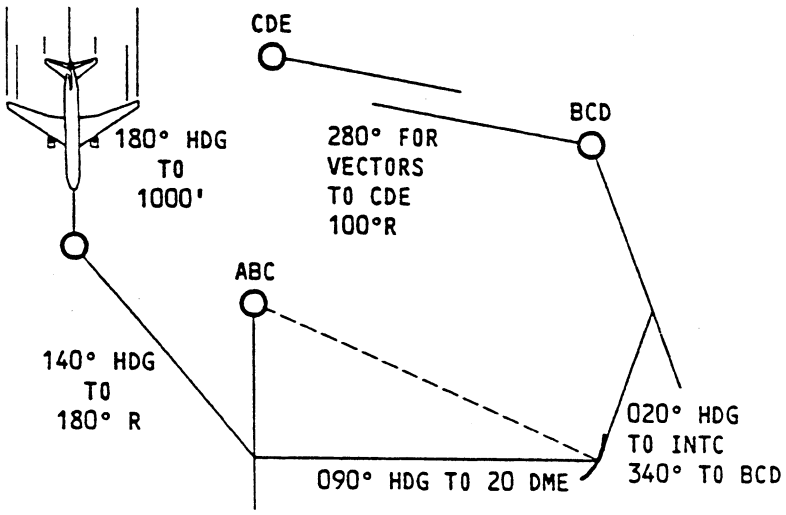
Conditional waypoints are automatically entered into a route as a result of selecting a procedure on a DEPARTURES or ARRIVALS page. Conditional waypoints cannot be manually entered on a route or legs page. These waypoints are events when a condition occurs and are not at a geographically fixed position. There are five types of conditions; passing through an altitude, radial, DME distance, intercepting a course and heading vectors to a course or fix. Only altitude conditional waypoints are displayed on the HSI map. Altitude and course intercept conditional waypoints are displayed on the CDU inside ( ) marks.

## CONDITIONAL WAYPOINTS

Example:




Meaning:



## CDU TYPICAL PAGES

### GENERAL

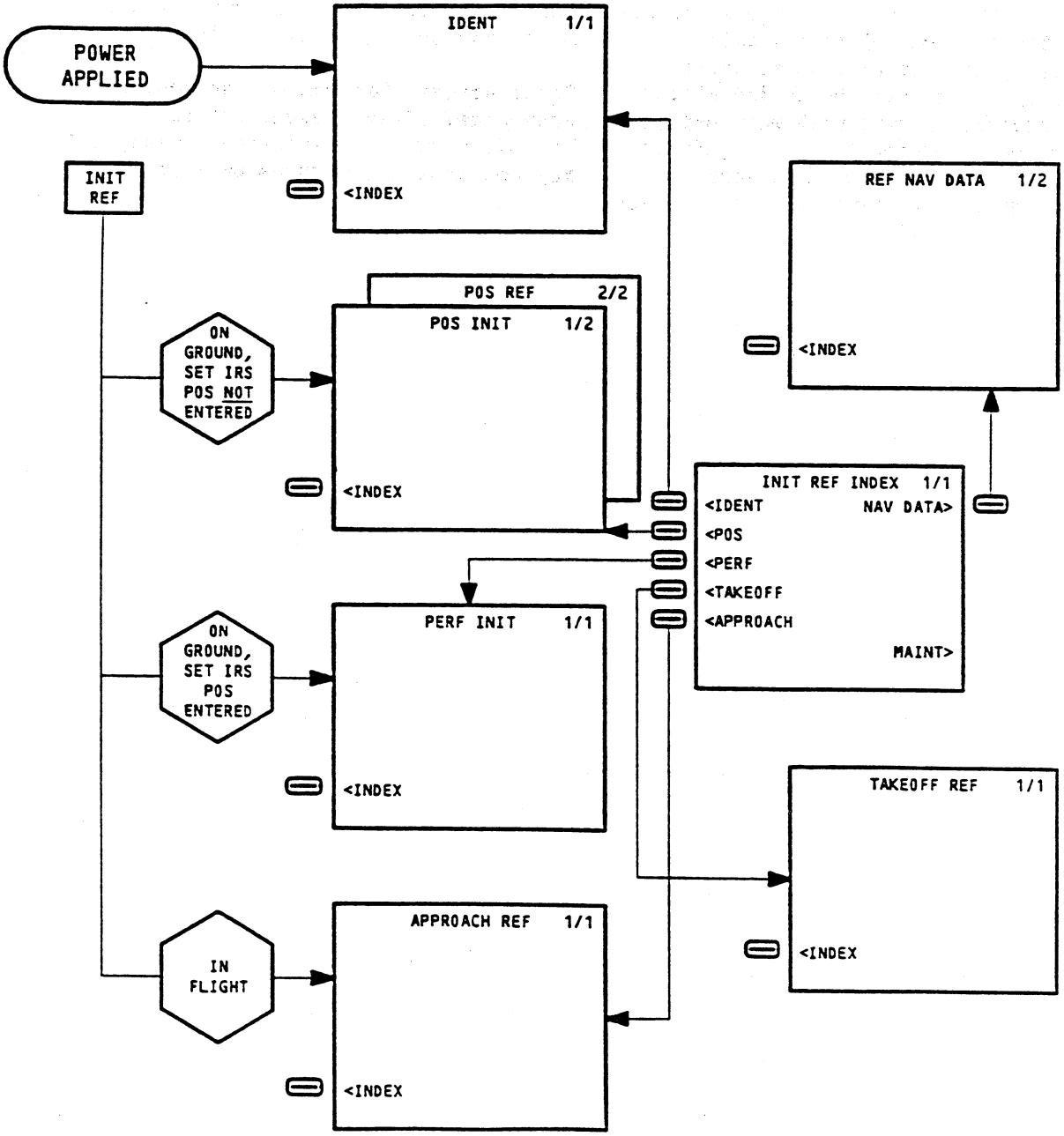
The CDU pages shown in this section are typical of those that can be displayed on the CDU. However, due to differences in data bases and the data entered into the CDU, displayed pages for each flight will be different from those in this section. Since it is not possible to show all conceivable displays, the set of typical pages shown appeared when the Boeing Flight Test navigation data base was installed and a route entered from Boeing Field to Moses Lake. (Minor modifications were made to the displays to illustrate some conditions.)

The pages presented are in an order that is intended to be convenient for a flight crew member reviewing what can be displayed on the CDU. The first series of pages deal with initialization and reference information. Next are the pages used to enter or modify the route of flight. Then, pages used for monitoring flight progress are shown. The final series includes pages used for monitoring and modifying the vertical profile.

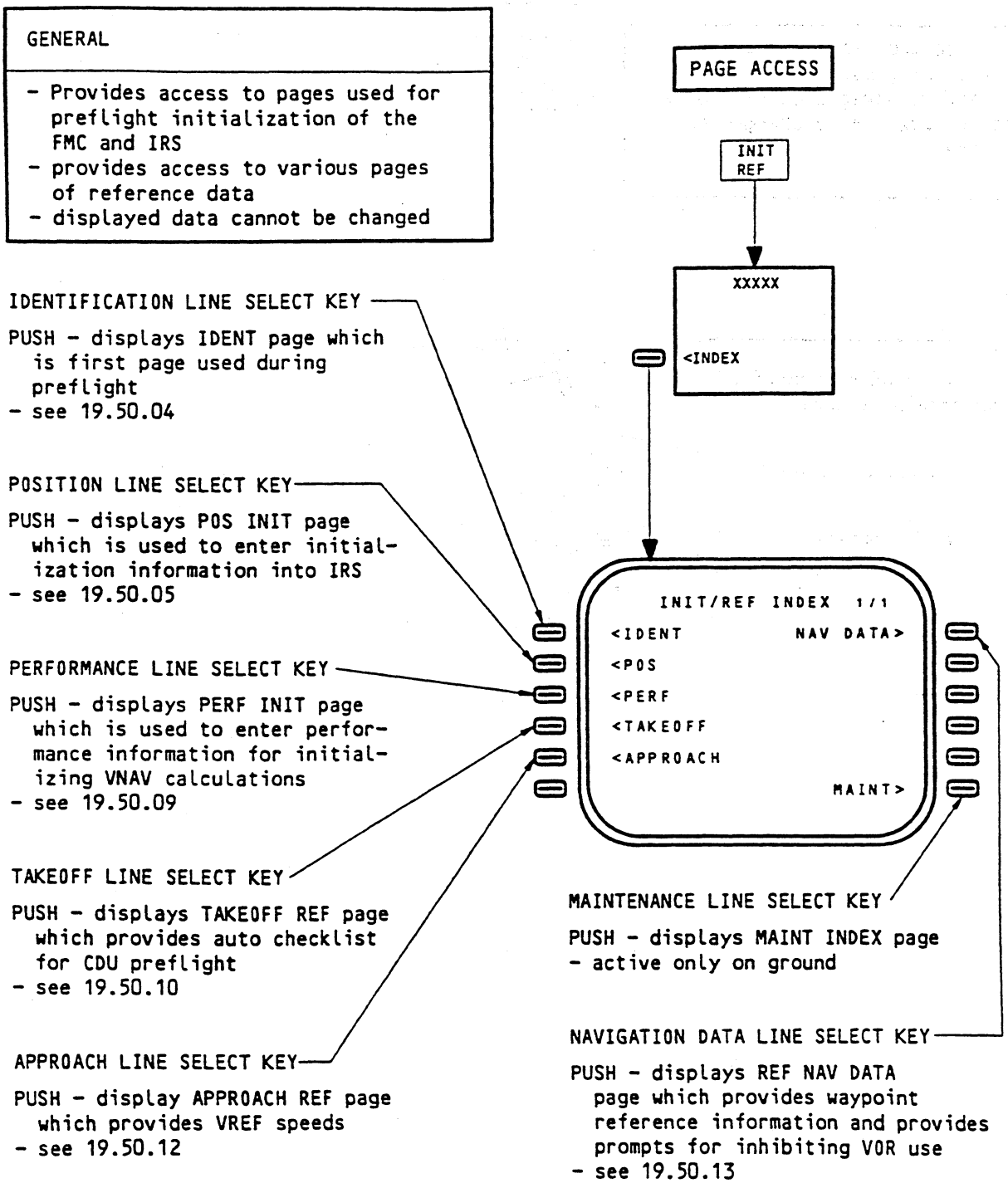
Pages access diagrams are presented for each page. They present typical methods used for displaying a page, but may not show all methods available.

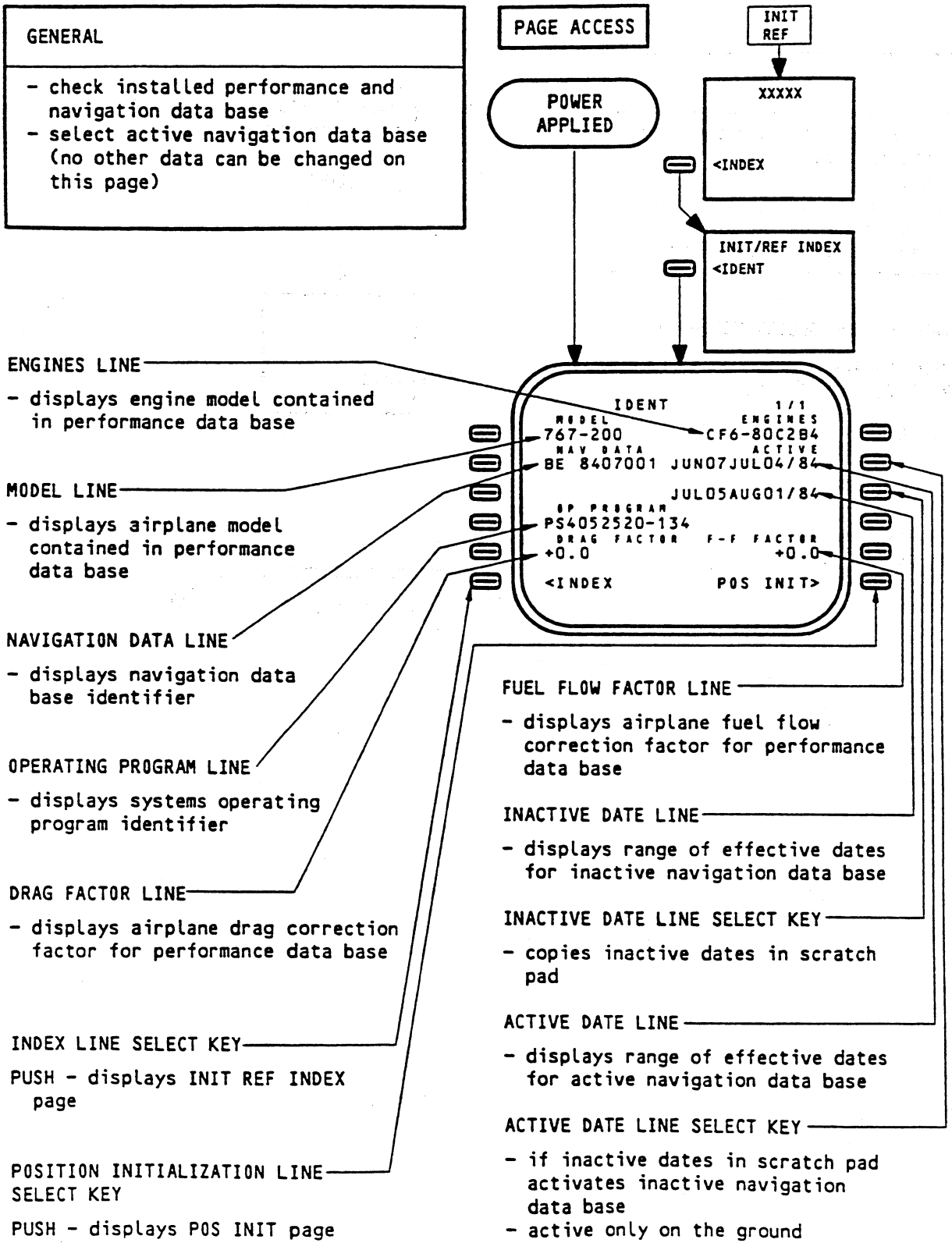
## INITIALIZATION AND REFERENCE PAGES

An initialization or reference page appears automatically when power is first applied to the system or when the INIT REF key is pushed. If the desired page is not displayed, pushing the INDEX Line Select Key displays the INIT REF INDEX page. The desired page can then be selected from the index. The one exception to this is the POS REF page which first requires displaying the POS INIT page, then pushing the NEXT PAGE key.




INITIALIZATION/REFERENCE PAGES






IDENTIFICATION

## GENERAL

- enter present position into IRS during preflight alignment
- enter heading into IRS during IRS attitude mode operation
- check CDU time reference

PAGE ACCESS

INIT REF

IDENT

POS INIT>

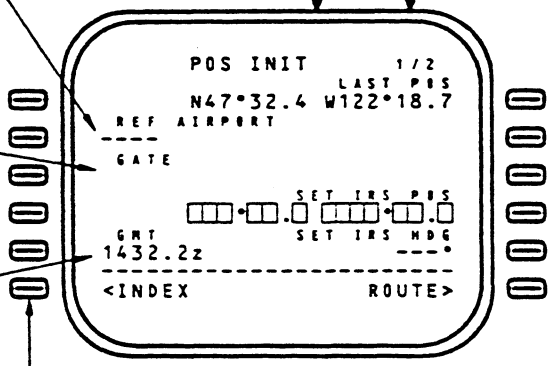
ON GROUND, SET IRS POS NOT ENTERED

REFERENCE AIRPORT LINE

- valid entry is four character ICAO airport identifier contained in the data base
- entry displays airport reference point latitude and longitude
- entry deletes previous gate numbers and allows another gate entry
- blank at liftoff

GATE LINE

- entering reference airport displays dashes and allows gate entry
- valid entry is gate identifier contained in the data base for reference airport
- entry displays gate latitude and longitude
- blanks at liftoff or returns to dashes with a different REF AIRPORT entry



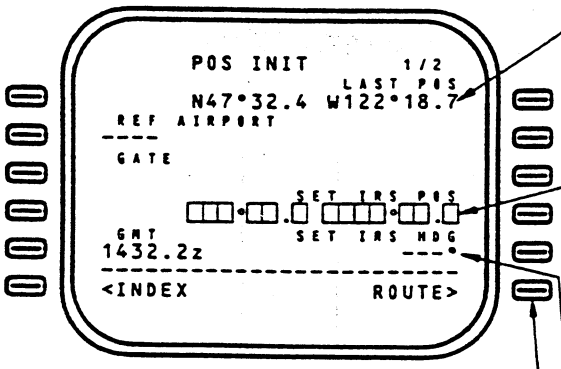

INITIAL DISPLAY

INDEX LINE SELECT KEY

PUSH - displays INIT REF INDEX page

GMT LINE

- at power application, synchronizes to time on Captain's clock when operative; otherwise, time on First Officer's clock
- hour can be changed by entering desired hour reference (minutes cannot be changed by CDU entry)
- minutes set by resetting pilot's clock




INITIAL DISPLAY

LAST POSITION LINE

- displays present position as calculated by flight management computer

SET IRS POSITION LINE

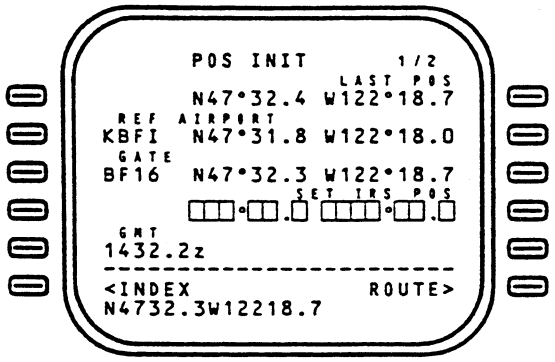
- boxes displayed when any IRS in align mode and present position not yet entered
- entry can be via the keyboard or line selecting LAST POS, REF AIRPORT or GATE
- entering latitude and longitude sends present position to all inertial reference systems
- blank except when an IRS is in align mode

SET IRS HEADING LINE

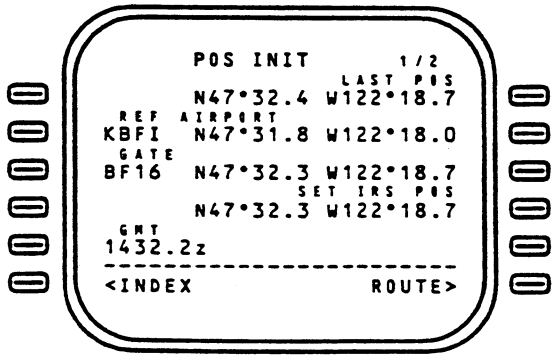
- entering heading resynchronizes (updates) IRS magnetic heading signal for all inertial reference systems in attitude mode
- valid entry is three character heading
- blank except when an IRS is in attitude mode

ROUTE LINE SELECT KEY

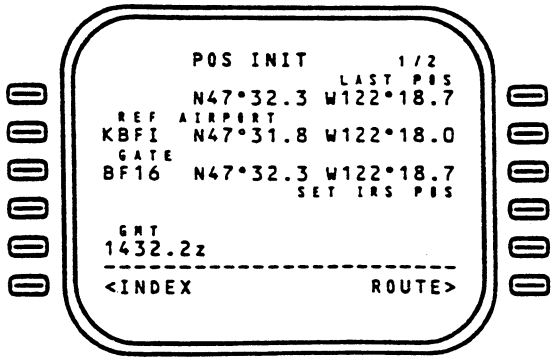
PUSH - displays RTE page
- used to continue preflight sequence




After entering reference airport and gate identifiers and selecting gate coordinates to scratch pad




After entering latitude and longitude in SET IRS POSITION line




After all inertial reference systems enter Navigation mode

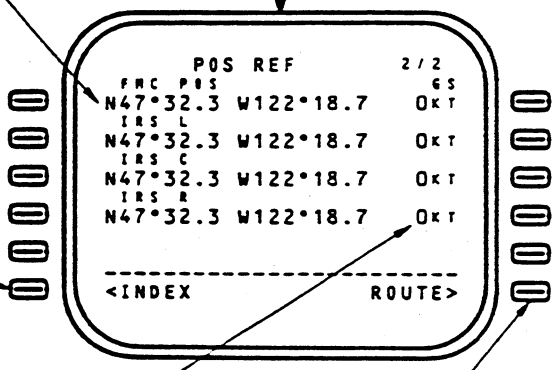
**GENERAL**

- determine present position and ground speed as calculated by the Flight Management Computer and each IRS
- used to detect errors in IRS

PAGE ACCESS

POS INIT 1/2

NEXT PAGE




**POSITION LINES**

- displays present positions as calculated by Flight Management Computer and IRS
- FMC position blank until an IRS enters navigation mode
- IRS position blank from power application until position entered

**INDEX LINE SELECT KEY**

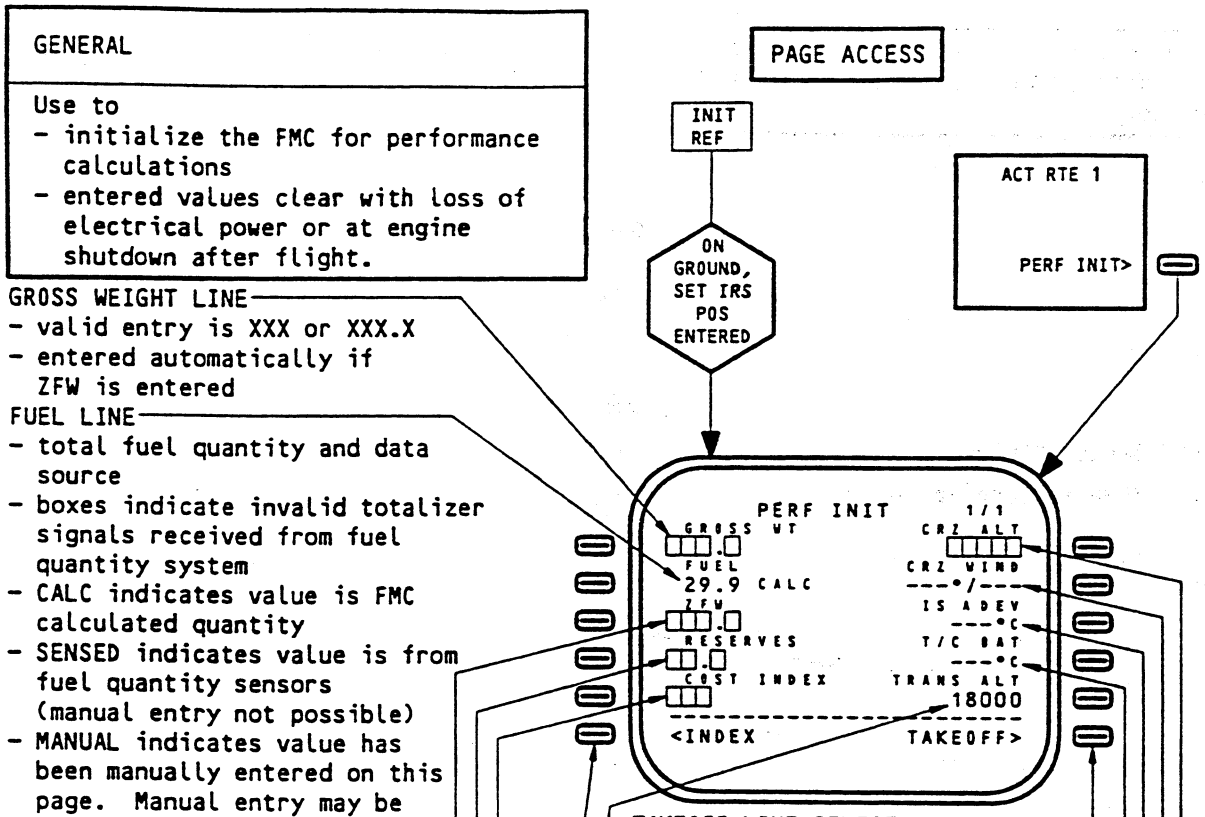
PUSH - displays INIT REF INDEX page

**GROUND SPEED LINES**

- display ground speed as calculated by Flight Management Computer and IRS
- blank from power application until IRS enters navigation mode
- value frozen at engine shutdown following a flight until power removed or ground speed exceeds 100 kts

**ROUTE LINE SELECT KEY**

PUSH - displays RTE page used to continue preflight sequence




GROSS WEIGHT LINE
- valid entry is XXX or XXX.X
- entered automatically if ZFW is entered

FUEL LINE
- total fuel quantity and data source
- boxes indicate invalid totalizer signals received from fuel quantity system
- CALC indicates value is FMC calculated quantity
- SENSED indicates value is from fuel quantity sensors (manual entry not possible)
- MANUAL indicates value has been manually entered on this page. Manual entry may be deleted

ZERO FUEL WEIGHT LINE
- valid entry is XXX or XXX.X
- entered automatically if GROSS WT is entered

RESERVES LINE
- valid entry is XX or XX.X

COST INDEX LINE
- used in computations of ECON speeds
- value (0-999) determined by operator
- 0 makes ECON speed same as MAX RANGE speed. 999 used for minimum time flight
- company route may enter automatically

INDEX LINE SELECT KEY
PUSH - displays INIT REF INDEX page

TRANSITION ALTITUDE
- 18000 when power applied
- can be changed by crew
- changed automatically after selecting a departure procedure containing a different stored value (if not previously changed by crew)
- used to change CDU altitude displays between feet and FLs. Does not effect pitch command

TAKEOFF LINE SELECT KEY
PUSH - displays TAKEOFF REF page

TOP OF CLIMB OAT LINE
- entered automatically if ISA DEV is entered
- used to improve ETA and fuel estimates

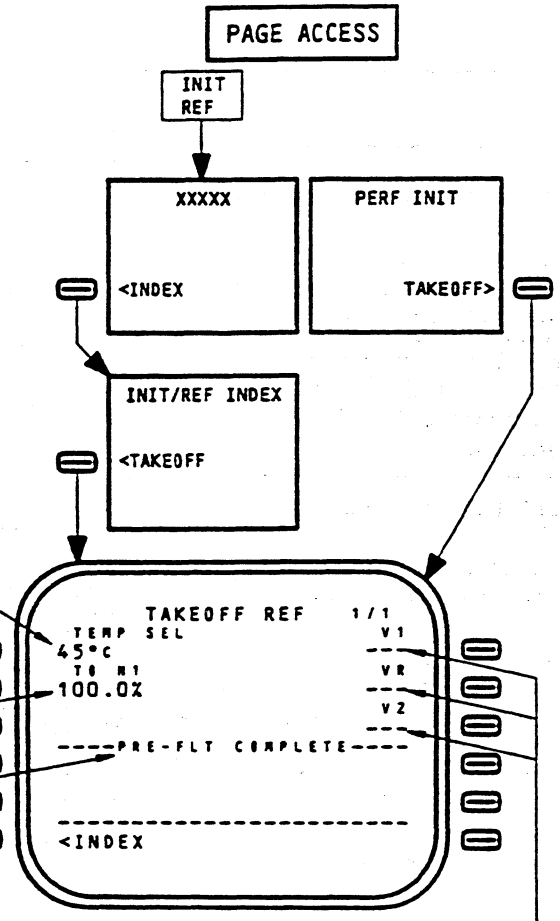
ISA DEVIATION LINE
- entered automatically if T/C OAT is entered
- used to improve ETA and fuel estimates

CRUISE WIND LINE
- valid wind direction is 3 digits
- enters winds on RTE DATA page
- entry of average true wind improves ETA and fuel estimates

CRUISE ALTITUDE LINE
- valid entry is XXX (flight level), FLXXX or XXXXX (feet)
- enters cruise altitude on CLB and CRZ pages

PERFORMANCE INITIALIZATION

| GENERAL |
| --- |
| - displays preflight status<br>- used to display V1 and VR on ADI speed tape |




TEMPERATURE SELECT LINE

- displays TMSP selected assumed temperature
- boxes or blank displayed prior to temperature entry

TAKEOFF N1

PRE-FLIGHT COMPLETE LABEL

- displayed when preflight is complete on POS INIT, PERF INIT, ROUTE and DEPARTURE pages
- not displayed if takeoff runway and first waypoint not linked (Route Page 1 displays dashes below VIA)

INDEX LINE SELECT KEY

PUSH - displays INIT REF INDEX page

V1, VR, and V2 LINES

- entry permitted on ground
- entry displays V1 and VR on ADI speed tape

PREFLIGHT STATUS LABEL

- displayed when POS INIT, PERF INIT, ROUTE or DEPARTURE prompts are displayed
- prompts indicate pages requiring preflight entries

POSITION INITIALIZATION LINE

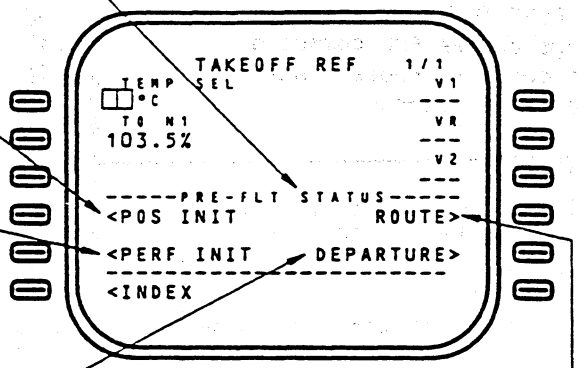
- displayed when POS INIT page contains box prompts
- pushing line select key displays POS INIT page

PERFORMANCE INITIALIZATION LINE

- displayed when PERF INIT page contains box prompts
- pushing line select key displays PERF INIT page

DEPARTURE LINE

- displayed when active route does not contain a departure runway and/or leg to first waypoint
- pushing line select key displays DEPARTURES page for active route




ROUTE LINE

- displayed when neither route is active
- pushing line select key displays RTE 1 page 1

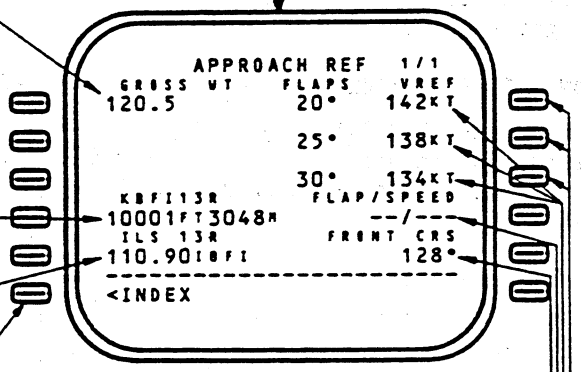
## GENERAL

- used to display data relative to approach
- used to display VREF on ADI speed tape

PAGE ACCESS

INIT REF

IN FLIGHT




**GROSS WEIGHT LINE**

- displays FMC computed weight, pilot entered weight or boxes
- displays boxes prior to entering gross weight on PERF INIT or this page
- leaving page causes FMC computed weights or boxes to replace any manually entered weights

**RUNWAY LENGTH LINE**

- displays length of departure runway as entered in route before 50 nm from departure point or before the half-way point whichever is less
- displays length of destination runway as entered in the active route after 50 nm from departure point or after the half-way point whichever is less
- blank prior to entering runway in route and after engine shutdown on ground

**ILS LINE**

- displays the runway identifier and corresponding ILS frequency and facility identifier (if applicable) as stored in the nav data base for the above runway
- blank prior to entering runway in route

**INDEX LINE SELECT KEY**

PUSH - displays INIT REF INDEX page

**FRONT COURSE LINE**

- displays FRONT CRS for the ILS to the left

**FLAP/SPEED LINE**

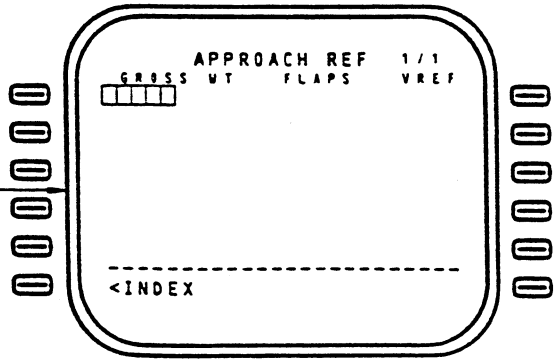
- entry permitted 2 minutes after takeoff
- entry displays VREF on ADI speed tape

**VREF LINES**

- displays computed VREF for the indicated landing flap settings at displayed gross weight
- blank prior to entering gross weight on PERF INIT or this page

**VREF LINE SELECT KEYS**

- copies Flap/VREF in scratch pad

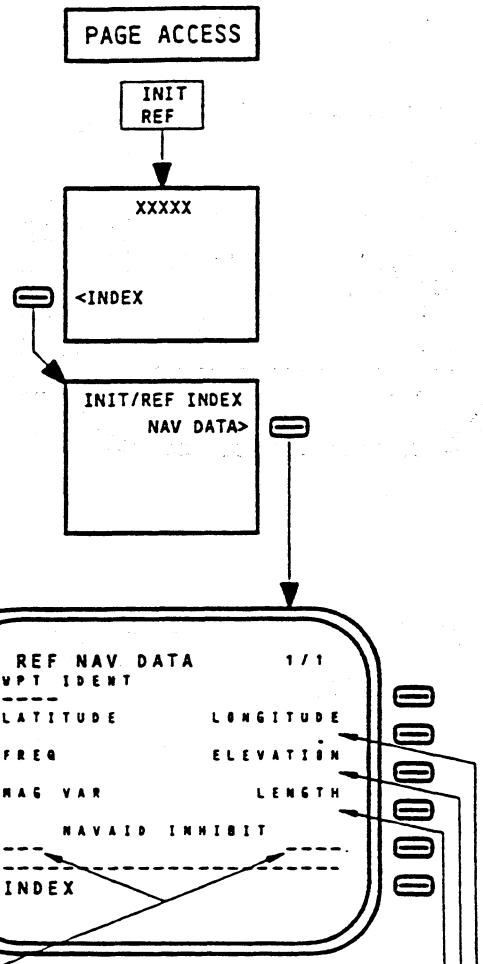



**APPROACH REFERENCE PAGE**

- prior to gross weight and runway entry

APPROACH REFERENCE

| GENERAL |
| --- |
| - provides information for waypoints in the data base or active route<br>- used to select navigation aid inhibit |




WAYPOINT IDENTIFICATION LINE

- valid entry is any waypoint in data base, active route or destination runway
- changing the page causes waypoint to be replaced with dashes and associated data is removed

LATITUDE LINE

- displays latitude of the entered waypoint

FREQUENCY LINE

- displays frequency of the entered waypoint if it is a navigation aid
- otherwise, data line and label are blank

MAGNETIC VARIATION LINE

- displays magnetic variation of the entered waypoint if it is a navigation aid
- otherwise, data line and label are blank

INDEX LINE SELECT KEY

PUSH - displays INIT REF INDEX page

NAVIGATION AID INHIBIT LINES

- VOR navigation aids entered here are restricted from use for navigation updating

LENGTH LINE

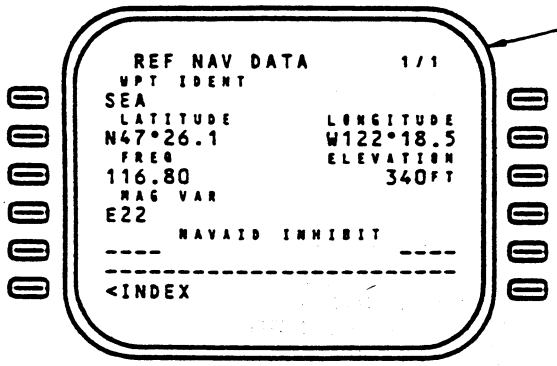
- displays runway length, if it is the entered waypoint
- otherwise, data line and label are blank

ELEVATION LINE

- displays elevation if the entered waypoint is a navigation aid or runway
- otherwise, data line and label are blank

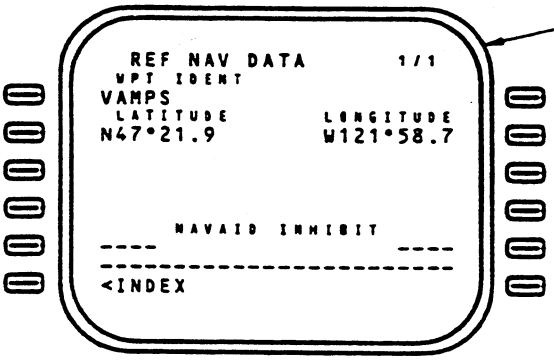
LONGITUDE LINE

- displays longitude of the entered waypoint



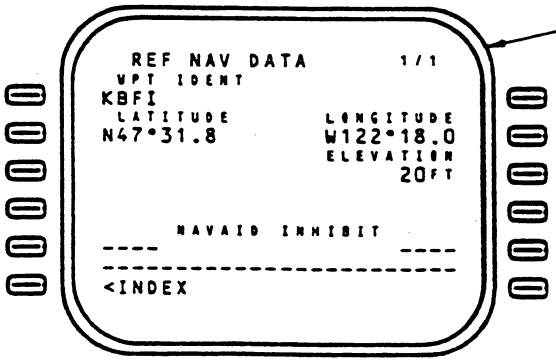

REFERENCE NAVIGATION DATA

- navigation aid entered in WPT IDENT




REFERENCE NAVIGATION DATA

- intersection entered in WPT IDENT




REFERENCE NAVIGATION DATA

- AIRPORT entered in WPT IDENT

REFERENCE NAVIGATION DATA

## GENERAL

- used to enter a route into the FMC for subsequent reference and guidance
- active route clears at engine shutdown after flight
- active route deactivated with loss of electrical power

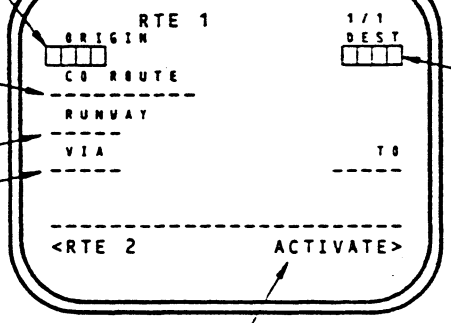
## PAGE ACCESS

RTE

POS INIT
ROUTE>

RTE 2
<RTE 1

RTE 2 NOT ACTIVE




### ORIGIN LINE

- valid entries are ICAO airport identifiers contained in the data base
- entry clears previous route
- entries allow entry of departure or arrival procedures
- entry inhibited in flight for active route

### COMPANY ROUTE LINE

- valid entries are routes contained in the data base
- entry clears old route and enters new route
- entry inhibited in flight for active route

### RUNWAY LINE

- valid entries are origin airport runways contained in the data base
- may be entered by line selection on DEPARTURES page
- deleted upon reaching first waypoint

### VIA LINES

- valid entries are DIRECT or airways contained in the data base
- airways entries are allowed if waypoint on previous line is stored in data base as airway waypoint
- procedure names (SID, STAR, etc) automatically appear when selected on DEPARTURES or ARRIVALS page

### ROUTE 2 LINE SELECT KEY

PUSH - displays RTE 2 page

### ACTIVATE LINE

- displayed on non-active page
- after activation, ACTIVATE replaced with PERF INIT, TAKEOFF or OFFSET---

### ACTIVATE LINE SELECT KEY

PUSH - activates displayed route if EXEC key also pushed

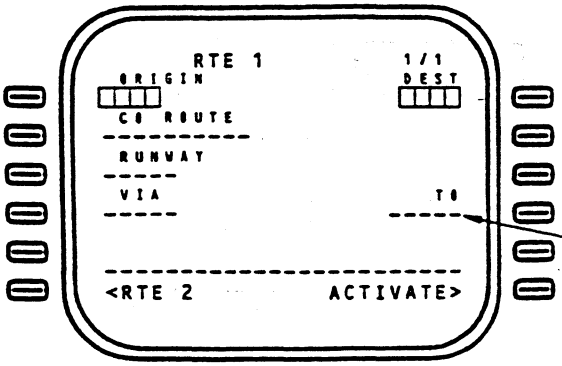
- RTE LEGS (DIR/INTC) Page 1 displayed in flight

### DESTINATION LINE

- valid entries are ICAO airport identifiers in data base
- entry allows entry of arrival procedures

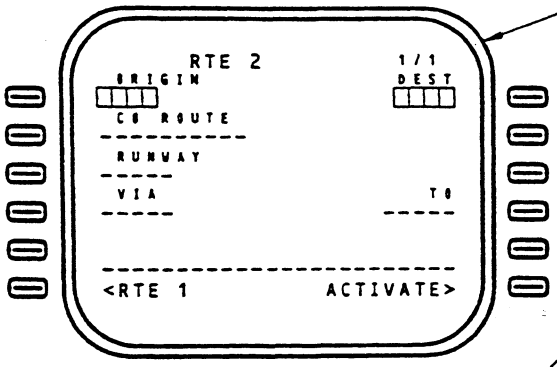
165635

ROUTE



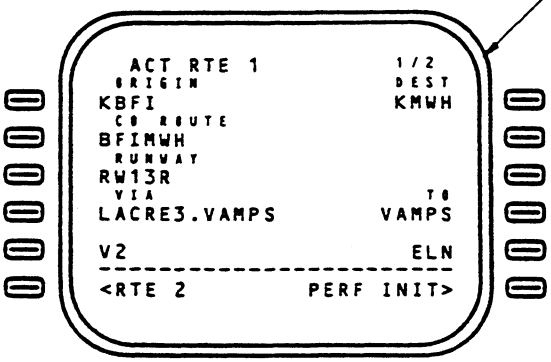

TO LINES

- the following entries are valid waypoint identifiers contained in the data base or defined geographic points:
  - published waypoints, e.g., entered and displayed as LACRE
  - intersections (place bearing/place bearing) e.g., entered as SEA123/ELN240, displayed as SEANN where NN is FMC assigned.
  - place bearing/distance e.g., entered as TCM094/35 and displayed as TCMNN, where NN is FMC assigned
  - VHF navaid, e.g., entered and displayed as SEA
  - destination airport runway, e.g., entered as 14 and displayed as RW14
  - ICAO airport, e.g., KJFK, EDAF, etc.
  - latitude/longitude, e.g., entered as N4706.6 W00004.3 and displayed as WPTNN, where NN is FMC assigned. Entries require leading zeroes. Trailing zeroes are optional when latitude and longitude are whole degrees, e.g., N43W040
  - conditional waypoints associated with procedure selected on DEPARTURES or ARRIVALS pages
  - boxes are displayed for discontinuities (gaps in route)
  - dashes displayed at end of route



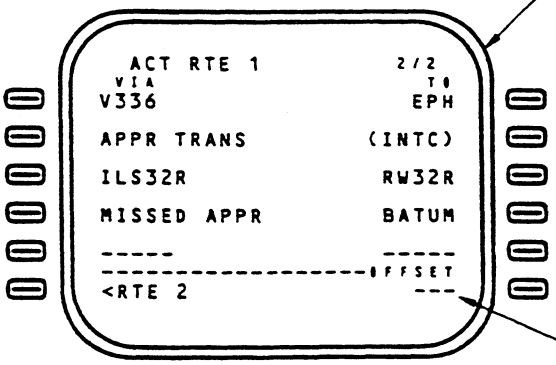

RTE 2 Page

- displayed after pushing RTE 2 line select key on RTE 1 page or line selection on Route 2 DEPARTURES or ARRIVALS page




ACT RTE 1 1/2

- route one has been entered and made active as indicated in page title. The route is displayed on two pages. The active route is displayed on the HSI map in magenta and is used by the FMC for calculating AFDS commands for LNAV and VNAV modes of operation
- the displayed route is from the KBFI to the KMWH airport
- the route was entered by use of data base company route BFIMWH
- the route begins on runway 13R, and continues via the LACRE 3 SID and VAMPS transition to VAMPS. From VAMPS the route is via airway V2 to ELN

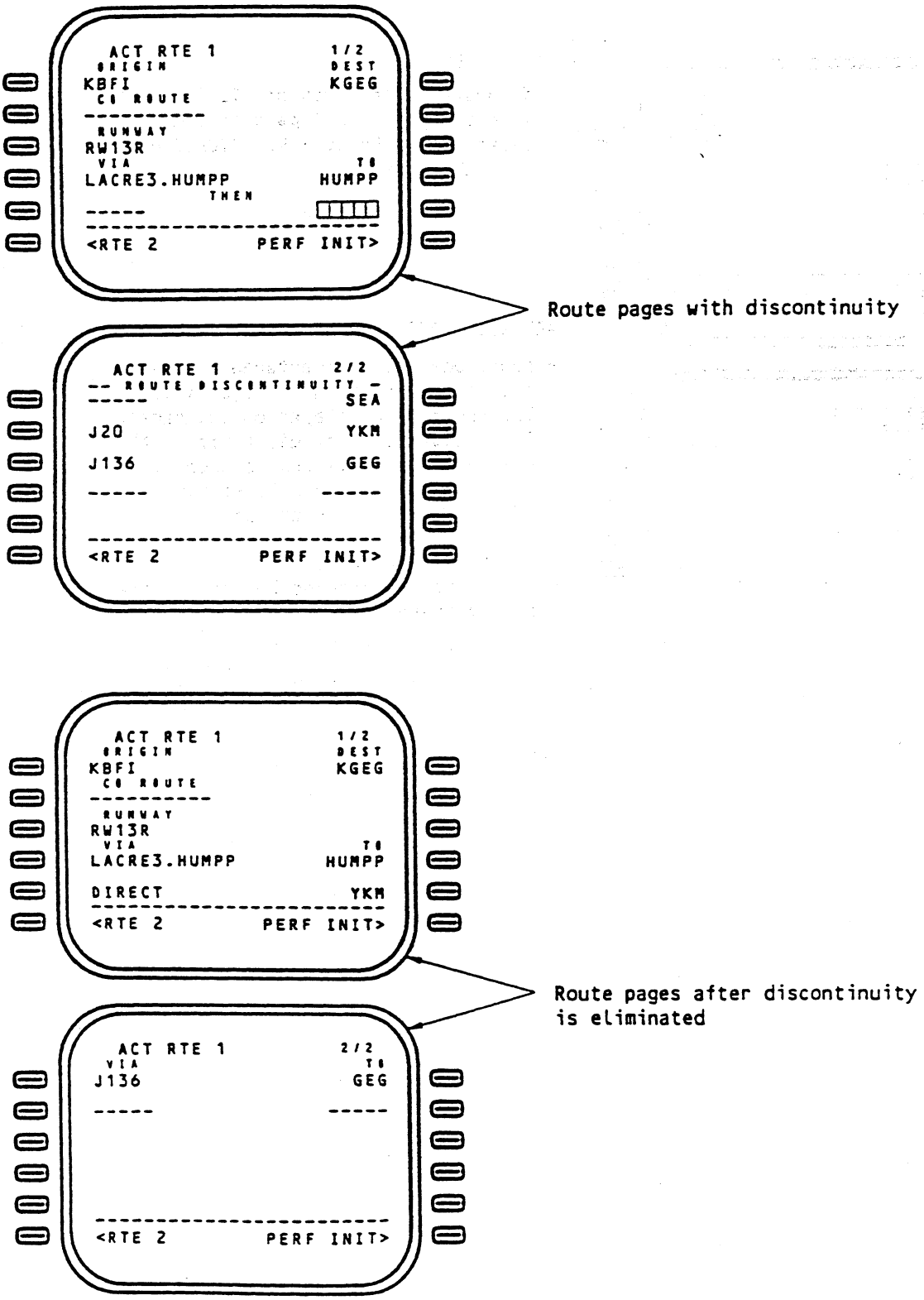


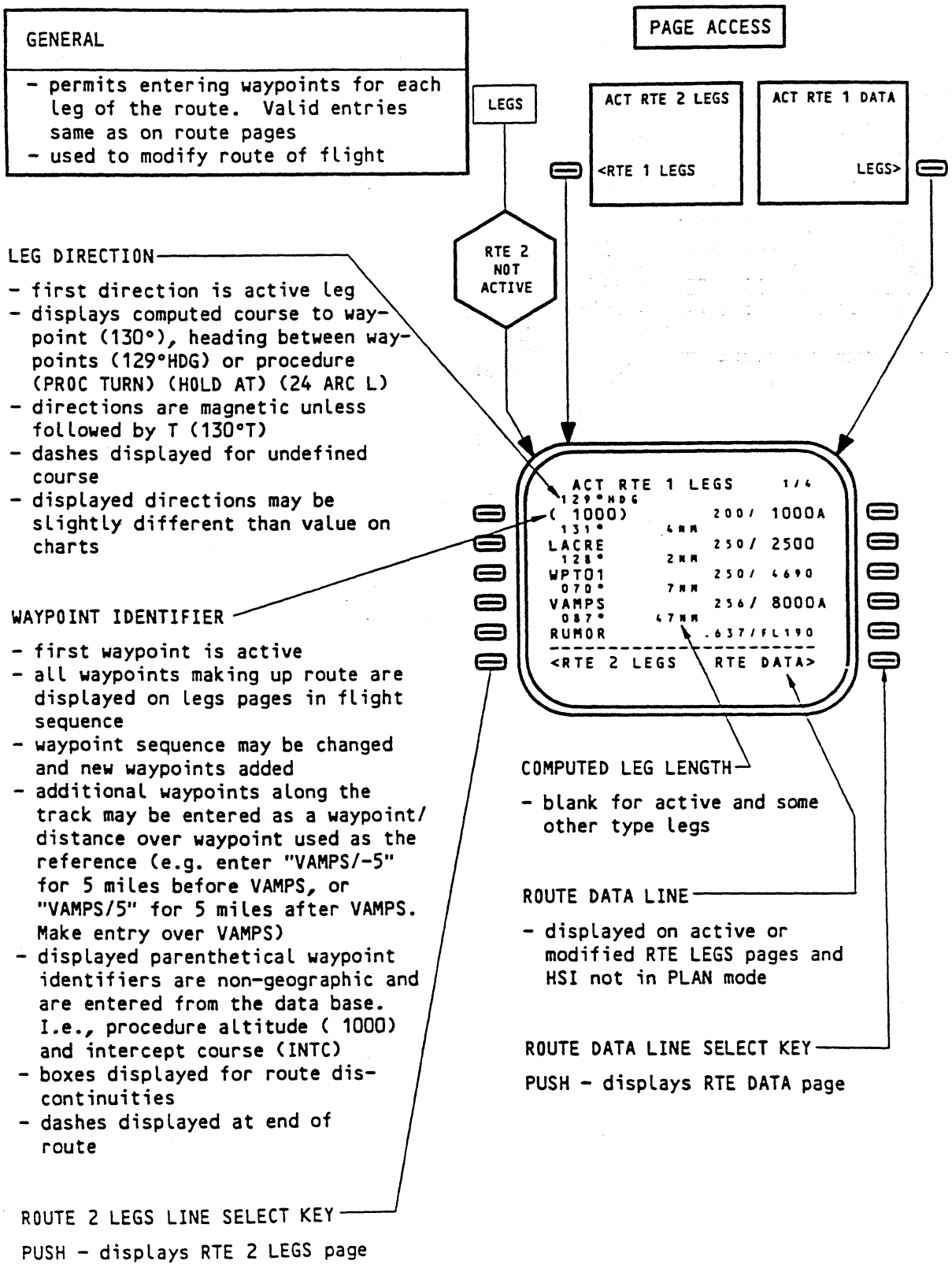

ACT RTE 1 2/2

- from ELN the route follows V336 to EPH, then an approach transition to intercept the ILS32R approach to runway 32R. Waypoints contained in ( ) marks are conditional waypoints. Conditional waypoints are NOT geographically fixed
- from the runway the route continues via the missed approach procedure to BATUM
- BATUM is the end of the entered route. It is followed by dashes that may be filled in with additional routing

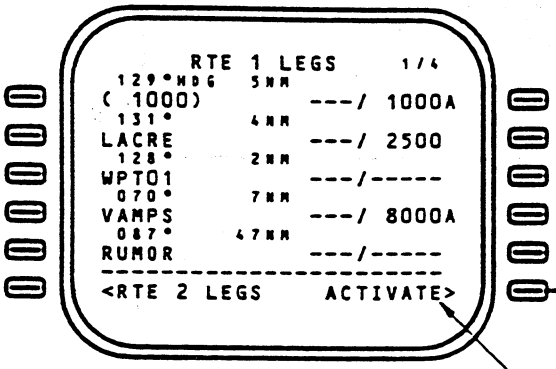
OFFSET LINE

- displayed in flight when offset entry possible
- valid entry is L (or R) XX (XX is any number)
- offset propagates along the route to an approach or approach transition, discontinuity, end of route, or holding pattern
- offset removed by deleting, entering zero or DIR/INTC






ROUTE LEGS

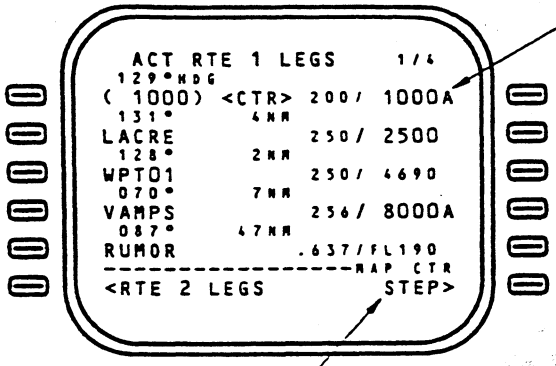



ACTIVATE LINE SELECT KEY

PUSH - activates displayed route
- illuminates EXEC key

ACTIVATE LINE

- displayed only on inactive page
- after activation on the ground, ACTIVATE is replaced with RTE DATA
- after activation in flight, RTE LEGS (DIR/INTC) Page 1 is displayed




SPEED/ALTITUDE LINES

- waypoint crossing constraints (restrictions) may be entered by crew on this page or may be entered automatically as part of a procedure
- large characters are constraints
- small characters are estimates
- valid entry for airspeed is XXX/
- speed constraint entries require altitude constraint at same waypoint
- valid entry for altitude is XXX, XXXX or XXXXX that are less than cruise altitude. Enter FL190 or 19000 feet as 190 or 19000. Enter FL090 or 9000 feet as 090 or 9000. Enter 900 feet as as 009 or 0900. Enter 90 feet as 0090
- if constraint is to cross the waypoint at a specific barometric altitude, enter the altitude only. If constraint is to cross at or above altitude, enter "A" after altitude. If constraint is to cross at or below altitude, enter "B" after altitude. If constraint is to cross between two altitudes, enter lower altitude followed by "A", then enter upper altitude followed by "B" (Example: 220A240B).
- climb at or above speed/altitude constraints automatically deleted when airplane reaches altitude (Example: If airplane reaches 8000 feet before VAMPS, 8000A contraint is deleted)
- climb and descent speed constraints are treated by FMC as "at or below" speed limitations for entered altitude
- FMC cannot comply with descent speed constraint when vertically off descent path
- FMC cannot comply with multiple descent speed contraints
- dashes displayed in predicted descent region prior to descent path calculation. Descent path calculation requires altitude entry below cruise altitude

MAP CENTER STEP

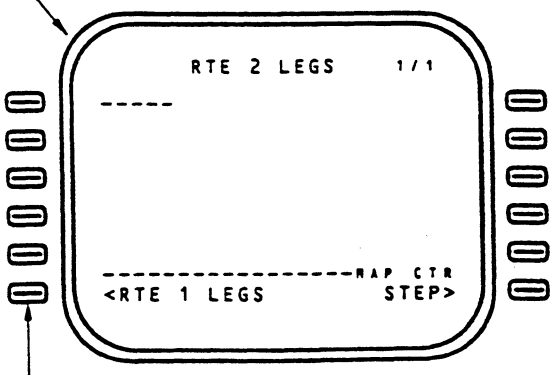
- displayed when HSI in PLAN mode

<CTR> - appears adjacent to the waypoint around which the HSI plan mode is centered

- pushing MAP CTR STEP line select key steps map center to next waypoint

RTE 2 LEGS

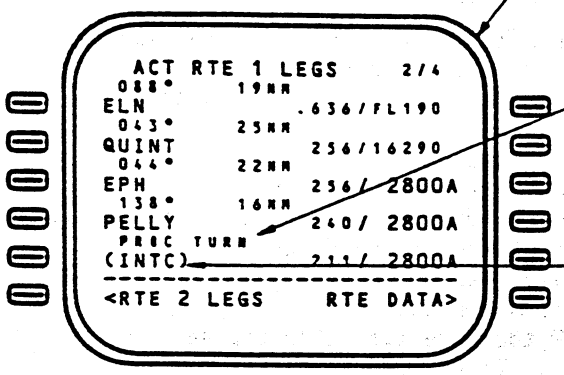
- displayed after pushing RTE 2 LEGS line select key on RTE 1 LEGS page
- permits entering waypoints for each leg of route 2




RTE 1 LEGS LINE SELECT KEY

PUSH - displays RTE 1 LEGS page

ROUTE LEGS




ACT RTE 1 LEGS Page 2/4

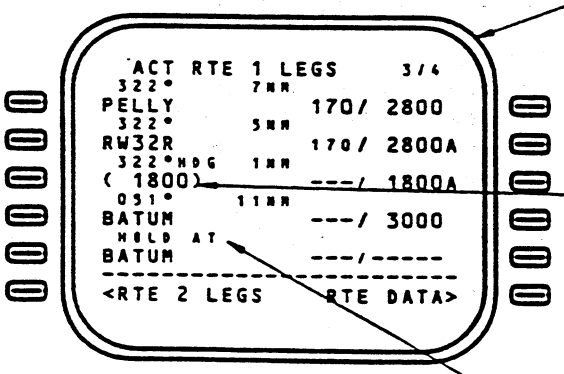
- displayed after pushing NEXT PAGE from ACT RTE 1 LEGS Page 1/4
- permits same enties as page 1/4

PROCEDURE TURN

- indicates after PELLY the route includes the published procedure turn

(INTERCEPT)

- indicates conditional waypoint at point where procedure turn is completed and 322° course to PELLY is intercepted




ACT RTE 1 LEGS Page 3/4

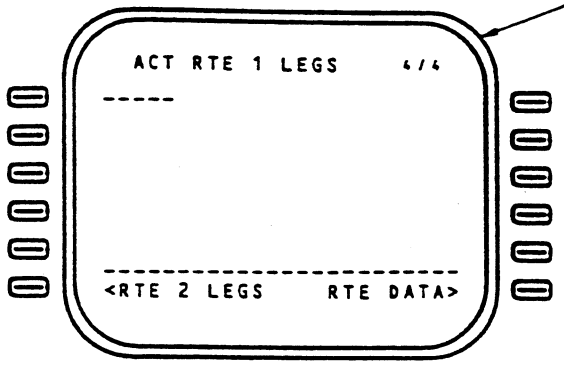
- displayed after pushing NEXT PAGE from ACT RTE 1 LEGS Page 2/4
- permits same entries as Page 1/4

( 1800)

- indicates a conditional waypoint at 1800 feet. With LNAV engaged guidance from runway 32R will be a 322° heading until above 1800 feet. Then, a turn to track course 051° to BATUM

HOLD AT

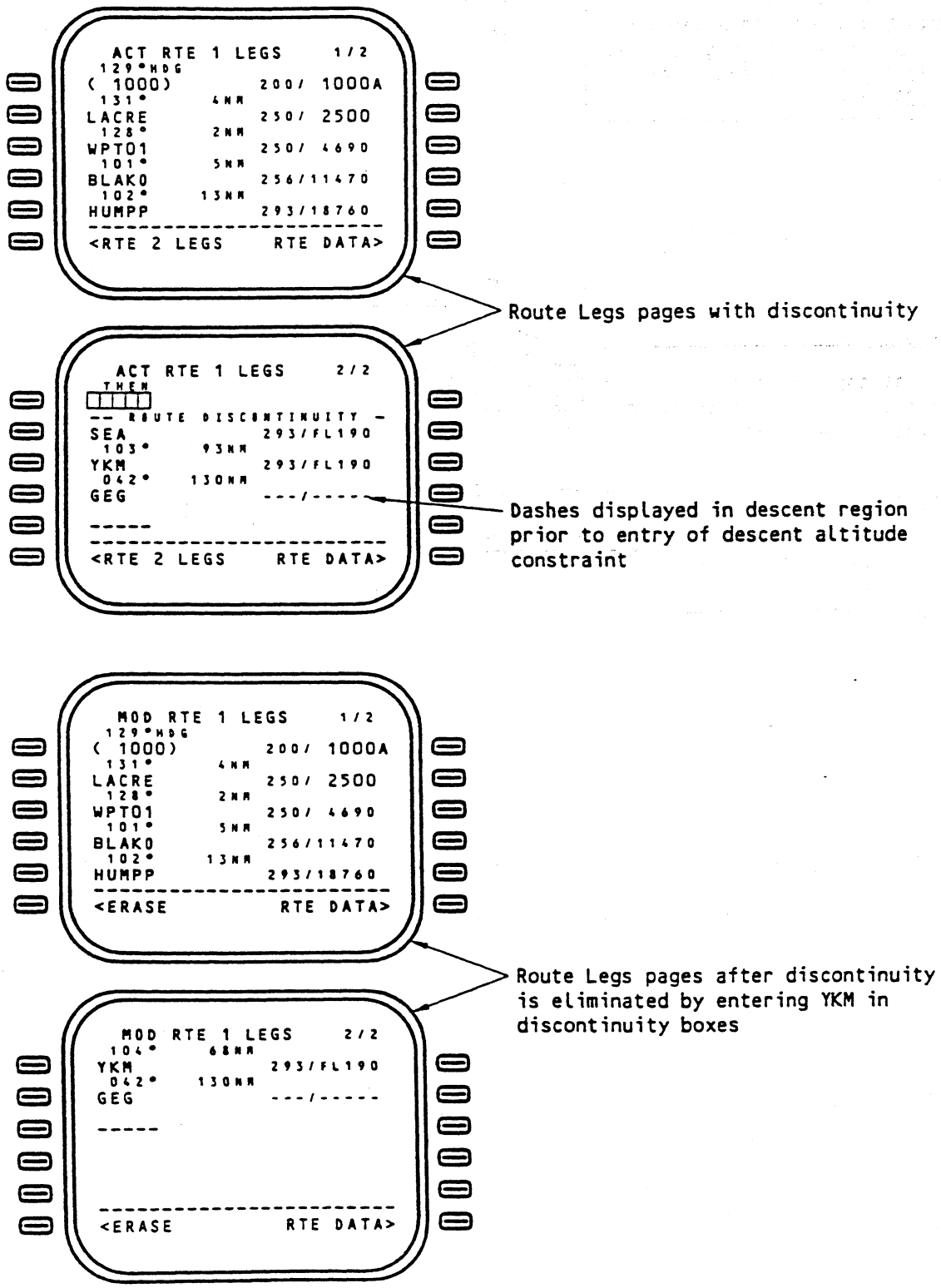
- indicates a holding procedure exists in route at waypoint BATUM




ACT RTE 1 LEGS Page 4/4

- permits entry of additional waypoints

ROUTE LEGS




ROUTE LEGS

## GENERAL

- permits flying direct to or intercepting a course to a waypoint
- direct to and intercept leg to boxes can be displayed at bottom of any ACT RTE LEGS page

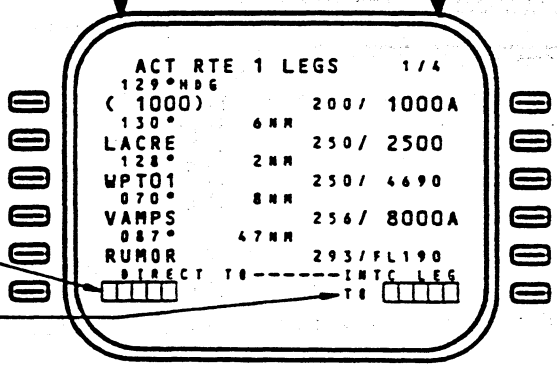
## PAGE ACCESS

DIR INTC

RTE

ACTIVATE>

IN FLIGHT

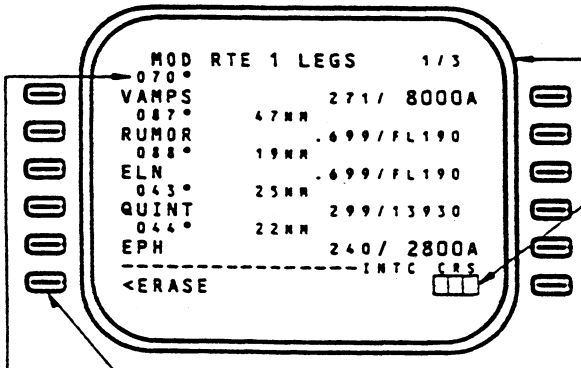



### DIRECT TO LINE

- valid entry is any waypoint
- airplane flies from present position direct to entered waypoint

### INTERCEPT LEG TO LINE

- valid entry is any waypoint
- after waypoint entry, INTC CRS line appears (see below)




After entering VAMPS in INTC LEG TO boxes on above page

### INTERCEPT COURSE LINE

- displayed after pushing INTC LEG TO line select key on direct intercept page
- permits changing inbound course to active waypoint (in this case 070° to VAMPS)

### COURSE TO ACTIVE WAYPOINT

- prior to executing, displays inbound course at waypoint; may be changed by entry in INTC CRS boxes and for airway in active route value that automatically appears is correct even if different than charted value by a few degrees
- after executing, displays current required track to fly inbound course to waypoint

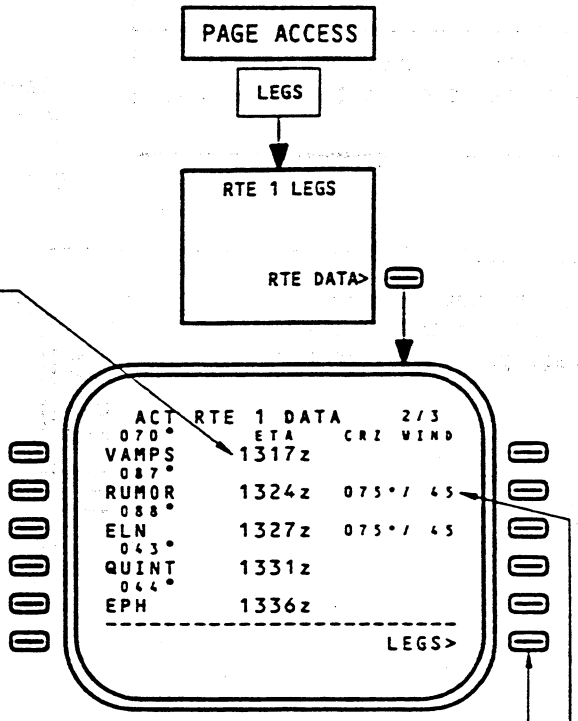
### ERASE LINE SELECT KEY

- displayed only on MOD pages

PUSH - displays previous unmodified page

ROUTE LEGS (DIRECT/INTERCEPT)

| GENERAL |
| --- |
| - displays ETA at all route waypoints<br>permits entry of forecast winds at<br>cruise waypoints |




ESTIMATED TIME OF ARRIVAL

- FMC calculated time at waypoint
- ETA calculations assume flying planned vertical profile speeds and a direct flight across discontinuities

LEGS LINE SELECT KEY

PUSH - displays RTE LEGS page

WIND

- transferred from PERF INIT page to cruise waypoints
- if no wind entry is made on the PERF INIT page, 000°/00 is displayed
- can be overwritten. Overwrites are displayed in large characters
- entry of true wind at waypoints improve ETA and fuel estimates

145645

**GENERAL**

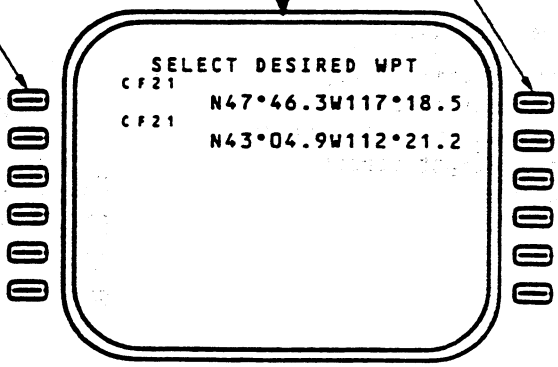
- used to select a specific waypoint location when the identifier is not unique

**PAGE ACCESS**

displayed automatically when an identifier stored in the data base is entered and has more than one geographic location

WAYPOINT LINE SELECT KEYS

PUSH - selects that waypoint location for use and returns to the page previously in use




## SELECT DESIRED WAYPOINT

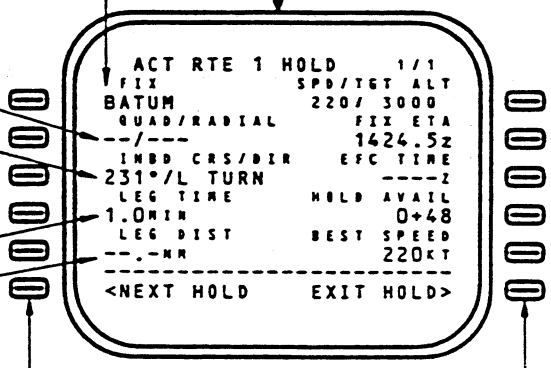
## GENERAL

- used to modify holding pattern
- modifications made to a holding pattern while active in the hold only become effective on the next crossing of the holding fix
- used to exit holding pattern

PAGE ACCESS

HOLD

HOLDING FIX IN ROUTE




FIX LINE

- identifies inserted holding fix

QUADRANT/RADIAL LINE

- normally displays dashes
- permits entry of holding quadrant/radial
- overrides INBD CRS/DIR
- valid entry is X/XXX or XX/XXX

INBOUND COURSE/DIRECTION LINE

- permits keyboard entry for inbound course and direction
- overrides QUAD/RADIAL
- valid entry is XXX (course), XXX/X or /X (turn direction)

LEG TIME LINE

- displays 1.0 min at or below 14,000 feet and 1.5 min above 14,000 feet
- can be changed by crew entry
- overrides LEG DIST display
- displays dashes if LEG DIST value is entered

LEG DISTANCE LINE

- normally displays dashes
- value can be entered by crew or by stored procedure
- overrides LEG TIME display

NEXT HOLD LINE SELECT KEY

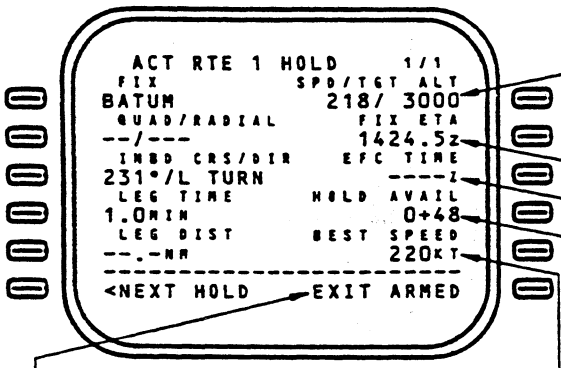
PUSH - displays prompts for entering another new holding pattern in route

EXIT HOLD LINE SELECT KEY

PUSH - arms flight back to the FIX to leave holding pattern

145647

ROUTE HOLD




SPEED/TARGET ALTITUDE LINE

- displays target speed/altitude or dashes. Small numbers are predictions. Large numbers are constraints
- entry of TGT ALT higher than fix waypoint altitude, but equal to or lower than cruise altitude, results in climb after entering holding
- entry of TGT ALT lower than fix waypoint altitude results in cruise descent after entering holding
- valid entry is XXX/ (for SPD), XXX, XXXX or XXXXX (for TGT ALT) or a combination of SPD/TGT ALT. Speed entry requires altitude constraint

EXIT ARMED LINE

- displayed after EXIT HOLD line select key is pushed
- upon execution, flight back to the FIX and along the active route is activated

FIX ETA LINE

- displays the next time the fix will be passed

EFC TIME LINE

- displays crew entered Expect Further Clearance time
- if TGT ALT is not defined, EFC TIME entry is inhibited
- entry alters downstream predictions

HOLD AVAILABLE LINE

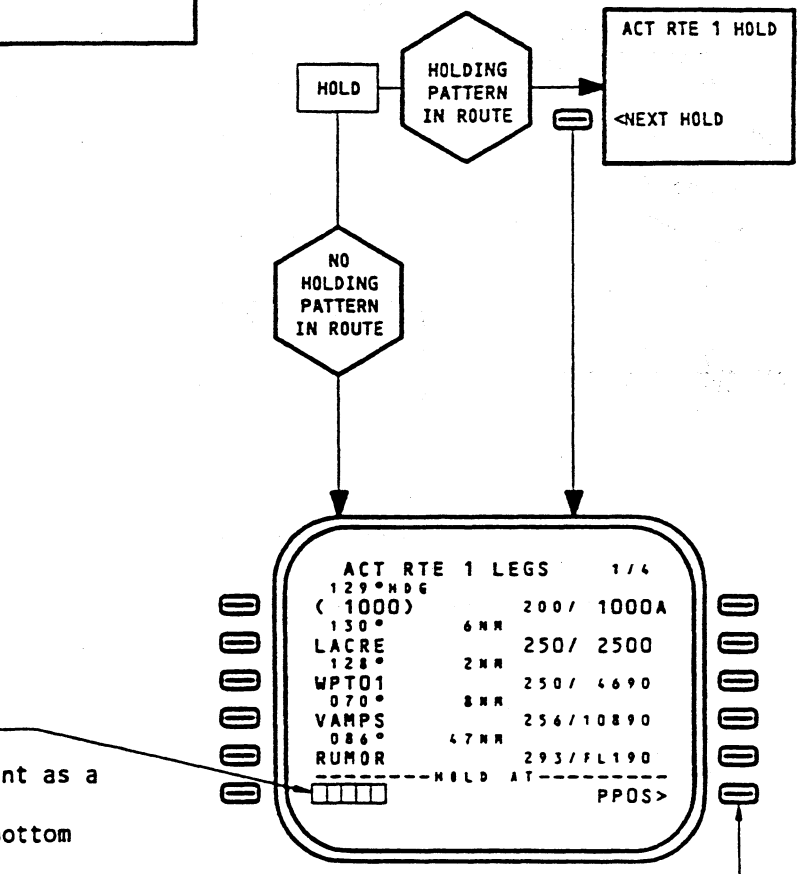
- displays holding time available before exit is required to reach destination with entered fuel RESERVES

BEST SPEED LINE

- displays best holding speed for current altitude and conditions
- may be greater than FAA and ICAO maximum holding speeds

| GENERAL |
| --- |
| - used to enter a holding pattern in route |

PAGE ACCESS




HOLD AT LINE

- permits entry of a waypoint as a holding fix
- can be displayed at the bottom of any RTE LEGS page
- if on an offset path, the airplane will not enter a pre-planned holding pattern

PRESENT POSITION LINE SELECT KEY

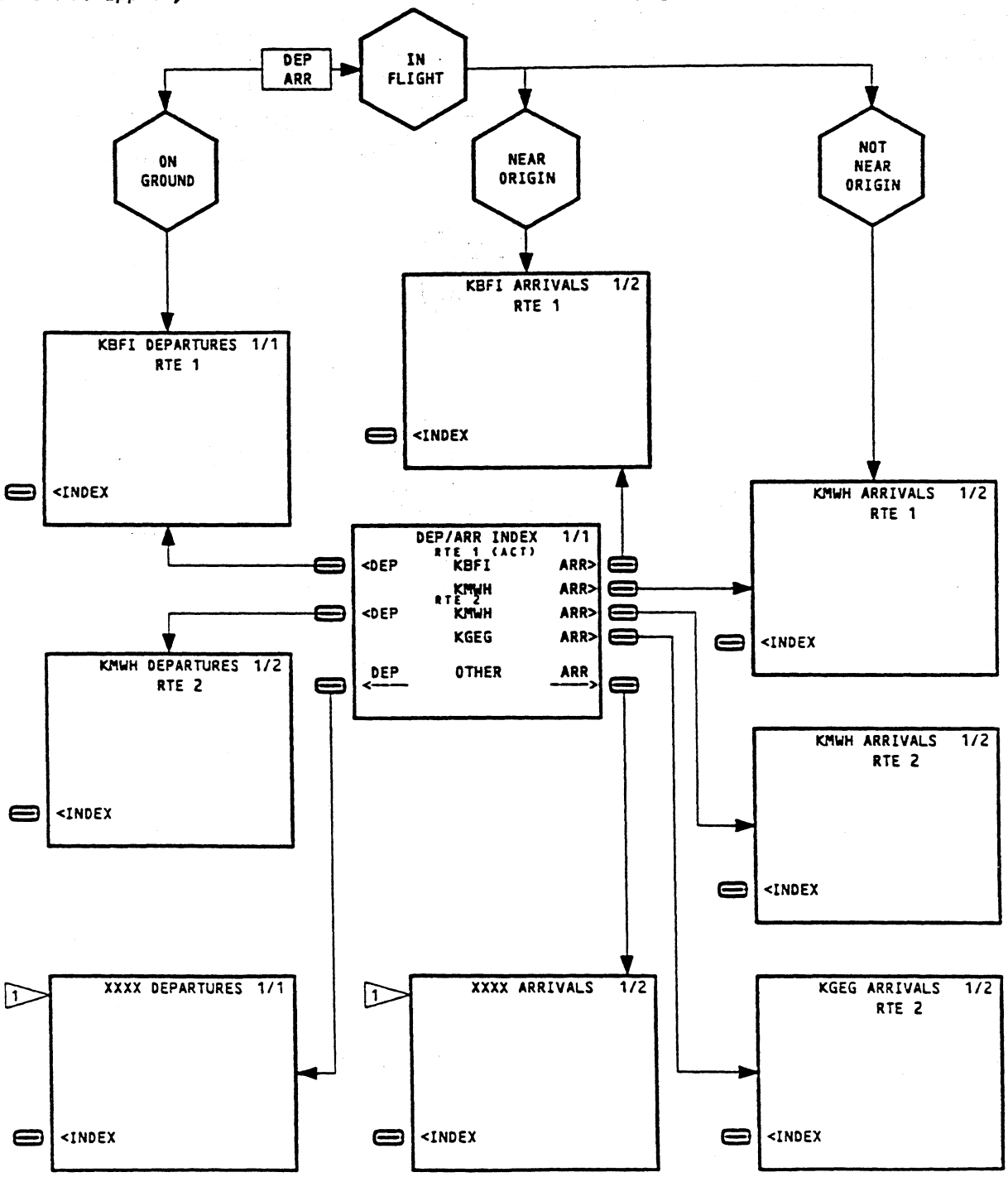
PUSH - creates a holding pattern with the holding fix at present position when the EXEC key is pushed

145649

RTE 1 LEGS (HOLD)

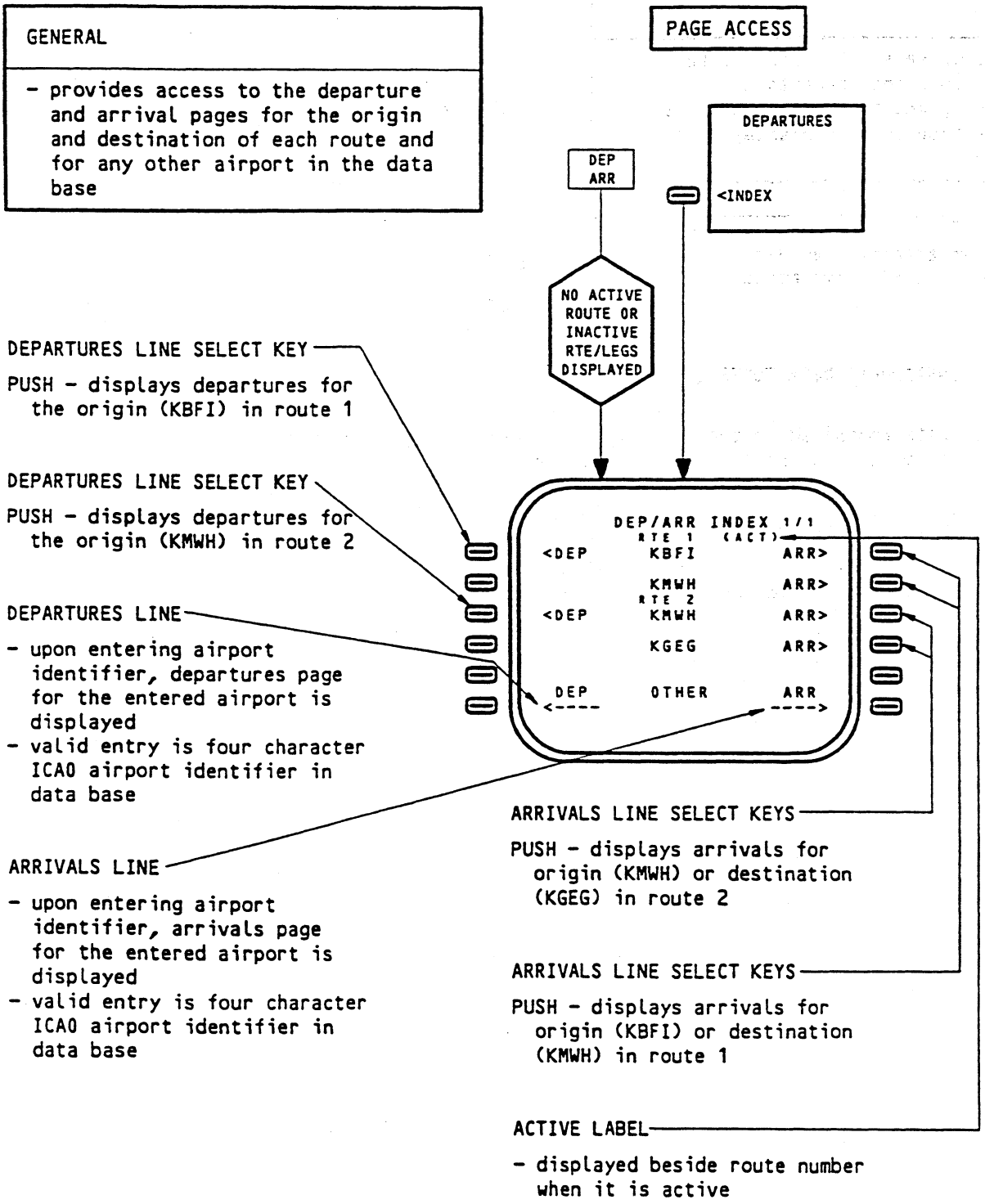
## DEPARTURES AND ARRIVALS PAGES

Pushing the DEP ARR key displays one of the departure or arrivals pages as indicated below. The diagram assumes route 1 is active. If the desired page does not appear, select index then select the desired page.



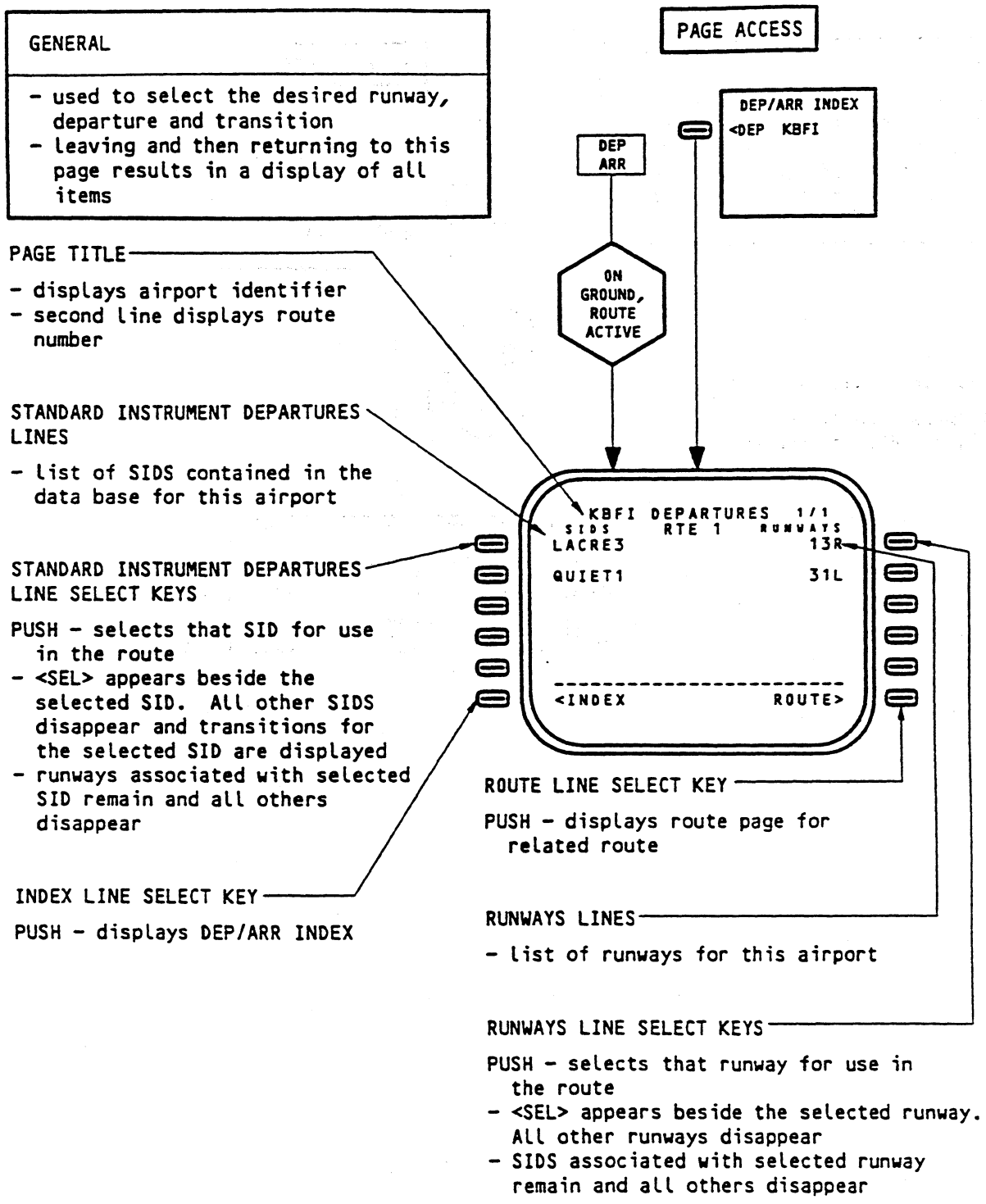

1 Procedures cannot be selected on these pages.

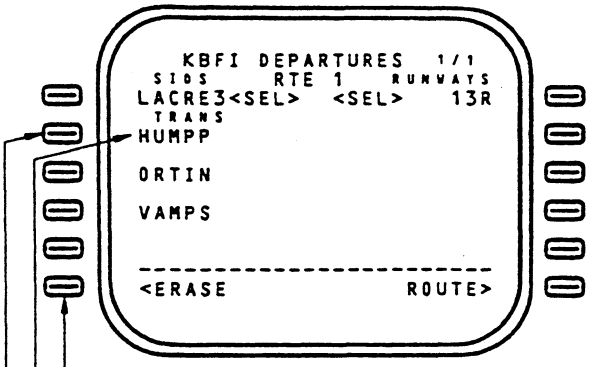
DEPARTURE/ARRIVALS PAGES




774301

DEPARTURE/ARRIVAL INDEX






ERASE LINE SELECT KEY

PUSH - deletes selections (modifications) made to active route
- redisplays entire list of SIDS and runways

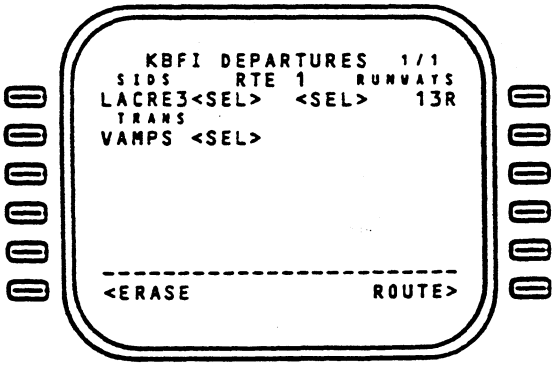
TRANSITION LINES

- list of transitions for the selected SIDS

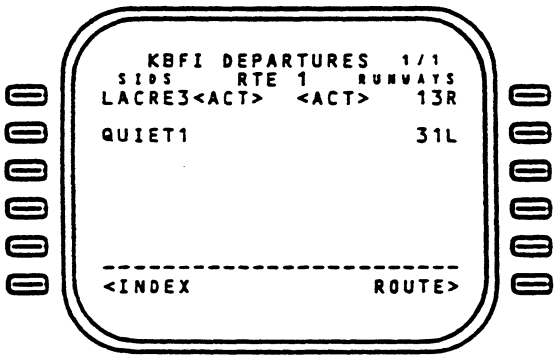
TRANSITION LINE SELECT KEYS

PUSH - selects that transition for entry into the route
- <SEL> appears beside the selected transition. All other transitions disappear

145653



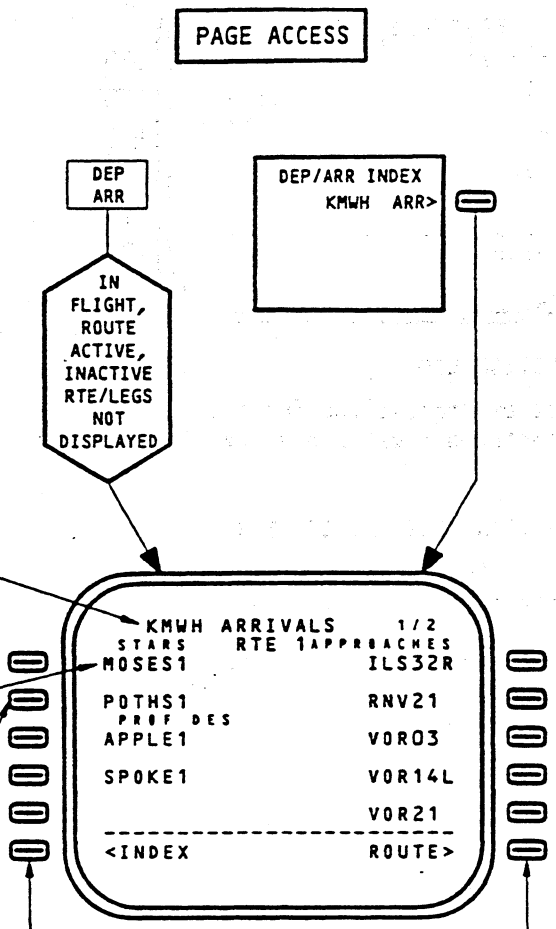

After selecting runway, SID and transition




After executing complete list of SIDS and runways reappear

## GENERAL

- used to select the desired STAR or profile descent, approach and transitions
- leaving and then returning to this page results in a display of all items
- when using the DEP/ARR key to access the page, and less than 50NM from the departure airport or less than halfway along the active route, whichever is less, ARRIVALS for the departure airport are displayed. Otherwise ARRIVALS for the destination are displayed.




PAGE TITLE

- displays airport identifier
- second line displays route number

STANDARD TERMINAL ARRIVAL ROUTES/ PROFILE DESCENTS LINES

- list of STARS and PROF DES for this airport
- NONE displayed if no STARS in data base

STANDARD TERMINAL ARRIVAL ROUTES/ PROFILE DESCENTS LINE SELECT KEYS

PUSH - selects that STAR or PROF DES for use in the route

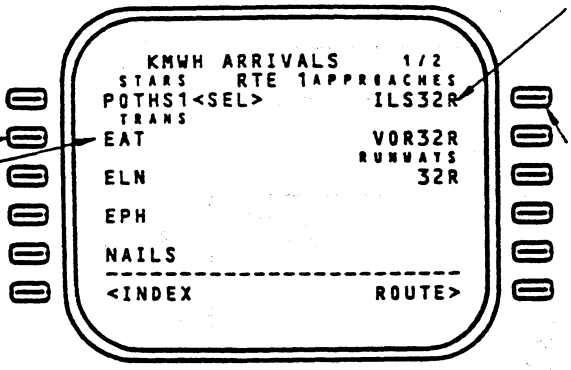
- <SEL> appears beside the selected arrival procedure. All other arrival procedures disappear and transitions for the selected procedure are displayed
- selecting a procedure deletes any previously selected procedure

INDEX LINE SELECT KEY

PUSH - displays DEP/ARR INDEX

ROUTE LINE SELECT KEY

PUSH - displays route page for related route




APPROACH LINES

- list of approaches for this airport

APPROACHES LINE SELECT KEYS

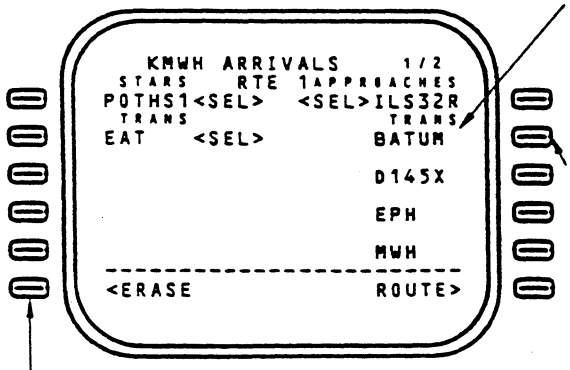
PUSH - selects that approach for entry into the route
- <SEL> appears beside the selected approach. All other approaches and runways disappear and transitions for the selected approach are displayed
- selecting an approach deletes any previously selected approach

TRANSITION LINES

- list of transitions for the selected arrival procedure

TRANSITION LINE SELECT KEYS

PUSH - selects that transition for entry into the route
- <SEL> appears beside the selected transition. All other transitions disappear




TRANSITION LINES

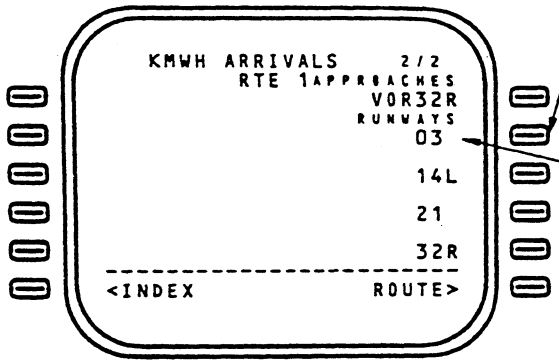
- list of transitions for the selected approach

TRANSITION LINE SELECT KEYS

PUSH - selects that transition for entry into the route
- <SEL> appears beside the selected transition. All other transitions disappear
- if no transition is selected, a straight in approach is entered

ERASE LINE SELECT KEY

PUSH - deletes selections (modifications) made to active route
- redisplays entire list of STARS, APP & RWs



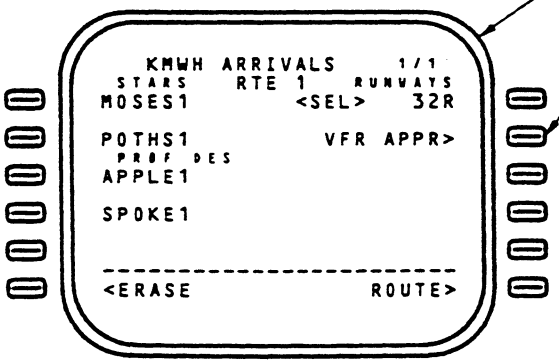

RUNWAY LINE SELECT KEYS

PUSH - enters selected runway and an eight mile VFR final approach fix in route with discontinuity before and after the fix
- <SEL> appears beside the selected runway. All other runways and approaches disappear. Any approach previously selected is deleted
- enters final approach fix waypoint constraint of 170 kts and 2,000 feet above runway and displays VFR APPR prompt if data base contains VFR approach for selected runway

RUNWAY LINES

- list of runways for this airport

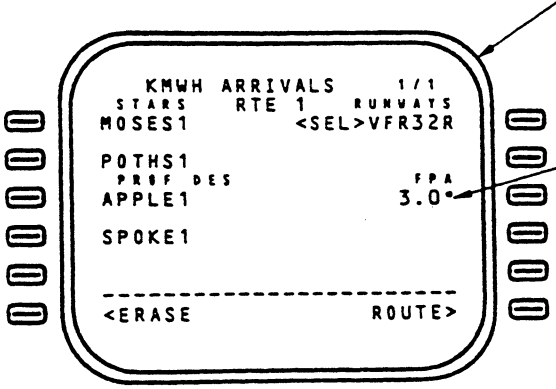
After selecting runway with VFR approach in data base.




VFR APPROACH LINE SELECT KEY

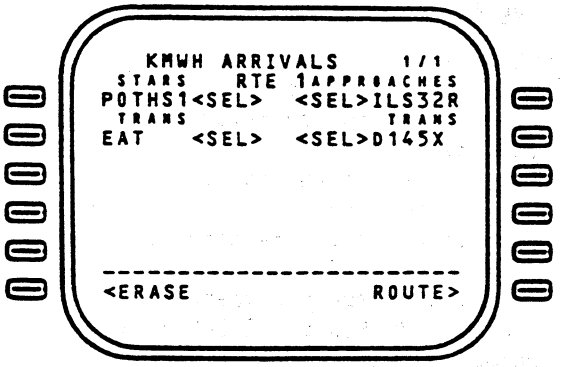
PUSH - selects VFR approach for the selected runway. Straight in approach beginning 8 miles from the runway threshold is entered into the route following a discontinuity
- enters runway constraint 50 feet above runway

After selecting VFR approach.

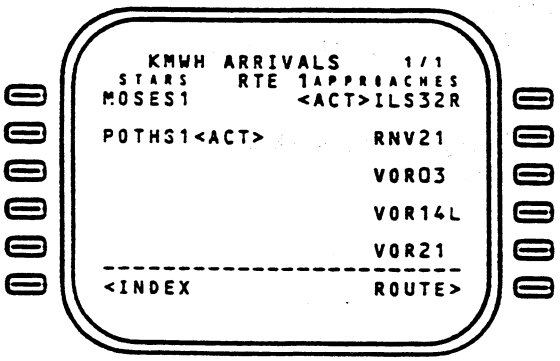



FLIGHT PATH ANGLE LINE

- displays descent path angle to runway constraint
- automatically set to 3.0°
- valid entry is X.X




After selecting STAR, STAR transition, approach and approach transition.

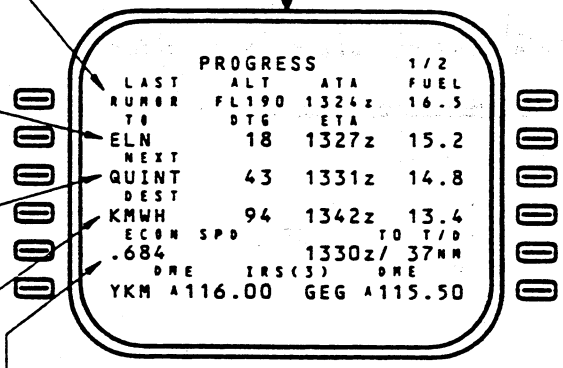



After executing selections.

| GENERAL |
| --- |
| - displays information relative to the progress of the flight |

PAGE ACCESS

PROG




LAST WAYPOINT LINE

- displays last waypoint and altitude, time and fuel remaining at that waypoint

TO WAYPOINT LINE

- displays waypoint identifier, distance to go, estimated time of arrival and estimated fuel remaining at the active waypoint

NEXT WAYPOINT LINE

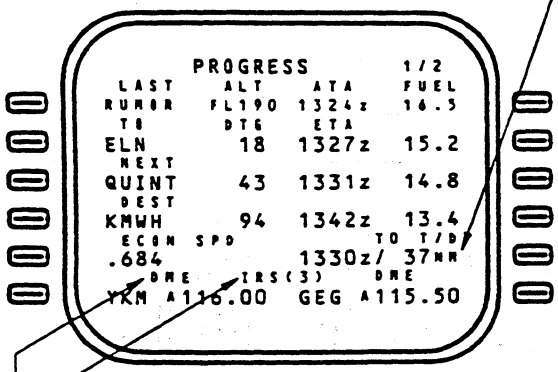
- displays waypoint identifier, distance to go, estimated time of arrival and estimated fuel remaining for the waypoint after the active waypoint

DESTINATION LINE

- displays destination identifier, distance to go, estimated time of arrival and estimated fuel remaining for the destination
- if a modification is in progress, information is relative to the modified flight plan. The DEST label is replaced with MOD
- alternate destination waypoint may be entered over the displayed destination. The DEST label is replaced by DIR TO ALTERNATE and the information shown is based on flying direct to the alternate. May be reset to destination by use of Delete Key or both pilots leaving page

SPEED DISPLAY

- displays active command speed and mode
- LRC SPD or ECON SPD are displayed if active on performance page
- SEL SPD is displayed when a selected airspeed or mach is active
- LIM SPD is displayed if speed is being limited by VMO, MMO, FLAP limit or ALPHA limit
- MCP SPD is displayed when speed intervention is active
- E/OUT SPD is displayed when the engine out mode is active




TO TOP OF DESCENT DISPLAY

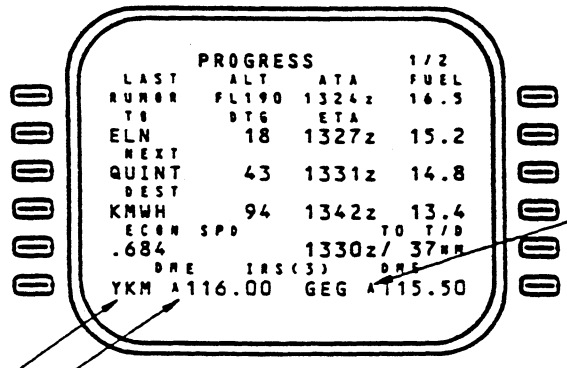
- displays ETA and distance to top of descent when cruise is active and within 200 miles of T/D
- other displays are:
  TO T/C - when climb is active
  TO E/D - when descent is active
  TO STEP CLIMB - when remaining cruise distance permits
  LEVEL AT - when ENG OUT CRZ DES or D/D is active

IRS (N) DISPLAY

- indicates the number or identification of IRS units supplying usable position data to the FMC (N=3, L, C, R or 0)

FMC UPDATE DISPLAY

- indicates update mode of the FMC
- displays are:
  DME
  VOR-DME
  LOC




TUNING MODE

- displays the method by which a station is tuned
- displays are:
  M - manually tuned via VOR control panel
  A - auto tuned via FMC
  P - auto tuned via FMC as mandated by selected procedure
  R - remote tuning permitted when in auto or remote mode. Remotely tuned by entering station identifier or frequency from scratch pad. Auto tuning restored by entering A, accelerating through 100 kts, toggling VOR/DME Switch, moving HSI Mode Selector to ILS then MAP, or removing FMC power

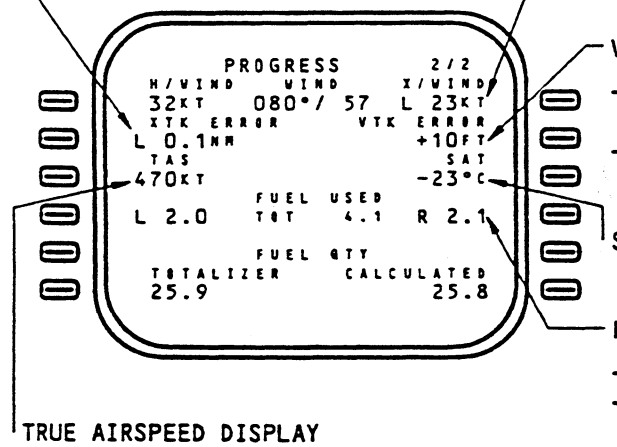
FREQUENCY DISPLAY

- displays tuned VOR frequency

IDENTIFIER DISPLAY

- displays identifier of tuned frequency

PROGRESS




CROSSTRACK ERROR DISPLAY

- indicates distance airplane is left or right of active route

WIND LINE

- displays current headwind (H/WIND), tailwind, (T/WIND), and crosswind (X/WIND) referenced to airplane heading
- displays current wind direction and speed referenced to true north

VERTICAL TRACK ERROR DISPLAY

- displays distance airplane is off vertical path
- blank when descent is not active

STATIC AIR TEMPERATURE DISPLAY

FUEL USED LINE

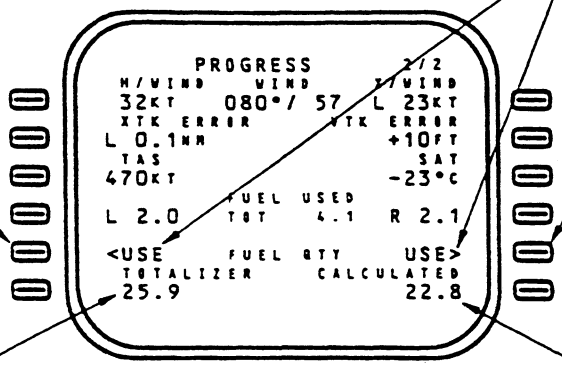
- displays total fuel used
- displays fuel used by each engine as calculated from fuel flow

TRUE AIRSPEED DISPLAY

TOTALIZER USE LINE SELECT KEY

PUSH - FMC uses Fuel Quantity Processor computations to determine fuel quantity and blanks the CALCULATED and FUEL USED displays

- Performance Initialization Page fuel quantity relabeled SENSED




USE PROMPT DISPLAYS

- blank unless a difference of 3,000 pounds (1,360 kg) or more exists between TOTALIZER and CALCULATED fuel quantity
- CDU message FUEL DISAGREE-PROG 2/2, or FUEL QTY ERROR-PROG 2/2, is displayed

CALCULATED USE LINE SELECT KEY

PUSH - FMC uses CALCULATED fuel quantity values and blanks the TOTALIZER display

CALCULATED (FUEL QUANTITY)

- prior to engine start, displays fuel quantity calculated by Fuel Quantity Processor
- after engine start, displays fuel quantity calculated by decreasing fuel on board at engine start at EICAS fuel flow signal rate

TOTALIZER (FUEL QUANTITY)

- displays fuel quantity calculated by Fuel Quantity Processor
- blank if fuel value manually entered on Performance Initialization Page

922580

## GENERAL

- permits creating waypoints (fixes) from the intersection of active route and bearings from the entered fix
- bearings are magnetic between 73°N and 60°S, otherwise true north

PAGE ACCESS

FIX

FIX LINE

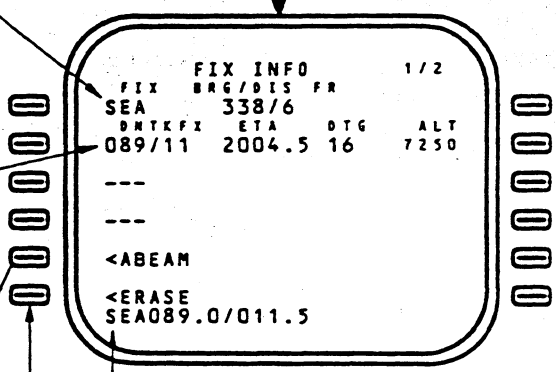
- valid entry is navaid or waypoint identifier in data base
- displays bearing and distance from selected fix to the airplane
- displays selected fix on HSI map

DOWNTRACK FIX LINE

- valid entry is 3 character bearing from fix
- displays selected bearing, distance from the FIX to the intersection on the active route, estimated time of arrival at the intersection, distance to go to the intersection and predicted altitude at the intersection. Intersection not displayed if behind the airplane, at a route waypoint, or cross the route on a DME arc leg
- three DNTKFX entries can be made

ABEAM LINE SELECT KEY

PUSH - displays bearing and distance from the FIX to the point abeam the FIX on the active route, ETA, DTG and predicted altitude

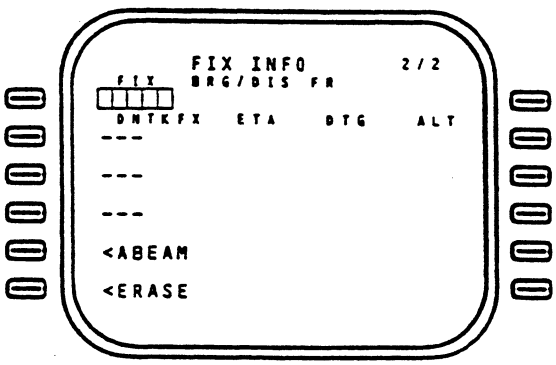



SCRATCHPAD ENTRY

- DNTKFX has been copied in scratchpad for entry into route

ERASE LINE SELECT KEY

PUSH - removes all FIX data from the CDU and HSI

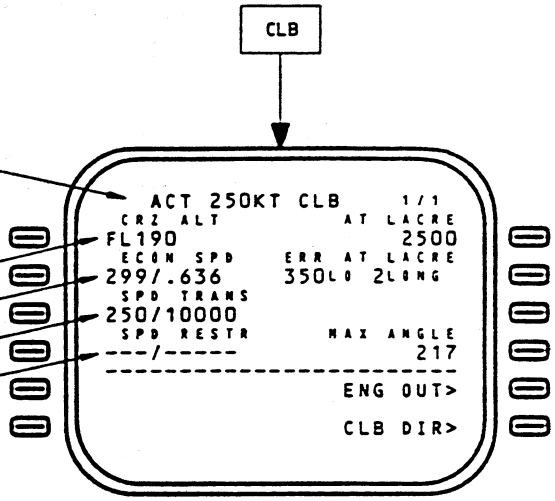



Prior to entering information

FIX INFORMATION

| GENERAL |
| --- |
| - used to select climb speed<br>- available speeds are: economy, selectable speed and engine out |

PAGE ACCESS




PAGE TITLE

- displays active climb speed: XXXKT if controlling to a fixed speed, M.XXX if controlling to a fixed mach or ECON if controlling to economy speed based on cost index entered on PERF INIT page
- ENG OUT displayed if engine out is selected
- MCP SPD displayed if speed intervention is selected on MCP
- LIM SPD displayed if controlling to a limit speed (e.g., flap placard)

CRUISE ALTITUDE

- altitude forwarded from PERF INIT or CRZ page
- valid entry is XXX (flight level), XXXX or XXXXX (feet)
- boxes displayed after reaching cruise altitude

ECONOMY/SELECTED SPEED

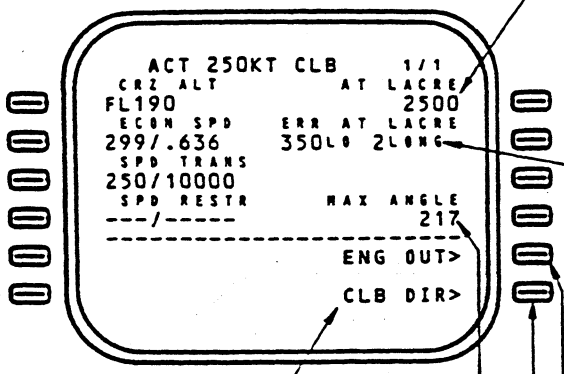
- displays command speed used above all waypoint speed constraints, speed restrictions and speed transition altitudes
- speed and/or mach may be entered

SPEED RESTRICTION

- displays dashes prior to entry
- permits entry of a speed limit below an altitude less than cruise altitude
- valid entry is speed/altitude (Example: 215/3020)

SPEED TRANSITION

- displays data base speed limit associated with the ORIGIN airport
- automatically displays 250/10000 if not specified in data base
- blanks when speed transition removed




WAYPOINT CONSTRAINT LINE

- displays the next climb waypoint constraint
- constraints entered on RTE LEGS page
- can be deleted here or on the RTE LEGS page
- airplane flys the constraint speed or the current performance speed, whichever is less
- label can also be HOLD AT XXXXX (XXXXX is the holding fix) followed by a speed/altitude constraint
- blank if no constraint exists

ERROR AT WAYPOINT LINE

- displays predicted undershoot for next waypoint constraint. Displays altitude discrepancy and distance past waypoint where altitude will be reached
- blank (including label) if no error is predicted

CLIMB DIRECT LINE

- displayed when climb altitude constraint exists

MAXIMUM ANGLE LINE

- displays maximum angle of climb speed

CLIMB DIRECT LINE SELECT KEY

PUSH - deletes all altitude contraints at waypoints between the current altitude and the MCP altitude

ENGINE OUT LINE SELECT KEY

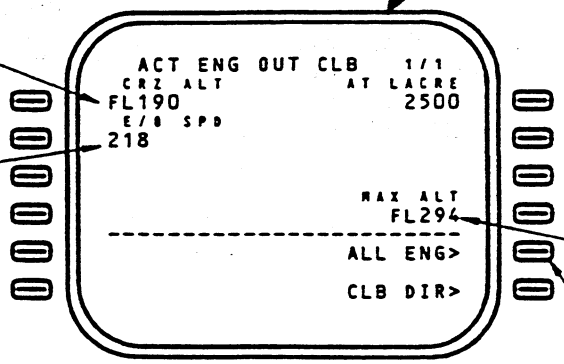
PUSH - commands engine out performance calculations for climb and cruise
- changes cruise altitude if set above maximum engine out altitude
- changes command speed to engine out speed

| GENERAL |
| --- |
| - execution of ENG OUT climb causes a recalculation of all climb and cruise performance data, based on single engine performance values |

PAGE ACCESS

XXXX CLB

ENG OUT>




CRUISE ALTITUDE LINE

- automatically resets to MAX ALT when previous CRZ ALT above MAX ALT
- may enter another altitude

ENGINE OUT SPEED LINE

- displays engine out climb speed
- cannot change

ALL ENGINE LINE SELECT KEY

PUSH - display returns to the all engine performance profile

MAXIMUM ALTITUDE LINE

- displays the maximum attainable altitude with one engine out, maximum continuous thrust and engine out climb speed

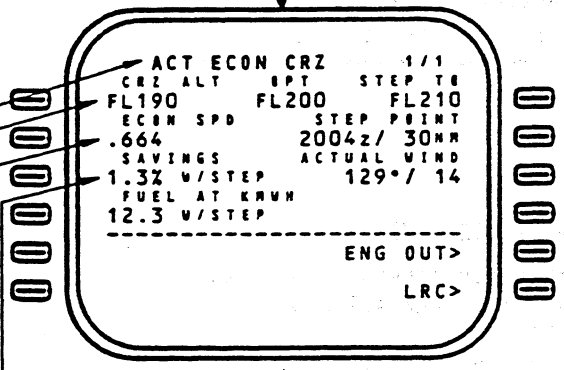
145665

**GENERAL**

- used to evaluate or change cruise altitude and speed
- available speeds are: economy, selected speed, long range cruise, engine out, cruise climb and cruise descent

**PAGE ACCESS**

CRZ




**PAGE TITLE**

- displays active cruise speed:
- XXXKT if controlling to a fixed speed, M.XXX if controlling to a fixed mach or ECON if controlling to economy speed based on cost index set on PERF INIT page
- LRC displayed if long range cruise selected
- ENG OUT displayed if engine out selected
- MCP SPD displayed if speed intervention selected on MCP
- LIM SPD displayed if controlling to a limit speed (e.g., VMO/MMO)
- CRZ CLB or CRZ DES displayed if new cruise altitude entered on active page

**CRUISE ALTITUDE LINE**

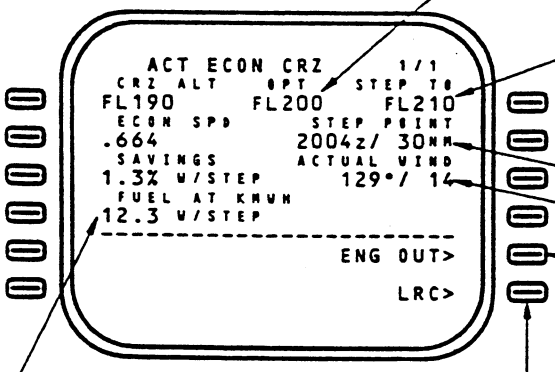
- valid entry is XXX (flight level), XXXX or XXXXX (feet).
- entry while page is active changes page title to CRZ CLB or CRZ DES

**SAVINGS/PENALTY LINE**

- displays predicted savings or penalty associated with flying the step climb/descent (W/STEP) or flight plan modification (W/MOD)
- after passing the STEP POINT, based on making a step at current position
- label is PENALTY if appropriate
- most accurate when estimated wind for step altitude is entered
- indicates percent change in cost when operating in ECON mode
- indicates percent change in fuel
- consumption when <u>not</u> in ECON mode

**SPEED LINE**

- displays command speed or mach
- label can show ECON, LRC, SEL or E/O SPD




OPTIMUM ALTITUDE

- displays the most economical altitude to fly based on gross weight, cost index and trip length

STEP TO ALTITUDE

- displays 2000 ft. higher than CRZ ALT
- may be overwritten by crew. New value remains until a new CRZ ALT is entered
- valid entry is XXX (flight level), FLXXX or XXXXX (feet)
- blank when there is no active flight plan or when within 200 NM of T/D

STEP POINT

- displays ETA and distance to go to optimum step climb point if the airplane is within 1000 NM of the step point and more than 200 NM from T/D
- label changes to TO T/D when within 200 NM of T/D. ETA and distance are then relative to T/D

ACTUAL WIND

- displays current wind
- can be overwritten. Overwrites labeled EST WIND
- entry of average true wind at the STEP TO altitude improves Step Climb information
- DELETE the EST WIND to return to ACTUAL WIND

FUEL AT DESTINATION LINE

- displays predicted fuel at destination
- blank when prediction is 100 thousand pounds or greater
- if step information is displayed, fuel display assumes step will occur as displayed and fuel value is suffixed by W/STEP
- after passing the STEP POINT, the fuel value is based on making a step from the current position
- label is suffixed by W/MOD if a flight plan modification is pending

LONG RANGE CRUISE LINE SELECT KEY

PUSH - changes command speed to LRC

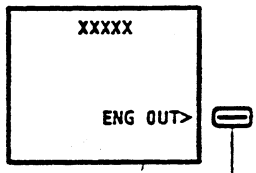
ENG OUT LINE SELECT KEY

PUSH - commands engine out performance calculations
- changes cruise altitude if set above drift down altitude
- changes command speed to engine out speed

A54236

| GENERAL |
| --- |
| - used to make an Engine Out Drift Down |

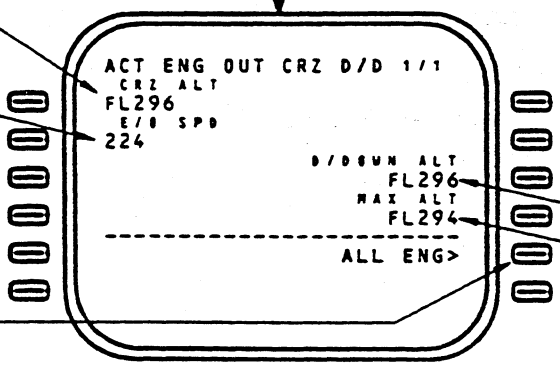
PAGE ACCESS





CRUISE ALTITUDE
- displays Drift Down Altitude
- may enter lower altitude

ENGINE OUT SPEED
- displays minimum drag speed
- cannot change




ALL ENGINE LINE SELECT KEY
PUSH - commands all engine speed and thrust schedule

MAXIMUM ALTITUDE
- displays maximum attainable altitude with one engine out, maximum continuous thrust, engine out speed and at current weight

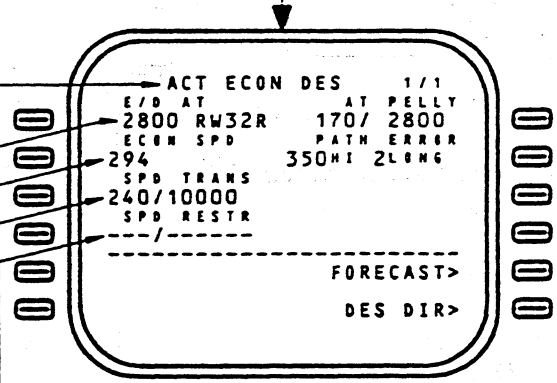
DRIFT DOWN ALTITUDE
- displays maximum attainable altitude with one engine out, maximum continuous thrust, engine out speed at predicted weight at end of drift down

## GENERAL

- used to evaluate or revise the descent phase of the flight
- available speeds are: economy and selected speed
- page is blank with DES as title if no waypoint constraints lower than CRZ ALT exist

PAGE ACCESS

DES




PAGE TITLE

- displays active descent speed: XXXKT if target is a fixed speed, M.XXX if target is a fixed mach or ECON if target is economy speed based on cost index set on PERF INIT page
- MCP SPD displayed if speed intervention selected on MCP
- LIM SPD displayed if controlling to a limit speed (e.g., flap placard)
- END OF DES displayed when E/D waypoint reached if not followed by a climb segment

END OF DESCENT AT LINE

- displays last altitude constraint in descent
- entered on RTE LEGS page
- with multiple E/D constraints at same altitude HSI map shows first constraint as E/D and this line shows last constraint

SPEED LINE

- displays command speed and mach
- label can show ECON or SEL SPD
- mach and/or speed can be entered. Valid mach entry is .X, .XX or .XXX. Label changes to SEL SPD
- when transitioning to a selected speed segment, label automatically changes to SEL SPD
- when SEL SPD is displayed, an ECON prompt is diplayed on this page

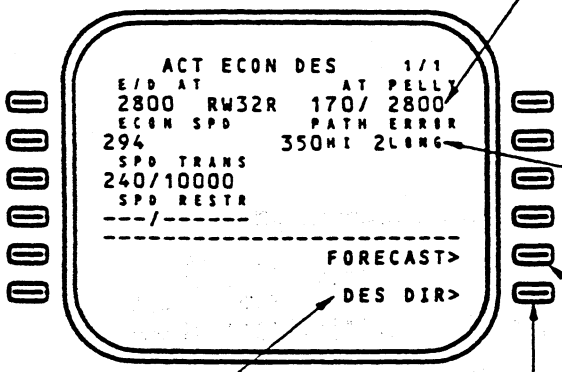
SPEED RESTRICTION

- displays dashes before entry
- permits entry of a speed limit at an altitude higher than E/D altitude
- when transitioning to the limiting speed, dashes are displayed

SPEED TRANSITION

- displays 10 knots less than the data base speed limit at destination airport
- automatically displays 240/10000 if a different value is not in the data base for destination
- blank below SPD TRANS altitude
- deleting causes the airplane to fly economy or selected speed if not limited by a waypoint constraint or speed restriction

145669




WAYPOINT CONSTRAINT LINE

- displays next descent waypoint constraint
- constraints entered on a RTE LEGS page by procedure selection or crew entry
- can be deleted here or on the RTE LEGS page
- label can also be HOLD AT XXXXX (XXXXX is the holding fix), AT VECTORS or AT (INTC)

PATH ERROR LINE

- displays vertical distance in feet, and horizontal distance in NM, from descent path to airplane
- displayed when descent is active
- blank if descent page not active or modification in progress

FORECAST LINE SELECT KEY

PUSH - displays DESCENT FORECASTS page

DESCEND LINE

- displays DES DIR when descent is active and a waypoint constraint exists
- displays DES NOW when the descent page is not active

DESCEND LINE SELECT KEY

DES DIR displayed
PUSH - deletes all waypoint constraints between the current altitude and the MCP altitude

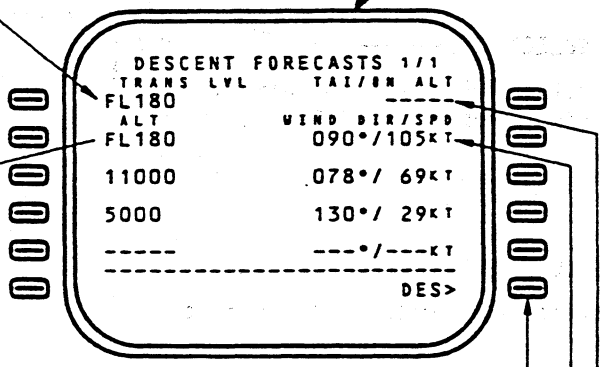
DES NOW displayed
PUSH - begins descent of approximately 1000 feet per minute using the active cruise speed schedule. Throttles may be manually repositioned to adjust vertical speed. Upon intercepting the planned descent path, the airplane transitions to the planned descent

| GENERAL |
| --- |
| - used to enter forecast winds and altitude where thermal anti-icing will be turned on to more accurately define the descent path |

PAGE ACCESS

XXXX DES

FORECAST>




TRANSITION LEVEL LINE

- automatically display FL180
- can be changed by crew
- changed automatically if an arrival procedure with a different transition level is selected
- used to change descent CDU displays between FL's and feet

WIND LINES

- permits entry of altitudes where forecast winds are known

DESCENT LINE SELECT KEY

PUSH - displays descent page

DIRECTION/SPEED LINES

- permits entry of forecast winds for the entered altitudes
- entry should be referenced to true north

THERMAL ANTI-ICE ON LINE

- permits entry of altitude where anti-ice will be turned on

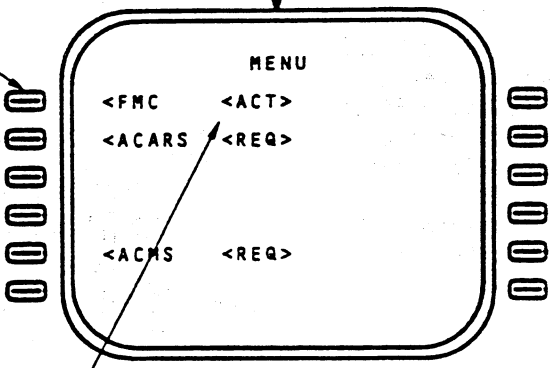
145671

DESCENT FORECASTS

| GENERAL |
| --- |
| - used to select CDU function |

PAGE ACCESS

MENU




FMC LINE SELECT KEY

PUSH - activates CDU control of FMC
- <ACT> appears beside FMC

ACARS LINE SELECT KEY

PUSH - activates CDU control of AIRINC Communications Addressing & Reporting System
- displays ACARS page

ACMS LINE SELECT KEY

PUSH - activates CDU control of Aircraft Condition Monitoring System
- displays ACMS page

CDU STATUS

<ACT> - indicates active CDU function

<REQ> - indicates inactive CDU function

MENU (As installed)

## NAVIGATION/STANDBY

### DESCRIPTION

#### INTRODUCTION

This section provides a detailed description of the Standby Navigation System (SNS). Information in this section is limited to that which is unique to the SNS; information which is common with the Flight Management System is not repeated.

#### GENERAL

The SNS is an IRS based system which provides lateral navigation capability independent of the FMC. The IRS combined with the CDU is the SNS. In the event of FMC failure, the SNS provides a backup mode of operation which is immediately available for use.

Similar to the FMC, the SNS performs computations related to lateral navigation.

##### System Components

The SNS is comprised of two separate systems: Left and Right. Each system is independent of the other, consisting of its own CDU and IRS.

During FMC operation, all memory and computing capability are contained within the FMC.

During SNS operation, each CDU uses its own internal memory and computing capability. Since each CDU performs its own computations based on inputs from its own IRS, the information available for display is independent of the other CDU.

##### Memory

In contrast to the FMC, the SNS has neither a performance data base nor a permanent navigation data base. Thus, there is no stored information from which the desired waypoints can be extracted by use of their identifier. All waypoints in the CDU route must be defined in terms of latitude and longitude. The CDU has a temporary memory which stores the current active route. These waypoints are stored with their identifier. Their sequence can be revised using the Legs Page. All new waypoints must be entered as a latitude/longitude.

OPERATION

If both FMCs fail, each CDU is used to navigate with the respective IRS. Only the IRS Legs Page and the IRS Progress Page are available in standby navigation.

Positioning a Navigation Instrument Source Selector to the CDU position displays the standby navigation route on the related HSI. The route can be flown using the AFDS Heading Select Mode. LNAV and VNAV modes are inoperative during standby navigation.

Lateral Navigation

All computations from the CDU are based on a direct great-circle course between waypoints. The CDU does not accept "undefined" waypoints/legs; that is, no fixed heading or course legs, and no conditional waypoints. The CDU automatically replaces an undefined leg with a discontinuity. However, individual legs of a procedure that are a great-circle course can be entered.

Only the active leg course can be referenced to magnetic north; all downpath legs are displayed as true course because the IRS can provide magnetic variation only for present position.

Radio Tuning

The radios must be manually tuned. Navigation computations use the IRS present position. No radio updating occurs.

| GENERAL |
| --- |
| - provides means of entering and displaying details of each leg of the route |

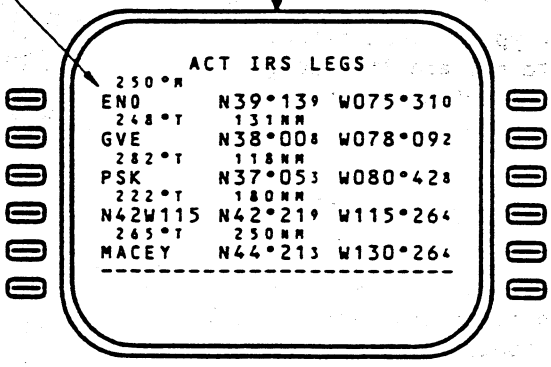
PAGE ACCESS

LEGS

FMC IS FAILED

WAYPOINT INFORMATION

- displays waypoint identifier, latitude and longitude, and computed course to the waypoint
- the first waypoint is the active waypoint
- computed course, for other than active waypoint is relative to true north. The active waypoint course is relative to the current selected heading reference (magnetic or true)
- displays leg segment distance for legs other than the active leg
- valid entries are waypoint identifiers currently in active route, or latitude and longitude
- active waypoint can be changed. Normal DIR/INTC feature is inoperative in SNS



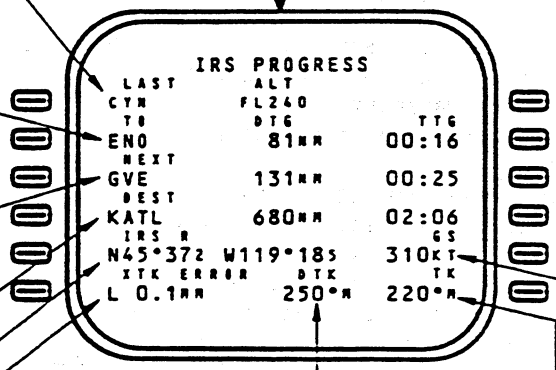
**GENERAL**

- displays current dynamic flight information relative to the progress of the flight

PAGE ACCESS

PROG

FMC IS FAILED




**LAST WAYPOINT LINE**

- displays last waypoint and crossing altitude

**TO WAYPOINT LINE**

- displays waypoint identifier, distance to go, and time to go from the present position along the route

**NEXT WAYPOINT LINE**

- displays waypoint identifier, distance to go, and time to go from the present position along the route

**DESTINATION LINE**

- displays destination identifier, distance to go, and time to go
- entry of a route waypoint results in the information shown based on flying direct to the waypoint and the DEST label changing to ENROUTE WPT
- entry of a waypoint not in the route results in direct to the waypoint information and a DIR TO ALTERNATE label

**DESIRED TRACK**

- displays desired track angle relative to the selected heading reference (M-magnetic, T-true)

**CROSS TRACK ERROR**

- displays current crosstrack error

**IRS**

- displays current latitude/longitude
- header shows the specific source

**TRACK**

- displays current track angle relative to the selected reference

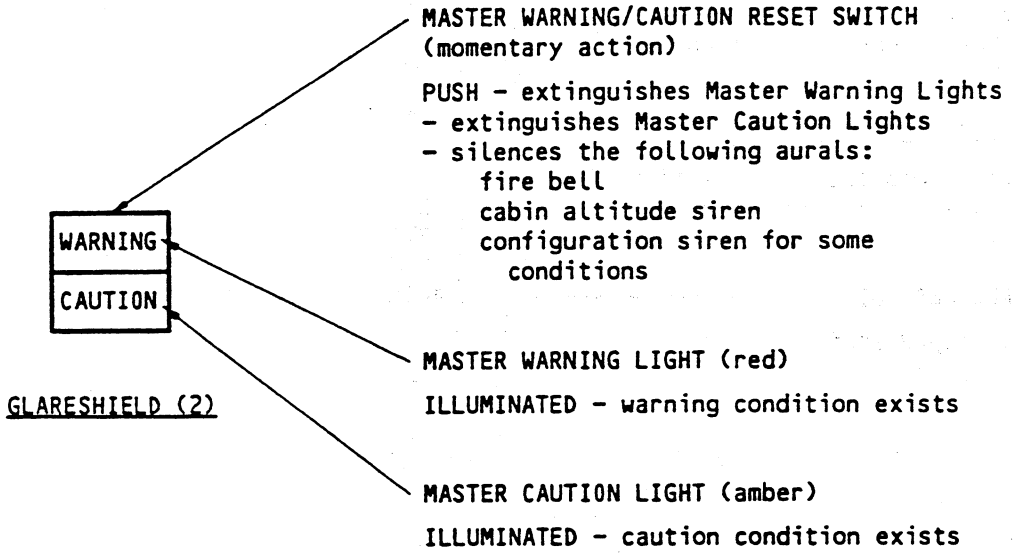
**GROUNDSPEED**

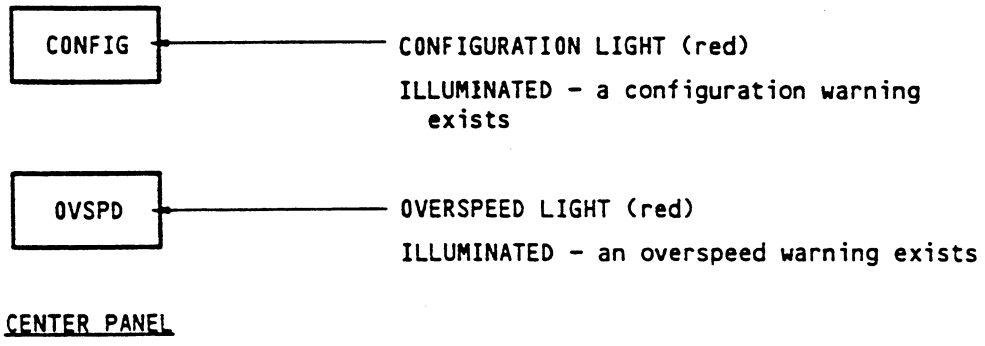
- displays current groundspeed

IRS PROGRESS

# CHAPTER 22

## WARNING SYSTEMS



WARNING MESSAGES (red)
- conditions that require prompt corrective action

CAUTION MESSAGES (amber)
- conditions that require timely corrective action

ADVISORY MESSAGES (amber)
- conditions that require time available corrective action

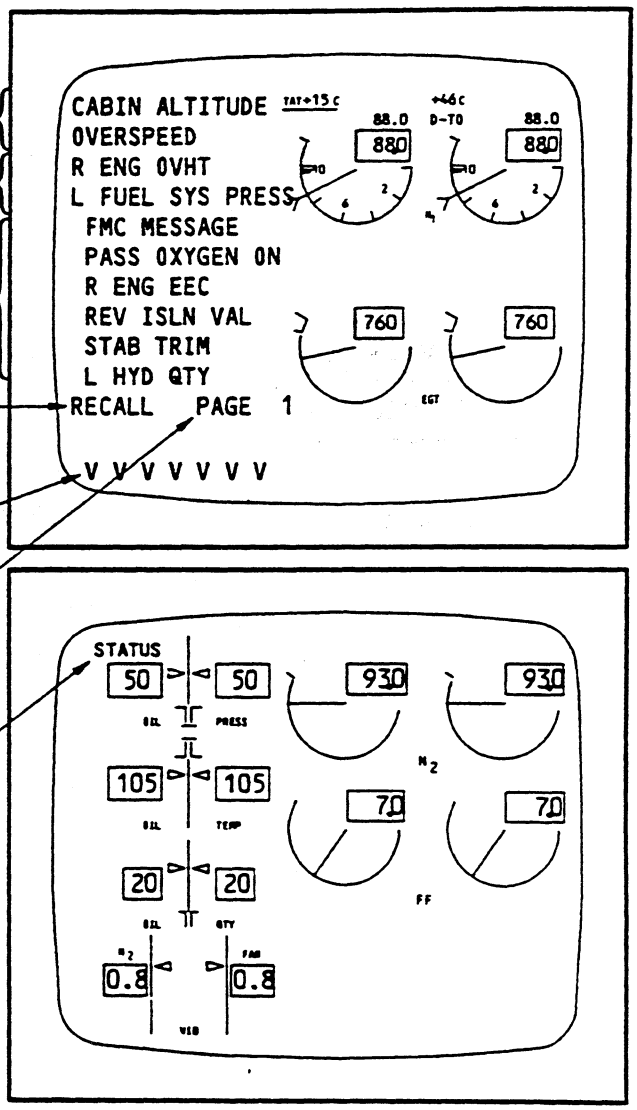
RECALL MESSAGE (white)
- displayed when recall switch is pushed

ENGINE SECONDARY DATA CUE
IN VIEW - secondary engine data should be displayed on lower CRT

PAGE NUMBER (white)
IN VIEW - more than one page of alert messages exists
- indicates number of page selected

STATUS CUE (cyan)
IN VIEW - a new status condition exists

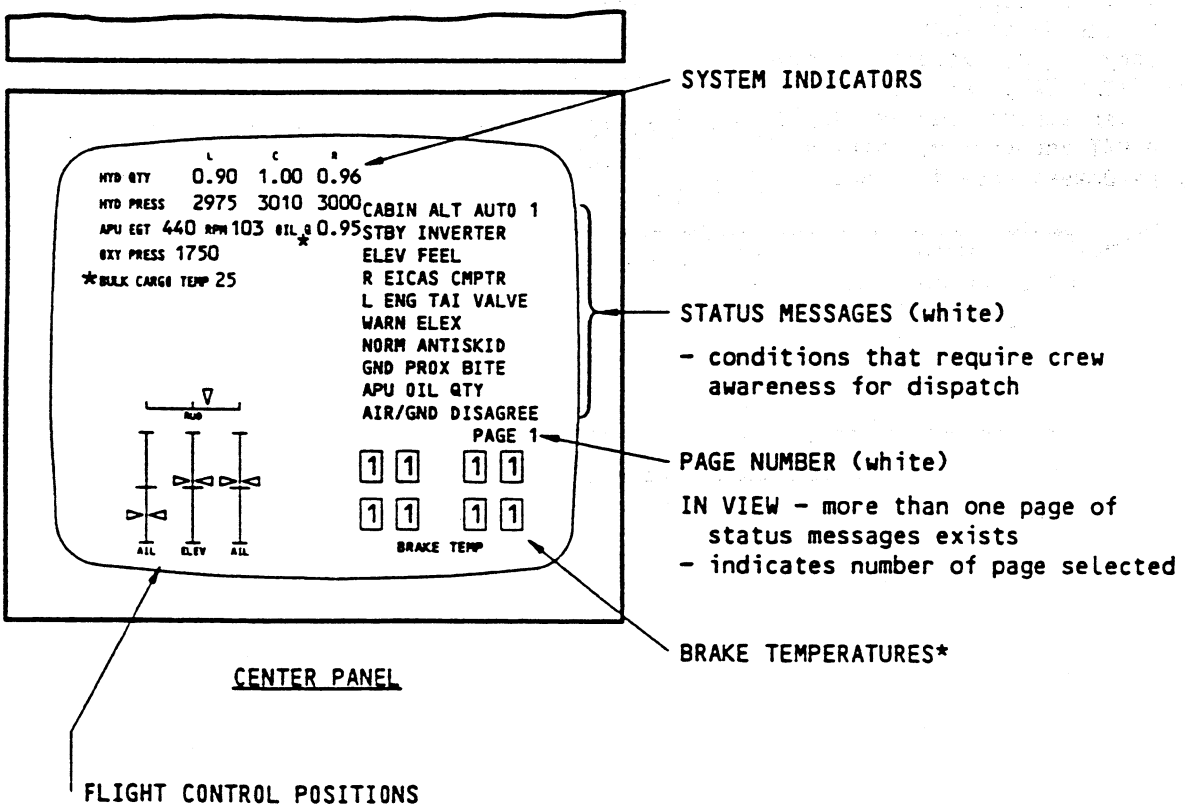
EICAS FULL UP ENGINE MODE
WITH TYPICAL ALERT MESSAGES




CENTER PANEL

CREW ALERTING MESSAGE DISPLAY

EICAS STATUS DISPLAY WITH
TYPICAL STATUS MESSAGES




* As installed

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EICAS STATUS DISPLAY

STATUS DISPLAY SWITCH
(momentary action)

PUSH - if status mode is not displayed, status mode appears on lower EICAS CRT
- if status mode is displayed and additional status page exists, the next status page appears
- if status mode is displayed and no additional status page exists, the status mode disappears
- secondary engine exceedances move to upper EICAS CRT, partial compacted mode, when status mode is displayed
- if one CRT inoperative, status display unavailable inflight

COMPUTER SELECTOR

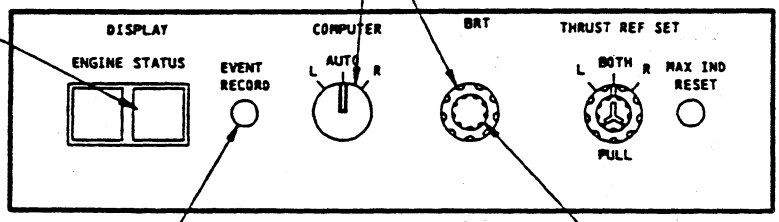
L - left EICAS computer controls displays

AUTO - EICAS control automatically transfers to the right EICAS computer if the left computer fails

R - right EICAS computer controls displays
- allows manual override of automatic selection to improve quality of display

OUTER CONTROL

ROTATE - adjusts brightness of the lower display



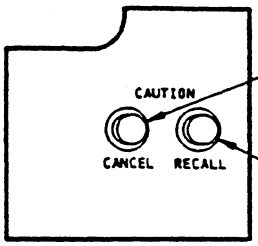

FORWARD ELECTRONICS PANEL

EVENT RECORD SWITCH
(momentary action)

PUSH - records EICAS information for use by maintenance

INNER CONTROL

ROTATE - adjusts brightness of the upper display




CENTER PANEL

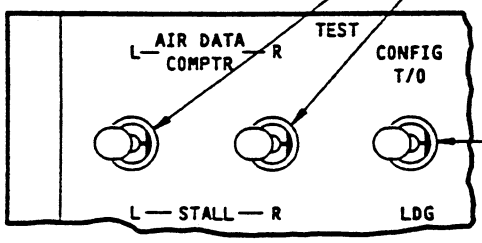
CANCEL SWITCH
(momentary action)

PUSH - removes currently displayed caution and advisory messages and page number from view
- displays next page, if any, of alert messages

RECALL SWITCH
(momentary action)

PUSH - redisplays the first page of cancelled caution and advisory messages if the associated faults still exist

EICAS CONTROLS




STALL TEST SWITCH
(spring loaded to neutral position)

L - vibrates left control column

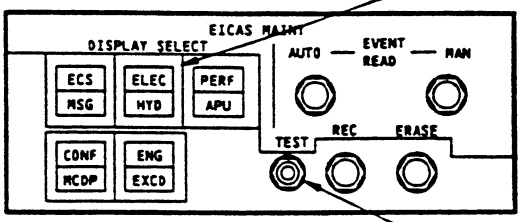
R - vibrates right control column

BOTH L and R - vibrates both control columns
- activates control column nudger

CONFIGURATION TEST SWITCH
(spring loaded to neutral position)

T/O - activates configuration warning if improper takeoff configuration exists

LDG - activates a landing configuration warning




ACCESSORY PANEL

DISPLAY SELECT SWITCHES

- control maintenance displays

EICAS TEST SWITCH
(alternate action)

ON - activates configuration warning
- sounds beeper
- illuminates Master Caution Lights
- displays test pattern on both EICAS displays and any fault messages

OFF - displays full up engine mode after test

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TEST SWITCHES

NOTE: EICAS Maint Module only active when airplane is on the ground.

ENVIRONMENTAL CONTROL SYSTEM/ MESSAGES SWITCH

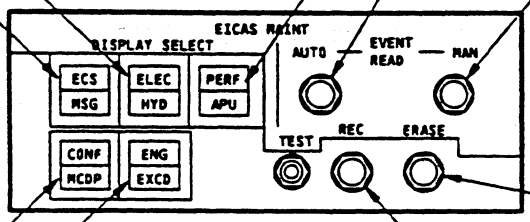
PUSH - displays environmental control systems data on the left and maintenance message list on the right of Lower CRT

PUSH - returns to full engine display

ELECTRICAL/HYDRAULICS SWITCH

PUSH - displays electrical on the top and hydraulic systems information on the bottom of Lower CRT

PUSH - returns to full engine display




ACCESSORY PANEL

ENGINE EXCEEDANCE SWITCH

PUSH - displays recorded engine exceedance information
- if no exceedance exists, display is blank

PUSH - returns to full engine display

CONFIGURATION/MAINTENANCE CONTROL DISPLAY PANEL SWITCH

PUSH - displays configuration of the EICAS and associated equipment and provides remote readout for the Maintenance Control/Display Panel on the lower CRT

PUSH - returns to full engine display

PERFORMANCE/AUXILIARY POWER UNIT SWITCH

PUSH - displays engine performance on the top and APU information on the bottom of Lower CRT

PUSH - returns to full engine display

READ AUTO SWITCH

- active when ECS/MSG, ELEC/HYD or PERF/APU selected

PUSH - displays auto event data stored in memory

PUSH - returns to normal (real time) data

READ MANUAL SWITCH

- active when ECS/MSG, ELEC/HYD or PERF/APU selected

PUSH - displays manual event data stored in memory

PUSH - returns to normal (real time) data

EVENT ERASE SWITCH

- active when ECS/MSG, ELEC/HYD or PERF/APU selected and READ AUTO or READ MANUAL selected

PUSH - erases displayed maintenance data

EVENT RECORD SWITCH

- active when ECS/MSG, ELEC/HYD or PERF/APU selected

PUSH - records displayed data in memory

MAINTENANCE SWITCHES

## SYSTEM DESCRIPTION

### GENERAL

The Engine Indication and Crew Alerting System (EICAS) primarily displays engine indications and provides a centrally located crew alerting system for non-normal situations. EICAS also shows dispatch related system status not otherwise displayed in the cockpit. Finally, on the ground, EICAS provides a variety of system maintenance data.

Two EICAS computers receive inputs from engine and system sensors and continually monitor each other. The computers display information from the sensors on two Cathode Ray Tubes (CRTs).

A Computer Selector determines which computer controls EICAS CRTs. When the selector is in the AUTO position the left computer is used. If the left computer fails, control switches to the right computer. When the L position is selected only the left computer can control the CRTs. When the selector is in the R position only the right computer can control the CRTs. This can be used to correct display faults not automatically detected by the system.

The brightness controls are used to adjust the brightness level of the CRTs. To change the upper display only, the outer control must be held, as the knobs are clutched.

The pilots' EVENT RECORD switch will cause engine parameters and other EICAS information available on maintenance pages, even when not displayed, to be recorded simultaneously for maintenance analysis. Only the last event recorded will be retained.

System lights and a Standby Engine Indicator (SEI) provide backup indication for the CRT displays.

### ENGINE INDICATION

Information concerning the engine indication portion of EICAS appears in the Power Plant chapter.

### CREW ALERTING

The crew alerting portion of EICAS continually monitors all aircraft systems. If a fault occurs or any system fault light illuminates in the cockpit, EICAS displays a crew alerting message on the upper CRT. In addition to the display messages, some crew alerts are also indicated by aural tones and Master Warning/Caution Lights.

All crew alerting messages are divided into one of three categories; warnings, cautions or advisories.

Warnings indicate operational or aircraft system conditions that require prompt corrective action. They are the most urgent type of crew alert. An engine fire is a typical warning.

Cautions indicate operational or aircraft system conditions that require timely corrective action. They are less urgent than warnings. An engine overheat is a typical caution.

Advisories indicate operational or aircraft system conditions that require corrective action on a time available basis. Advisories are the least urgent type of crew alert. A yaw damper fault is a typical advisory.

Aurals

Various aurals call attention to warnings and cautions.

There are three or four* types of warning aurals; a bell, a voice, a siren and a wailer*.

The bell indicates fire warnings. A description of the fire bell and methods for silencing it appear in the Fire Protection chapter.

Ground proximity warnings are indicated by a voice. This aural is described in the Ground Proximity Warning System section of this chapter.

Traffic Alert and Collision Avoidance System (TCAS) voice messages are described in the TCAS section of this chapter.

The siren indicates cabin altitude, autopilot disconnect*, configuration and overspeed warnings. The siren consists of alternating high and low tones. Methods for silencing the siren appear in the Air Conditioning and Pressurization chapter, the Automatic Flight chapter and the Configuration Warning and Overspeed Warning sections of this chapter.

The wailer* indicates autopilot disconnect, and methods for silencing are described in the Autopilot chapter.

There are two types of caution aurals; a voice and a beeper.

Ground proximity cautions are indicated by a voice. Voice aurals are described in the Ground Proximity Warning System section of this chapter.

The beeper sounds for all other cautions. The beeper consists of a tone that sounds four times in less than a second. The beeper automatically silences after the four beeps.

All aurals automatically silence when the associated non-normal condition no longer exists.

Master Warning/Caution Lights

Two Master Warning Lights illuminate when any warning occurs. The lights remain on as long as the warning exists. However, pushing either Master Warning/Caution Reset Switch extinguishes both Master Warning Lights for the duration of that warning and resets the lights for future warnings.

Pushing the reset switch silences the fire bell and the cabin altitude siren. Further information appears in the Fire Protection and the Air Conditioning and Pressurization chapters.

Pushing the reset switch may also silence the landing configuration siren, depending on the reason for activation. This is discussed in the Configuration Warning section of this chapter.

Two Master Caution Lights illuminate when any caution occurs. The lights remain on as long as the caution exists. However, pushing either Master Warning/Caution Reset Switch extinguishes both Master Caution Lights for the duration of that caution and resets the lights for future cautions.

Display Messages

Crew alerting messages appear on the upper CRT to indicate all non-normal conditions detected by EICAS. Messages are arranged by their urgency and order of occurence.

If the upper CRT fails, the messages automatically appear on the lower CRT.

*As installed

Display Messages (Cont)

Warnings are indicated by red messages at the top of the message list. Cautions apear as amber messages below the lowest warning. Advisories are also indicated by amber messages, but are indented one space so they can be distinguished from cautions. Advisories appear below the lowest caution.

The most recent warning, caution and advisory message appears at the top of it's respective group of messages.

A message is automatically removed from the display when the associated condition no longer exists. In this case, messages which appeared below the deleted message, each move up one line.

When a new fault occurs, its associated message is inserted on the appropriate line of the display. This may cause older messages to move down one line. For example, a new caution message would cause all existing caution and advisory messages to move down a line.

If there are more messages than can be displayed at one time, the lowest message is removed and a white page number appears on the lower right side of the message list. Messages bumped from the bottom of one page appear on the next page.

The Cancel and Recall Switches are used to manipulate the message lists. Pushing the Cancel Switch removes the caution and advisory messages from the display. Warning messages cannot be cancelled. If there is an additional page of messages, pushing the Cancel Switch displays the next page. Warning messages are carried over from the previous page. When the last page of messages is displayed, pushing the switch once more removes the last caution and advisory messages and the page number.

Pushing the Recall Switch displays the caution and advisory messages that were removed with the Cancel Switch, if the associated faults still exist. If there is more than one page of messages, page one is displayed. A white RECALL message appears for about one second on the lower left side of the message list to indicate the Recall Switch was pushed.

New display messages appear on the page being viewed. For example, if page three is selected and a new caution occurs, the caution message appears on page three below any warning messages. If the Recall Switch is subsequently pushed, the new caution message appears as the top caution message on page one.

Inhibits

Portions of the crew alerting system are inhibited or deactivated to prevent distractions during certain phases of flight.

The fire bell and the Master Warning Lights are inhibited, for fire warnings only, during a portion of the takeoff. The inhibit begins at nose gear strut extension and ends at either 20 seconds elapsed time or the first penetration of 400 feet radio altitude, whichever occurs first. If a fire exists when the inhibit is removed, both Master Warning Lights and the bell activate.

Inhibits (Cont)

The beeper and the Master Caution Lights are inhibited, for all cautions, during a portion of the takeoff. The inhibit begins at an airspeed of 80 knots and ends at either 20 seconds elapsed time since nose gear strut extension or the first penetration of 400 feet radio altitude, whichever occurs first. If a takeoff abort is initiated above 80 knots, the inhibit lasts until the airplane is slowed down to below 75 knots airspeed. If a caution exists when the inhibit is removed, both Master Caution Lights and the beeper activate.

When an engine is shutdown, a L or R ENG SHUTDOWN caution message appears and the following advisory messages are inhibited:

L or R ENG ANTI-ICE
L or R ENG BLEED OFF
L or R ENG EEC
L or R ENG OIL PRESS
L or R GEN DRIVE
L or R GEN OFF
L or R HYD PRIM PUMP

When the airplane is on the ground and both Fuel Control Switches are in CUTOFF, the beeper and the Master Caution Lights are deactivated for all cautions. The beeper and Master Caution Lights do not activate for cautions that exist when the inhibit is removed. Once the caution is corrected, the crew alerting system is reset. For example, if a hydraulic system is depressurized when the engines are off and an engine is then started, the beeper and Master Caution Lights do not activate. Once the hydraulic system is pressurized, the crew alerting system is reset. If the hydraulic system is subsequently depressurized, the beeper and Master Caution Lights activate.

During engine start new caution and advisory messages except L, R ENG SHUTDOWN and STARTER CUTOUT are inhibited until the engine reaches idle RPM. If a start valve does not open, the inhibit is cancelled and the L, R ENG STARTER message is displayed.

Multiple display messages of a similar nature are sometimes replaced by a single, more general display message. For example, if only the forward or aft entry door is open on the left side, a L FWD ENT DOOR or L AFT ENT DOOR message appears. If both doors are open, only a L ENTRY DOORS message appears.

Some display messages are also inhibited for a brief time period even though system lights are illuminated. This inhibit prevents normal in transit indications from appearing on the display. For example, the GEAR Light illuminates as soon as landing gear retraction begins. However, the associated GEAR DISAGREE display message is inhibited for 25 seconds, allowing sufficient time for normal landing gear retraction to occur.

STATUS

The EICAS status page displays and messages are used in conjunction with the alert messages and discrete lights to determine the airplane's condition for dispatch.

Status messages indicate equipment faults that affect airplane dispatch and are not necessarily identified by either an alert message or discrete light.

All alert and status messages are listed in the Dispatch Deviation Guide or airline equivalent and provide a cross reference to the MEL (Minimum Equipment List) for possible dispatch relief.

When the Status Switch is pushed, the status display appears on the lower CRT. System indicators appear in the top left corner of the display. These indications are described in the systems chapters.

Flight control positions for the rudder, ailerons and elevators appear in the bottom left corner of the status display. These indicators are described in the Flight Controls chapter.

White, status messages appear on the right side of the status display. These messages indicate equipment faults that require awareness at dispatch and that are not otherwise shown in the cockpit.

Status messages are arranged by order of occurrence. The most recent status message appears at the top of the list.

A message is automatically removed from the display when its associated condition no longer exists. Messages, which appear below the deleted message, each move up one line.

When a new status condition occurs, its associated message is inserted at the top of the list and all other messages move down one line.

If there are more messages than can be displayed at one time, the lowest message is removed and a white page number appears on the lower right side of the message list. Message bumped from the bottom on one page appear on the next page.

If there is an additional page of status messages, pushing the Status Switch displays the next page. When the last page of messages is displayed, pushing the switch again removes the status display from the lower CRT and blanks the screen.

New status messages appear at the top of the page being viewed. If the status display is deselected and subsequently reselected the message list is reordered, with the newest status message now appearing at the top of the first page.

A Status Cue appears in the upper left corner of the lower CRT if a new status message occurs and the status display is not currently selected. The cue disappears when the status page is displayed. Status messages do not need to be checked in flight, however, they can be useful in anticipating possible ground maintenance actions.

Brake temperature indications appear on the lower right side of the status display. These indications are described in the Landing Gear chapter.

MAINTENANCE

The maintenance portion of EICAS is used to monitor, record and retrieve maintenance information associated with systems and engine performance.

The EICAS MAINT Control panel can only be used on the ground. It provides a means of monitoring additional real time parameters for maintenance information and can also be used to retrieve recorded displays of systems information, engine performance data and engine exceedances stored in the EICAS computer memory due to an AUTO or MAN Event. This information is used by maintenance for trend analysis and troubleshooting airplane systems. Retrieval of this information is inhibited during all flight operations.

The DISPLAY SELECT switches are used to display ECS/MSG (Environmental Control Systems/Maintenance Messages), ELEC/HYD (Electrical/Hydraulic), PERF/APU (Performance/Auxiliary Power Unit), CONF/MCDP (Configuration/Maintenance Control Display Panel) and ENG EXCD (Engine Exceedances) pages.

The AUTO and MAN EVENT READ switches select data from the Auto or Manual Event computer memory for display when a DISPLAY SELECT switch is pushed.

The REC switch records displayed data in the Manual Event memory for later retrieval.

The ERASE switch erases displayed data stored in the EICAS memory.

The TEST switch initiates an EICAS self test when the parking brake is set. The system remains in self test until the switch is reset.

AUTO EVENTS are instantaneously recorded when system or engine limits are exceeded and are restricted to one event per page for systems and 2 events for engines. However, when a red band exceedance occurs after an amber band exceedance has been recorded, the first auto event is automatically replaced by the higher priority second auto event. The auto event must be cleared before a second auto event of the same level can be recorded for that system.

MANUAL EVENTS may be recorded by pressing the pilot's EVENT RECORD switch. A subsequent manual event can be recorded for that system by pressing the switch again. Only the last manual event recorded will be retained for future retrieval.

Maintenance displays can only be displayed on the ground.

The maintenance displays appear on the lower CRT when the Display Select Switches are pushed. Pushing the Display Select Switch again or the Engine Switch cancels the maintenance mode and returns the EICAS displays to the engine indicating mode. The maintenance mode is also cancelled by pushing the Status Switch, returning the lower CRT to the status mode of operation.

A test of EICAS is initiated with the EICAS Test Switch. The test can only be displayed on the ground with the parking brake set. When the test switch is pushed, a beeper sounds, the Master Caution Lights illuminate, test patterns appear on both CRTs and the Standby Engine Indicator comes on. A configuration warning also occurs if the airplane is not properly configured for takeoff. A TEST IN PROGRESS message appears during the test and disappears when the test is complete. A TEST OK message then appears if the test is passed. A TEST FAIL message appears if faults are detected. Pushing the test switch once more cancels the test and returns the displays to the engine indicating mode.

NON-NORMAL INDICATIONS

If a fault is detected in one of the CRTs, the faulty display is blanked. Engine indications and crew alerting messages appear on the operable display. An EICAS DISPLAY advisory message displays when one of the CRT fails.

To ensure that all engine indications can be displayed with a CRT failure, an EICAS compacted display mode is available. The compacted display mode is described in the Power Plant chapter.

When a CRT fails, status can only be displayed on the ground.

If the EICAS Control Panel fails an EICAS CONT PNL advisory message displays and the EICAS full up engine mode automatically displays. The full up engine mode is described in the Power Plant chapter. The Cancel and Recall Switches will not operate when the EICAS Control Panel fails, however, BRT and COMPUTER select controls remain operative.

If both EICAS computers or CRTs fail, a Standby Engine Indicator (SEI) is automatically activated. The SEI, system lights and system indicators are used to monitor the engines and system operation when a total EICAS failure occurs.

TAKEOFF CONFIGURATION WARNING

Takeoff configuration warning is armed when the airplane is on the ground and either engine is accelerated towards takeoff thrust. The takeoff warning is given for any of the following conditions:

- leading edge slats not in takeoff position
- trailing edge flaps not in takeoff position
- slat/flap position disagrees with flap lever position
- stabilizer position outside of takeoff range
- spoiler lever not in DOWN detent position
- parking brake valve closed

The takeoff configuration warning consists of:

- illumination of the Master Warning Lights
- illumination of the Configuration Warning Light
- activation of the aural warning siren
- four possible warning messages
  "FLAPS"
  "SPOILERS"
  "STABILIZER"
  "PARKING BRAKE"

The Master Warning light and aural cease immediately and the messages are cancelled shortly after the configuration error is corrected.

Holding the Configuration Test Switch in the T/O (Takeoff) position simulates accelerating an engine to takeoff power. No warnings occur when testing an airplane properly configured for takeoff. If the airplane is not configured for takeoff a configuration warning results. Releasing the test switch cancels the test.

## LANDING CONFIGURATION WARNING

Landing configuration warning is armed when the airplane is in the air and any landing gear is not down and locked. The warning is given for any of the following conditions:

1) Airplane at or below 800 feet radio altitude and either thrust lever set to idle thrust

2) landing flaps selected

NOTE: The Landing Configuration warning is given for condition 1 at any altitude if the Left Radio Altimeter has failed.

The landing configuration warning consists of:

- illumination of the Master Warning Lights
- illumination of the Configuration Warning Light
- activation of the aural warning siren
- a GEAR NOT DOWN warning message

All warning indications are cancelled when the configuration error is corrected. The aural warning associated with condition (1) is also silenced by pushing the Master Warning/Caution Reset Switch.

Pushing the Ground Proximity/Configuration Gear Override Switch inhibits the warning aurals for both condition (1) and (2).

Holding the Configuration Test Switch in the LDG (Landing) position results in a configuration warning regardless of landing gear position. All warning indications disappear when the switch is released.

## STALL WARNING

Warning of an impending stall is provided by two independent stall warning systems. Both systems are energized in flight and deactivated on the ground through air/ground logic.

The warning is given by vibrating both control columns. If the flaps are in the retracted position and the angle of attack continues to increase, a control column nudger moves the column forward.

Holding the Stall Warning Test Switches in either the L or R position checks the left and right stall warning systems, respectively. If the systems are tested at the same time, both columns vibrate and the control column nudger activates.

## OVERSPEED WARNING

An overspeed warning occurs whenever the Vmo/Mmo limits are exceeded.

The overspeed warning consists of:

- illumination of the Master Warning Lights
- illumination of the Overspeed Light
- activation of the aural warning siren
- an OVERSPEED warning message

All warning indications remain activated until the speed is reduced below Vmo/Mmo.

## ALERT MESSAGES - ALPHABETICAL

W = Warning C = Caution A = Advisory

| MESSAGE | TYPE | REFERENCE CHAPTER | MESSAGE | TYPE | REFERENCE CHAPTER |
|---|---|---|---|---|---|
| ACCESS DOORS | A | 5 | C DEM HYD OVHT | A | 16 |
| AFT CABIN TEMP | A | 6 | C HYD 1 OVHT | A | 16 |
| AFT CARGO DOOR | A | 5 | C HYD 2 OVHT | A | 16 |
| AFT CARGO FIRE | W | 12 | C HYD DEM PUMP | A | 16 |
| AFT CARGO OVHT | A | 6 | C HYD PRIM 1 | A | 16 |
| AFT FUEL X-FEED | A | 15 | C HYD PRIM 2 | A | 16 |
| AILERON LOCKOUT | A | 13 | C HYD QTY | A | 16 |
| AIR/GND SYS | A | 18 | C HYD SYS PRESS | C | 16 |
| ALTITUDE ALERT | C | 7 | C IRS DC FAIL | A | 19 |
| ANTISKID | A | 18 | C IRS FAULT | A | 19 |
| ANTISKID OFF | A | 18 | C IRS ON DC | A | 19 |
| APU BAT DISCH | A | 10 | C TAIL HYD VAL | A | 13 |
| APU BLEED VAL | A | 20 | C WING HYD VAL | A | 13 |
| APU BTL | A | 12 | CABIN ALTITUDE | W | 6 |
| APU FAULT | A | 8 | CABIN AUTO INOP | C | 6 |
| APU FIRE | W | 12 | CAPT PITOT | A | 17 |
| APU FUEL VAL | A | 8 | CARGO BTL 1 | A | 12 |
| APU GEN OFF | A | 10 | CARGO BTL 2 | A | 12 |
| ATC FAULT | A | 19 | CARGO DOORS | C | 5 |
| ATT DISAGREE | C | 14 | CTR L FUEL PUMP | A | 15 |
| AUTO SPEEDBRAKE | A | 13 | CTR R FUEL PUMP | A | 15 |
| AUTOBRAKES | A | 18 | | | |
| AUTOPILOT | C | 7 | E/E ACCESS DOOR | A | 5 |
| AUTOPILOT DISC | W | 7 | EICAS CONT PNL | A | 22 |
| AUTOTHROT DISC | C | 7 | EICAS DISPLAY | A | 22 |
| | | | EMER DOORS | A | 11 |
| BATTERY OFF | A | 10 | EMER LIGHTS | A | 11 |
| BODY DUCT LEAK | C | 20 | ENG BTL 1 | A | 12 |
| BRAKE SOURCE | A | 18 | ENG BTL 2 | A | 12 |
| BULK CARGO DOOR | A | 5 | ENGINE CONTROLS | A | 21 |
| BULK CARGO OVHT | A | 6 | | | |
| C BLD ISLN VAL | A | 20 | FIRE/OVHT SYS | A | 12 |

NOTE: The EICAS message listing is for reference only. Messages that are annunciated on EICAS are listed alphabetically by type and by reference chapter.

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## ALERT MESSAGES - ALPHABETICAL (CONT)

W = Warning C = Caution A = Advisory

| MESSAGE | TYPE | REFERENCE CHAPTER | MESSAGE | TYPE | REFERENCE CHAPTER |
|---|---|---|---|---|---|
| FLAP LD RELIEF | A | 13 | L DEM HYD OVHT | A | 16 |
| FLAPS | W | 22 | L DRAG BRACE | C | 18 |
| FLT CONT VALS | A | 13 | L EEC OFF | C | 21 |
| FLT DECK TEMP | A | 6 | L EMER DOOR | A | 11 |
| FMC MESSAGE | A | 19 | L ENG ANTI-ICE | A | 17 |
| F/O PITOT | A | 17 | L ENG BLD OVHT | A | 20 |
| FUEL CONFIG | A | 15 | L ENG BLEED OFF | A | 20 |
| FUEL CROSSFEED | A | 15 | L ENG CONTROL | A | 21 |
| FUEL JET NOZ | A | 15 | L ENG EEC | A | 21 |
| FWD ACCESS DOOR | A | 5 | L ENG EEC MODE | A | 21 |
| FWD CABIN TEMP | A | 6 | L ENG FUEL FILT | A | 21 |
| FWD CARGO DOOR | A | 5 | L ENG FUEL VAL | A | 21 |
| FWD CARGO FIRE | W | 12 | L ENG HPSOV | C | 20 |
| FWD CARGO OVHT | A | 6 | L ENG LIM PROT | C | 21 |
| FWD EQPT COOLING | C | 6 | L ENG LOW IDLE | A | 21 |
| FWD EQPT OVHT | A | 6 | L ENG OIL PRESS | C/A* | 21 |
| FWD EQPT SMOKE | A | 6 | L ENG OVHT | C | 12 |
| FWD EQPT VAL | A | 6 | L ENG PRV | C | 20 |
| FWD FUEL X-FEED | A | 15 | L ENG REV LIMTD | A | 21 |
| | | | L ENG RPM LIM | A | 21 |
| GEAR DISAGREE | C | 18 | L ENG SHUTDOWN | C | 22 |
| GEAR DOORS | A | 18 | L ENG STARTER | A | 21 |
| GEAR NOT DOWN | W | 22 | L ENGINE FIRE | W | 12 |
| | | | L ENTRY DOORS | A | 5 |
| IAS/ALT DIFF | A | 14 | L FMC FAIL | A | 19 |
| IDLE DISAGREE | A | 21 | L FUEL JET PUMP | A | 15 |
| INSTR SWITCH | A | 14 | L FUEL SPAR VAL | A | 21 |
| | | | L FUEL SYS PRESS | C | 15 |
| L AC BUS OFF | C | 10 | L FWD ENT DOOR | A | 5 |
| L AFT ENT DOOR | A | 5 | L FWD FUEL PUMP | A | 15 |
| L AFT FUEL PUMP | A | 15 | L FWD WINDOW | A | 17 |
| L AOA PROBE | A | 17 | L GEN DRIVE | A | 10 |
| L AUX PITOT | A | 17 | L GEN OFF | C/A* | 10 |
| L BLD DUCT LEAK | C | 20 | L HYD DEM PUMP | A | 16 |
| L BLD ISLN VAL | A | 20 | L HYD PRIM PUMP | A | 16 |
| L BUS ISOLATED | A | 10 | L HYD QTY | A | 16 |
| | | | | | * As installed |

## ALERT MESSAGES - ALPHABETICAL (CONT)

W = Warning C = Caution A = Advisory

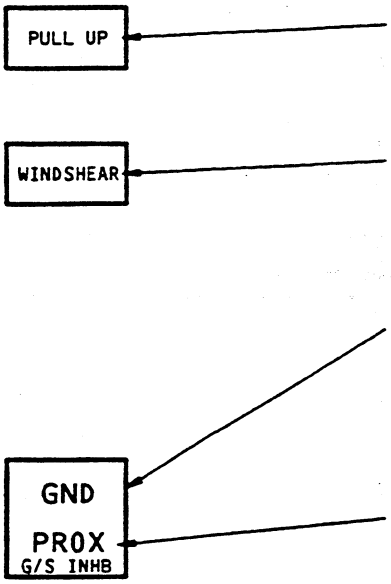
| MESSAGE | TYPE | REFERENCE CHAPTER |
|---|---|---|
| L HYD SYS PRESS | C | 16 |
| L IRS DC FAIL | A | 19 |
| L IRS FAULT | A | 19 |
| L IRS ON DC | A | 19 |
| L JET XFER VALVE | A | 15 |
| L OIL FILTER | A | 21 |
| L PACK OFF | A | 6 |
| L PACK TEMP | A | 6 |
| L PRIM HYD OVHT | A | 16 |
| L RECIR FAN | A | 6 |
| L REV ISLN VAL | A | 21 |
| L SIDE BRACE | C | 18 |
| L SIDE WINDOW | A | 17 |
| L STARTER CUTOUT | C | 21 |
| L STRUT DCT LEAK | C | 21 |
| L TAIL HYD VAL | A | 13 |
| L UTIL BUS OFF | A | 10 |
| L WING ANTI-ICE | A | 17 |
| L WING HYD VAL | A | 13 |
| L WING SLIDE | A | 11 |
| L YAW DAMPER | A | 13 |
| LE SLAT ASYM | C | 13 |
| LE SLAT DISAGREE | C | 13 |
| LOW FUEL | C | 15 |
| MACH/SPD TRIM | A | 13 |
| MAIN BAT DISCH | A | 10 |
| MAIN CARGO DOOR | C | 5 |
| MID CABIN TEMP | A | 6 |
| NOSE A/G SYS | A | 18 |
| OVERSPEED | W | 22 |
| PARKING BRAKE | W | 22 |
| PARKING BRAKE | A | 18 |
| PASS OXYGEN ON | A | 11 |
| PROBE HEAT | A | 17 |
| R AC BUS OFF | C | 10 |
| R AFT ENT DOOR | A | 5 |
| R AFT FUEL PUMP | A | 15 |
| R AOA PROBE | A | 17 |
| R AUX PITOT | A | 17 |
| R BLD DUCT LEAK | C | 20 |
| R BLD ISLN VAL | A | 20 |
| R BUS ISOLATED | A | 10 |
| R DEM HYD OVHT | A | 16 |
| R DRAG BRACE | C | 18 |
| R EEC OFF | C | 21 |
| R EMER DOOR | A | 11 |
| R ENG ANTI-ICE | A | 17 |
| R ENG BLD OVHT | A | 20 |
| R ENG BLEED OFF | A | 20 |
| R ENG CONTROL | A | 21 |
| R ENG EEC | A | 21 |
| R ENG EEC MODE | A | 21 |
| R ENG FUEL VAL | A | 21 |
| R ENG FUEL FILT | A | 21 |
| R ENG HPSOV | C | 20 |
| R ENG LIM PROT | C | 21 |
| R ENG LOW IDLE | A | 21 |
| R ENG OIL PRESS | C/A* | 21 |
| R ENG OVHT | C | 12 |
| R ENG PRV | C | 20 |
| R ENG RPM LIM | A | 21 |
| R ENG REV LIMTD | A | 21 |
| R ENG SHUTDOWN | C | 22 |
| R ENG STARTER | A | 21 |
| R ENG FIRE | W | 12 |

* As installed

## ALERT MESSAGES - ALPHABETICAL (CONT)

W = Warning C = Caution A = Advisory

| MESSAGE | TYPE | REFERENCE CHAPTER | MESSAGE | TYPE | REFERENCE CHAPTER |
|---|---|---|---|---|---|
| R ENTRY DOORS | A | 5 | R WING SLIDE | A | 11 |
| R FMC FAIL | A | 19 | R YAW DAMPER | A | 13 |
| R FUEL JET PUMP | A | 15 | RAT UNLOCKED | A | 16 |
| R FUEL SPAR VAL | A | 21 | RSV BRAKE VAL | A | 18 |
| R FWD FUEL PUMP | A | 15 | RUDDER RATIO | A | 13 |
| R FWD WINDOW | A | 17 | SPEEDBRAKES EXT | C | 13 |
| R GEN DRIVE | A | 10 | SPOILERS | W | 22 |
| R GEN OFF | C/A* | 10 | SPOILERS | A | 13 |
| R HYD DEM PUMP | A | 16 | STAB TRIM | A | 13 |
| R HYD PRIM PUMP | A | 16 | STABILIZER | W | 22 |
| R HYD QTY | A | 16 | STARTER CUTOUT | C | 21 |
| R HYD SYS PRESS | C | 16 | STANDBY BUS OFF | A | 10 |
| R IRS DC FAIL | A | 19 | | | |
| R IRS FAULT | A | 19 | TAILSKID | A | 18 |
| R IRS ON DC | A | 19 | TAT PROBE | A | 17 |
| R JET XFR VALUE | | | TE FLAP ASYM | C | 13 |
| R OIL FILTER | A | 21 | TE FLAP DISAGREE | C | 13 |
| R PACK OFF | A | 6 | TRIM AIR | A | 6 |
| R PACK TEMP | A | 6 | | | |
| R PRIM HYD OVHT | A | 16 | UNSCHD STAB TRIM | C | 13 |
| R RECIR FAN | A | 6 | | | |
| R REV ISLN VAL | A | 21 | WHEEL WELL FIRE | W | 12 |
| R SIDE BRACE | C | 18 | WINDOW HEAT | A | 17 |
| R SIDE WINDOW | A | 17 | | | |
| R STARTER CUTOUT | C | 21 | | | |
| R STRUT DCT LEAK | C | 21 | | | |
| R TAIL HYD VAL | A | 13 | | | |
| R UTIL BUS OFF | A | 10 | | | |
| R WING ANTI-ICE | A | 17 | | | |
| R WING HYD VAL | A | 13 | | | * As installed |




PULL UP LIGHT (red)

ILLUMINATED - a pull up warning exists

WINDSHEAR LIGHT (red)

ILLUMINATED - a windshear condition has been detected

GLIDE SLOPE INHIBIT SWITCH
(momentary action)

PUSH - inhibits below glide slope cautions

GROUND PROXIMITY LIGHT (amber)

ILLUMINATED - a ground proximity caution exists

GROUND PROXIMITY FLAP OVERRIDE SWITCH
(alternate action, guarded)

OVRD - inhibits ground proximity Mode 4-B cautions

GROUND PROXIMITY/CONFIGURATION GEAR OVERRIDE SWITCH
(alternate action, guarded)

OVRD - inhibits ground proximity Mode 4-A cautions
- inhibits landing configuration warning siren

CENTER PANEL

GROUND PROXIMITY TEST SWITCH
(spring loaded to neutral position)

GND PROX - momentary position, prepares system for test

RELEASE - sounds the "GLIDE SLOPE" aural
- illuminates the Ground Proximity Light
- sounds the "PULL UP" aural
- illuminates the Pull Up Light
- sounds the "WINDSHEAR" aural
- illuminates the WINDSHEAR light

ACCESSORY PANEL

SYSTEMS DESCRIPTION

CAUTION: THE GROUND PROXIMITY WARNING SYSTEM MAY NOT BE DEACTIVATED EXCEPT FOR APPROVED PROCEDURES WHERE USE OF FLAPS AT LESS THAN NORMAL LANDING FLAP POSITION OR LANDING GEAR UP IS SPECIFIED.

The ground proximity warning system alerts the flight crew when one of the following thresholds are exceeded between 0 and 2,450 feet radio altitude.

- Mode 1 - Excessive descent rate
- Mode 2 - Excessive terrain closure rate
- Mode 3 - Altitude loss after takeoff or go-around
- Mode 4 - Unsafe terrain clearance while not in the landing configuration
- Mode 5 - Below glide slope deviation
- Windshear Mode - Significant windshear exists

NOTE: The ground proximity warning system will not provide a warning of flight toward vertically sheer terrain or of slow descents into unprepared terrain while in the landing configuration.

Aural warnings for modes 1 and 2 are accompanied by illumination of the Master Warning Lights and the Pull Up Light. The aural warning for the windshear mode is accompanied by illumination of the Windshear light. Aural cautions for modes 1 through 5 are accompanied by illumination of the Ground Proximity Light. The Master Caution Lights do not illuminate for ground proximity cautions.

The ground proximity warning system will adjust the warning and alert envelopes to avoid nuisance warnings or alerts at airports with unique terrain conditions.

In addition to the five alerting modes, the ground proximity system provides voice callouts of radio altitude during approach and landing. Once the altitude has been called out, it will not activate another callout until the airplane climbs through 1000 feet radio altitude.

There are two combinations of voice callouts. Some airplanes have voice callouts at 100, 50, and 30 feet.

Other airplanes have callouts at 200, 100, 50, 40, 30, 20, and 10 feet. These airplanes also have voice callouts of "MINIMUMS, MINIMUMS."

The "MINIMUMS, MINIMUMS," voice alert occurs at the decision height altitude set on either the captain's or first officer's radio altimeter, whichever setting is reached first.

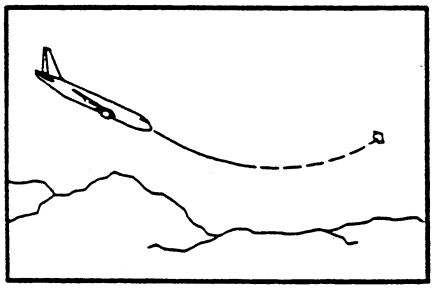
MODE 1 - EXCESSIVE DESCENT RATE

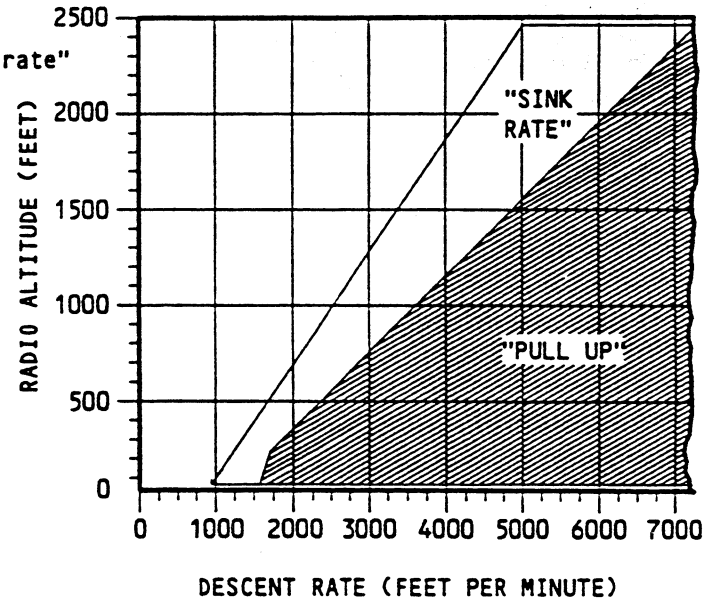
Mode 1 has two boundaries and is independent of airplane configuration. Penetration of the first boundary generates a repeated aural alert of "SINK RATE". Penetrating the second boundary causes the repeated aural warning "WHOOP WHOOP PULL UP".

MODE 1 - EXCESSIVE DESCENT RATE

FLIGHT PATH PROFILE ——————————— EXCESSIVE DESCENT RATE ENVELOPE

Aural warning - "Whoop whoop pull up"
Visual - PULL UP
Aural alert - "Sink rate, sink rate"
Visual - GND PROX G/S INHB



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MODE 2 - EXCESSIVE TERRAIN CLOSURE RATE

Mode 2A provides monitoring when the airplane is not in the landing configuration. Penetrating the envelope causes an aural alert of "TERRAIN" repeated twice, followed by the repeated aural warning "WHOOP WHOOP PULL UP".

After the closure condition no longer exists the repeated "TERRAIN" alert message is heard. An altitude gain requirement function is initiated requiring a barometric altitude gain to stop the alert. If either the landing gear or flaps are extended, the altitude gain function is inhibited unless terrain closure rate continues. If both the landing gear and flaps are extended, the "WHOOP WHOOP PULL UP" aural is replaced by "TERRAIN-TERRAIN".

As airspeed is increased from 220 knots to 310 knots the highest radio altitude at which a Mode 2A warning will occur is increased to 2,450 feet.

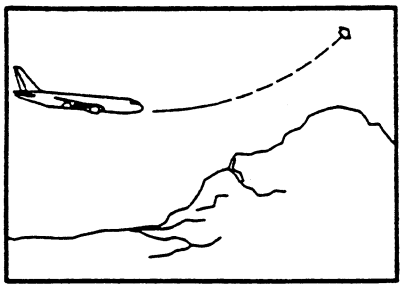
Mode 2B provides monitoring when the flaps are in the landing position. Entering the envelope with the landing gear extended causes the repeating "TERRAIN" aural alert to sound. Entering the envelope with the landing gear not extended causes the aural alert "WHOOP WHOOP PULL UP" to sound.

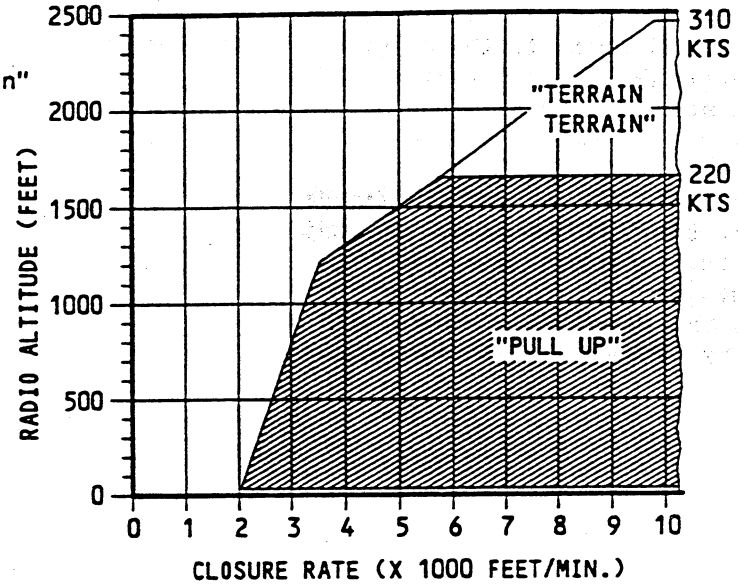
The height of the floor of the Mode 2B envelope will vary between 200 and 600 feet radio altitude based on barometric descent rate. This will provide additional protection against nuisance alerts during approaches where the runway threshold is in close proximity to rising terrain, as in the case of an airport on a plateau.

## MODE 2A - EXCESSIVE TERRAIN CLOSURE RATE WITH FLAPS NOT IN LANDING POSITION

FLIGHT PATH PROFILE ——————— EXCESSIVE TERRAIN CLOSURE RATE ENVELOPE

Aural warning - "Whoop whoop pull up"
Visual - PULL UP
Aural alert - "Terrain, terrain"
Visual - GND PROX G/S INHB

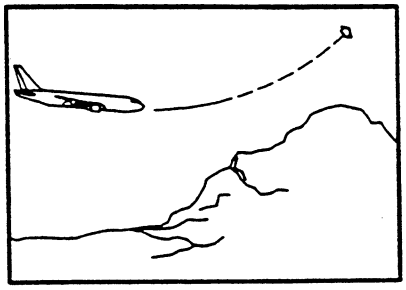


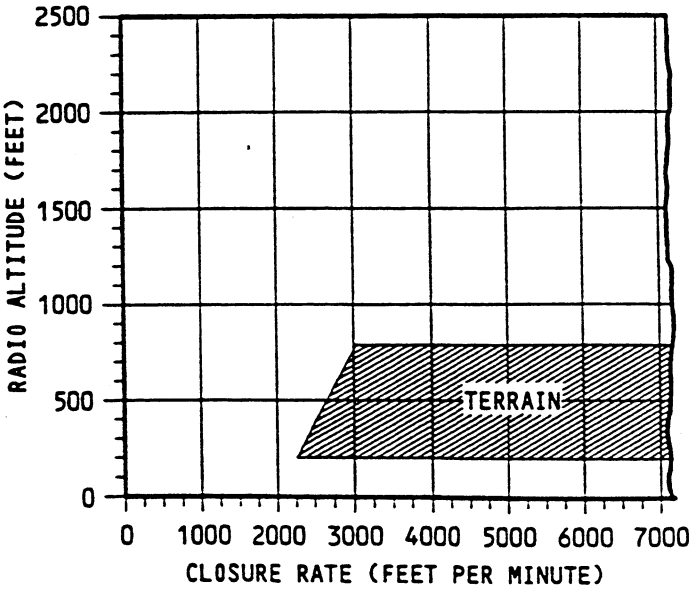



## MODE 2B - EXCESSIVE TERRAIN CLOSURE RATE WITH FLAPS IN LANDING POSITION

FLIGHT PATH PROFILE ——————— EXCESSIVE TERRAIN CLOSURE RATE ENVELOPE

Aural alert - "Terrain, terrain"
Visual - GND PROX G/S INHB



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MODE 3 - ALTITUDE LOSS AFTER TAKEOFF OR GO-AROUND

Mode 3 provides a caution if an altitude decrease occurs during the initial takeoff climb or during a go-around. Entering the caution envelope causes a repeated aural alert of "DON'T SINK". The caution continues until a positive rate of climb is established. If the airplane descends again before climbing to the original descent altitude, another caution is generated based on the original descent altitude.

If the original descent radio altitude is greater than 150 feet, and the radio altitude then decreases approximately 25% of the original descent radio altitude, the "DON'T SINK" aural is replaced by a "TOO LOW TERRAIN" aural.

On approach, in the landing configuration, Mode 3 arms when the airplane descends below 245 feet radio altitude in the landing configuration, then becomes active if either the gear or flaps are retracted.

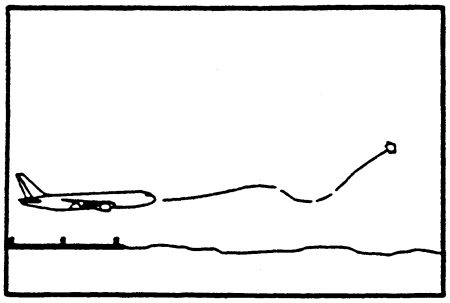
Mode 3 is effective between 30 and 1330 feet radio altitude and generates a caution when the accumulated barometric altitude loss equals approximately 10 percent of the existing radio altitude.

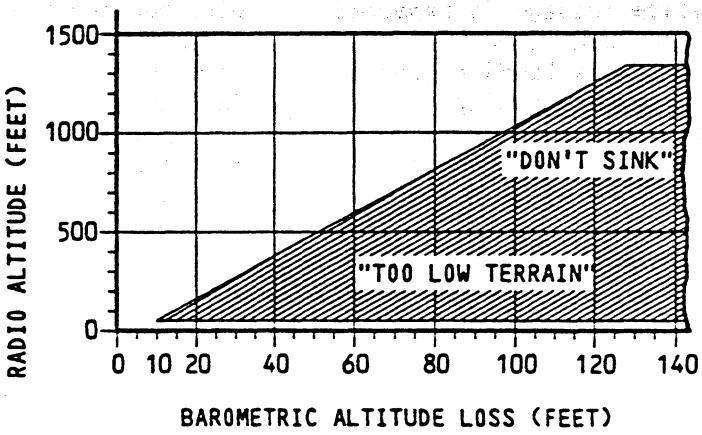
## MODE 3 - ALTITUDE LOSS AFTER TAKEOFF OR GO-AROUND

FLIGHT PATH PROFILE ---------- EXCESSIVE ALTITUDE LOSS AFTER TAKEOFF OR GO-AROUND ENVELOPE

Aural alert - "Don't sink" or "Too low terrain"

Visual - GND PROX G/S INHB



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MODE 4A - UNSAFE TERRAIN CLEARANCE WITH LANDING GEAR NOT DOWN AND FLAPS NOT IN LANDING POSITION

This mode provides a caution when the landing gear is not down and the flaps are not in the landing position. When this envelope is penetrated below 190 knots, the aural alert "TOO LOW GEAR" is repeated. When the envelope is penetrated above 190 knots the aural "TOO LOW TERRAIN" is sounded. Between 190 knots and 250 knots the upper boundary of the envelope is extended to 1000 feet radio altitude. The applicable voice message is repeated until the flight condition is corrected. Once the landing gear or flaps are set to the landing configuration, Mode 4B is armed to replace Mode 4A until landing or go-around.

MODE 4B - UNSAFE TERRAIN CLEARANCE WITH GEAR OR FLAPS NOT IN LANDING POSITION

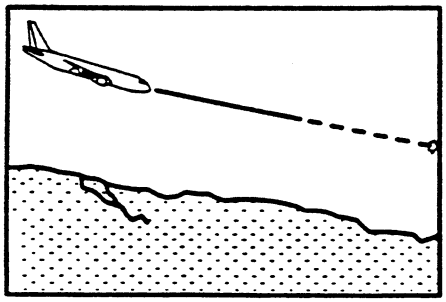
This mode provides a caution when either the landing gear is down and the flaps are not in the landing position, or when the landing gear is not down and the flaps are in the landing position. If the envelope is penetrated below 159 knots the aural alert "TOO LOW FLAP" is repeated. When the envelope is penetrated above 159 knots the aural alert "TOO LOW TERRAIN" is repeated. If the landing gear is not extended, the aural "Too Low Gear" will replace the aural "Too Low Flap". Between 159 knots and 250 knots the upper boundary of the envelope is increased to 1000 feet radio altitude. The applicable voice message is repeated until the flight condition is corrected.

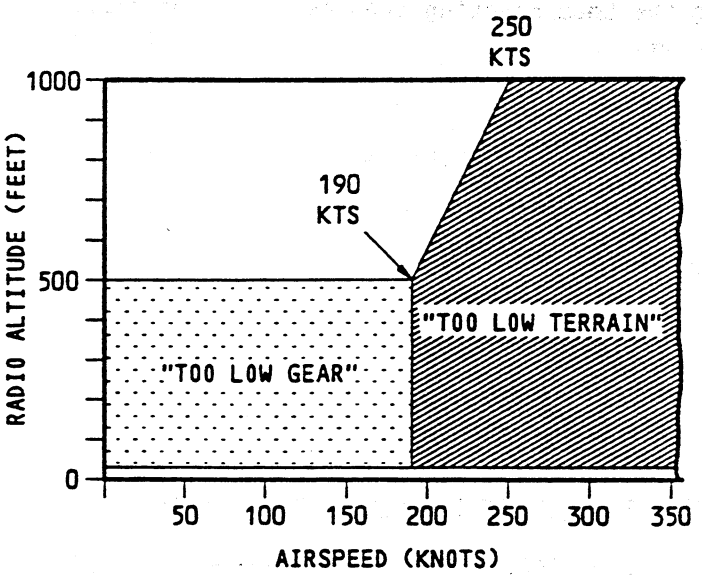
## MODE 4A - UNSAFE TERRAIN CLEARANCE WITH LANDING GEAR NOT DOWN AND FLAPS NOT IN LANDING POSITION

FLIGHT PATH PROFILE ———————— UNSAFE TERRAIN CLEARANCE ENVELOPE

Aural alert - "Too low gear" or "Too low terrain"

Visual - GND PROX G/S INHB



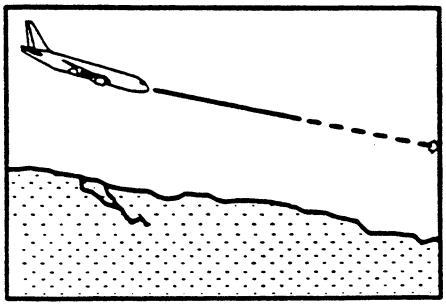


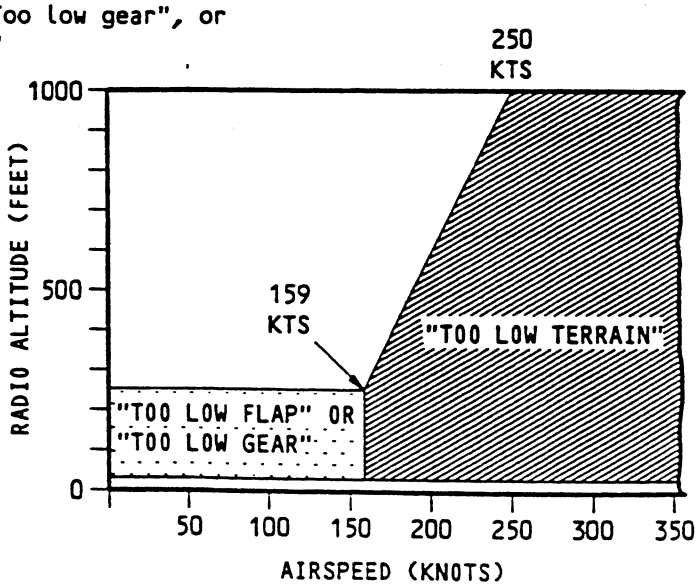

## MODE 4B - UNSAFE TERRAIN CLEARANCE WITH LANDING GEAR DOWN OR FLAPS NOT IN LANDING POSITION

FLIGHT PATH PROFILE ———————— UNSAFE TERRAIN CLEARANCE ENVELOPE

Aural alert - "Too low flap", "Too low gear", or "Too low terrain"

Visual - GND PROX G/S INHB



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## MODE 5 - BELOW GLIDE SLOPE DEVIATION

Mode 5 alerts the flight crew of a descent of more than 1.3 dots below an ILS glide slope. The envelope has two areas of aural alerting, soft and loud. In both areas, the aural alert "GLIDE SLOPE" repetition rate is increased as glide slope deviation increases and radio altitude decreases. The voice message amplitude is increased when entering the loud alerting area as shown below.

The mode is armed when a valid signal is being received by the left glide slope receiver, the radio altitude is 1000 feet or less and the landing gear is down.

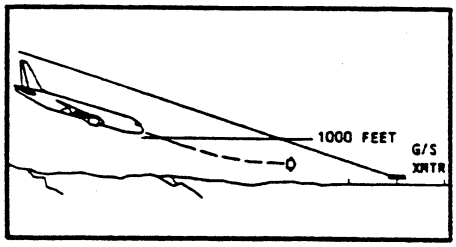
The glide slope alert can be inhibited or cancelled whenever Mode 5 is armed by pushing the Glide Slope Inhibit Switch. The mode rearms when climbing above 1000 feet radio altitude or descending below 30 feet radio altitude.

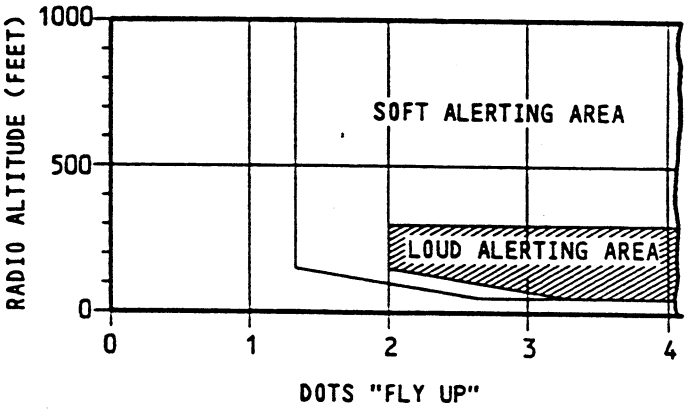
MODE 5 - BELOW GLIDE SLOPE DEVIATION CAUTION

FLIGHT PATH PROFILE ——————————— BELOW GLIDE SLOPE DEVIATION ENVELOPES

Aural alert - "Glide slope"

Visual - GND PROX G/S INHB



WINDSHEAR MODE

The GPWS provides aural and visual warnings of significant windshear conditions. The aural warning consists of a two-tone siren followed by the words "Windshear, Windshear, Windshear". The aural warning is activated only once during a windshear encounter. The visual warning is provided by illumination of the Master Warning and WINDSHEAR lights, and annunciation of the word "WINDSHEAR" in red on the ADI. The WINDSHEAR light and ADI annunciation remain illuminated until the windshear dissipates. The windshear warnings take priority over all other GPWS modes.

Windshear warnings are available only below 1500 feet radio altitude. On takeoff, warnings become available at rotation.

## TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (As Installed)

### GENERAL

The Traffic Alert and Collision Avoidance System (TCAS) alerts the crew to traffic that may present a collision hazard and provides the crew with a vertical avoidance maneuver. TCAS is independent of the ground based ATC system.

TCAS equipment interrogates the transponders of other aircraft in the vicinity to determine their range, bearing and altitude. TCAS generates a Traffic Advisory (TA) when another aircraft is approximately 40 seconds from the point of closest approach. If the other aircraft continues to close, a Resolution Advisory (RA) is generated when the other aircraft is approximately 25 seconds from the point of closest approach. The RA provides a vertical restriction or maneuver to maintain or increase separation from the traffic.

Non-transponder equipped aircraft are invisible to TCAS and no RA is generated for aircraft operating in Mode A only.

### ADVISORIES AND DISPLAYS

Annunciations associated with TCAS are displayed on the ADI and on the HSI Traffic Display. Refer to Chapter 14 for further information.

A Traffic Advisory is indicated by the aural "TRAFFIC, TRAFFIC" which sounds once and is then reset until the next TA occurs. The TRAFFIC message appears on the Traffic Display. The range and relative bearing of the other aircraft are also displayed. If the other aircraft's transponder is operating in Mode C or S, altitude information and vertical motion, if appropriate, are also displayed.

Resolution Advisories are indicated by one or more of the aurals shown in the table on page 22.50.02. The TRAFFIC message and the other aircraft's range, relative bearing and altitude appear on the Traffic Display. An RA pitch restriction or maneuver appears on the ADI.

NOTE: Maneuvering is required if any portion of the airplane symbol is within the red region on the ADI (EFIS display).

An OFFSCALE message appears during a TA or RA if the traffic's position is outside of the selected Traffic Display's range.

A TA or RA message followed by the traffic's range, altitude and (if applicable) vertical motion arrow appear on the Traffic Display if TCAS cannnot determine the other aircraft's bearing.

### TCAS INHIBITS

TCAS alerts are inhibited by GPWS, and windshear warnings, and at low altitudes where the Traffic Avoidance Maneuver would be inappropriate.

If an inhibit occurs during an RA, the RA aural is silenced and the traffic display symbol reverts to a TA symbol. If an inhibit occurs during a TA, only the TA aural is silenced.

### MODE CONTROL

The TCAS operating mode is controlled from the transponder panel. TCAS is normally operated in the TA/RA (TA and RA) mode. However, sometimes it is necessary to operate in the TA only mode to prevent undesired RAs.

TA only mode is used during engine out operation to prevent RAs when adequate thrust is not available to follow the RA commands. Also, TA mode can be used when intentionally operating near other aircraft that may cause RAs, such as during parallel approaches and VFR operations.

| AURAL | MEANING |
|---|---|
| "MONITOR VERTICAL SPEED, MONITOR VERTICAL SPEED" | Avoid certain deviations from current vertical speed. |
| "CLIMB, CLIMB, CLIMB" | Climb at the pitch required. |
| "DESCEND, DESCEND, DESCEND" | Descend at the pitch required. |
| "REDUCE CLIMB, REDUCE CLIMB" | Reduce climb pitch as required. |
| "REDUCE DESCENT, REDUCE DESCENT" | Reduce descend pitch as required. |
| "CLIMB, CROSSING CLIMB, CLIMB, CROSSING CLIMB" | Directs a climb and informs pilot that safe vertical separation will result in climbing through intruders altitude. |
| "DESCEND, CROSSING DESCEND, DESCEND, CROSSING DESCEND" | Directs a descent and informs pilot that safe vertical separation will result in descending through intruders altitude. |
| "INCREASE CLIMB, INCREASE CLIMB" | Increase climb rate after an initial "CLIMB" RA is received. |
| "INCREASE DESCENT, INCREASE DESCENT" | Increase descent rate after an initial "DESCEND" RA is received. |
| "CLIMB - CLIMB NOW" "CLIMB - CLIMB NOW" | Reversal maneuver after an initial "DESCEND" RA is received. |
| "DESCEND - DESCEND NOW" "DESCEND - DESCEND NOW" | Reversal maneuver after an initial "CLIMB" RA is received. |
| "CLEAR OF CONFLICT" | The RA encounter is terminated. |

Resolution Advisory Aurals