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747-400
Operations Manual
Volume 2
Delta Air Lines, Inc.

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Preface

Model Identification

Chapter P2

Section 1

General

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

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

Airplane Number is supplied by the operator. Registry Number is supplied by the national regulatory agency. Serial and Tabulation Numbers are supplied by Boeing.

Ship Number	Registry Number	Serial Number	Tabulation Number
6301	N661US	23719	RT401
6302	N662US	23720	RT402
6303	N663US	23818	RT403
6304	N664US	23819	RT404
6305	N665US	23820	RT405
6306	N666US	23821	RT406
6307	N667US	24222	RT407
6308	N668US	24223	RT408
6309	N669US	24224	RT409
6310	N670US	24225	RT410
6311	N671US	26477	RM241
6312	N672US	30267	RM242
6313	N673US	30268	RM243

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Ship Number	Registry Number	Serial Number	Tabulation Number
6314	N674US	30269	RM244
6315	N675NW	33001	RM245
6316	N676NW	33002	RM246

Preface

Introduction

Chapter P2

Section 2

General

The manufacturer has developed normal and non-normal procedures for the B747-400 aircraft, Delta Air Lines, Inc. has modified some of these procedures for simplification and standardization, when appropriate, with other aircraft operated by Delta Air Lines, Inc. Finally, the FAA has approved the procedures presented in this Operations Manual.

These procedures are intended to be followed during normal ground operations and in flight. Deviation from these procedures should be made only with good cause and based on the safest course of action. The captain's best judgment must be applied if an abnormality occurs that is not covered by these procedures.

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Corrections to the Manual

Log on to the Delta Flight Operations Portal, <http://dlnet.delta.com> and submit a Publications Change Request (PCR) to correct any errors or discrepancies discovered in this manual, or to submit a suggested change to any Aircraft Operating Manual, Volume 1, Volume 2, Quick Reference Handbook (QRH), Flight Crew Training Manual (FCTM), Normal Checklist, Airway Manual (AM), Flight Operations Manual (FOM), Operating Experience (OE/TOE) guide, Fleet Bulletin (FB), or All Pilot Bulletin (APB).

There are links to the PCR form on each fleet page and also on the Flight Ops Manuals/Library Services page. Once submitted, the PCR is automatically routed to the applicable Fleet Technical Manager and Technical Writer for that manual.

Organization

The operations manual is organized in the following manner.

Volume 1

- Preface - Contains general information regarding the manual's purpose, structure, and content. It also contains lists of abbreviations, a record of revisions and a list of effective pages.
- Limitations - Covers operational limitations.
- Normal Procedures - Covers all amplified normal operating procedures and are based on a thorough analysis of crew activity required to operate the aircraft, and reflect the latest knowledge and experience available.
- Normal Operational Information - Contains reference material used to support normal procedures.
- Supplementary Procedures is organized by system and covers:
 - any procedure that is non-routine in nature,
 - any first-flight-of-the-day test or other systems test,
 - guidance on lengthy operating procedures, and
 - adverse weather procedures and guidance.
- Differences - Notes differences between aircraft models and variants.

Volume 2

- Preface - Contains general information regarding the manual's purpose, structure, and content. It also contains lists of abbreviations, a record of revisions and a list of effective pages.
- Contains general aircraft and systems information. These chapters are generally subdivided into sections covering controls and indicators and systems descriptions.

QRH

- Non-normal checklists - Contains checklists used to manage non-normal situations.
- Non-normal Operational Information - Contains reference material used to support non-normal procedures.
- Non-normal Checklist Instructions - Contains non-normal checklist instructions and evacuation flow/philosophy.
- Revision Record - Contains general information regarding the manual's purpose, structure, and content. It also contains lists of abbreviation, a record of revision and a list of effective pages.

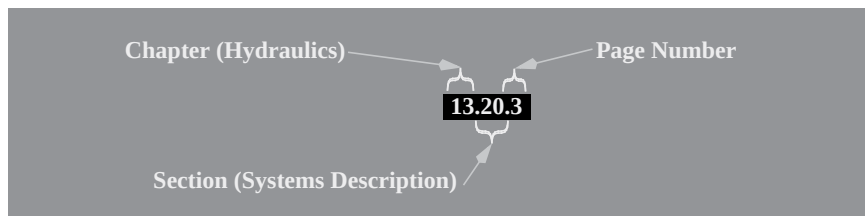
FCTM

- Preface - Contains general information regarding the manual's purpose, structure, and content. It also contains lists of abbreviations, a record of revisions and a list of effective pages.
- Provides information and recommendations on aircraft operations, maneuvers, techniques, and human factors.

Page Numbering

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

Example Page Number



Warnings, Cautions, and Notes

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

Warning - A warning is an instruction about a hazard that if ignored could result in injury, loss of aircraft control, or loss of life. A warning will appear prior to the applicable step or item.

WARNING: Do not pressurize any hydraulic or pneumatic system until clearance is obtained from Maintenance.

Caution - A caution is an instruction concerning a hazard that if ignored could result in damage to equipment. A caution will appear prior to the applicable step or item.

CAUTION: Do not set takeoff thrust until oil temperature is above 50°C.

Note - A note provides amplified information, instruction, or emphasis. A note will appear after the applicable step or item.

Note: The checklist must not be modified in any way.

Airplane Effectivities

Differences in airplane configuration are shown by use of airplane effectivities throughout Volumes 1 and 2, QRH, and the FCTM. The following rules are used to express airplane effectivities:

- Aircraft effectivities are listed by model and/or ship number. A range of aircraft is defined by a dash, e.g. 6301 - 6308. A comma in the effectivity range indicates a break in the range, e.g. 6301 - 6305, 6307-6309; aircraft 6306 is excluded from the range. Aircraft introduced to the fleet following manual publication are effective as subsequent ships, e.g. 6301 & Subsequent.
- Aircraft effectivities apply only to the paragraph, illustration, operational note, procedural step, etc. and to subordinate items (if any). Refer to the examples below.

I

Example (with subordinate items):

9951 – 9961	
CTR TK PUMP (affected).....	OFF
Do not open the WING X FEED valve.	
OUTR TK XFR.....	ON

In this example, the effectivity 9951 - 9961 applies to the first procedural step (CTR TK PUMP.....) and the further indented/subordinate step (Do not...). The effectivity does not apply to the next equivalently indented step (OUTR TK XFR.....).

Example (without subordinate items):

Using ship number:

9951 – 9961	
CTR TK PUMP (affected).....	ON
OUTR TK XFR.....	OFF

In this example, the effectivity 9951 - 9961 applies to the first procedural step (CTR TK PUMP.....) only. The effectivity does not apply to the next procedural step (OUTR TK XFR.....).

Using model number:

767-300	
EQUIPMENT COOLING mode selector.....	AUTO

In this example, the 767-300 will have the selector in the AUTO position.

When airplane effectivities are centered immediately below a checklist title, the entire checklist applies to the listed airplanes. In the following example, the FUEL L + R CTR PUMPS LO PR checklist is applicable to 9951-9961 only:

FUEL L + R CTR PUMPS LO PR
9951-9961

Preface

Abbreviations

Chapter P2

Section 3

General

The following abbreviations may be found throughout the manual. Some abbreviations may also appear in lowercase letters. Abbreviations having very limited use are explained in the chapter where they are used. Since this list is compiled across several fleets, there may be some abbreviations that do not apply

to this specific fleet.

A	
ABV	Above
A/C	Aircraft
AC	Alternating Current or Aircraft
ACARS	Aircraft Communications Addressing and Reporting System
ACE	Actuator Control Electronics
ACP	Audio Control Panel
ACT	Active
ADC	Air Data Computer
ADF	Automatic Direction Finder
ADI	Attitude Director Indicator
ADIRS	Air Data Inertial Reference System
ADIRU	Air Data Inertial Reference Unit
ADM	Air Data Module
ADR	Air Data Reference
AED	Automatic External Defibrillator

AFDC	Autopilot Flight Director Computer
AFDS	Autopilot Flight Director System
AFE	Above Field Elevation
AFM	Airplane Flight Manual (FAA approved)
AFM - DPI	Airplane Flight Manual - Digital Performance Information
AFS	Automatic Flight System (Autopilot or Autothrottle)
A/G	Air/Ground
AGL	Above Ground Level
AH	Alert Height
AHRS	Attitude Heading Reference System
AI	Anti-Ice
AIL	Aileron
ALFA	Safe Stall Margin Speed
ALT	Altitude
ALT ACQ	Altitude Acquire
ALT HOLD	Altitude Hold
ALTN	Alternate
AM	Amplitude Modulation

AIMS	Airplane Information Management System
AMI	Airline Modifiable Information
ANP	Actual Navigational Performance
ANT	Antenna
ANU	Aircraft Nose Up
AOA	Angle of Attack
AOC	Airline Operational Communication Data Link
A/P	Autopilot
APL	Airplane
APP or APPR	Approach
APU	Auxiliary Power Unit
ARINC	Aeronautical Radio, Incorporated
ARM	Aircraft Restrictions Manual
ARPT	Airport
ARR	Arrival
ART	Automatic Reserve Thrust
ASA	Autoland Status Annunciator
ASAP	As Soon As Possible
ASI	Airspeed Indicator
A/SKID	Anti-Skid
ASR	Airport Surveillance Radar
ASYM	Asymmetry
A/T	Autothrottle

ATA	Actual Time of Arrival
ATC	Air Traffic Control
A/THR	Auto Thrust Function
ATIS	Automated Terminal Information Service
ATM	Assumed Temperature Method
ATT	Attitude
AUTO	Automatic
AUTO-THROT	Autothrottle
AUX	Auxiliary
AVAIL	Available
AWABS	Automated Weight and Balance System
AWI	Altitude Warning Indicator
AWY	Airway

B	
BARO	Barometric
BAT	Battery
B/C or B/CRS or BAC or BCS	Back Course
BCL	Battery Charge Limiter
BFO	Beat Frequency Oscillator
BITE	Built-In Test Equipment
BKR	Breaker
BLD	Bleed
BLW	Below

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BMC	Bleed Air Monitoring Computer
BRG	Bearing
BRT	Bright
BSCU	Brake Steering Control Unit
BTC	Bus Tie Contactor
BTL	Bottle
BTL DISCH	Bottle Discharge (fire extinguisher)
BTMS	Brake Temperature Monitoring System

C	
C	Captain or Celsius or Center or Cool
CAA	Civil Aviation Authority
CADC	Central Air Data Computer
CALSEL	Call Select
CANC/RCL	Cancel/Recall
CANPA	Constant Angle Non-Precision Approach
CAP	Capture
CAPT	Captain
CAWS	Central Aural Warning System
CB or C/B	Circuit Breaker
CCD	Cursor Control Device
CDI	Course Deviation Indicator
CDL	Configuration Deviation List

CDS	Common Display System
CDU	Control Display Unit
CDFS	Centralized Fault Display System
CFIT	Controlled Flight Into Terrain
CG	Center of Gravity
CHKL	Checklist
CHR	Chronograph
CIDS	Cabin Intercommunication Data System
CKD	Checked
CKT	Circuit
CL	Close
CLB	Climb
CLMP	Computer Lockout Manual Power
CLR	Clear
CMD	Command
CO	Company
COMM	Communication
COMP	Comparator
COMPT	Compartment
CON	Continuous
CONFIG	Configuration
CONT	Control
COOL	Cooling
CO RTE	Company Route
CRS	Course
CRT	Cathode Ray Tube
CRZ	Cruise

CSM/G	Constant Speed Motor/Generator
CTL	Control
CTR	Center
CVR	Cockpit Voice Recorder
CWS	Control Wheel Steering

D	
DA	Decision Altitude
DA(H)	Decision Altitude (Height)
DC	Direct Current
DCU	Display Concentrator Unit
D/D	Direct Descent
DDA	Derived Decision Altitude (MDA +50 feet)
DDG	Dispatch Deviations Guide
DDRMI	Digital Distance and Radio Magnetic Indicator
DEL	Delete
DEP	Departure
DEP ARR	Departure Arrival
DEPR	Depressurize
DES	Descent
DEST	Destination
DEU	Display Electronic Unit
DFCS	Digital Flight Control System
DFDR	Digital Flight Data Recorder
DFGC	Digital Flight Guidance Computer

DFGS	Digital Flight Guidance System
DH	Decision Height
DIFF	Differential
DIR	Direct
DIR TO	Direct To
DISC	Disconnect
DISCH	Discharge
DIST	Distance
DK	Deck
DMC	Display Management Computer
DME	Distance Measuring Equipment
DN	Down
DPC	Display Processing Computer
DSP	Display Select Panel
DSPL	Display
DTG	Distance to Go
DTW	Distance to Waypoint
DU	Display Unit

E	
EADI	Electronic Attitude Director Indicator
ECB	Electronic Control Box
ECU	Electronic Control Unit
ECON	Economy
E/D	End of Descent
EDP	Engine Driven Pump
E/E	Electrical/Electronic

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EEC	Electronic Engine Control
EFI	Electronic Flight Instruments
EFIS	Electronic Flight Instrument System
EFOB	Estimated Fuel on Board
EGPWS	Enhanced Ground Proximity Warning System
EGT	Exhaust Gas Temperature
EHSI	Electronic Horizontal Situation Indicator
EICAS	Engine Indication and Crew Alerting System
EIS	Electronic Instrument System
EIU	Engine Interface Unit
ELAC	Elevator Aileron Computer
ELEC	Electrical
ELEV	Elevator
EMER	Emergency
EMER GEN	Emergency Generator
ENG	Engine
ENG OUT	Engine Out
ENT	Entry
EO or E/O	Engine Out
EOAP	Electronic Overhead Annunciation Panel
EPR	Engine Pressure Ratio
EQPT or EQUIP	Equipment
ER	Extended Range

ETOPS	Extended Range Operation with Twin Engine Airplanes
EVAC	Evacuation
EVMU	Engine Vibration Monitoring Unit
E/WD	Engine/Warning Display
EXEC	Execute
EXT	Extend or External

F	
F	Fahrenheit
FAC	Final Approach Course
FAA	Federal Aviation Administration
FADEC	Full Authority Digital Engine Control
FAF	Final Approach Fix
FAR	Federal Aviation Regulation
FCB	Flight Crew Bulletin
FCC	Flight Control Computer
FCTL	Flight Control
FCTM	Flight Crew Training Manual
FCU	Flight Control Unit
FD, F/D or FLT DIR	Flight Director
FF	Fuel Flow
FFM	Force Fight Monitor
FGCP	Flight Guidance Control Panel
FGS	Flight Guidance System
FILT	Filter

FIR	Flight Information Region
FL	Flight Level
FL CH or FLCH	Flight Level Change
FLT	Flight
FLT CTRL or F/CTL	Flight Control
FLPRN	Flaperon
FMA	Flight Mode Annunciator
FMC	Flight Management Computer
FMCG	Flight Management Guidance Envelope Computer
FMS	Flight Management System
FOB	Fuel On Board
F/O or F O	First Officer
FOM	Flight Operations Manual
FPA	Flight Path Angle
F-PLN	Flight Plan
FPM	Feet Per Minute
FPV	Flight Path Vector
FREQ	Frequency
F/S	Fast/Slow
FT	Feet
FWD	Forward
FWC	Flight Warning Computer
FWSOV	Fire Wall Shut Off Valve
FX	Fix

G	
GA	Go-Around
GCU	Generator Control Unit
GE	General Electric
GEN	Generator
GLC	Generator Line Contractor
GLS	GPS Landing System
GMT	Greenwich Mean Time
GND	Ground
GNSS	Global Navigation Satellite System
GP or G/P	Glide Path
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
GS	Ground Speed
G/S	Glide Slope
GW	Gross Weight

H	
HAA	Height Above Airport
HAT	Height Above Touchdown
HDG	Heading or Hydraulic Driven Generator
HDG REF	Heading Reference
HDG SEL	Heading Select
HF	High Frequency

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HGS	Head-Up Guidance System (HGS® is a registered trademark of Flight Dynamics)
HI	High
HLD	Hold
HMU	Hydro-Mechanical Unit
HP	High Pressure
HPA	Hectopascals
HPSOV	High Pressure Shut Off Valve
HPV	High Pressure Valve
HSI	Horizontal Situation Indicator
HUD	Head-Up Display
HYD	Hydraulic
HZ	Hertz

I	
IAF	Initial Approach Fix
IAN	Instrument Approach Navigation
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organization
IDENT	Identification
IDG	Integrated Drive Generator
IFE	In-Flight Entertainment System
IFR	Instrument Flight Rules
IGN	Ignition
IGS	Instrument Guidance System

ILS	Instrument Landing System
IM	Inner Marker
IMC	Instrument Meteorological Conditions
IN	Inches
INBD	Inboard
IND	Indicator
IND LTS	Indicator Lights
INOP	Inoperative
INIT	Initialization
INSTR	Instrument
INT or INTPH	Interphone
INTC	Intercept
INTC CRS	Intercept Course
IP	Instructor Pilot
IRS	Inertial Reference System
IRU	Inertial Reference Unit
ISA	International Standard Atmosphere
ISDU	Inertial System Display Unit
ISFD	Integrated Standby Flight Display
ISLN or ISOL	Isolation

J	
JAA	Joint Aviation Authority

K	
K, KT or KTS	Knots
KCAS	Knots Calibrated Airspeed
KGS	Kilograms
KIAS	Knots Indicated Airspeed

L	
L	Left
LAF	Load Alleviation Function
LAT	Latitude
LAT REV	Lateral Revision
LAV	Lavatory
LBS	Pounds
LD	Load
LDA	Localizer-type Directional Aid
LDG	Landing
LDG ALT	Landing Altitude
LE	Leading Edge
L/G	Landing Gear
LIM	Limit
LIM SPD	Limit Speed
LKD	Locked
L NAV or LNAV	Lateral Navigation
LOC	Localizer
LOC-BC	Localizer Back Course
LOM	Locator Outer Marker
LON or LONG	Longitude

LP	Low Pressure
LR	Long Range
LRC	Long Range Cruise
LRU	Line Replaceable Unit
LSK	Line Select Key
LT	Light
LVL	Level
LVL/CH	Level Change
LWR CTR	Lower Center
LWR DSPLY or LWR DSPL	Lower Display

M	
M	Mach
MAC	Mean Aerodynamic Chord
MAG	Magnetic
MAHP	Missed Approach Holding Point
MAN	Manual
MAP	Missed Approach Point
MASI	Mach/Airspeed Indicator
MAX	Maximum
MB	Millibar
MCC	Maintenance Control Center
MCDU	Multi-purpose Control and Display Unit
MCO	Maintenance Carry Over
MCP	Mode Control Panel
MCT	Maximum Continuous Thrust

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MDA	Minimum Descent Altitude
MDA(H)	Minimum Descent Altitude (Height)
MDM	Mechanical Dispatch Manual
MEA	Minimum Enroute Altitude
MEL	Minimum Equipment List
MFD	Multifunction Display
MHZ	Megahertz
MIC	Microphone
MIN	Minimum
MKR	Marker
MLS	Microwave Landing System
MM	Middle Marker
MMO	Maximum Mach Operating Speed
MNPS	Minimum Navigation Performance Specification
MOCA	Minimum Obstruction Clearance Altitude
MOD	Modify
MORA	Minimum Off Route Altitude
MSA	Minimum Safe Altitude
MSG	Message
MSGS RCVD	Messages Received
MSL	Mean Sea Level
MTOW	Maximum Take-Off Weight

MTRS	Meters
MUH	Minimum Use Height
MZFW	Maximum Zero Fuel Weight

N	
N	Normal
NADP	Noise Abatement Departure Procedures
NAR	North American Route
NAV	Navigation
NAV RAD	Navigation Radio
ND	Navigation Display
NDB	Non Directional Beacon
NGS	Nitrogen Generating System
NLT	No Later Than
NM	Nautical Mile(s)
NNC	Non-Normal Checklists
NNM	Non-Normal Maneuvers
NPS	Navigation Performance Scales
NORM	Normal
NW	Nose Wheel
N1	Low Pressure Rotor Speed
N2	High Pressure Rotor Speed (Pratt & Whitney and GE engines) or Intermediate Pressure Rotor Speed (Rolls Royce Engines)
N3	High Pressure Rotor Speed (Rolls Royce Engines)

O	
OAP	Overhead Annunciator Panel (a.k.a. EOAP)
OAT	Outside Air Temperature
OCC	Operations Control Center
ODM	Operational Data Manual
OFST	Offset
OHU	Overhead Unit
OM	Outer Marker
OP	Open
OUTBD DSPL	Outboard Display
OVHD	Overhead
OVHT	Overheat
OVRD	Override
OVSPD	Overspeed
OXY or O2	Oxygen

P	
PA	Passenger Address
PAPI	Precision Approach Path Indicator
PAR	Precision Approach Radar
PASS	Passenger
pb	Push-Button
PBE	Protective Breathing Equipment
PCP	Pilot Call Panel

PDC	Pitch Data Computer or Performance Data Computer or Pre-Departure Clearance
PERF	Performance
PERF INIT	Performance Initialization
PES	Pitch Enhancement System
PF	Pilot Flying
PFAF	Precision Final Approach Fix
PFC	Primary Flight Computer
PFD	Primary Flight Display
PI	Performance Inflight
PIP	Product Improvement Package
PLI	Pitch Limit Indicator
PM	Pilot Monitoring
PMC	Power Management Control
PNL	Panel
POS	Position
POS INIT	Position Initialization
POS REF	Position Reference
PPI	Planned Position Indicator
PPOS	Present Position
PRED	Prediction
PRES or PRESS	Pressure
PREV	Previous

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PRI	Primary
PROC T	Procedure Turn
PROG	Progress
PROX	Proximity
PRSOV	Pressure Regulating Shutoff Valve
P/RST	Push To Reset
PRV	Pressure Regulating Valve
PSI	Pounds Per Square Inch
PTH	Path
PTT	Push To Talk
PTU	Power Transfer Unit
PWR	Power
PWS	Predictive Windshear System

Q	
Q	Quantity
QFE	Local Station Pressure
QNH	Altimeter Setting
QRH	Quick Reference Handbook
QT	Quart
QTY	Quantity

R	
R	Right
RA	Radio Altitude or Resolution Advisory
RAAC	Rotor Active Clearance Control
RAD	Radio

RAIM	Receiver Autonomous Integrity Monitoring
RAT	Ram Air Temperature or Ram Air Turbine
RCDR or REC	Recorder
RCL	Request for Clearance
RDMI	Radio Distance Magnetic Indicator
REC	Recorder
RECIR or RECIRC	Recirculation
REF	Reference
RET	Retract
REV	Reverse
RF	Radius-to-Fix (RF) Legs or Refill
RMI	Radio Magnetic Indicator
RMP	Radio Management Panel
RNAV or RNV	Area Navigation
RNP	Required Navigational Performance
RPL	Rudder Pressure Limiter
RPM	Revolutions Per Minute
RPR	Rudder Pressure Reducer
RR	Rolls Royce
RSEP	Rudder System Enhancement Program
RST	Reset
RSVR	Reservoir
R/T	Radio Transmit
RTE	Route

RTO	Rejected Takeoff
RTP	Radio Tuning Panel
RUD	Rudder
RVR	Runway Visual Range
RVSM	Reduced Vertical Separation Minimum
RWY	Runway

S	
SAARU	Secondary Attitude Air Data Reference Unit
SAT	Static Air Temperature or Satellite
SB	Service Bulletin
S/B	Speedbrake
SC	Single Chime
S/C	Step Climb
SD	System Display
S/D	Step Display
SDAC	System Data Acquisition Concentrator
SDCU	Smoke Detection Control Unit
SDF	Simplified Directional Facility
SEC	Spoiler Elevator Computer
SEI	Standby Engine Indicator
SEL	Select
SELCAL	Selective Calling
SMGCS	Surface Movement and Guidance Control System
SENS	Sensitivity

SERV	Service
SFCC	Slat/Flap Control Computer
SG	Symbol Generator
SID	Standard Instrument Departure
SPD	Speed
SPDBRK	Speedbrake
SPD LIM	Speed Limit
SPLR	Spoiler
SRS	Speed Reference System
STA	Station
STAB	Stabilizer
STAR	Standard Terminal Arrival Route
STAT or STS	Status
STBY	Standby
STD	Standard
STRG	Steering
SW	Switch
SWTG	Switching
SYS	System

T	
T or TRU	True
T or TK or TRK	Track (to a Navaid)
TA	Traffic Advisory
TAA	Terminal Arrival Area
TACAN	Tactical Air Navigation
TAC	Thrust Asymmetry Compensation

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TAI	Thermal Anti-Ice
TAS	True Airspeed
TAT	Total Air Temperature
T/C	Top of Climb
TCA	Terminal Control Area
TCAS	Traffic Alert and Collision Avoidance System
TCI	Thrust Computer Indicator
T/D	Top of Descent
TDZ	Touch Down Zone
TDZE	Touch Down Zone Elevation
TE	Trailing Edge
TEMP	Temperature
TERR	Terrain
TFC	Traffic
TFR	Transfer
THR	Throttle or Thrust
THR HOLD	Throttle Hold
THS	Trimmable Horizontal Stabilizer
TK	Tank
TLA	Throttle Lever Angle
TMC	Thrust Management Computer
TMI	Track Message Identifier
TMSP	Thrust Mode Select Panel
TO or T/O	Takeoff
TOC	Top of Climb
TOD	Top of Descent

TO/GA or TOGA	Takeoff/Go-Around
TOGW	Takeoff Gross Weight
T-P	Turn Point
TPR	Turbine Pressure Ratio
TR	Traffic Resolution
TRP	Thrust Rating Panel
TRU	Transformer Rectifier Unit
TURB	Turbine or Turbulence

U	
UNLK	Unlock
UNLKD	Unlocked
UNSCHD or UNSCHED	Unscheduled
UPR DSPL	Upper Display
U.S.	United States
USB	Upper Side Band
UTC	Universal Time Coordinated
UTIL	Utility

V	
V	Volt
VA	Design maneuvering speed
VAL	Valve
VANP	Vertical Actual Navigational Performance
VASI	Visual Approach Slope Indicator

VDP	Visual Descent Point
VEF	Speed at Engine Failure
VERT	Vertical
VFE	Maximum Velocity Flaps Extended
VFR	Visual Flight Rules
VG	Vertical Gyro
VHF	Very High Frequency
VIB	Vibration
VLV	Valve
VMC	Visual Meteorological Conditions
VMCA	Minimum Control Speed Air or Single Engine Minimum Control Airspeed
VMCG	Minimum Control Speed Ground
VMO	Maximum Operating Speed
V NAV or VNAV	Vertical Navigation
VOR	VHF Omnidirectional Range
VR	Rotation Speed
VREF	Reference Speed
VRNP	Vertical Required Navigation Performance
V/S	Vertical Speed
VSCF	Variable Speed Constant Frequency
VSD	Vertical Situation Display
VSI	Vertical Speed Indicator
VTK	Vertical Track

V1	Takeoff Decision Speed
V1 (MCG)	Minimum V1 for Control on the Ground
V2	Scheduled Takeoff Target Speed

W	
W	Warm
WATRS	Western Atlantic Route System
WDR	Weight Data Record
WGS-84	World Geodetic System of 1984
WHC	Window Heat Computer
WHL	Wheel
WPT	Waypoint
WT	Weight
WTB	Wing Tip Brake
WXR	Weather Radar

X	
X-FEED	Crossfeed
XFR	Transfer
XMTR	Transmitter
XPDR or XPDR	Transponder
XTK	Cross Track

Preface

Revision Record

Chapter P2

Section 4

Revision Transmittal Letter

To: All holders of Delta Air Lines, Inc. 747-400 Operations Manuals.

Subject: Operations Manual Revision.

This revision reflects the most current information available to Delta Air Lines, Inc. through the subject revision date. The following revision highlights explain changes in this revision. General information below explains the use of revision bars to identify new or revised information.

Revision Record

No.	Revision Date	Date Filed
00	December 22, 2011	
02	March 14, 2013	
04	December 19, 2013	

No.	Revision Date	Date Filed
01	June 7, 2012	
03	August 13, 2013	
05	March 25, 2016	

General

Delta Air Lines, Inc. issues operations manual revisions to provide new or revised procedures and information. Formal revisions also incorporate appropriate information from previously issued Flight Crew Bulletins.

The revision date is the approximate date the revision material is distributed and considered current. The revision should be incorporated on the revision date, but may be incorporated as much as 21 days after the revision date.

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

The Revision Record should be completed by the person incorporating the revision into the manual.

Filing Instructions

Consult the List of Effective Pages (P2.5). Pages identified with an asterisk (*) are either replacement pages, new (original) issue pages, or deleted pages. Remove corresponding old pages and replace or add new pages. Remove pages marked DELETED; there are no replacement pages for deleted pages.

Be careful when inserting changes not to throw away pages from the manual that are not replaced. The List of Effective Pages determines the correct content of the manual.

Revision Highlights

This section (P2.4) replaces the existing section P2.4 in your manual.

Pages containing revised technical and non-technical material have revision bars associated with the changed text or illustration.

Repaginated material not containing technical revisions are identified only by a new page date.

Preface

Introduction

Organization

P2.2.3 - Updated language due to adding chapters 9 and 10 from the FCTM.

Airplane Effectivities

P2.2.5 - Removed “Continued on next page”.

P2.2.6 - Removed “Continued from previous page”.

Chapter 1 - Airplane General, Emergency Equipment, Doors, Windows

Section 10 - Dimensions

Principal Dimensions

1.10.1 - Revised graphic by replacing lateral dimension between wing landing gear centerline with lateral dimension between outermost wing landing gear wheels.

Section 30 - Controls and Indicators

Cabin Emergency Lights Switch

1.30.13 - Added Cabin Emergency Lights Switch section.

Section 40 - Systems Description

Portable Protective Breathing Equipment

1.40.9 - Added Portable Protective Breathing Equipment section.

Chapter 4 - Automatic Flight

Section 10 - Controls and Indicators

Autothrottle Disconnect and TO/GA Switches

4.10.17 - Deleted bullet; GPS activated.

Chapter 9 - Flight Controls

Section 20 - System Description

Ground Spoilers

9.20.12 - Revised language regarding Speedbrake lever for clarity.

Chapter 10 - Flight Instruments, Displays

Section 10 - Controls and Indicators

Control Panel ND Controls

10.10.30 - Deleted position bullet to reflect GPS installed.

Section 20 - System Description

Clocks

10.20.7 - Deleted paragraph to reflect GPS installed.

Flight Recorder (DFDR)

10.20.7 - Added section.

Chapter 11 - Flight Management, Navigation

Section 20 - Navigation Systems Description

Transponder

11.20.8 - Clarified Mode S transponder functionality on the ground.

Section 31 - Flight Management System Operation

Cruise

11.31.22 - Revised Step Climb description for clarity.

Chapter 15 - Warning Systems

Section 10 - Controls and Indicators

Ground Proximity Panel

15.10.12 - Revised text to include text from Master WARNING/CAUTION
Reset Switches and Lights description.

Preface

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* P2.3.1-14	March 25, 2016
* P2.4.1-4	March 25, 2016
* P2.5.1-2	March 25, 2016
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* = Revised, Added, or Deleted

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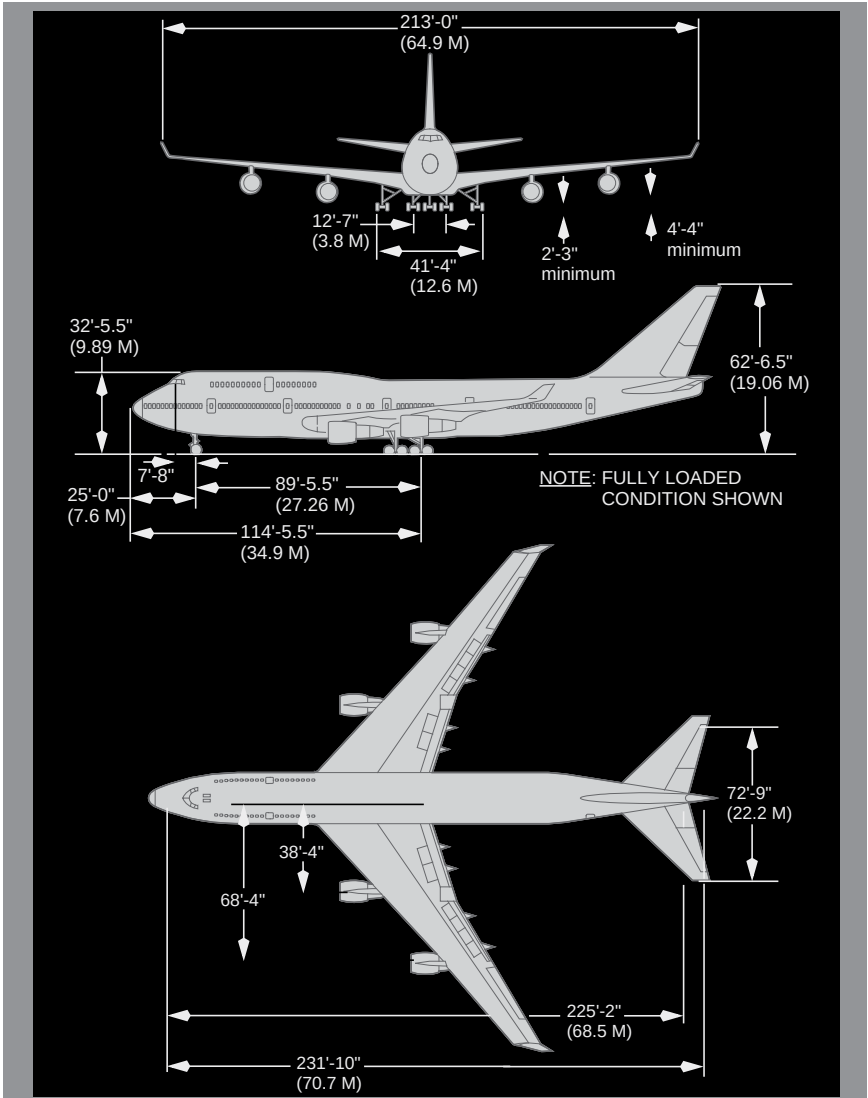
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Airplane General, Emergency Equipment, Doors, Windows Dimensions

Chapter 1

Section 10

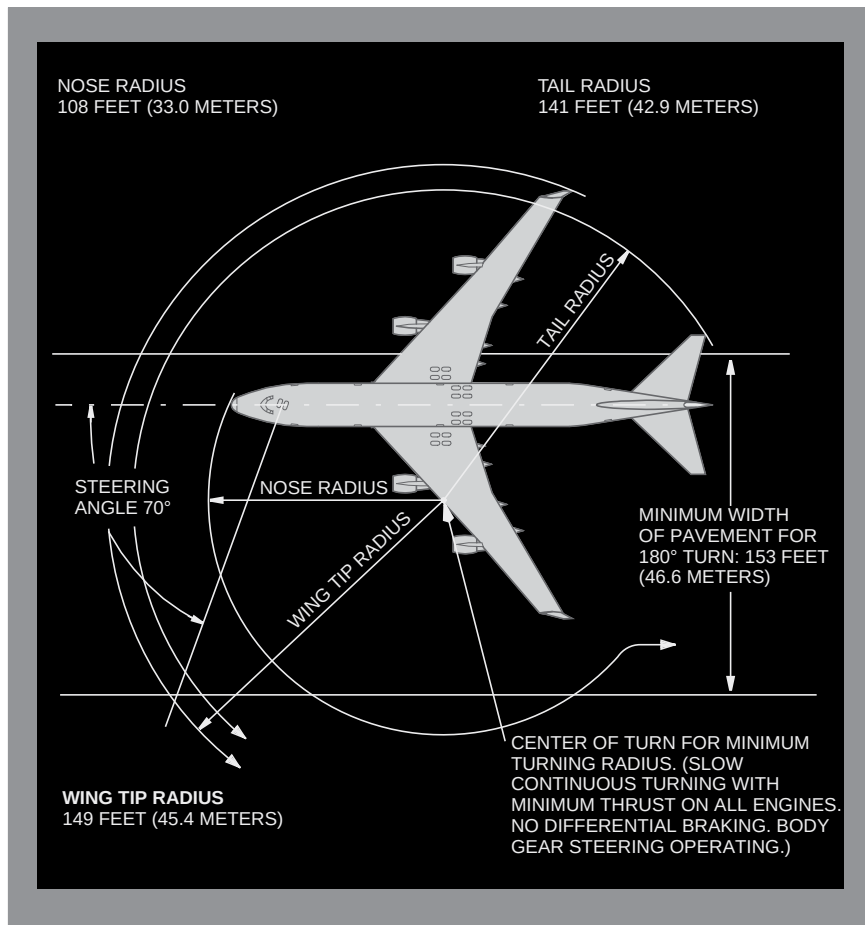
Principal Dimensions



Turning Radius

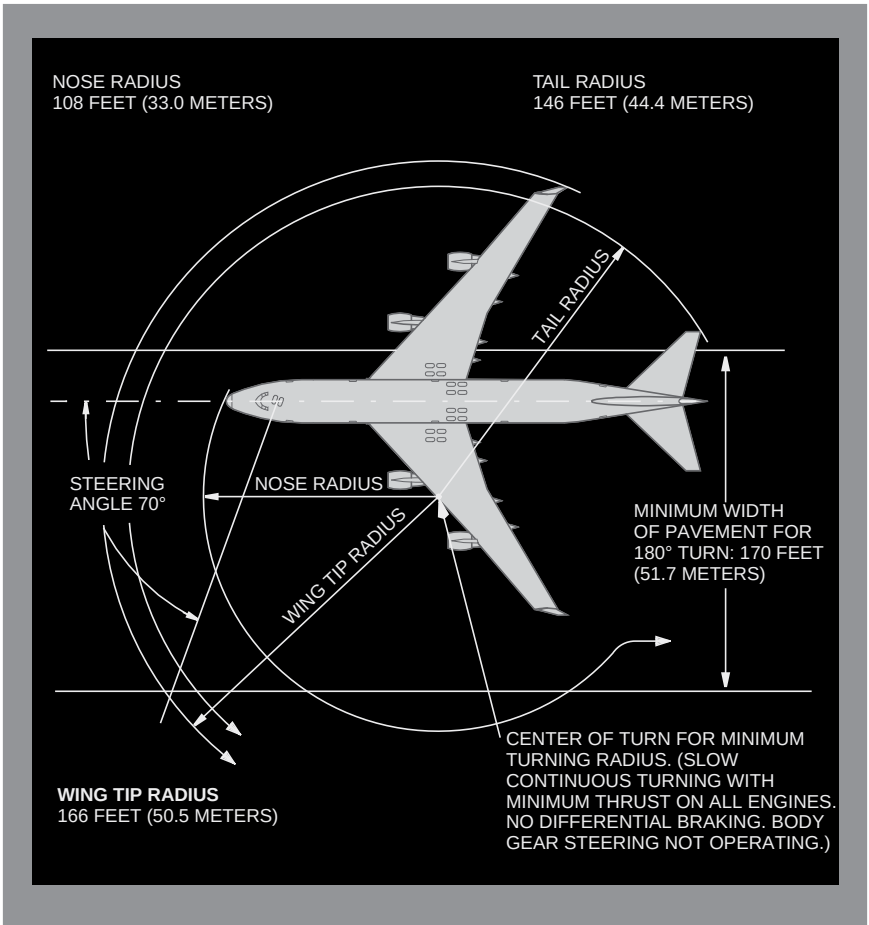
The wing tip swings the largest arc while turning and determines the minimum obstruction clearance path. All other portions of the airplane structure remain within this arc.

Body Gear Steering Activated



CAUTION: Do not attempt to make a turn away from an obstacle within (15 feet/4.6m) of the wing tip or within (56 feet/16.9m) of the nose.

Body Gear Steering Deactivated



CAUTION: Do not attempt to make a turn away from an obstacle within 11 feet of the wingtip or within 59 feet of the flight deck. Avoid use of excessive thrust in ramp area due to possible damage or injury from jet blast.

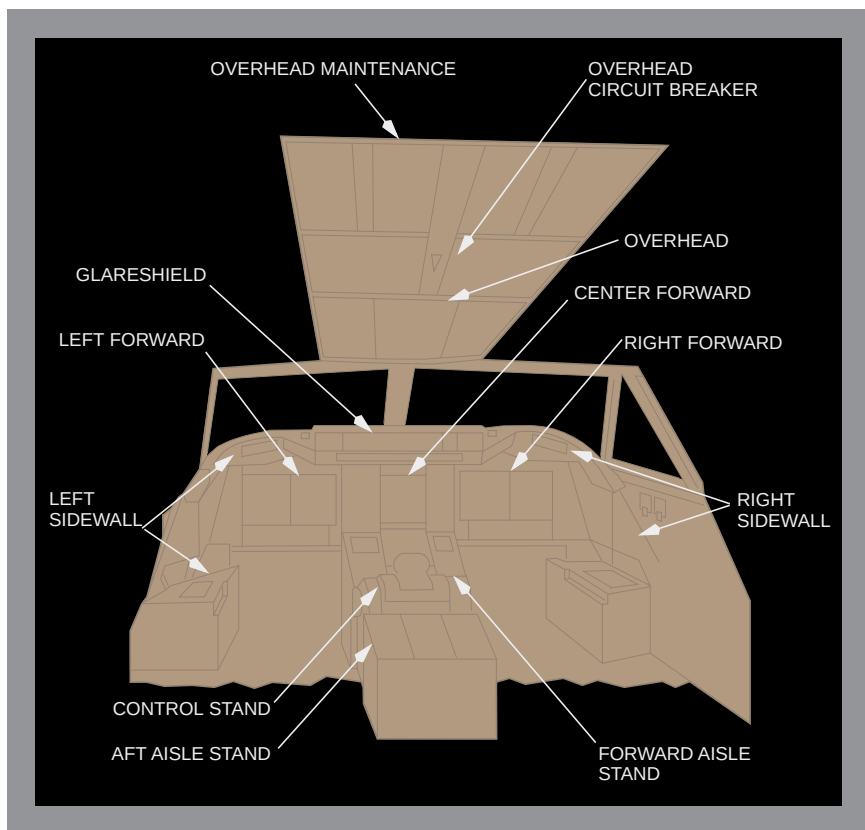
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Airplane General, Emergency Equipment, Doors, Windows Instrument Panels

Chapter 1

Section 20

Flight Deck Panels



On the following pages, circled numbers refer to chapters where information on the item may be found.

The panels, controls, and indicators shown in this chapter are representative of installed units and may not exactly match the latest configuration. Refer to the appropriate chapter system descriptions for current information.

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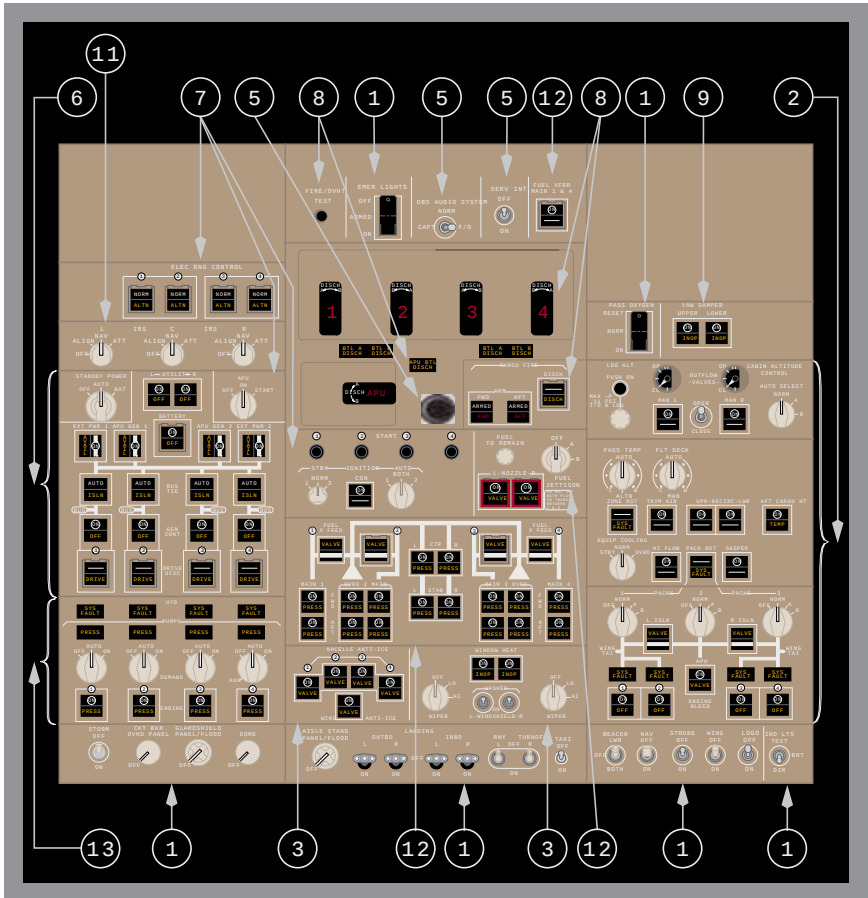
Airplane General, Emergency Equipment, Doors, Windows Inst. Panels, Overhead

Chapter 1

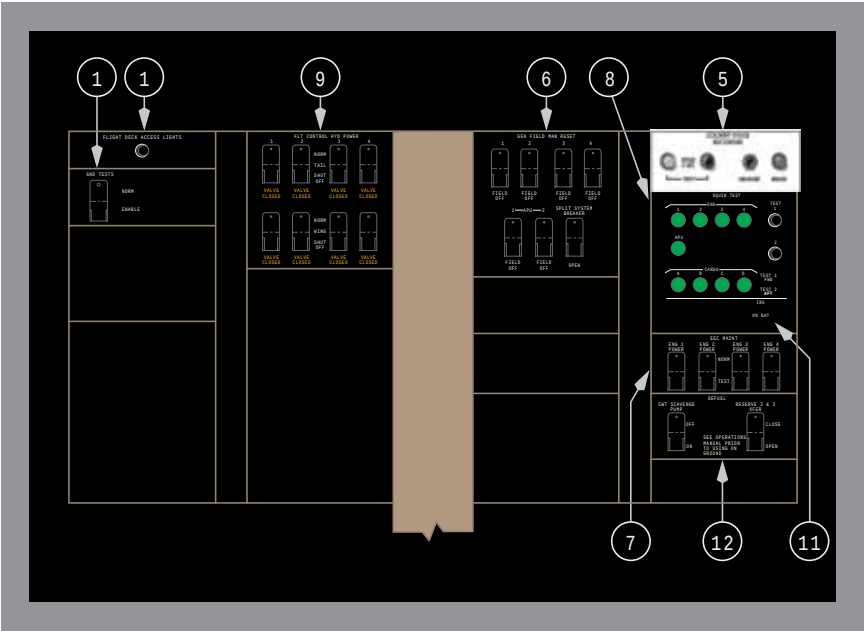
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Overhead Panels

Overhead Panel



Overhead Maintenance Panel



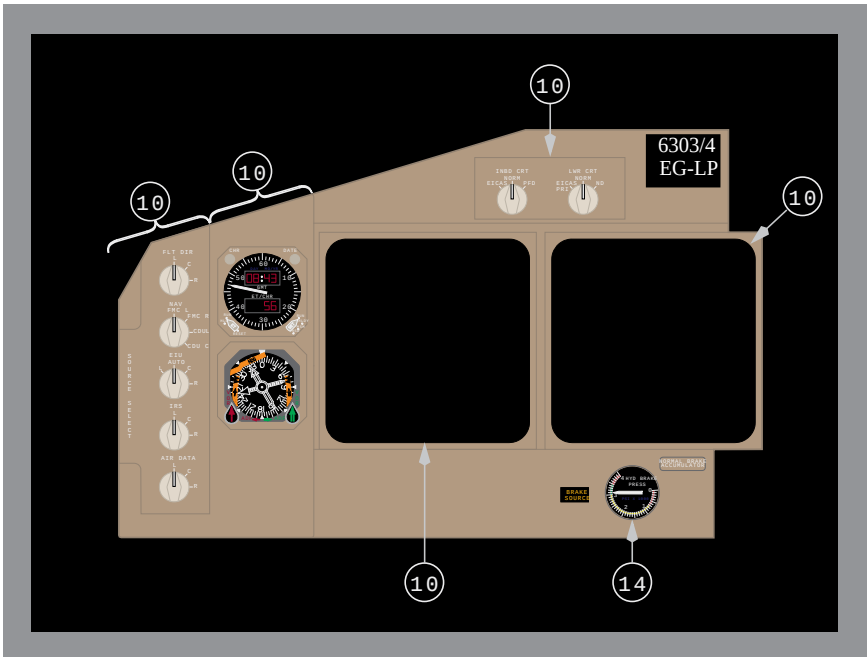
Airplane General, Emergency Equipment, Doors, Windows

Inst. Panels, Forward

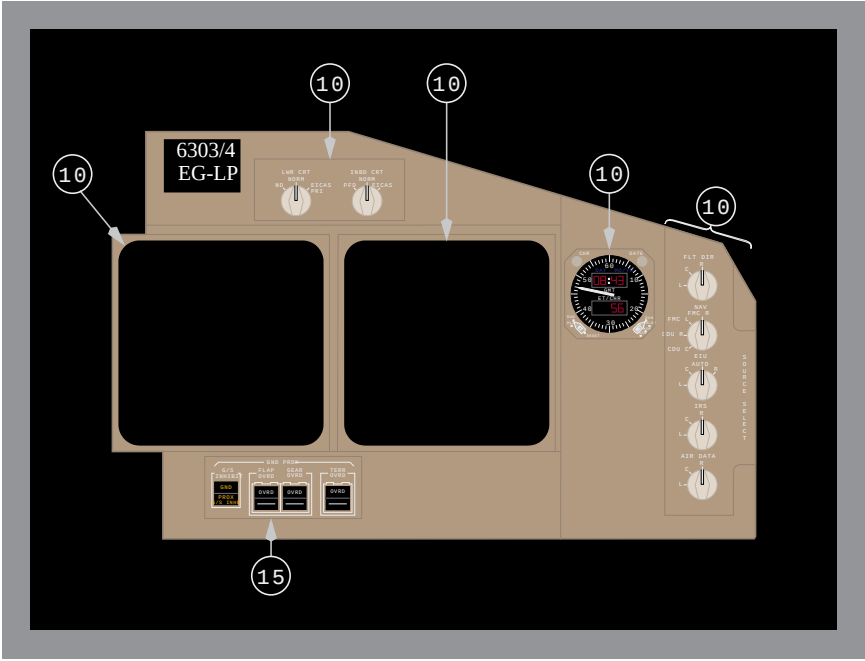
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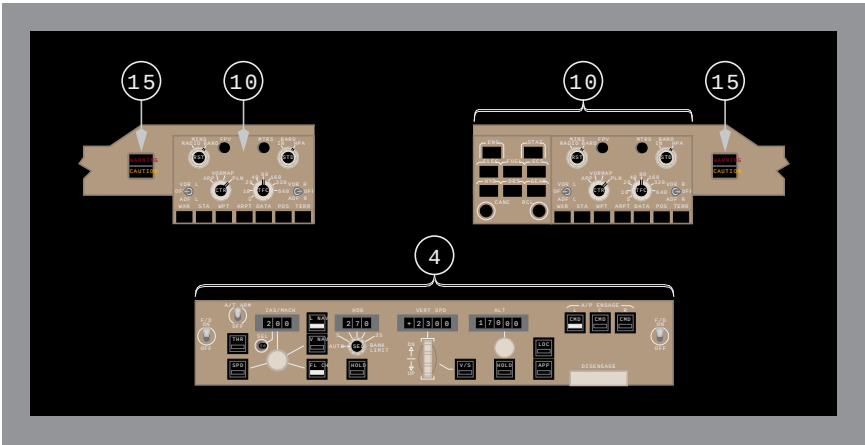
Left Forward Panel



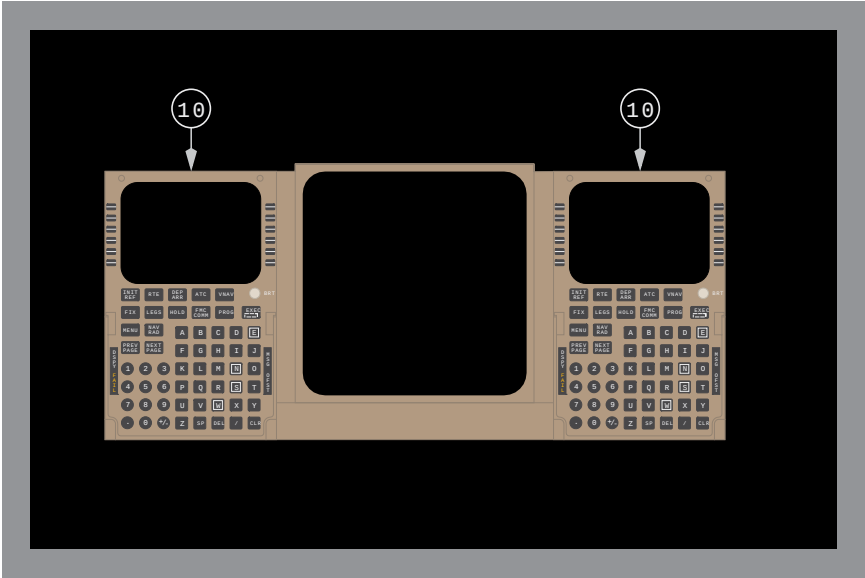
Right Forward Panel



Glareshield Panel



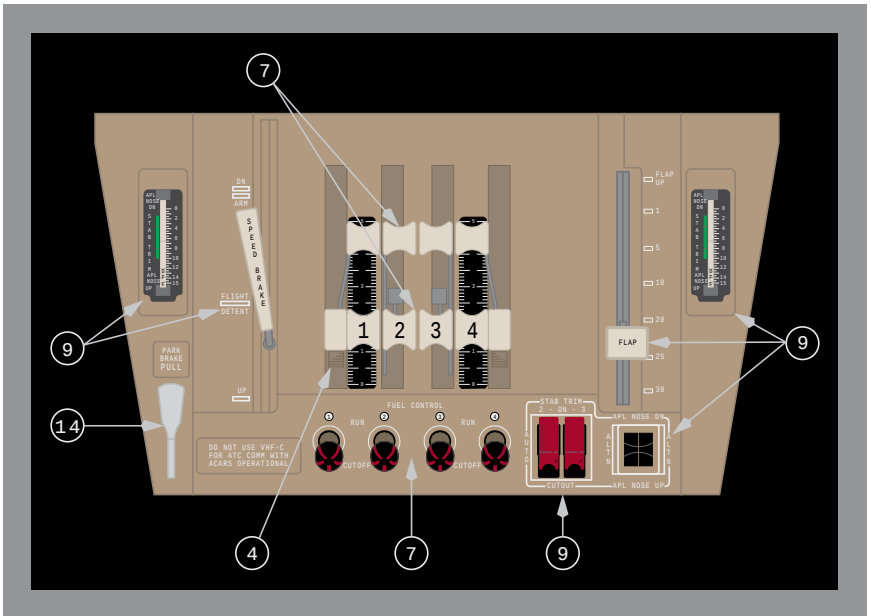
Forward Aisle Stand



**Airplane General, Emergency
Equipment, Doors, Windows
Inst. Panels, Aft and Side**

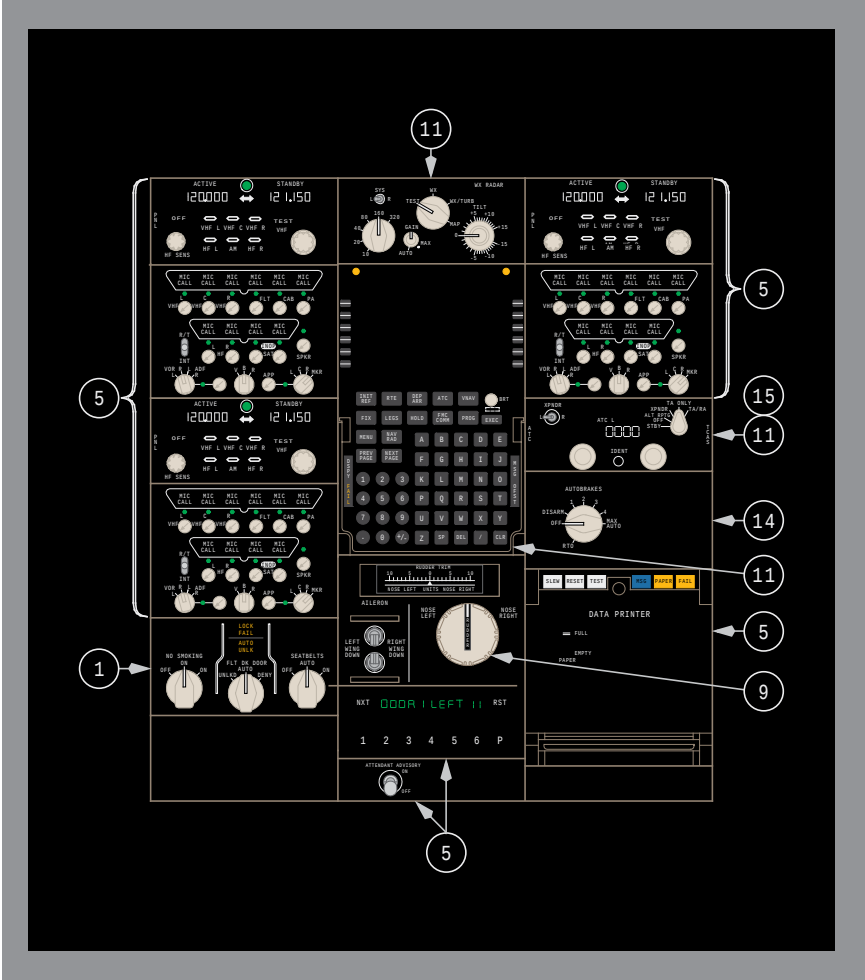
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Control Stand

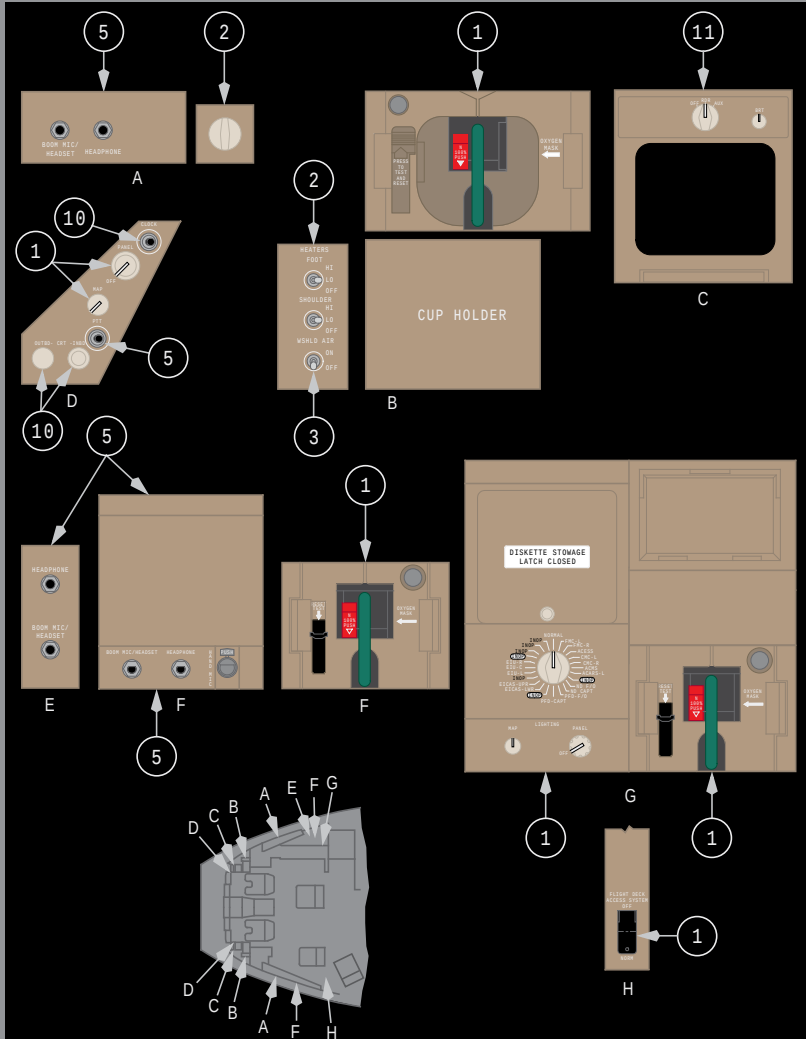


Aft Aisle Stand, Sidewall Panels

Aft Aisle Stand Panels



Left and Right Sidewall, First Observer, and Maintenance Access Terminal/Second Observer Panels



NOTE: PANELS A, B, AND D ARE SHOWN FOR CAPTAIN'S SIDE ONLY. FIRST OFFICER'S ARE OPPOSITE.

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Airplane General, Emergency Equipment, Doors, Windows Controls and Indicators

Chapter 1

Section 30

Push-Button Switches

The airplane has two types of push-button switches: alternate action and momentary action. Both types direct crew attention to system status and faults.

CAUTION: Flight crews should not change switch bulbs. Contact maintenance personnel whenever a bulb requires changing. Damage may result if bulbs are changed with the system powered. Switch bulb changes on the mode control panel may affect system operation in flight.

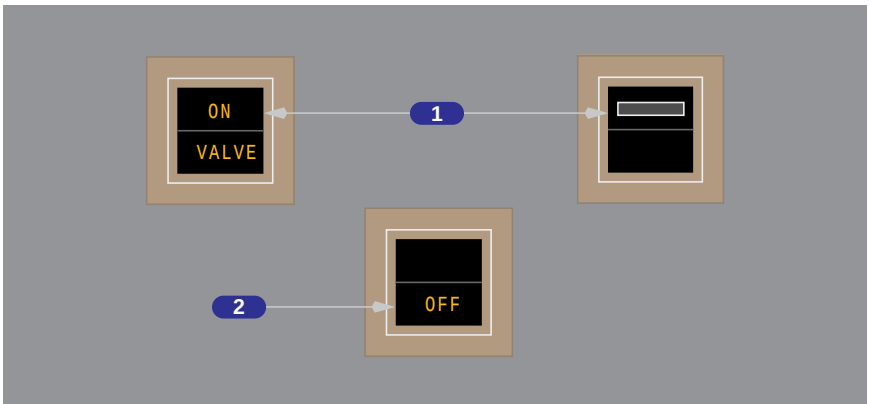
Alternate Action Switches

Alternate action switches have two positions: on and off.

When pushed in and flush with the panel, the switch is on. When the switch is on, a mechanical shutter on one half of the switch opens to show an illuminated legend, such as “ON”, “AUTO”, or a flow bar.

When pushed out and extended, the switch is off. When the switch is off, the mechanical shutter closes so the legend is not shown.

Additionally, the other half of many switches has a light to indicate system state, such as “PRESS”, “FAIL”, “INOP” or “OFF”.



1 Switch is ON

ON, AUTO, or flow bar visible.

For some switches, system status (for example, MAN, OFF, VALVE) may be shown in the lower half of the switch.

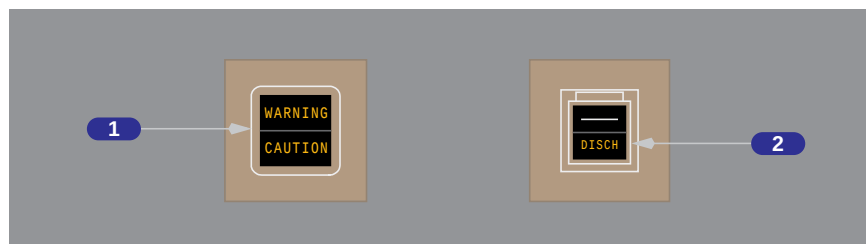
2 Switch is OFF

OFF or a line is visible -

- the top of the switch is blank
- a line indicates no label in this portion of the switch

Momentary Action Switches

Momentary action switches are spring loaded to the extended position. They activate or deactivate systems or reset system logic. The switch display indicates system status.



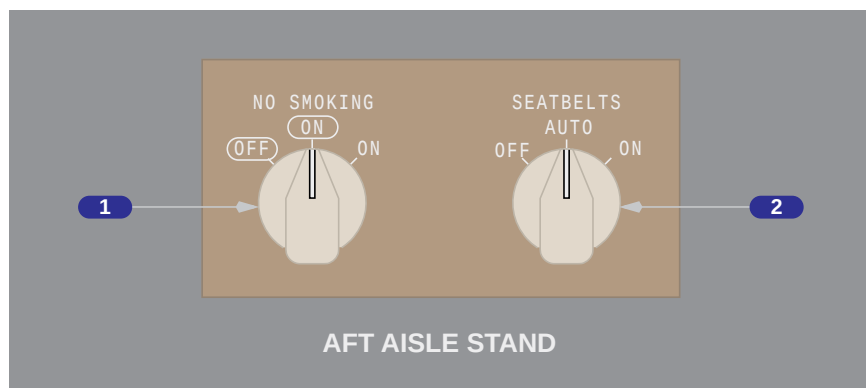
1 Push to Reset

Push - resets master lights and aural alerts.

2 System Operation

Push - activates or deactivates the system.

Passenger Signs



1 NO SMOKING Selector

Selector is inoperative. The NO SMOKING signs are illuminated when electrical power is applied to the airplane.

2 SEAT BELTS Selector

OFF - FASTEN SEAT BELTS and RETURN TO SEAT signs are not illuminated.

AUTO - FASTEN SEAT BELTS and RETURN TO SEAT signs illuminate or extinguish with reference to airplane altitude and system configuration (refer to Lighting System Description section).

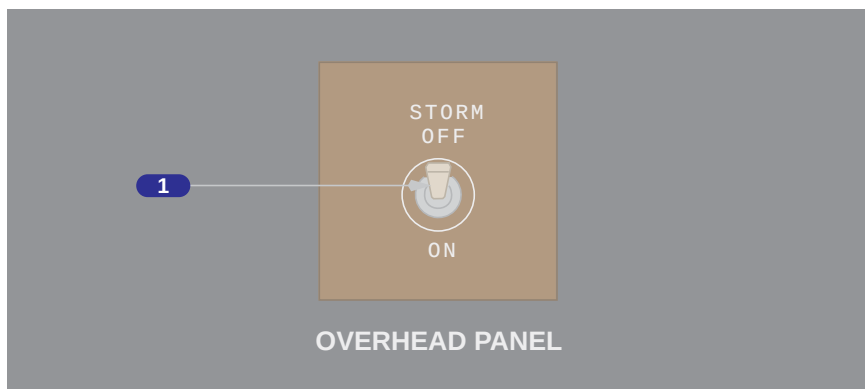
ON - FASTEN SEAT BELTS and RETURN TO SEAT signs illuminate.

Note: Anytime passenger oxygen deploys, FASTEN SEAT BELTS signs illuminate and RETURN TO SEAT signs extinguish, regardless of selector position.

Lighting

Flight Deck Lighting

Storm Lights Switch

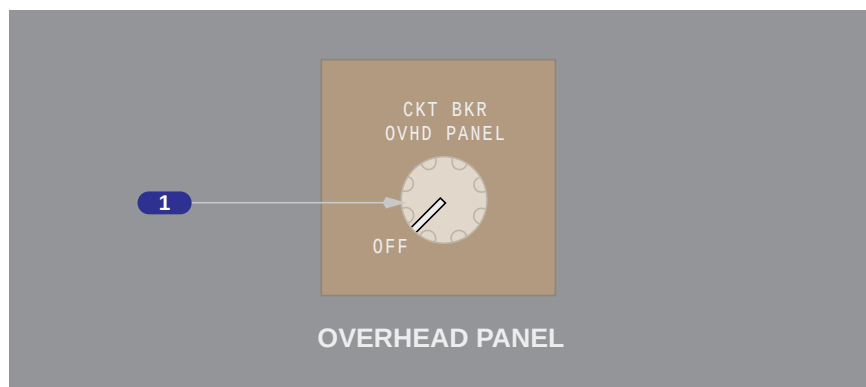


1 STORM Lights Switch

ON - overrides normal controls and illuminates the following lights at maximum brightness:

- Captain's and First Officer's lights
- glareshield lights
- aisle stand flood lights
- three dome lights

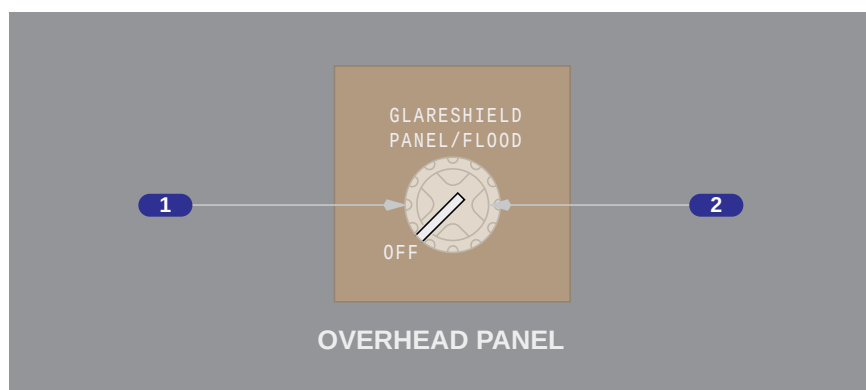
Circuit Breaker/Overhead Panel Lights Control



1 Circuit Breaker/Overhead (CKT BKR OVHD) Panel Lights Control

Rotate - controls circuit breaker panel and overhead panel brightness.

Glareshield Panel/Flood Lights Control



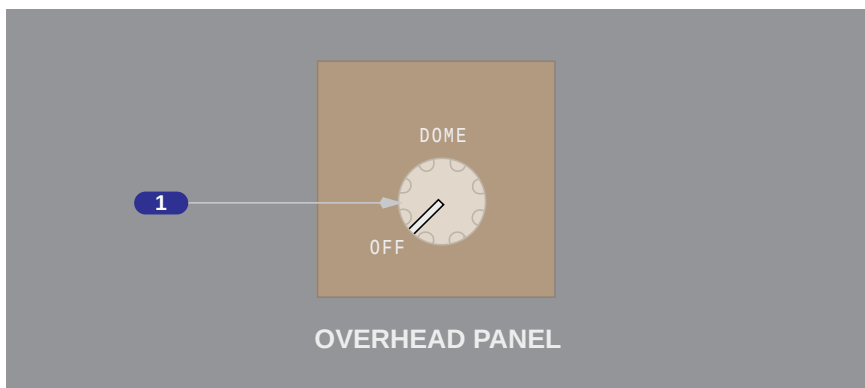
1 GLARESHIELD PANEL/FLOOD Lights Control (inner)

Rotate - controls left and right glareshield flood lights.

2 GLARESHIELD PANEL/FLOOD Lights Control (outer)

Rotate - controls glareshield panel and standby magnetic compass lights.

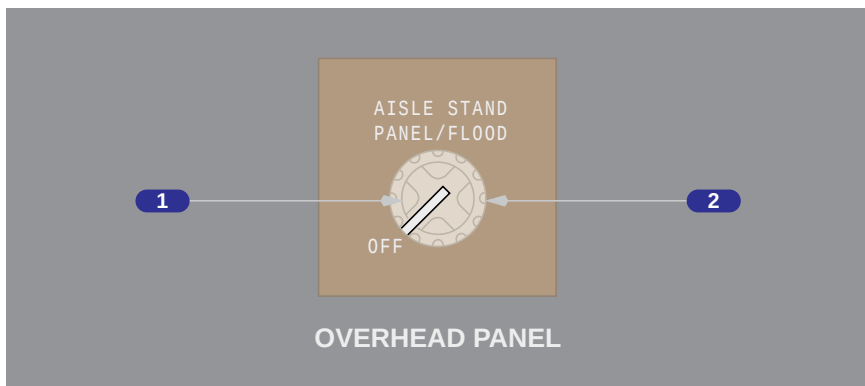
Dome Lights Control



1 DOME Lights Control

- controls dome light brightness
- overridden by storm lights switch

Aisle Stand Panel/Flood Lights Control



1 AISLE STAND PANEL/FLOOD Lights Control (inner)

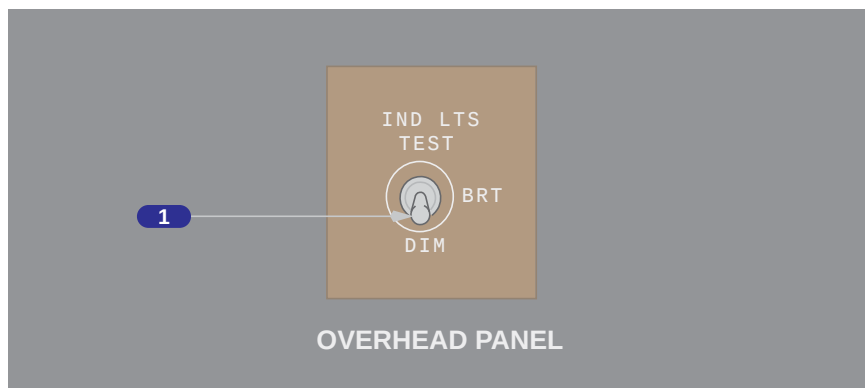
Rotate - controls aisle stand flood lights brightness.

2 AISLE STAND PANEL/FLOOD Lights Control (outer)

Rotate -

- controls aisle stand panel lights brightness
- controls the intensity of the stabilizer trim indicator lighting
- overridden by storm lights switch

Indicator Lights Switch



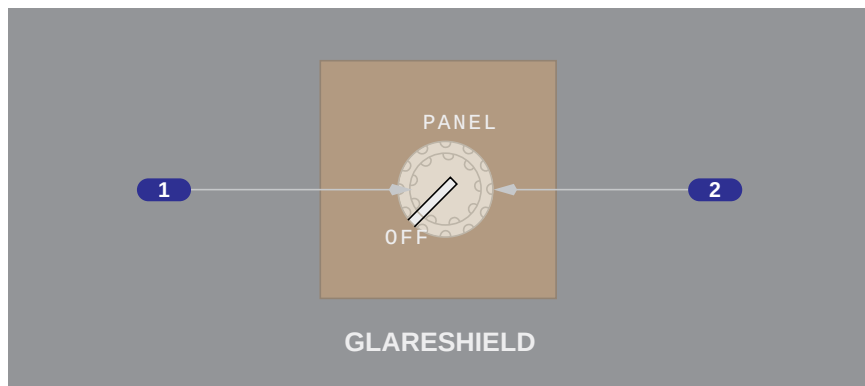
1 Indicator Lights (IND LTS) Switch

TEST (spring-loaded) - illuminates all annunciator lights to full brightness for 10 seconds to check the bulbs, then dims the lights as long as switch is held.

BRT - sets all illuminated annunciator lights to full brightness.

DIM - sets all illuminated annunciator lights to low brightness.

Captain's Panels Light Controls



1 Captain's Panels Light Controls (inner)

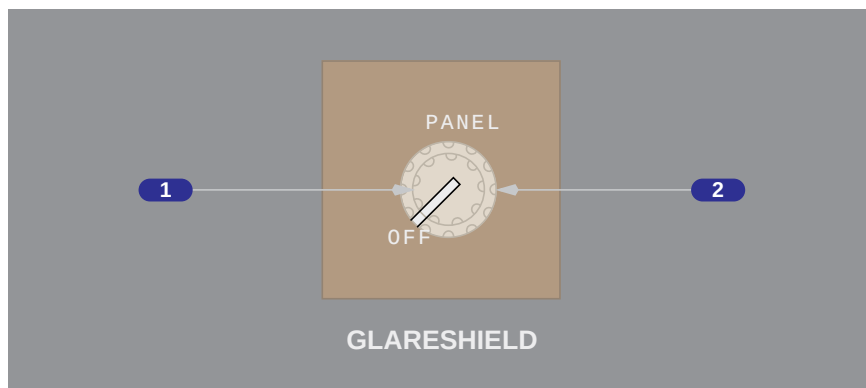
Rotate -

- controls Captain's and center panel floodlights brightness
- overridden by storm switch

2 Captain's Panels Light Controls (outer)

Rotate - controls Captain's main panel, left side of center panel, and Captain's lower auxiliary panel lighting.

First Officer's Panels Light Controls



1 First Officer's Panels Light Controls (inner)

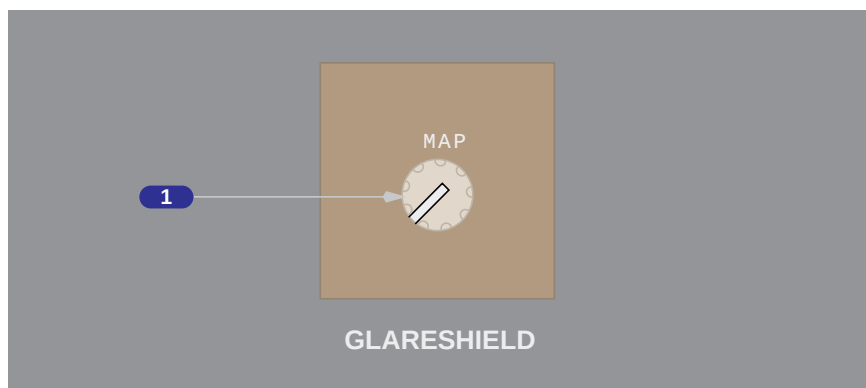
Rotate -

- controls First Officer's panel floodlights brightness
- overridden by storm switch

2 First Officer's Panels Light Controls (outer)

Rotate - controls First Officer's main panel, right side of center panel, and First Officer's lower auxiliary panel lighting.

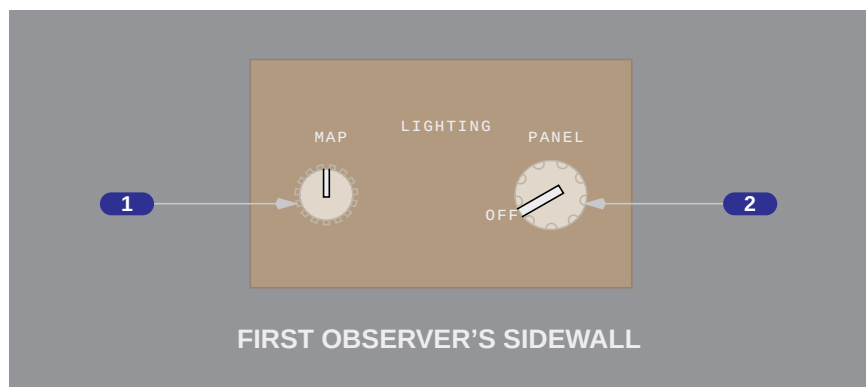
Captain's and First Officer's Map Light Controls



1 Captain's and First Officer's MAP Light Controls

Pull/Rotate - controls respective Captain's and First Officer's map light brightness.

First Observer's Map Light Controls



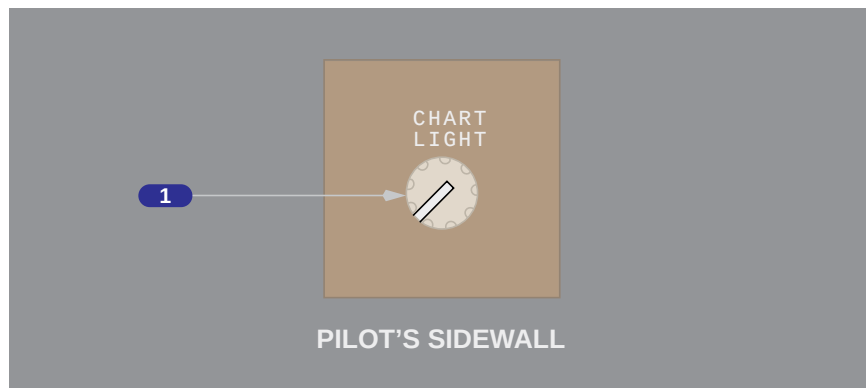
1 First Observer's MAP Light Switch

Pull/Rotate - controls First Observer's map light brightness.

2 First Observer's PANEL Light Switch

Rotate - controls First Observer's panel light brightness.

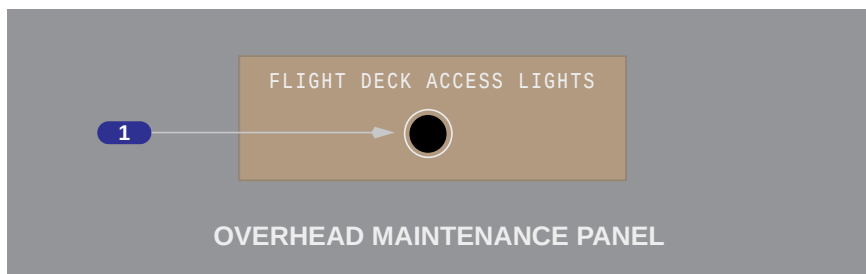
Captain's and First Officer's Chart Light Controls



1 Captain's and First Officer's CHART LIGHT Controls

Pull/Rotate - controls respective Captain's and First Officer's chart light brightness.

Flight Deck Access Lights Switches



1 FLIGHT DECK ACCESS LIGHTS Switch

Additional Access Lights switches are located at Door 2 left attendant's panel, and Main Equipment Center lower hatch.

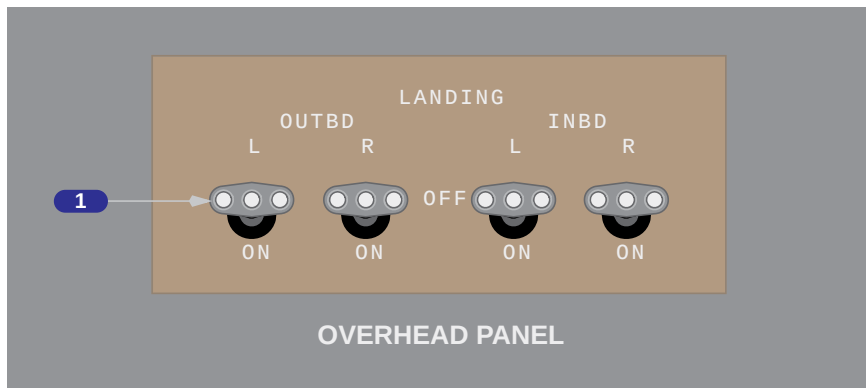
Push (any switch) - when the ground handling bus is powered, illuminates exit or entry path to or from flight deck; activates the following:

- Main Equipment Center lights
- direct ceiling light door 2
- direct ceiling lights upper deck

Second push (any switch) - extinguishes exit or entry path lighting.

Exterior Lighting

Landing Light Switches

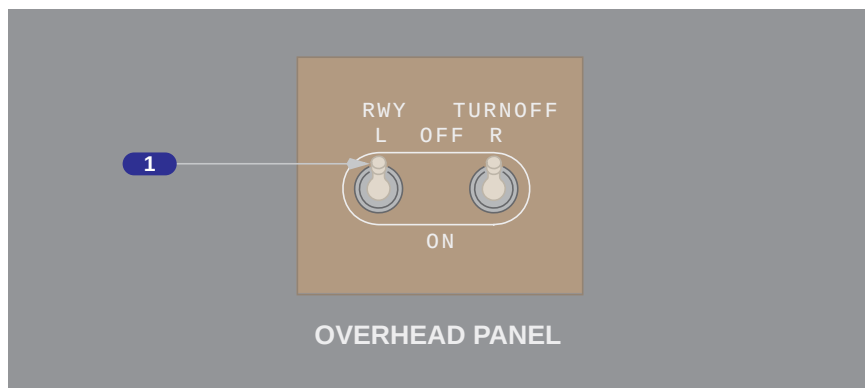


1 Outboard (OUTBD) and Inboard (INBD) LANDING Light Switches

ON (L or R)-

- illuminates respective wing landing light
- light intensity at maximum when Landing Gear lever in DOWN position

Runway Turnoff Light Switches

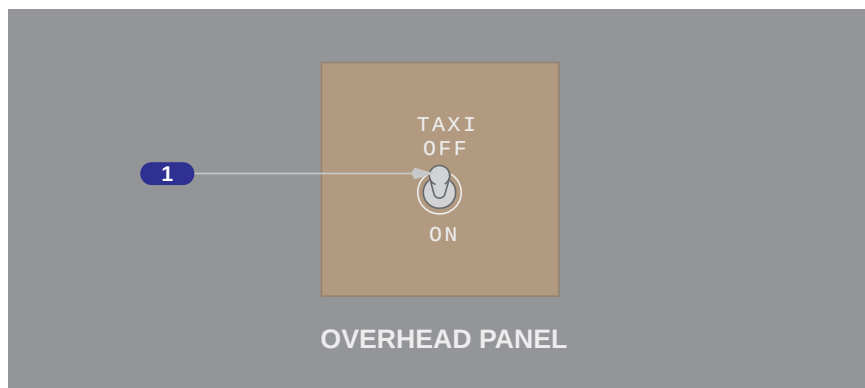


1 Runway (RWY) TURNOFF Light Switches

ON (L or R) -

- illuminates respective runway turnoff light
- lights extinguish when air/ground sensing system in air mode

Taxi Lights Switch

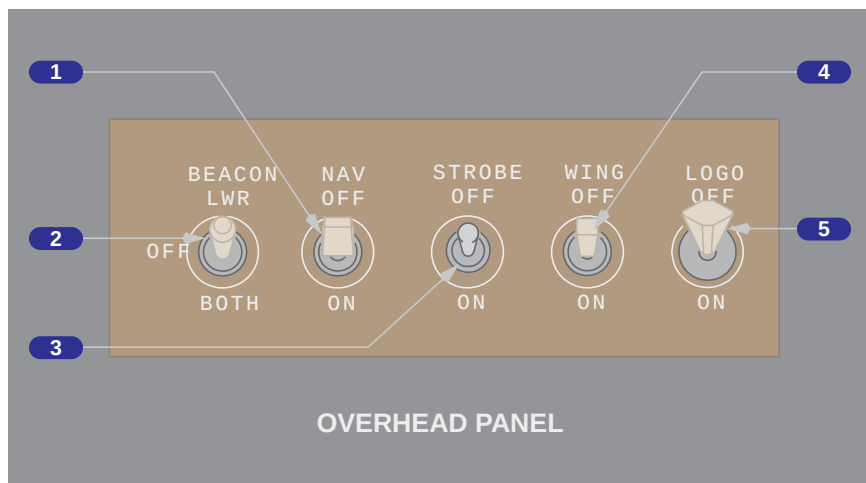


1 TAXI Lights Switch

ON -

- illuminates two taxi lights on nose landing gear
- lights extinguish when air/ground sensing system in air mode

Beacon, Navigation, Strobe, Wing, and Logo Light Switches



1 Navigation (NAV) Lights Switch

ON - illuminates red, green and white navigation lights.

2 BEACON Lights Switch

Lower (LWR) - activates lower red anti-collision beacon light.

BOTH - activates upper and lower red anti-collision beacon lights.

3 STROBE Lights Switch

ON - activates strobe lights.

4 WING Lights Switch

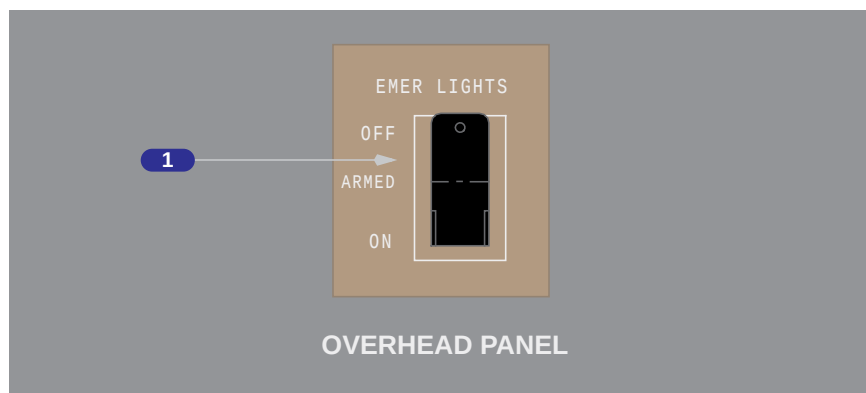
ON - illuminates wing leading edge illumination lights.

5 LOGO Lights Switch

ON - illuminates logo lights.

Emergency Lighting Controls

Flight Deck Emergency Lights Switch



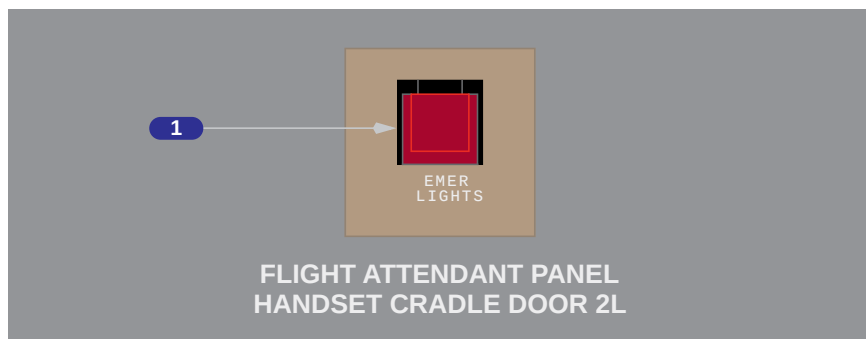
1 Flight Deck Emergency (EMER) LIGHTS Switch (not safety wired)

OFF - prevents emergency lights system operation if airplane electrical power fails or is turned off.

ARMED - all emergency lights illuminate if airplane electrical power fails or is turned off.

ON - all emergency lights illuminate.

Cabin Emergency Lights Switch

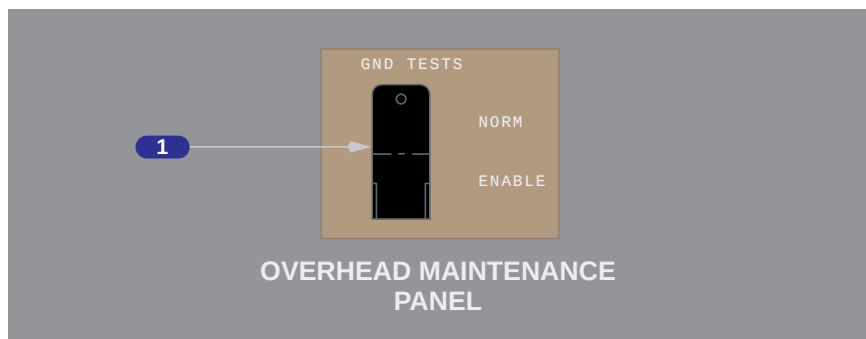


1 Cabin Emergency (EMER) LIGHTS Switch

Push -

- Illuminated (red) -
 - all passenger cabin and exterior emergency lights illuminate
 - bypasses flight deck emergency lights switch
- Extinguished - all passenger cabin and exterior emergency lights extinguish

Ground Tests Switch (not safety wired)



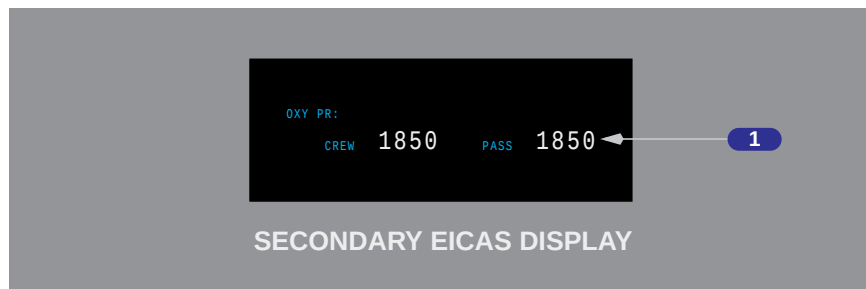
1 Ground (GND) TESTS Switch

ENABLE - allows CMC to initiate ground tests of airplane systems.

NORM (Normal - guard closed) - systems configured for flight.

Oxygen Systems

Oxygen Indications

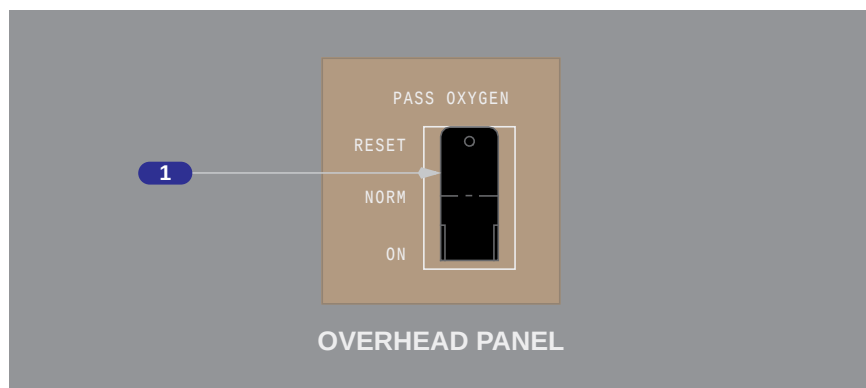


1 Oxygen Pressure (OXY PR) Display

Displays crew and passenger oxygen cylinder pressure (PSI).

Note: Access is through display select panel STAT switch.

Passenger Oxygen Switch (safety wired)



1 PASSENGER (PASS) OXYGEN Switch

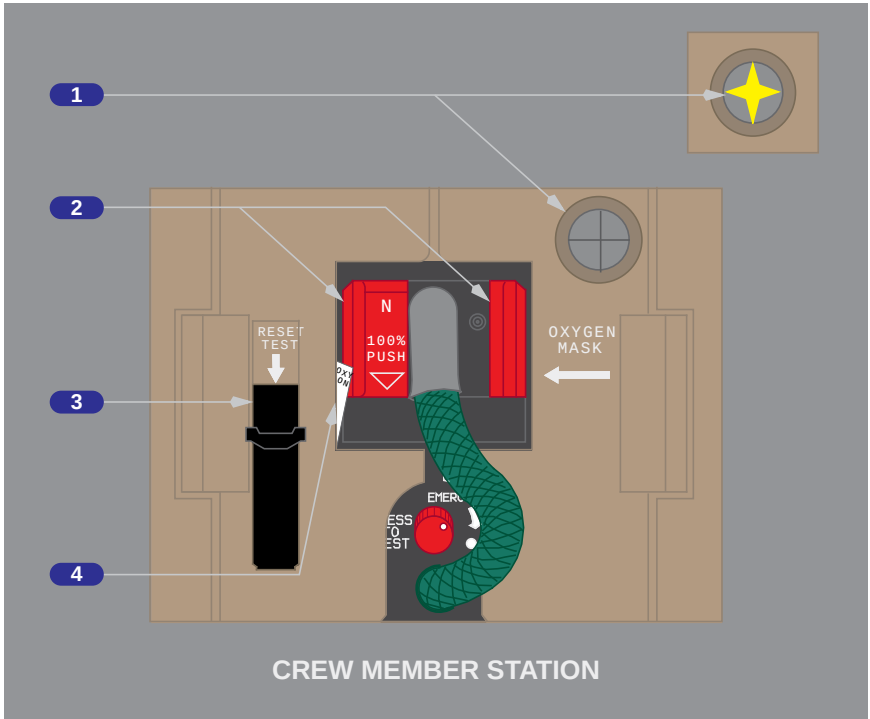
RESET (spring-loaded) - flow control units closed electrically when cabin altitude below 12,000 feet.

NORM (guard closed) - system activates if cabin altitude reaches approximately 14,000 feet.

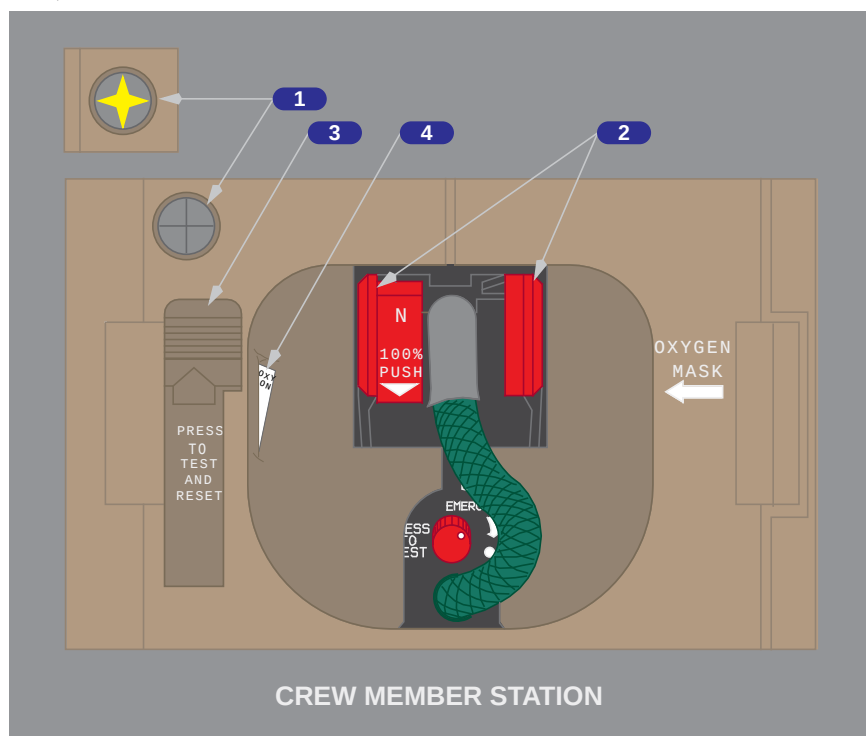
ON (spring-loaded) - passenger cabin oxygen masks drop.

Oxygen Mask Panel

6301 - 6314



6315, 6316



1 Oxygen Flow Indicator

Shows a yellow cross when oxygen flowing.

2 Oxygen Mask Release Levers

Squeeze and pull -

- unlocks oxygen panel doors
- releases mask
- oxygen turns on when oxygen panel doors open
- flow indicator shows a yellow cross momentarily as harness inflates
- when left-hand door opens, activates mask microphone

Squeeze (right lever) - inflates mask harness.

Release - deflates mask harness into position on head and face.

3 RESET/TEST Switch

Push -

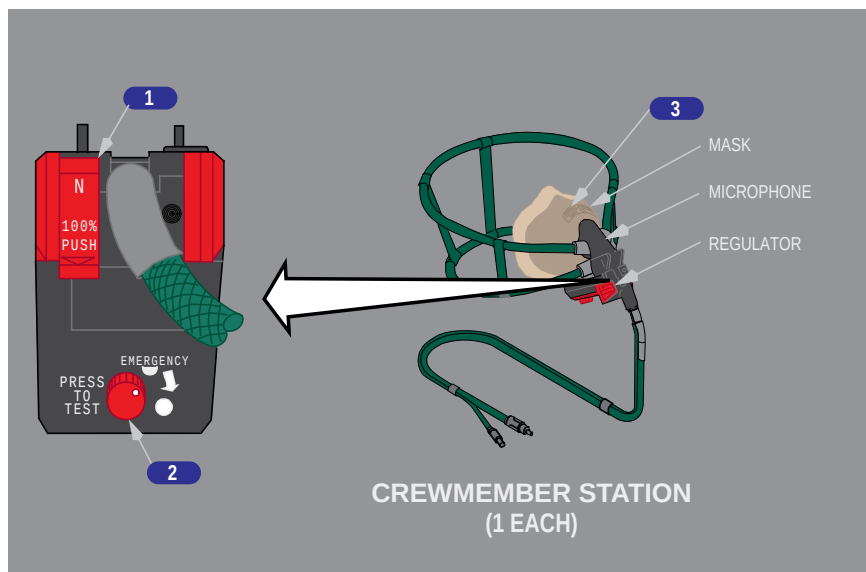
- with left oxygen panel door closed and OXY ON not displayed, turns oxygen on momentarily to test regulator
- with the left oxygen panel door closed and the OXY ON flag displayed, turns oxygen off, deactivates the mask microphone, and activates the boom microphone

4 Oxygen (OXY) ON Flag

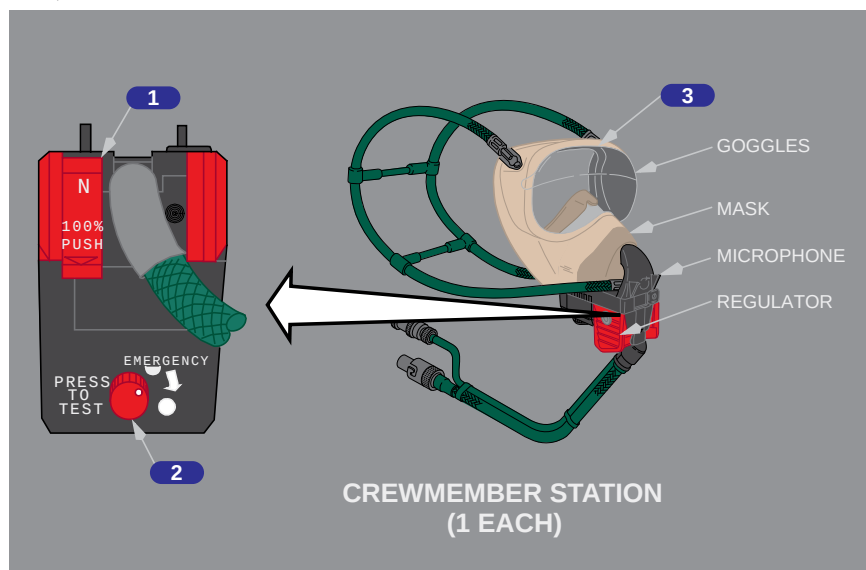
In view - oxygen is on.

Oxygen Mask and Regulator

6301 - 6314



6315, 6316



1 NORMAL/100% Switch

N - supplies an air/oxygen mixture on demand (the ratio depends on cabin altitude).

100% - supplies 100% oxygen on demand (not an air/oxygen mixture).

2 Oxygen Mask Emergency/Test Selector

Rotate (in the direction of the arrow) - supplies 100% oxygen under positive pressure at all cabin altitudes (protects against smoke and harmful vapors).

PRESS TO TEST- tests the positive pressure supply to the regulator.

3 Smoke Vent Valve Selector

6301 - 6314

Up - vent valve closed.

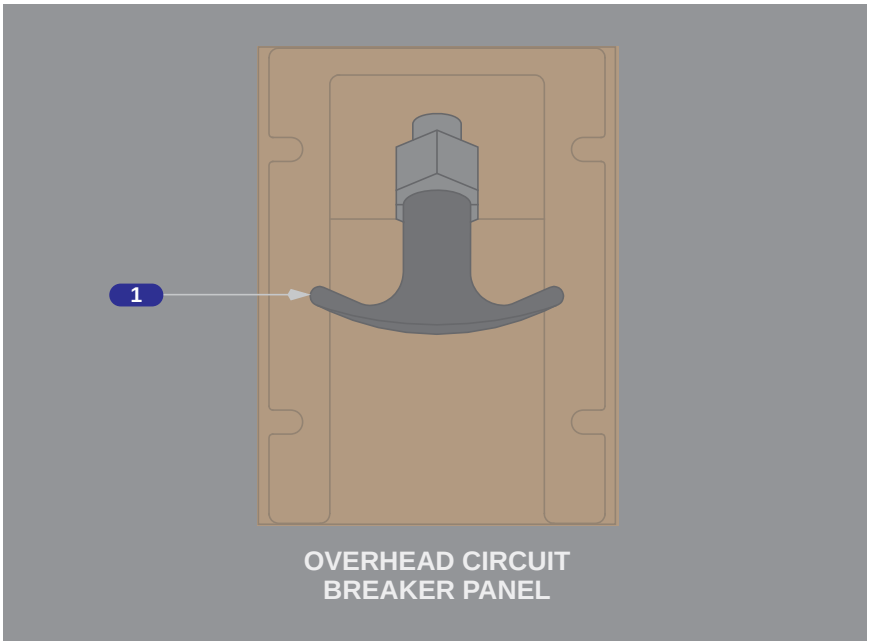
Down - vent valve open, allowing oxygen flow to smoke goggles.

3 Protective Strip

6315, 6316

There is a protective strip of clear plastic on the top portion of the lens. In case of condensation build-up caused by rapid depressurization, vision can be restored by peeling off this strip using the tab on the right side.

Smoke Evacuation Handle



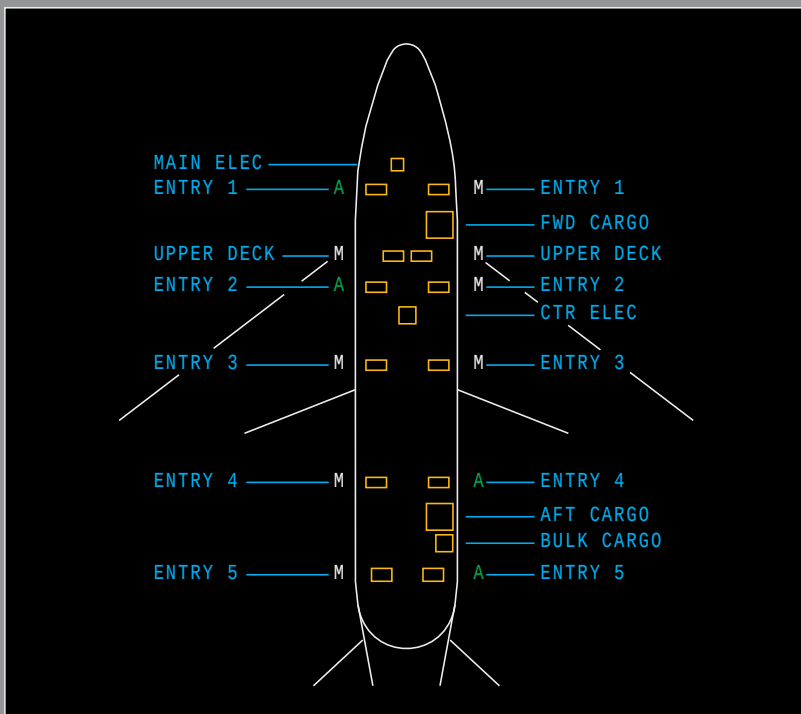
1 Smoke Evacuation Handle

Pull -

- opens flight deck smoke evacuation port
- effective only if airplane pressurized

Doors

Doors Synoptic Display



SECONDARY EICAS DISPLAY

 (AMBER) - DOOR OPEN
(BLANK) - DOOR CLOSED

CYAN NOMENCLATURE
DISPLAYED CONTINUOUSLY

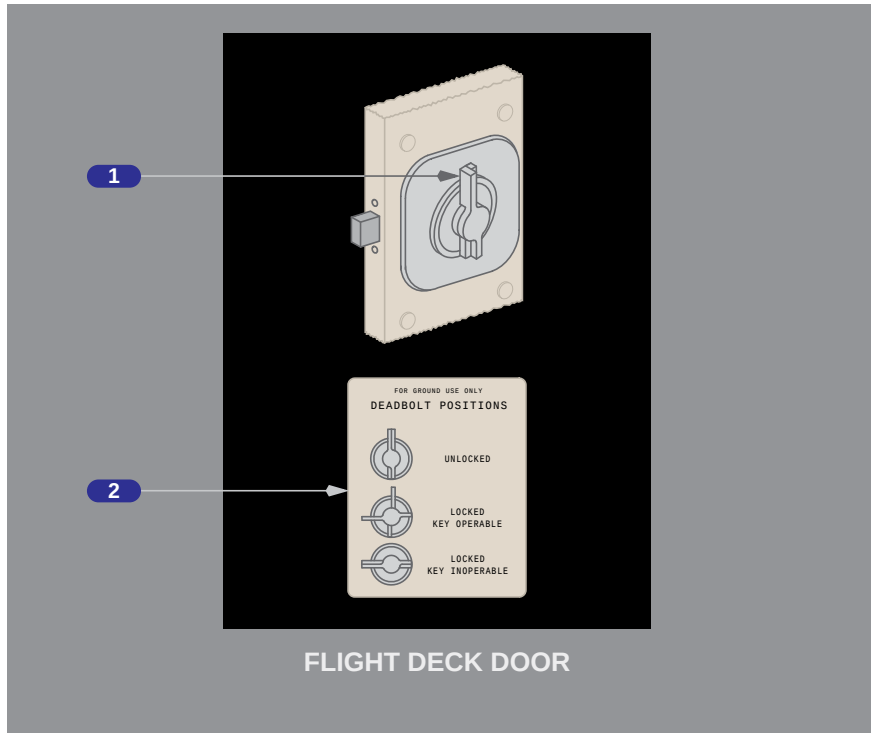
M (WHITE) - DOOR MODE SELECT
LEVER IN MANUAL POSITION

A (GREEN) - DOOR MODE SELECT
LEVER IN AUTOMATIC POSITION

Note: Overhead Escape Hatch is not depicted.

Flight Deck Door

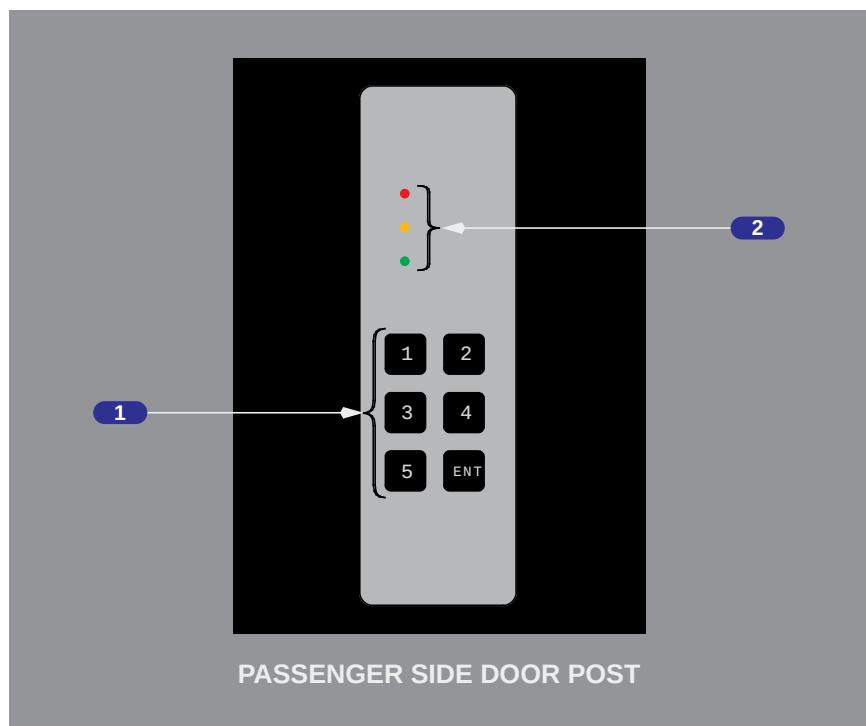
Deadbolt



1 Deadbolt Levers

2 Deadbolt Positions Placard

Flight Deck Emergency Access Panel



1 Keypad

Push - enters 3 to 8 digit emergency access code by pressing numeric then “ENT” keys. Entry of correct emergency access code sounds flight deck chime.

2 Access Lights

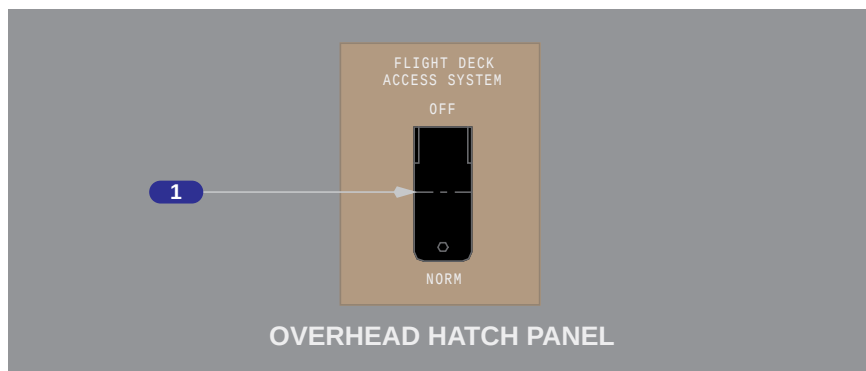
Illuminated (red) - activated

- door locked or Flight Deck Access switch OFF.

Illuminated (amber) - correct emergency access code entered.

Illuminated (green) - door unlocked.

Flight Deck Access System Switch



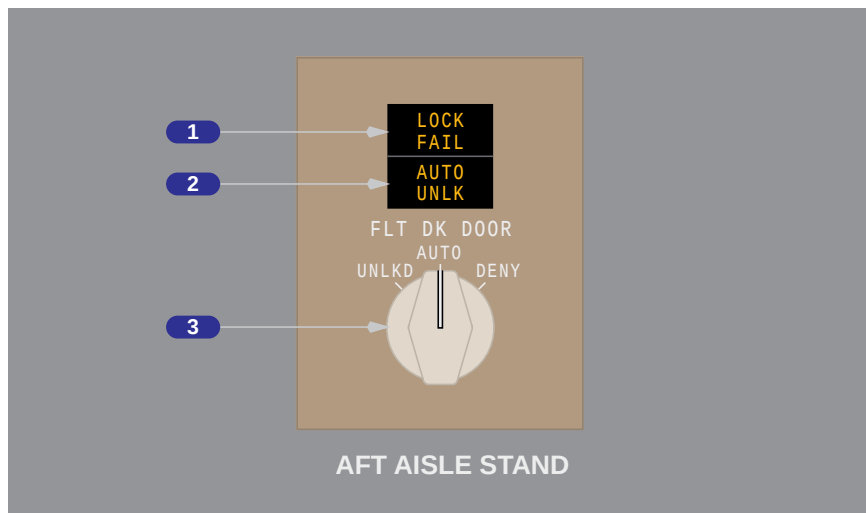
1 Flight Deck Access System Switch

OFF - removes electrical power from door lock.

NORM (Normal) - flight deck access system configured for flight.

Note: Not safety wired

Flight Deck Door Lock Panel



1 LOCK FAIL Light

Illuminated (amber) - Flight Deck Door Lock selector in AUTO and door lock has failed or Flight Deck Access System switch in OFF.

2 AUTO Unlock (UNLK) Light

Illuminated (amber) - correct emergency access code entered in keypad. AUTO UNLK light flashes and continuous chime sounds before timer expires and door unlocks.

3 Flight Deck (FLT DK) Door Lock Selector

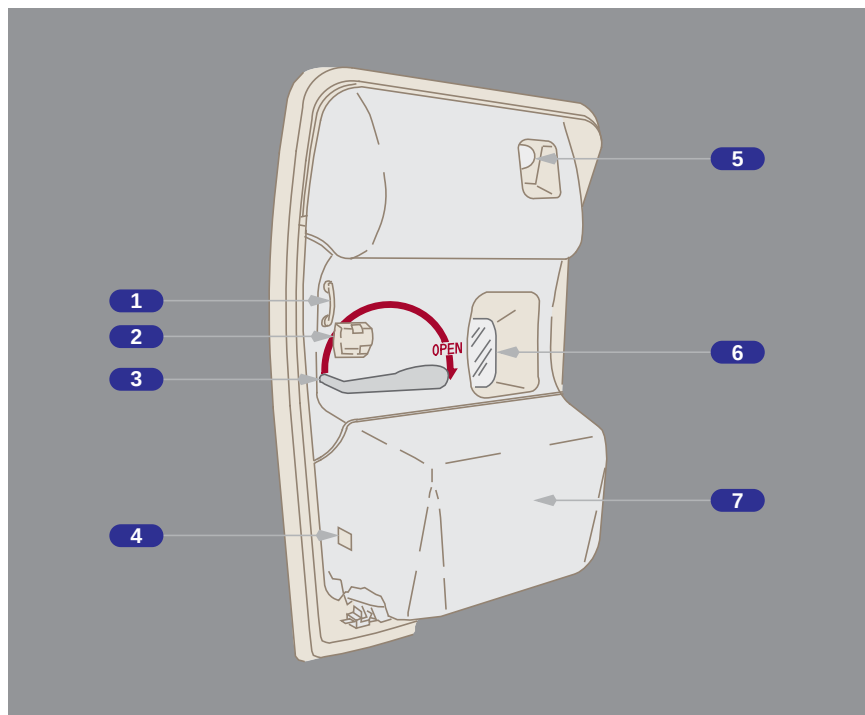
Spring loaded to AUTO. Selector must be pushed in to rotate from AUTO to UNLKD. Selector must not be pushed in to rotate from AUTO to DENY.

UNLKD - door unlocked while selector in UNLKD.

AUTO - door locked. Allows door to unlock after entry of emergency access code and expiration of timer, unless crew takes action.

DENY - rejects keypad entry request and prevents further emergency access code entry for a time period.

Passenger Entry Doors



1 Door Assist Handle

Allows manual assistance of door-opening motion.

2 Door Mode Select Panel

See following graphic.

3 Door Operating Handle

To open the door - rotate in the direction of arrow.

To close the door - rotate in the opposite direction of arrow.

4 Slide/Raft Gas Bottle Pressure Gage

Maintenance use only.

5 Escape Slide Lamp

Illuminates escape slide if door opened in automatic mode.

6 Viewing Window

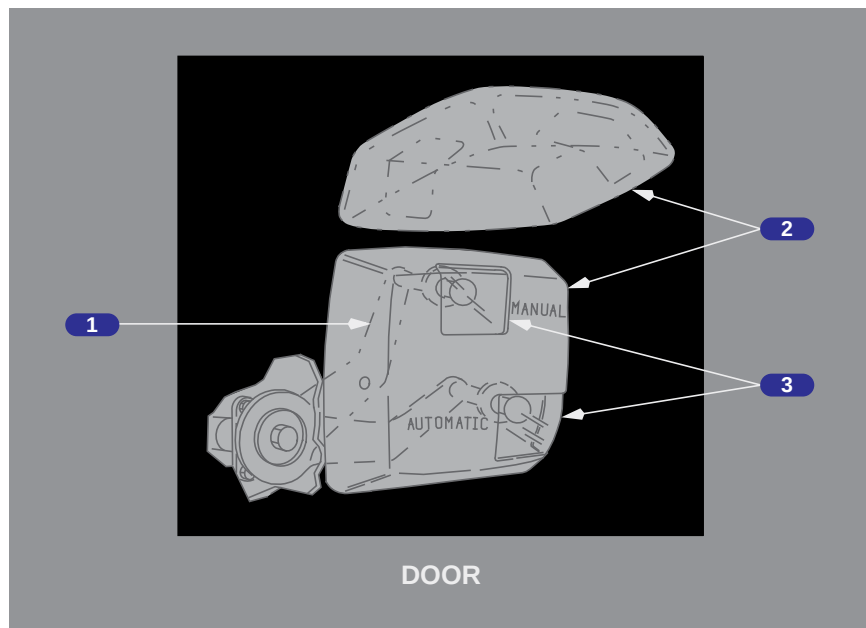
Allows observation outside the airplane.

7 Slide/Raft Bustle

Bustle contains the slide/raft.

Door Mode Select Panel

When door is opened from outside, door mode select lever moves to MANUAL. Lockout pin with warning flag may be installed. Lockout pin prevents handle movement from MANUAL.



1 Door Mode Select Lever

AUTOMATIC - if door operating handle moved to open position, door is powered open, and slide/raft deploys.

MANUAL - disables power assist door opening and automatic slide/raft deployment.

2 Access Cover

Open - allows access to door mode select lever.

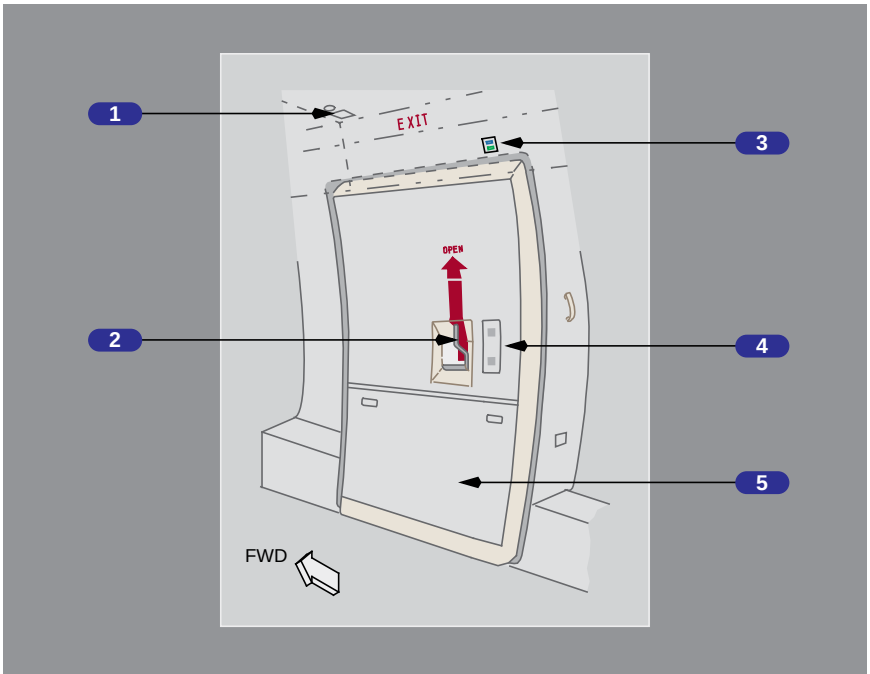
Closed - allows verification of door mode select lever position.

3 Clear Plastic Viewports

AUTOMATIC - knob visible in viewport verifies automatic mode armed.

MANUAL - knob visible in viewport verifies manual mode selected.

Upper Deck Emergency Doors



1 Door Operating Gas Bottle Pressure Gage

If gage needle is below green zone, system is unusable.

2 Door Operating Handle

OPEN -

- unlatches door and permits opening
- deploys slide with door mode select lever in AUTOMATIC

Down - closes door and engages latches.

3 Door Ground Mode Light/Battery Test Panel

See following graphic.

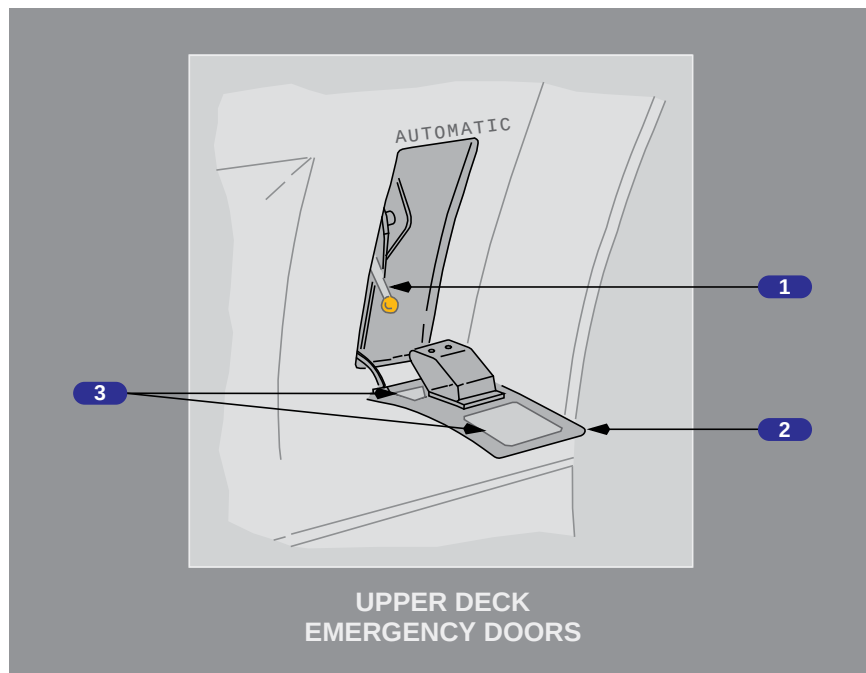
4 Door Mode Select Lever

See Upper Deck Emergency Door Mode Select Panel (next page).

5 Escape Slide Pack

- pressure in slide inflation bottles checked by maintenance
- rotates through the door opening when door is opened with door mode select lever in AUTOMATIC

Upper Deck Emergency Door Mode Select Panel



1 Door Mode Select Lever

AUTOMATIC - if door operating handle moved to open position, door is powered open, and slide/raft deploys.

MANUAL - disables power assist door opening and automatic slide/raft deployment.

2 Access Cover

Open - allows access to door mode select lever.

Closed - allows verification of door mode select lever position.

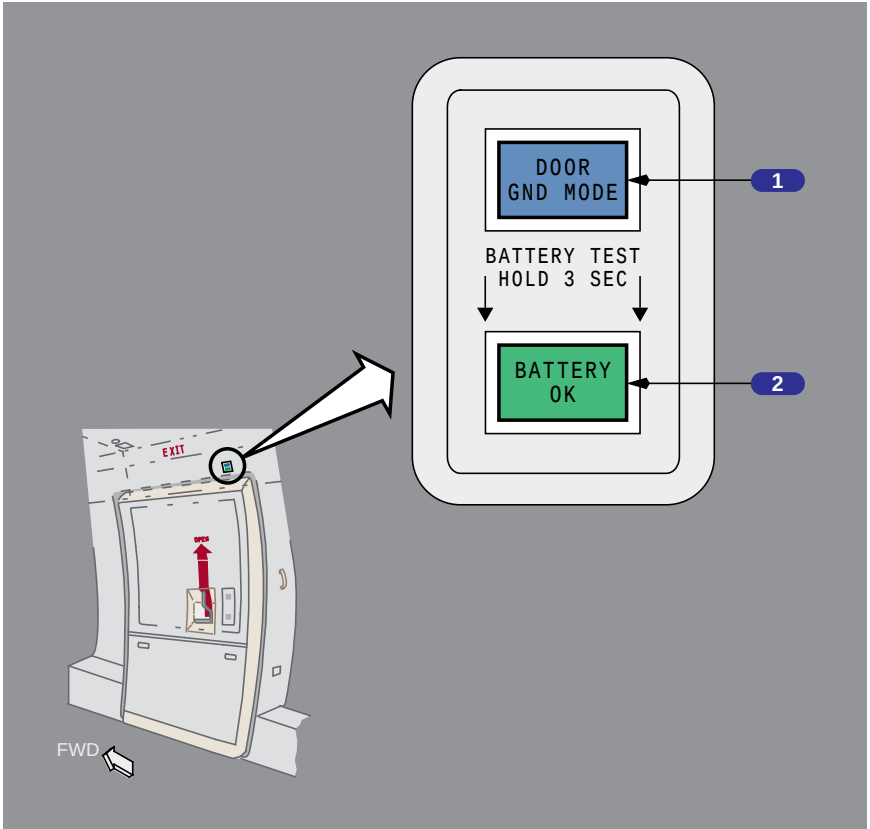
Cover will not close unless door mode select lever fully in **MANUAL** or **AUTOMATIC** position.

3 Clear Plastic Viewports

AUTOMATIC - knob visible in viewport verifies automatic mode armed.

MANUAL - knob visible in viewport verifies manual mode selected.

Door Ground Mode/Battery OK Panel



1 DOOR Ground (GND) MODE Light

Illuminated - on ground or in flight when the flight lock mechanism is not in the locked position.

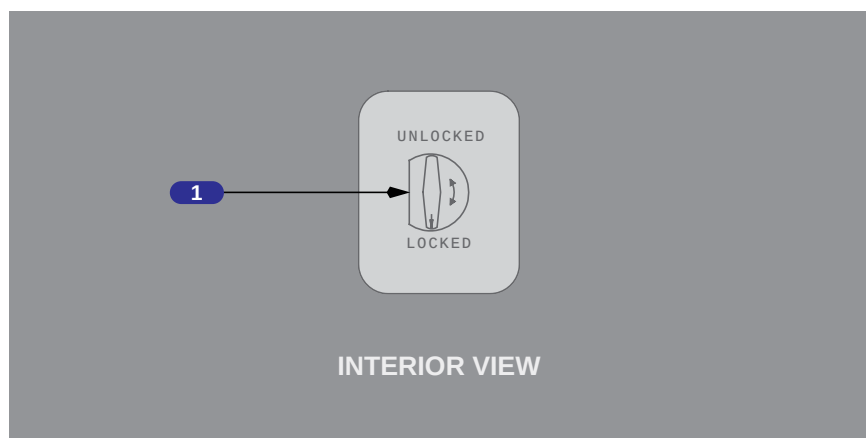
2 BATTERY OK Test Switch/Light

Push -

Illuminated (green) - battery charge is sufficient for door operation.

Note: Light must be pushed and held for 3 - 5 seconds before it will illuminate.

Overhead Escape Hatch Handle



1 Overhead Escape Hatch Handle

Rotate handle to unlock hatch.

Pull hatch inward.

Airplane General, Emergency Equipment, Doors, Windows Systems Description

Chapter 1

Section 40

Introduction

This chapter describes miscellaneous airplane systems, including:

- lighting systems
- oxygen systems
- emergency equipment
- doors
- flight deck seats

Lighting Systems

Lighting systems described in this chapter include:

- exterior lighting
- flight deck lighting
- passenger cabin lighting
- emergency lighting

Exterior Lighting

Exterior lighting consists of these lights:

- landing
- runway turnoff
- taxi
- strobe
- beacon
- navigation (position)
- logo
- wing leading edge illumination
- escape slide emergency lights

Landing Lights

Two landing lights are installed in the leading edge of each wing.

With the Landing Gear lever UP or OFF and the Landing Light switch ON, the wing landing lights are dimmed. With the Landing Gear lever in DOWN position and the switches ON, the wing landing lights are maximum brightness.

Runway Turnoff Lights

Two runway turnoff lights are mounted on the nose gear structure and are aimed approximately 65 degrees to left and right of the airplane center line. The runway turnoff lights illuminate only when the air/ground sensing system is in ground mode.

Taxi Lights

Two taxi lights are installed on the nose landing gear. The taxi lights illuminate only when the air/ground sensing system is in the ground mode.

Strobe Lights

The strobe lights are white anticollision strobe lights located on each forward wing tip and on the tail cone.

Beacon Lights

The beacon lights are red anticollision strobe lights located on the top and bottom of the fuselage.

Navigation Lights

The navigation lights are standard red (left forward wingtip), green (right forward wingtip), and white (tail cone) position lights.

Logo Lights

Logo lights are located on the stabilizer to illuminate the airline logo on the vertical tail surface.

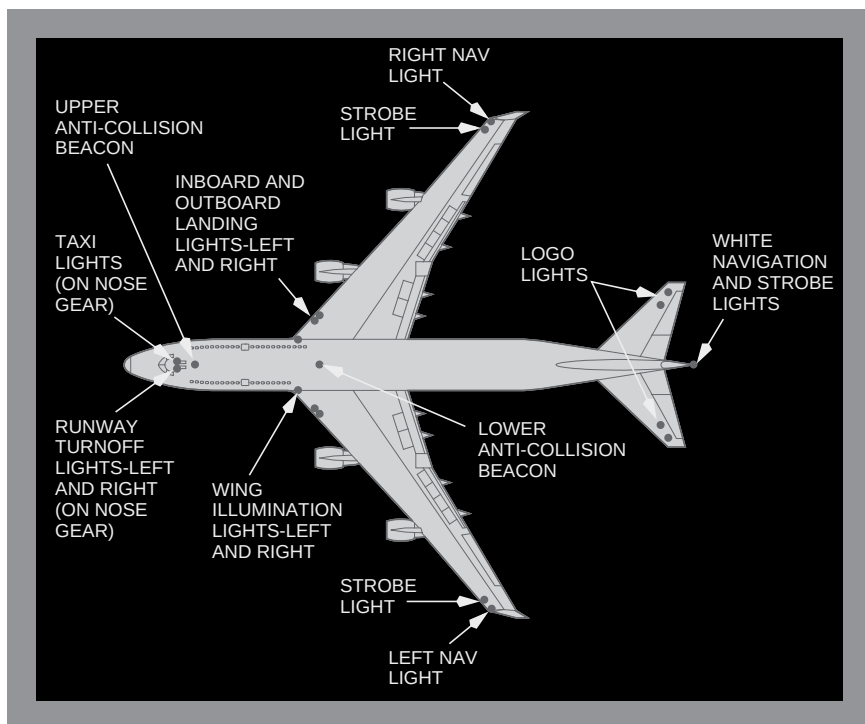
Wing Lights

Wing lights are installed on the fuselage and illuminate the wings and engine nacelles.

Service Lights

Service lights are located at various work areas, such as the wheel wells. Switches for these lights are located at the individual service areas.

Exterior Lighting Locations



Flight Deck Lighting

Flight deck lighting provides panel illumination, area lighting, and localized illumination. Flood lights and light plates provide panel illumination. Dome lights provide flight deck area lighting. A chart light and a utility light for each pilot, and map lights provide localized illumination.

Panel and flood lights illuminate the forward panels, glareshield, and aisle stand panels. When the Storm Light switch is on, the left and right forward panel flood lights, glare shield flood lights, dome lights, and aisle stand flood light illuminate at full brightness.

If normal electrical power is lost, the flood lights operate from standby electrical power. If normal power is lost to aisle stand integral panel lights, the aisle stand flood light illuminates at a reduced intensity.

Passenger Signs

The FASTEN SEAT BELTS signs are controlled by a selector on the aisle stand and illuminate when the following conditions are satisfied:

FASTEN SEAT BELTS signs (AUTO selected):

- landing gear not up and locked or
- flap lever not up, or
- airplane altitude below 10,300 feet, or
- cabin altitude above 10,000 feet, or
- passenger oxygen on

The FASTEN SEAT BELTS signs can be controlled manually by positioning the Seat Belts selector to ON or OFF. When the Seat Belts selector is in OFF position, and oxygen is ON, the FASTEN SEAT BELTS signs illuminate.

RETURN TO SEAT signs illuminate with the FASTEN SEAT BELTS signs, except when oxygen is deployed.

The memo message SEATBELTS ON displays when FASTEN SEAT BELTS signs are manually selected ON.

The memo message NO SMOKING ON is displayed when NO SMOKING signs are manually selected ON whenever power applied to the aircraft.

When FASTEN SEAT BELTS signs and NO SMOKING signs are both selected ON, the memo message PASS SIGNS ON displays, and memo messages SEATBELTS ON and NO SMOKING ON are inhibited.

When the FASTEN SEAT BELTS signs illuminate or extinguish, a low tone sounds over the PA system.

The NO SMOKING signs are permanently illuminated and cannot be controlled by the No Smoking selector.

Emergency Lighting

Interior emergency lighting consists of door, aisle, escape path, exit lights, and luminescent exit signs.

Escape path lighting consists of seat mounted locator lights spaced at intervals. Lights are also located on the stairway.

Additional battery powered exit identifier lights are located at each cabin exit.

When illuminated, the escape path lighting provides visual guidance for emergency evacuation if all sources of cabin lighting more than four feet above the aisle floor are obscured by smoke.

Exterior emergency lighting consists of escape slide and overwing lights.

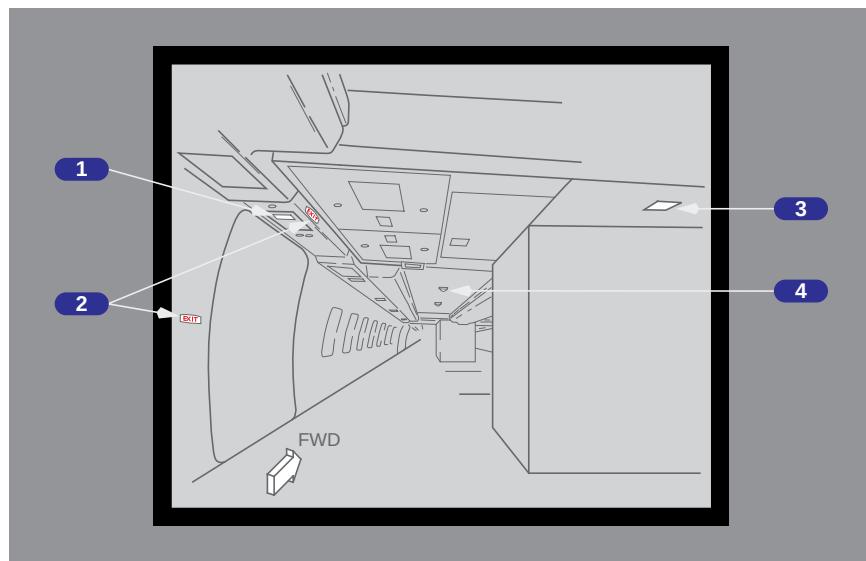
Emergency lighting is controlled by the Emergency Lights switch on the overhead panel. The switch can be used to manually activate or arm the system for automatic operation. Automatic operation occurs if DC power fails or is turned off when the system is armed. The emergency lighting system can also be controlled by the Emergency Lights switch on the main flight attendant switch panel.

When the Emergency Lights switch in the flight deck is armed, and the door mode select lever is in the armed position, moving the door handle to the open position causes the exterior fuselage light and the interior emergency lights at that door to illuminate.

The emergency lighting system is powered by remote batteries. Battery charge is maintained by DC bus 4. A fully charged battery provides at least 15 minutes of operation.

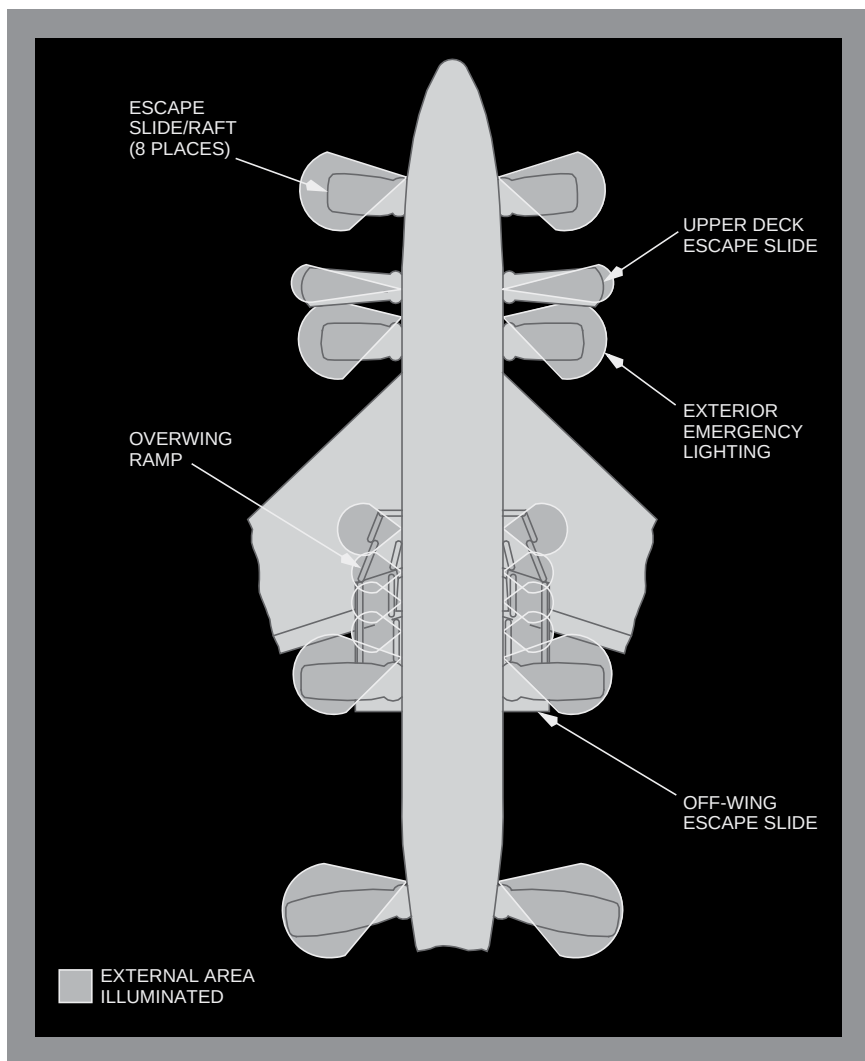
Interior Emergency Lighting Locations

All Emergency lights and EXIT signs are powered by remote NiCad batteries and are controlled by the Emergency Lights switch.



- 1** Emergency Door Light
- 2** EXIT Signs
- 3** Emergency Cross Aisle Light
- 4** Emergency Aisle Lights

Exterior Emergency Lighting Locations



Oxygen Systems

Two independent oxygen systems are provided, one for the flight crew and one for the passengers. Portable oxygen cylinders are located in the passenger cabin for emergency use.

Oxygen pressure displays on the EICAS STATUS page.

Flight Crew Oxygen System

6301 - 6314

The flight crew oxygen system uses quick-donning diluter-demand masks located at each crew station. Oxygen flow is controlled by a regulator mounted on each mask.

6315, 6316

The flight crew oxygen system uses quick-donning diluter-demand full-face masks located at each crew station. Oxygen flow is controlled by an automatic pressure breathing regulator mounted on each mask.

During the preflight check of the crew oxygen mask, a pressure decrease may indicate the crew oxygen cylinder shutoff valve is closed, and oxygen is unavailable.

Squeezing the red release levers with the thumb and forefinger allows the mask to be removed from stowage, inflates the mask harness and momentarily displays the yellow cross in the flow indicator. Releasing the levers after placing the mask over the head deflates the mask harness, fitting it securely to the head and face.

When the left-hand door to the mask stowage box is opened, the mask microphone activates in the removed mask.

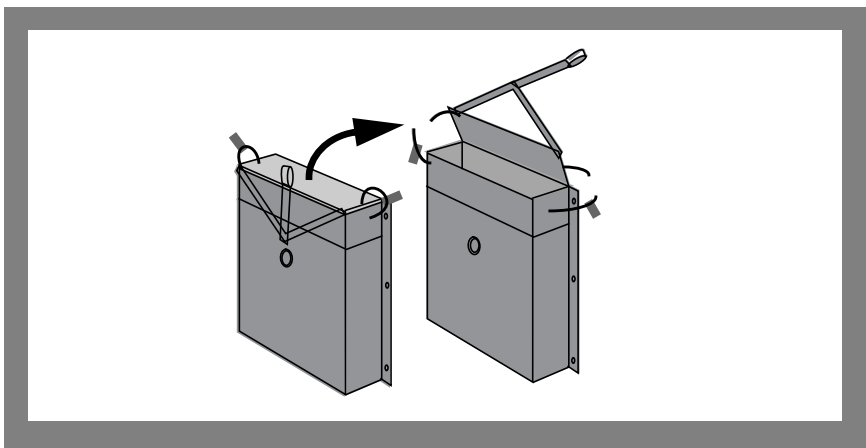
An OXYGEN ON flag appears in the mask compartment near the left-hand door of the stowage box, indicating the oxygen supply valve is open. The oxygen system is shut off by closing the left-hand door of the stowage box and pushing and releasing the RESET/TEST switch. This action shuts off oxygen to the mask, stows the flag, deactivates the mask microphone, and activates the boom microphone. The oxygen system can be reactivated by opening the left-hand door of the stowage box.

Portable Protective Breathing Equipment

Protective Breathing Equipment (PBE/Smoke Hood) devices for crew use (for combating fires and/or entering areas of smoke or fume accumulation) may be stowed throughout the airplane; however, they are normally found in the forward and aft sections of the passenger cabin. The device is placed over the head and, when activated, provides 15 minutes of oxygen. Manufacturer's operating instructions are placarded on the container.

The PBE is designed to protect crewmembers from the effects of smoke, heat, carbon dioxide or other harmful gases while combating fires onboard the airplane.

The preflight consists of inspecting the red seals and checking that the PBE is intact. If a seal is broken, refer to the MDM for dispatch procedures.



To Operate the PBE

- Remove the pouch from the compartment.
- Open the pouch by pulling the loose ends apart.
- Remove and unfold the hood.
- Position the hood so the clear side is facing downward, with the neck opening positioned towards you.
- Activate the oxygen flow by pulling apart the two oxygen cylinders sharply. One cylinder discharges rapidly to purge the hood of any contaminated air. In order to receive the full benefit of purging, you must get the hood on quickly (within 15 seconds). The second oxygen cylinder releases slowly, lasting 7-8 minutes. After both cylinders have fully discharged, the hood CO₂ scrubbers provide an additional 7-8 minutes of breathable air.
- Insert hands, palms together, into the neck opening and spread hands to enlarge opening.
- Slip hood over your head.

- Verify oxygen flow by illumination of the flashing green light.

Special Considerations

Once the hood is activated and donned, be aware of the following:

- A good neck seal is important; push long hair into the hood.
- You may experience light headedness; this is due to the relatively high oxygen content in the hood.
- A flashing red light will turn on after 15 minutes, indicating the oxygen supply is depleted. Leave the area, if possible, and remove the hood.
- You may feel warm inside the hood from the combined warmth of your body temperature, your exhaled breath and chemical process within the hood.
- Normal interphone and face-to-face communication procedures are recommended. Use the hand held mic with both flight deck speaker volumes high.
- Your ears may pop as the hood is pressurized.

Passenger Oxygen System

The passenger oxygen system is supplied by bottled gaseous oxygen. The oxygen bottles provide oxygen to the passenger, attendant station, and lavatory service units. The passenger oxygen masks are located above the passenger seats in passenger service units (PSUs). The masks automatically drop from the PSUs if cabin altitude exceeds approximately 14,000 feet. Passenger oxygen masks can be manually deployed from the flight deck by positioning the overhead panel Passenger Oxygen switch to ON position.

Oxygen flow to a mask begins when the mask is pulled down.

Oxygen flow can be reset by selecting the Passenger Oxygen switch to RESET position.

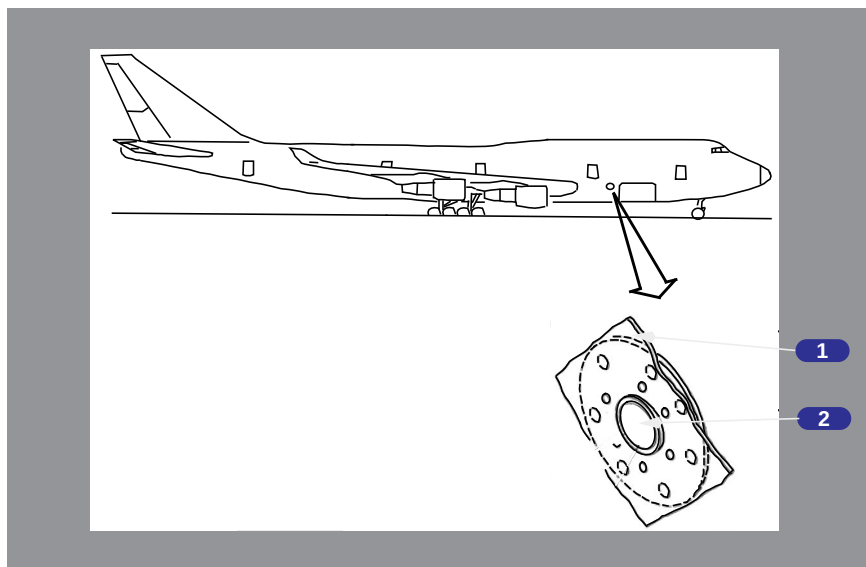
Passenger oxygen pressure displays on the EICAS STATUS page.

Portable Oxygen Bottles

Portable oxygen bottles are stowed in various locations in the passenger cabin, flight crew rest area, and flight deck. The bottles are fitted with disposable masks and are used for first aid (therapeutic) purposes or as walk-around units. All bottles are identical in size and capacity.

Overboard Discharge Port Indicator

One discharge port indicator serves the crew and passenger oxygen. The port is in the fuselage skin aft of the forward cargo door. A green plastic indicator disc seals the port to prevent entry of dirt and moisture. If oxygen pressure becomes excessive and ruptures the frangible disc at the cylinder, the indicator disc will be blown out of the fuselage port, providing visual evidence of the overboard discharge.



1 Airplane Skin

2 Green Indicator Disc

Intentionally
Blank

Airplane General, Emergency Equipment, Doors, Windows Emergency Equipment

Chapter 1

Section 45

Emergency Equipment Overview

This section describes the emergency equipment located throughout the airplane, including:

- emergency evacuation signal system
- fire extinguishers
- emergency equipment locations

Fire Extinguishers

Water and halon fire extinguishers are located throughout the passenger cabin.

Water Fire Extinguishers

Water fire extinguishers contain a solution of water mixed with antifreeze. Water fire extinguishers are to be used on fabric or paper fires only. They are not to be used on electrical or grease fires.

To use the water fire extinguisher, remove it from stowage and rotate the handle fully clockwise. Aim the nozzle at the base of the fire and press the trigger.

WARNING: Antifreeze compound has been added to the water which makes it unfit for drinking.

CAUTION: Do not use on electrical or grease-type fires.

Halon Fire Extinguishers

Halon fire extinguishers contain a liquefied gas agent under pressure. The extinguisher pressure indicator shows three pressure ranges:

- acceptable
- recharge
- overcharged

A safety pin with a pull ring prevents accidental trigger movement. When released, the liquefied gas agent vaporizes and extinguishes the fire. The extinguisher is effective on all types of fires, but is used primarily on electrical, fuel, and grease fires.

Direction for use of the fire extinguisher is printed on the extinguisher.

WARNING: If a halon fire extinguisher is to be discharged in the flight deck area, all flight crew members must wear oxygen masks and use 100% oxygen with emergency selected.

CAUTION: For electrical fires, remove the power source as soon as possible. Avoid discharging directly on persons due to possibility of suffocating effects. Do not discharge too close to fire as the discharge stream may scatter the fire. As with any fire, keep away from the fuel source. Avoid breathing vapors, fumes, and heated smoke as much as possible.

Miscellaneous Emergency Equipment

Additional emergency equipment is stowed at strategic locations throughout the airplane as shown in the Emergency Equipment diagram.

Emergency Locator Transmitter (ELT)

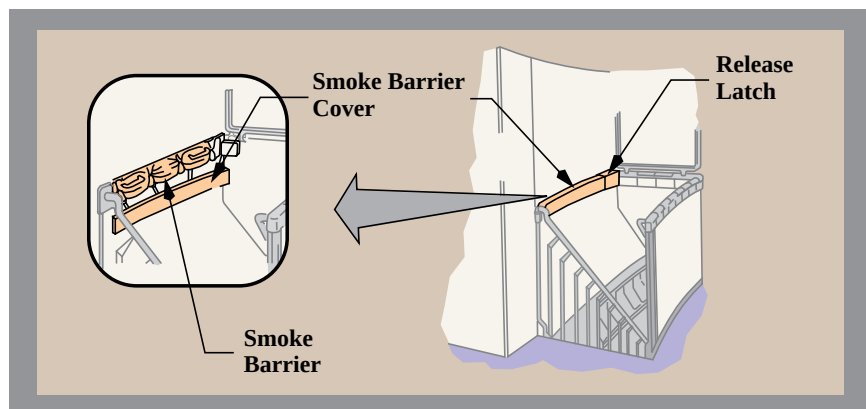
Passenger Cabin

On the passenger airplane, emergency locator transmitters (ELTs) are installed:

- 1 ELT - door 2L
- 1 ELT - door 4L

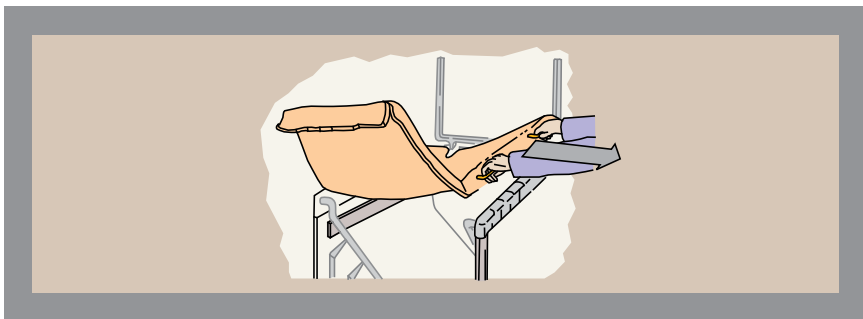
Smoke Barrier

A smoke barrier is installed at the top of the stairs on the upper deck. The smoke barrier may be used on the ground to prevent smoke migration by covering the stairwell between the main deck and the upper deck.

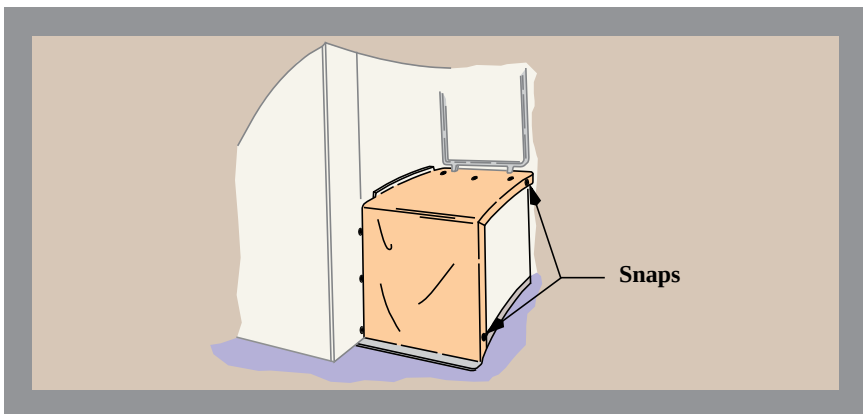


To deploy the smoke barrier:

- pull latch release
 - allows cover to fall free and expose the smoke barrier



- insert fingers in barrier loops
- pull barrier toward railing

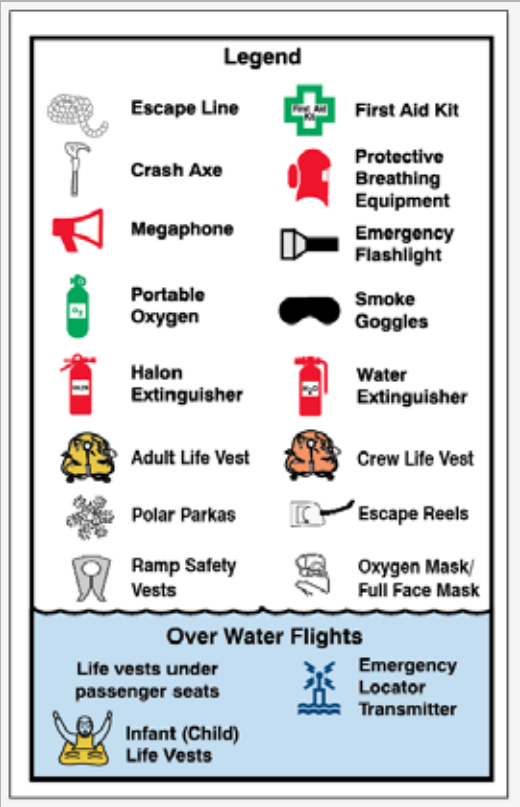


- drape barrier over railing
- engage snaps along top of stairwell and railing sides
- press flap at bottom of barrier against carpet
 - ensures good contact between velcro flap and carpet.

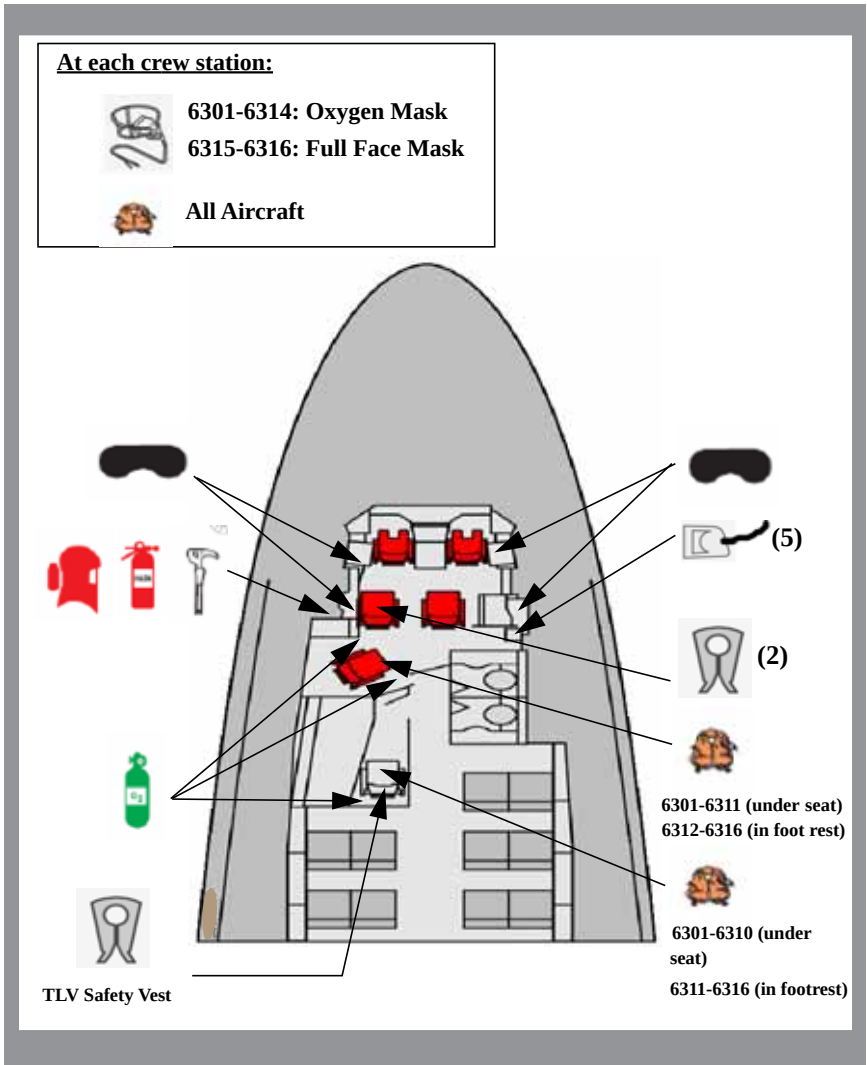
WARNING: The smoke barrier is for ground use only.

Note: The smoke barrier is used on the ground to prevent smoke from rising up the stairway into the upper deck area. In flight, normal airplane ventilation minimizes smoke migration into the upper deck area.

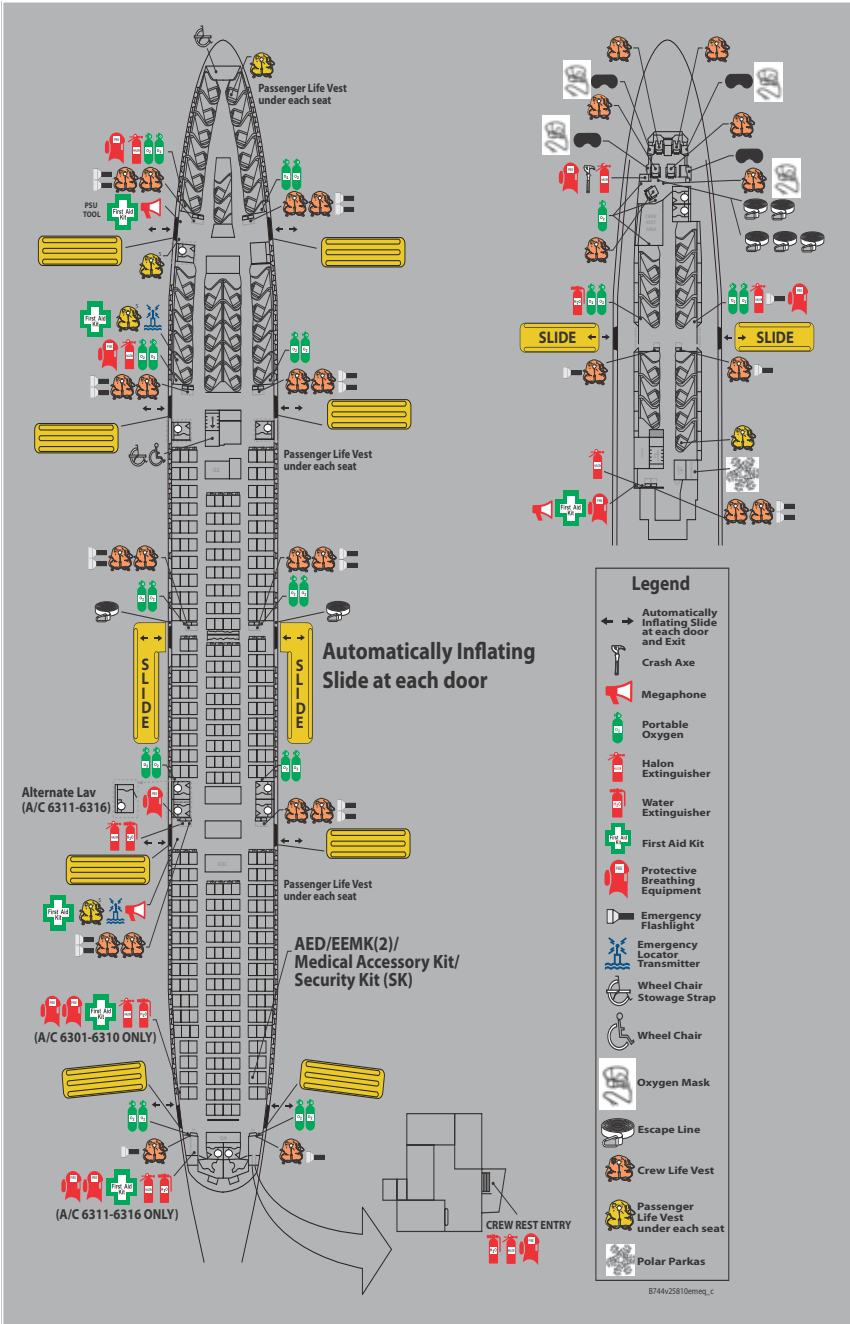
Emergency Equipment Symbols



Emergency Equipment Location Flight Deck



Emergency Equipment Locations



Airplane General, Emergency Equipment, Doors, Windows Systems Description

Chapter 1

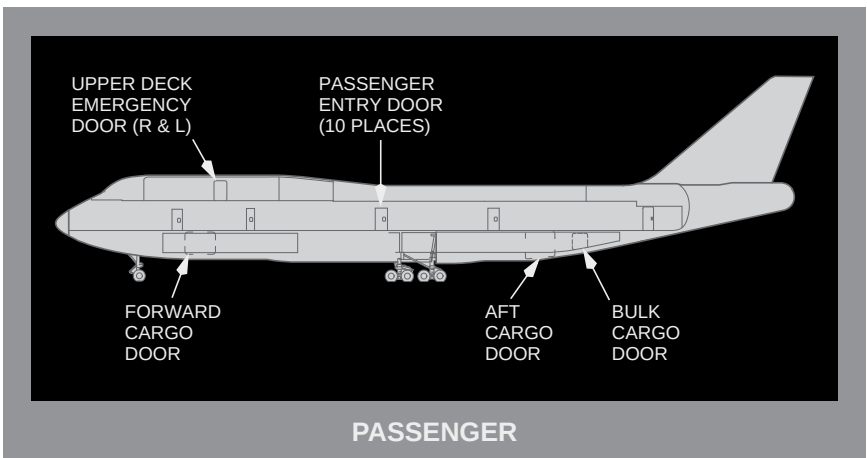
Section 50

Doors

The airplane has ten main deck passenger entry doors, one flight deck door (the flight deck/passenger cabin entry), two upper deck emergency doors, and three cargo doors. It also has two electrical and electronic (E/E) equipment access doors.

CAUTION: Do not operate the entry or cargo doors with winds at the door of more than 40 knots. Do not keep doors open when wind gusts are more than 65 knots. Strong winds can cause damage to the structure of the airplane.

Door Locations



Flight Deck Door

The flight deck door meets requirements for resistance to ballistic penetration and intruder entrance. The door opens into the flight deck. When closed, the door locks when electrical power is available and unlocks when electrical power is removed. A viewing lens in the door allows observation of the passenger cabin. The door can be manually opened from the flight deck by turning the door handle.

The door incorporates a deadbolt with a key lock. Rotating both concentric deadbolt levers to the locked (horizontal) position prevents the passenger cabin key from unlocking the door. Rotating only the forward deadbolt lever to locked allows the key to unlock the door.

The flight deck access system consists of an emergency access panel, a chime module, a Door Lock selector, two indicator lights, and an Access System switch. The emergency access panel includes a six button keypad for entering the numeric emergency access code along with red, amber, and green lights. The red light illuminates to indicate the door is locked. When the correct emergency access code is entered, the amber light illuminates. The green light illuminates to indicate the door is unlocked.

Two indicator lights and a three position rotary Door Lock selector are located on the aft aisle stand. Illumination of the amber LOCK FAIL light indicates the door lock has failed or the Access System switch is in the OFF position.

The emergency access code is used to gain access to the flight deck in case of pilot incapacitation. Annunciation of a flight deck chime and illumination of the amber AUTO UNLK light indicates the correct emergency access code has been entered and the door is programmed to unlock after a time delay. Selecting the DENY position on the Door Lock selector denies entry and prevents further keypad entry for several minutes. To allow entry, the selector is turned to the UNLKD position which unlocks the door while held in that position. If the emergency access code is entered and the pilot takes no action, the door unlocks after expiration of the time delay. Before the door unlocks, the chime sounds continuously and the AUTO UNLK light flashes.

By pressing “1” then “ENT” keys on the emergency access panel, the flight deck chime will sound (if programmed).

The door latch system incorporates a pressure rate-sensor that unlocks the door in the event of flight deck depressurization.

Passenger Entry Doors

The main deck passenger entry doors are used to enter and exit the airplane, and serve as emergency exits. The ten passenger entry doors are paired along the airplane fuselage. The doors are identified 1 through 5 left, and 1 through 5 right. The passenger entry doors can be opened or closed manually from inside or outside of the airplane.

The entry doors are translating, plug-type doors. During opening, the door first moves inward and upward, then translates outward and forward. Each door is held in the open position by a gust lock. The gust lock drops into a latch as the door nears its forward limit of travel. A window in each door allows observation outside the airplane.

Passenger Entry Door 1, 2, 4, and 5 Slide/Raft Operation

When the door mode select lever is in AUTOMATIC position and the door operating handle is rotated 180 degrees, the door begins to open and the power assist opening system activates.

The flight attendant must release the door operating handle and continue to assist the door opening motion by using the assist handles on the door and on the door surround panel until the door is in the full open and latched position. The door-mounted escape slide/raft deploys and inflates. If the slide/raft does not inflate automatically, pulling the manual inflation handle inflates the slide/raft.

When the door is to be opened from the interior and slide deployment is not desired, the door mode select lever must be in MANUAL position.

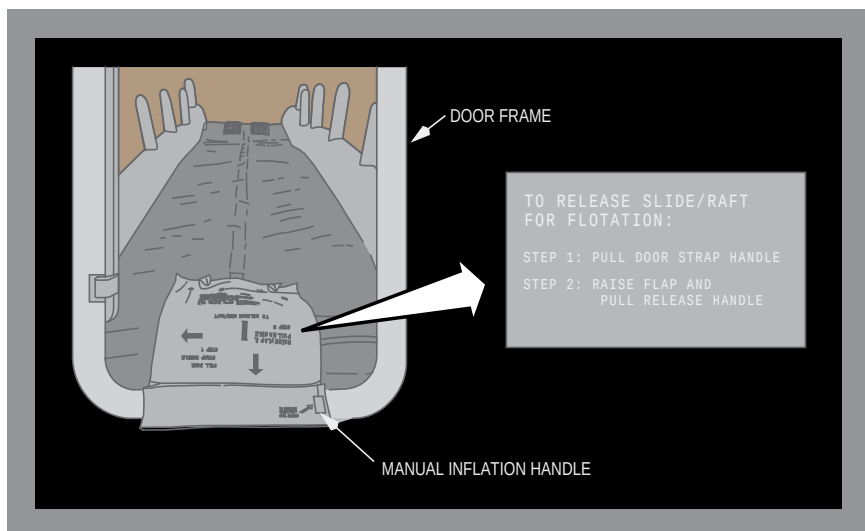
When the door mode select lever is in AUTOMATIC position and the door is opened using the exterior door handle, the door mode select lever mechanically positions to MANUAL and the door may be opened without slide deployment.

When the door is closed using either the exterior or interior door handles, the door mode select lever remains in MANUAL and must be positioned to AUTOMATIC to provide automatic slide deployment.

The door mode select lever should not be moved from MANUAL to AUTOMATIC or AUTOMATIC to MANUAL unless the door is fully closed.

Note: If both body gear are not extended, the airplane may tip tail down on the ground. Door 1 escape slides are then unusable.

Slide/Raft Deployed

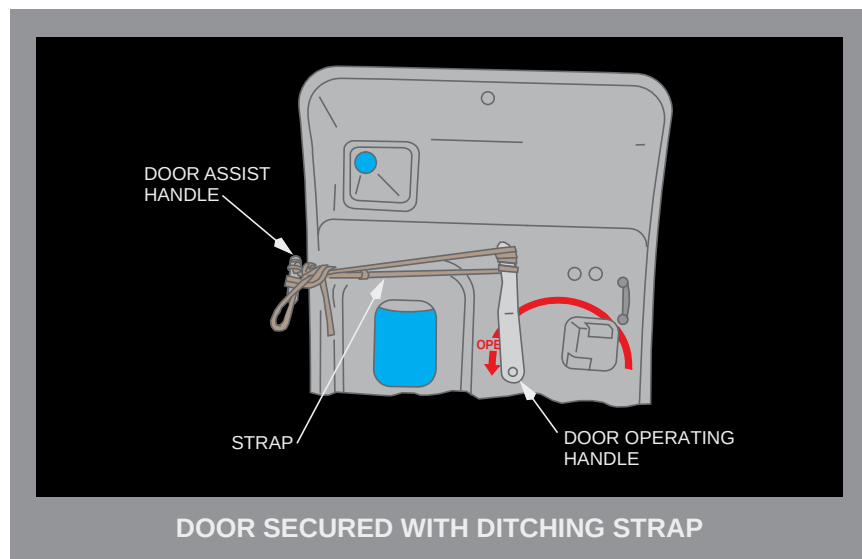


Securing Main Deck Doors 1, 2, 4, or 5 In The Open Position

To accomplish the smoke removal procedure, main entry doors (as designated by the Captain) need to be secured in the partially open position as follows:

- ditching straps forward of doors 3 left and right can be used to secure door 2 or 4 without detaching strap from its compartment
- attach snap end of strap to door assist handle on AFT door frame, place door operating handle to vertical (12 o'clock position), secure handle with several loops, return strap through assist handle and tie as shown below
- pressure on the door maintains tension on the strap so it may be left unattended

Note: If strap is not available, use any satisfactory item in the same manner to secure the doors.



Passenger Door 3

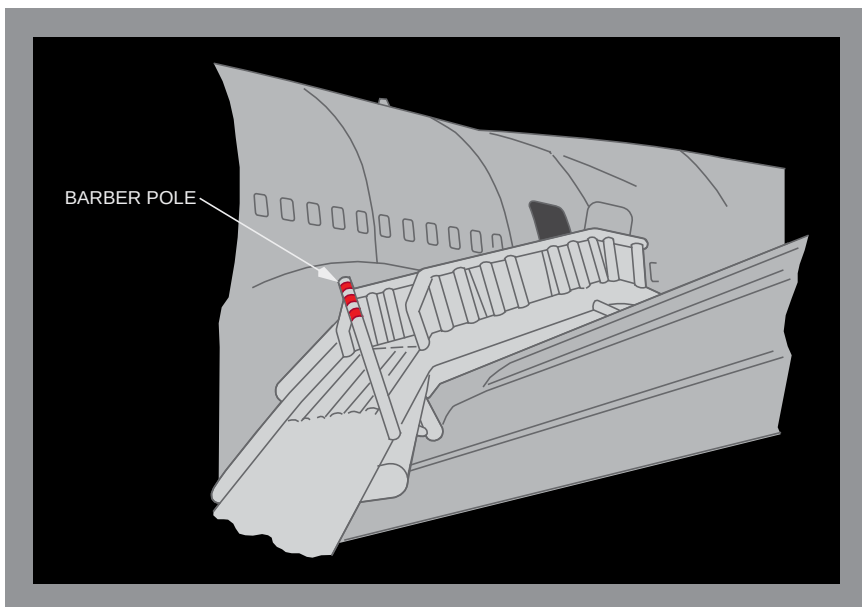
When the door mode select lever is in AUTOMATIC position and the door operating handle is rotated 180 degrees, the door begins to open and the power assist opening system activates.

The flight attendant must release the door operating handle and continue to assist the door opening motion by using the assist handles on the door and on the door surround panel until the door is in the full open and latched position. The door-mounted escape slide deploys and inflates. An off-wing deployment indicator is visible to the flight attendant at door 3 when the off-wing escape slide is properly deployed.

If the ramp/slide does not open automatically, pulling the manual inflation handle inflates it manually.

If door 3 is used during a ditching situation, placing the door mode select lever in MANUAL allows the door to be opened without deploying the ramp slide.

Door 3 Slide Deployed



Upper Deck Emergency Doors

Upper deck doors are used for emergency evacuation only. The escape slides cannot be used as rafts.

With the door mode select lever in AUTOMATIC position, lifting the door operating handle actuates the emergency power system for the door, moving the door up and out to full-open position. The escape slide deploys and inflates as the door opens.

A gas bottle powers each upper deck door opening mechanism. A pressure gage is located above each upper deck door for checking bottle pressure.

A green push-to-test battery OK light is located above each upper deck door.

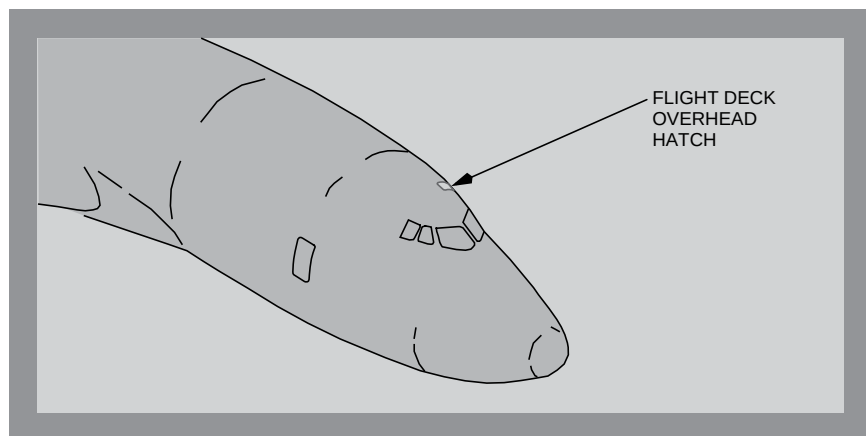
An automatic lock activates in flight to lock the upper deck door operating handles to prevent inadvertent operation. If the automatic lock fails to activate after takeoff, it is possible to open an upper deck door when cabin differential pressure is low.

Flight Deck Overhead Hatch

The flight deck overhead hatch located just aft of the overhead panels can be opened from either inside or outside the airplane.

The hatch is opened from inside the airplane by rotating the interior handle 180° counterclockwise. The hatch is opened from the outside by pressing the release trigger which allows the exterior handle to spring out from its recessed position. Rotating the handle then unlocks the hatch.

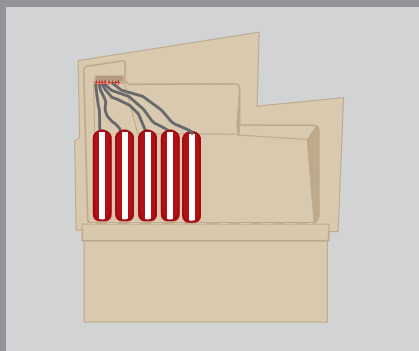
Flight Deck Overhead Hatch Location



Emergency Escape Devices

Five emergency escape devices are stowed adjacent to the flight deck overhead hatch.

The emergency escape device is used by removing it from the holder and departing through the escape hatch opening while holding the device handle. Crew members should hold their hands over their heads and place their backs against the aircraft when departing the aircraft. Inertial reels limit the speed of descent.



EMERGENCY ESCAPE DEVICES

Escape Ropes

Escape ropes, which serve as life lines for passengers evacuating through the overwing exits, are located in overhead compartment at door 3L and 3R. Attachments are located mid-wing.

Cargo Doors

The three cargo doors are on the right side of the airplane. The cargo doors all open upward. The forward and aft cargo doors open outward and the bulk cargo door opens inward.

Both forward and aft cargo doors are normally operated electrically from an exterior or interior fuselage-mounted control panel located with each door. A control panel light indicates cargo door latching. Forward and aft cargo door locking is accomplished manually. If necessary, the forward and aft cargo doors may be operated manually.

The bulk cargo door is manually opened and closed, and is counterbalanced for ease of operation.

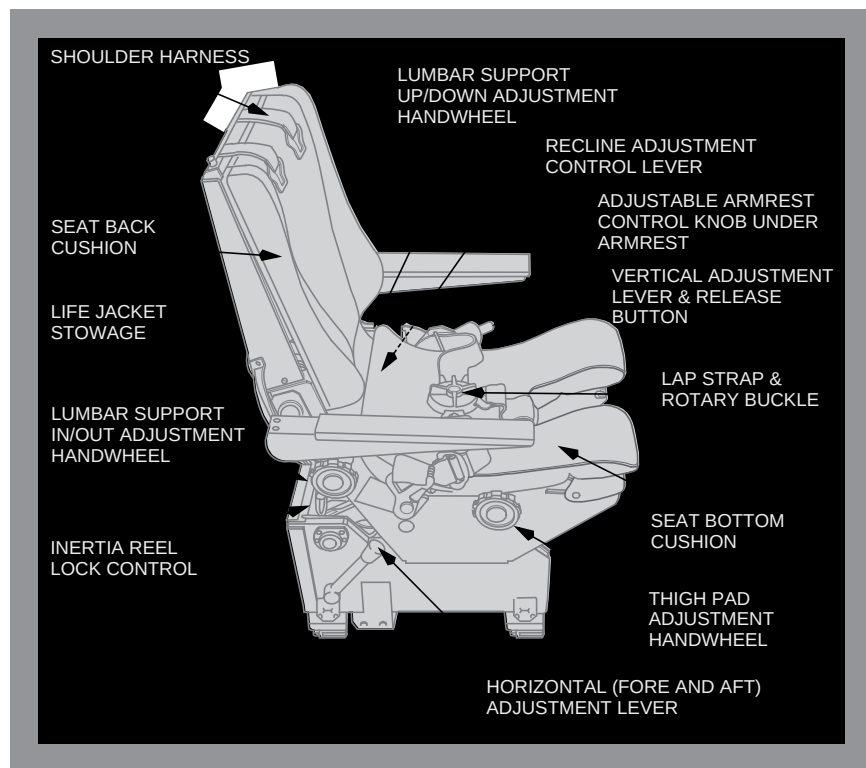
Flight Deck Seats

The flight deck has four seat types:

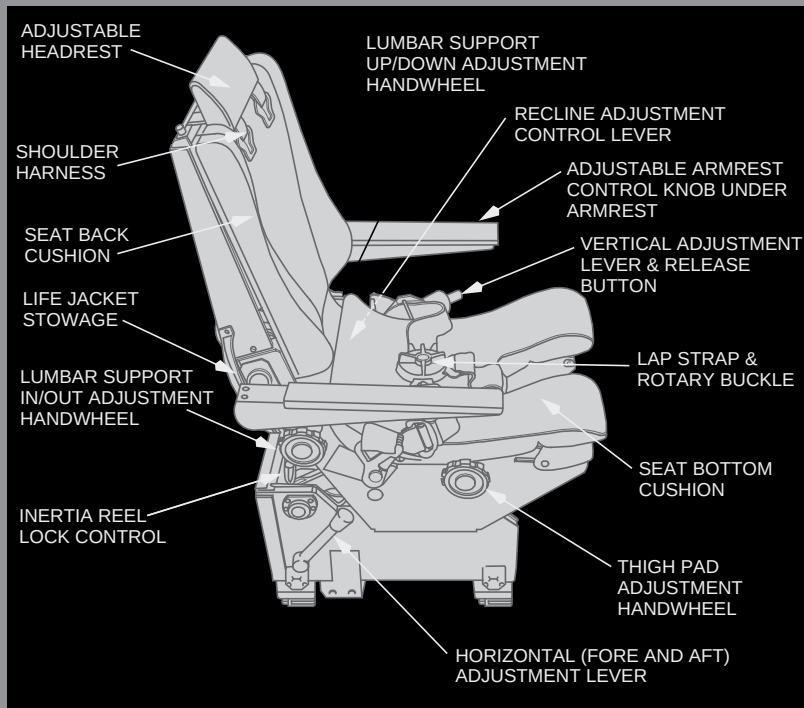
- pilot seats (captain and first officer)
- first observer seat
- second observer seat
- third observer seat

Pilot Seats

6301-6314



6315-6316

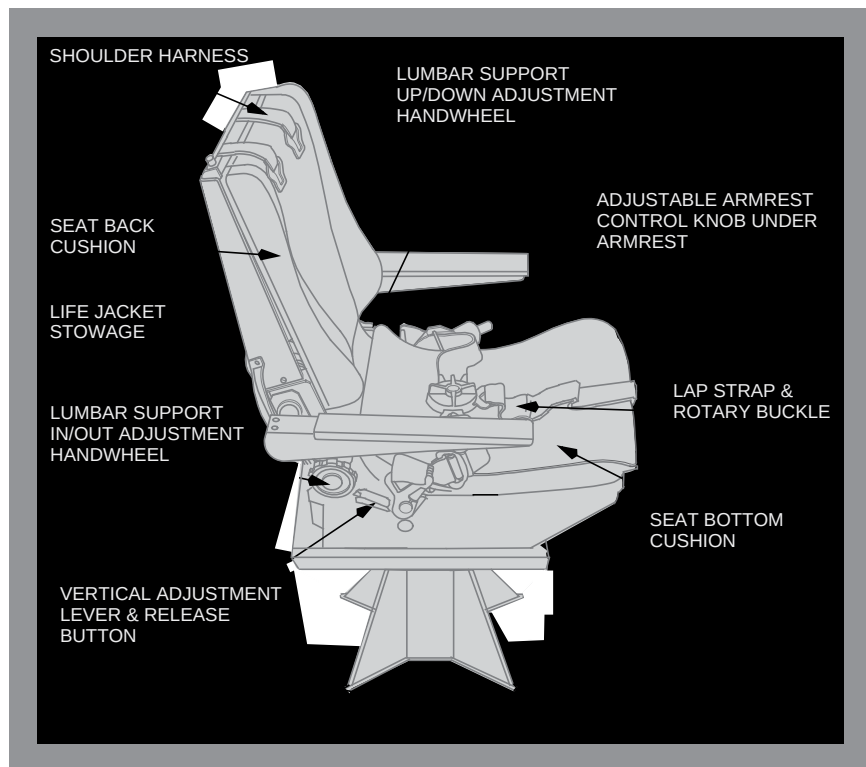


Observer Seats

The first observer seat is pedestal-mounted. It adjusts manually in the vertical, forward, and aft directions. The seat has:

- a folding arm rest on the left side
- lap belt
- crotch strap
- inertial-reel shoulder harness with manual locks

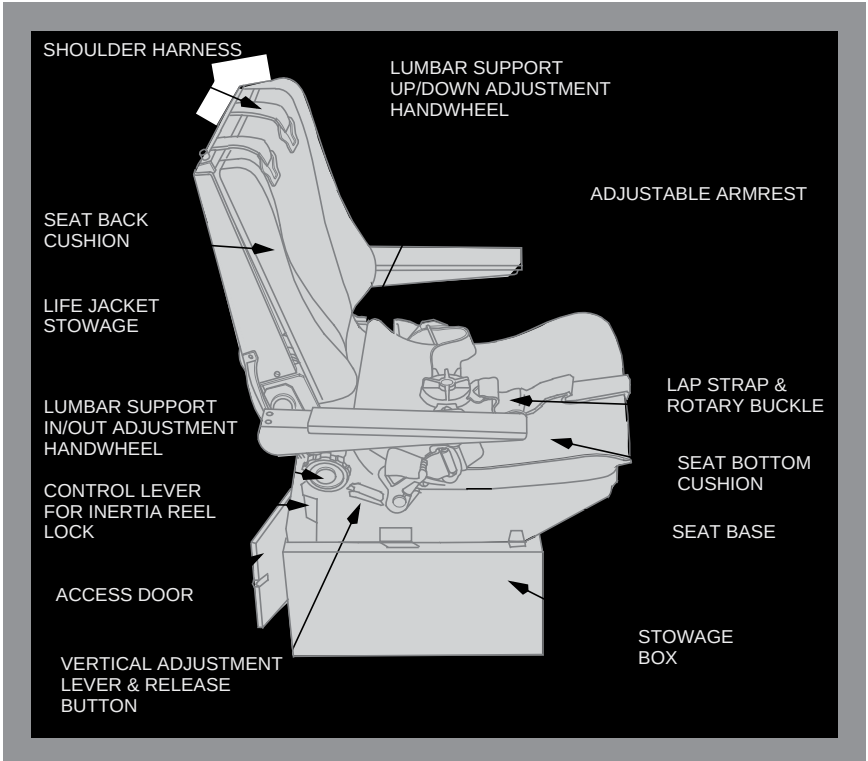
First Observer's Seat



The second observer seat is not adjustable. The seat has:

- folding arm rests
- lap belt
- crotch strap
- shoulder harness with manual locks

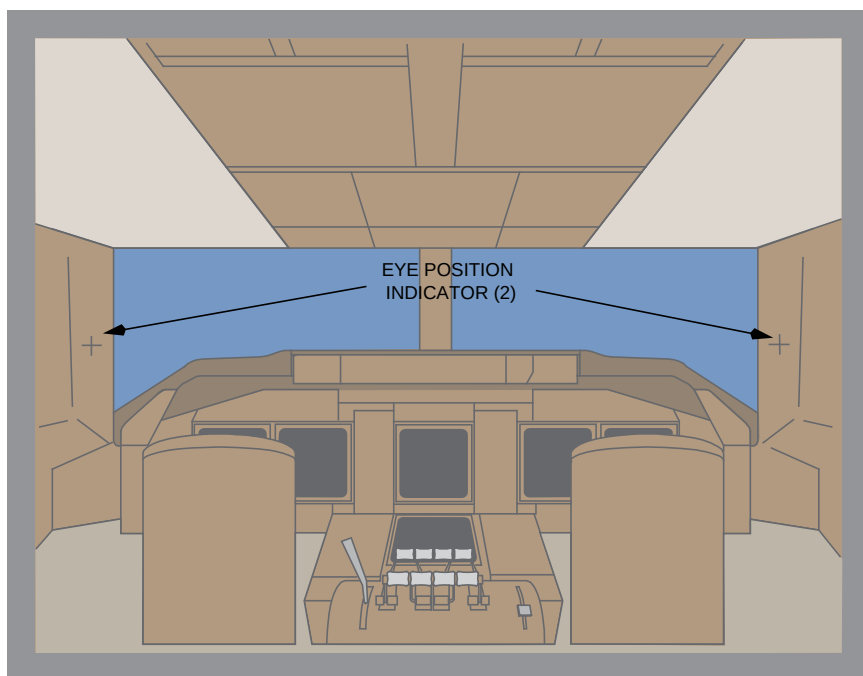
Second Observer's Seat



Optimum Eye Position

Adjusting the seat obtains the optimum eye position as shown on the following illustration. The vertical line on the eye position indicator just passes out of peripheral vision (looking straight ahead) when the seat is properly adjusted.

Note: The recline adjustment will be in an optimum position near or slightly aft of the full upright position.



Seat Belt Airbag System

Airbag equipped seat belts are installed in all Business Elite seats.

The system is specifically designed to improve occupant protection from serious head injury during a survivable crash, and to enhance the occupant's ability to egress the aircraft.

The airbag system is designed with built-in safety features to prevent inadvertent deployment that could result in injury to occupants, crew, or maintenance staff.

The seat belt airbag system consists of the following components:

- Inflator and Inflator Fitting
- Electronics Module Assembly
- Cable Interface Assembly
- Battery

The seat belt uses a lift flap buckle modified to include a magnet that closes the enabling switch upon buckling the seat belt halves. The enabling switch provides circuit continuity when the two seat belt halves are connected, allowing the Electronics Module Assembly (EMA) to activate the system.

The system is battery operated. During normal operations the EMA draws no power from the battery, therefore, the battery service life is defined by the storage life of the battery. Under operating and environmental conditions, the battery service life is seven years.

Proper deployment of the airbag system requires the EMA to recognize and deploy the inflator at a predetermined threshold (G force). The deployment threshold does not allow inadvertent deployment during normal operations such as: hard landing, luggage or food cart strikes on the seat, or random vibration.

Seat Belt Extension Use with the Seat Belt Airbag System

If a seat belt extension is needed in Business Elite, it must be the one specifically designed for the seat belt airbag system. (A regular seat belt extension will not latch into the airbag seat belt.) The approved seat belt extension utilizes a different part number from a non-airbag seat belt extension. Using a seat belt extension deactivates the seat belt airbag system, allowing the restraint to be used with child seats.

Seat belt extenders are not interchangeable between Business Elite and Economy Comfort/Economy.

Seat Belt Airbag System Operating Procedures

- Passengers requiring a seat belt extension may be accommodated in Business Elite without restriction.
- Children under 2 years of age accommodated in Business Elite must either be in an approved child restraint or sitting in the lap of an adult.
- Child restraints must be used with a seat belt extension. This will deactivate the seat belt air bag.
- The airbag system is designed to work with passengers in the brace position. No special safety instructions are necessary.
- If a seat in Business Elite is unoccupied, the seat belt halves should not be buckled together.
- If the system is inoperable, either the seat group or the seat position shall be placarded as inoperative.

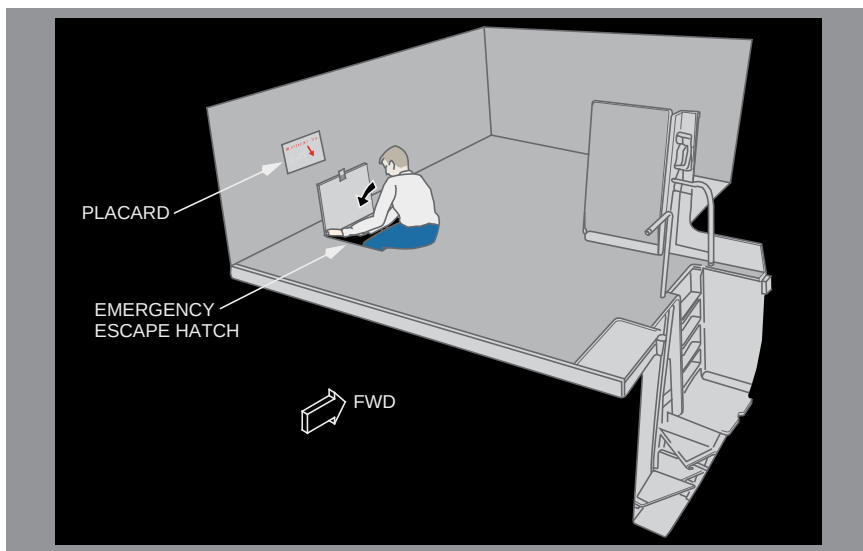
Door 5 Overhead Crew Rest

The door 5 overhead crew rest area is entered through a locked door on the right side of the airplane aft of door 5R. An emergency escape hatch is located on the floor on the left side of the crew rest area. To use the emergency escape hatch follow the placarded instructions. In some cases, a bunk must be moved to access the emergency escape hatch.

Evacuation Using Emergency Escape Hatch

The following can be used as a general guideline for evacuation of door 5 crew rest area. For egress, open the emergency escape hatch and latch it open. If the ceiling panel is in place, sit on floor with legs in hatch and kick out ceiling panel. Lower legs into hatch opening and sit on floor facing outboard, reach out and grab the outboard handholds (keeping elbows close to sides), and swing down to main deck.

Door 5 Overhead Crew Rest Emergency Escape Hatch



Intentionally
Blank

Airplane General, Emergency Equipment, Doors, Windows EICAS Messages

Chapter 1

Section 60

Airplane General, Emergency Equipment, Doors EICAS Messages

The following EICAS messages can be displayed.

EICAS Alert Messages

Message	Level	Aural	Message Logic
>CREW OXY LOW	Advisory		Crew oxygen pressure low.
DOOR AFT CARGO	Caution	Beeper	Aft cargo door not closed and latched and locked condition sensed.
DOOR BULK CARGO	Advisory		Bulk cargo door not closed and latched condition sensed.
DOOR ELEC CTR	Advisory		Electrical equipment door not closed and latched condition sensed.
DOOR ELEC MAIN	Advisory		Electrical equipment door not closed and latched condition sensed.
DOOR ENTRY L1, L2, L3, L4, L5 R1 R2, R3, R4, R5	Advisory		Main deck entry door not closed and latched condition sensed.
DOOR FWD CARGO	Caution	Beeper	Forward cargo door not closed and latched and locked condition sensed.
DOOR L, R UPPER DK	Advisory		Upper deck door not closed and latched condition sensed.
DOOR U/D FLT LK	Caution	Beeper	Upper deck door automatic lock failed to activate after takeoff.
DOORS ELEC	Advisory		Both electrical equipment doors not closed and latched condition sensed.
DOORS ENTRY L, R	Advisory		Two or more entry doors on the same side not closed and latched condition sensed.
DOORS UPR DECK	Advisory		Both upper deck doors not closed and latched condition sensed.

Message	Level	Aural	Message Logic
>EMER LIGHTS	Advisory		Emergency Lights switch not ARMED, or Emergency Lights switch ARMED and emergency lights activated by switch at flight attendant's panel.
PASS OXYGEN ON	Advisory		Passenger oxygen system activated.

EICAS Memo Messages

Message	Level	Aural	Message Logic
DOORS AUTO	Memo		Indicates position of mode select levers for main deck and upper deck doors when on the ground.
DOORS AUTO/MAN	Memo		Indicates position of mode select levers for main deck and upper deck doors when on the ground.
DOORS MANUAL	Memo		Indicates position of mode select levers for main deck and upper deck doors when on the ground.
NO SMOKING ON	Memo		No Smoking switch in ON position.
PASS SIGNS ON	Memo		No Smoking and Seat Belts switches in ON position.
SEATBELTS ON	Memo		Seat Belts switch in ON position.

Air Systems

Chapter 2

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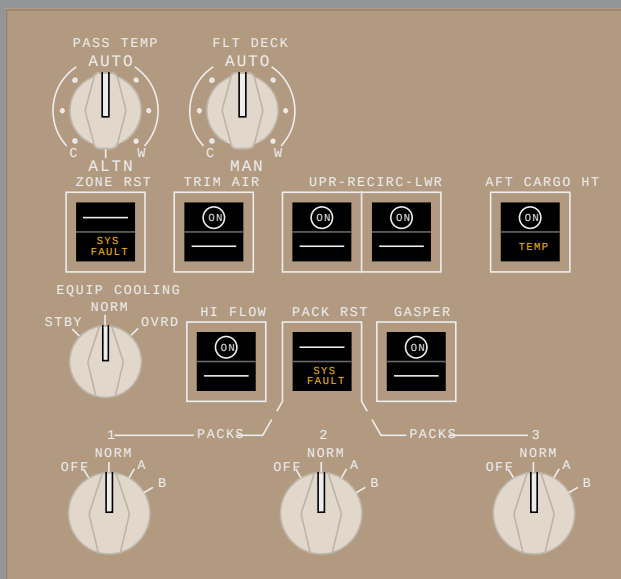
Air Systems Controls and Indicators

Chapter 2 Section 10

Air Conditioning System

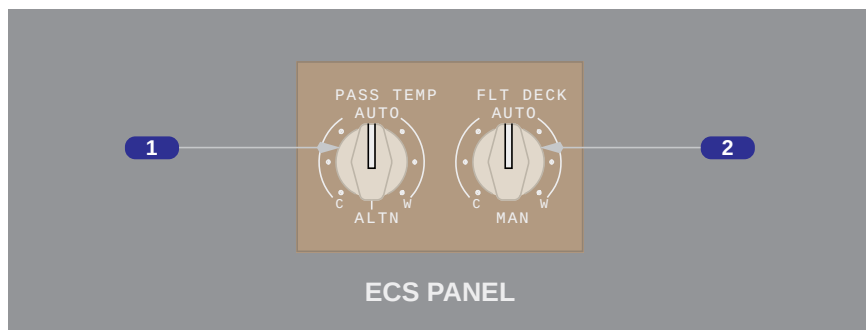
Air Conditioning

ECS Control



OVERHEAD PANEL

Passenger and Flight Deck Temperature Selectors



1 Passenger (PASS) Temperature (TEMP) Selector

AUTO -

- provides automatic control of passenger zone temperatures
- sets master temperature for all zones
- range C to W sets temperature from 65°F (18°C) to 85°F (29°C)
- in backup mode, range C to W sets average cabin temperature from 65°F (18°C) to 85°F (29°C) and cabin temperature panel control of zone temperatures is inhibited

ALTN - (Not Used at Delta Air Lines)

- zone trim air valves remain in last position and master trim air valve remains open
- zone temperature controller bypassed
- pack output temperature regulated to provide average cabin temperature of 75°F (24°C)
- cabin temperature panel control of zone temperatures inhibited

2 Flight (FLT) DECK Temperature (TEMP) Selector

AUTO -

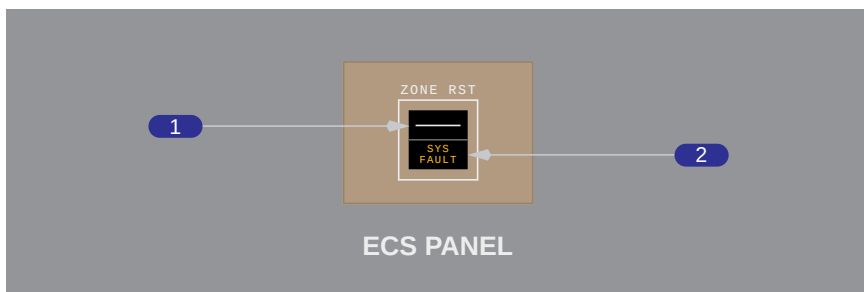
- provides automatic control of flight deck temperature
- range C to W sets flight deck temperature from 65°F (18°C) to 85°F (29°C)

MAN (spring loaded to 6 o'clock position) - flight deck trim air valve controlled manually

C (cool) - valve moves toward closed to provide cooler air

W (warm) - valve moves toward open to provide warmer air

Zone Reset Switch and Zone System Fault Light



1 ZONE Reset (RST) Switch

Push -

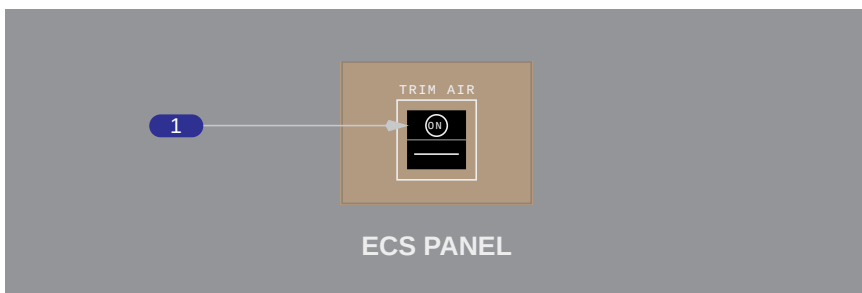
- resets zone temperature controller if fault no longer exists
- reopens master trim air valve if duct overheat no longer exists

2 Zone System (SYS) FAULT Light

Illuminated (amber) -

- temperature zone duct overheat or zone temperature controller fault has occurred
- master trim air valve failed closed
- Trim Air switch off
- master trim air valve closed and pack air continues to flow

Trim Air Switch



1 TRIM AIR Switch

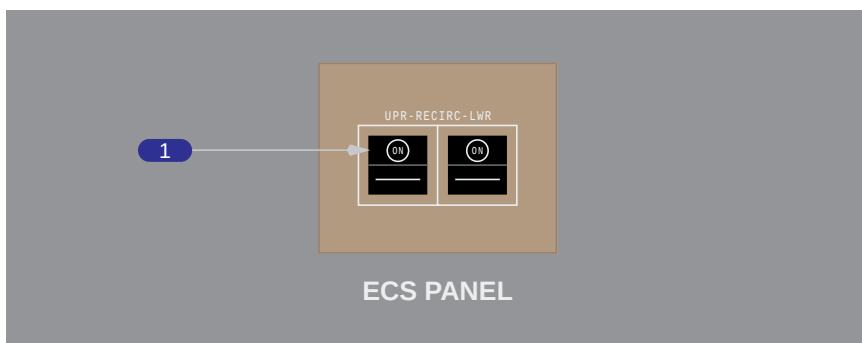
ON -

- master trim air valve open and zone trim air valves operate automatically
- automatic and manual selection of pack controller A or controller B enabled

Off -

- master trim air valve closed
- pack output temperature in backup mode regulated to provide average passenger cabin temperature from 65°F (18°C) to 85°F (29°C) as selected by passenger temperature selector in AUTO
- advisory messages >TRIM AIR OFF and TEMP ZONE are displayed on EICAS
- cabin temperature panel control of temperatures inhibited
- pack controller A selected and both automatic and manual selection of pack controller B inhibited
 - if pack controller A failed, pack controller B selected automatically

Recirculation Fans Switch



1 Recirculation (RECIRC) Fans Switch

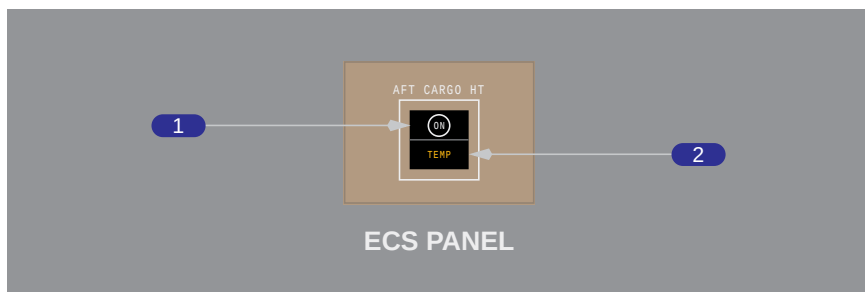
ON -

- recirculation fans controlled automatically to maintain proper cabin ventilation.
- each switch controls two recirculation fans.

Off -

- recirculation fans off.
- automatic control is inhibited.

Aft Cargo Heat Switch



1 AFT CARGO Heat (HT) Switch

ON -

- Overheat Shutoff valve opens to provide bleed air heat to aft and bulk cargo compartments
- Temperature Control valve closes and opens automatically to maintain temperature
- Overheat Shutoff valve closes and opens for overheat protection

Off -

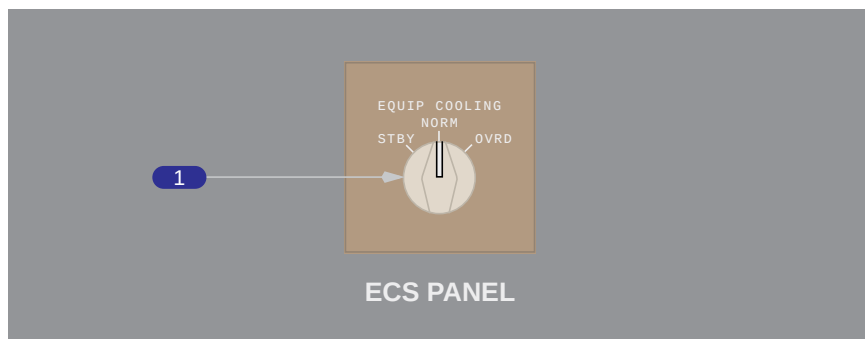
- shuts off aft cargo heat bleed air to compartment.
- closes Overheat Shutoff valve and Temperature Control valves.

2 Aft Cargo Temperature (TEMP) Light

Illuminated (amber) -

- compartment temperature excessive (temperature control valve fails to close)
- overheat shutoff valve closes
- inhibited on the ground

Equipment Cooling Selector



1 Equipment (EQUIP) COOLING Selector

NORM -

Ground operation based on ambient temperature. OAT >45°F equipment cooling air exhausted overboard. OAT <45°F equipment cooling air exhausted into forward cargo compartment

- with two or more engines running (one on each wing) - cooling air exhausted into forward cargo compartment - equipment cooling ground exhaust valve closed
- with a single internal fault, inboard exhaust valve closes and cooling system reconfigures to allow internal closed loop recirculation of cooling air

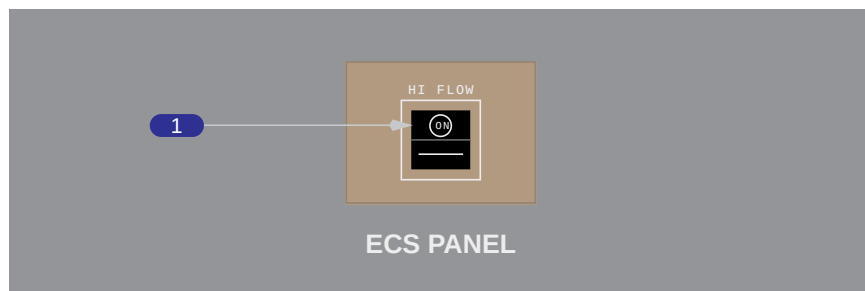
STBY -

- equipment cooling ground exhaust valve closed and inboard exhaust valve open
- automatic control bypassed to configure system for flight
- all other automatic system operation same as in NORM
- with a single internal fault, equipment cooling valves close to allow internal circulation of cooling air

OVRD -

- equipment cooling ground exhaust valve closed. Inboard exhaust valve closed
- equipment cooling supply valve closed. Cooling air supplied through flight panels
- smoke/override valve open; differential pressure exhausts cooling air overboard
- the Nitrogen Generating System (NGS) is shutdown

Pack High Flow Switch



1 Pack High (HI) FLOW Switch

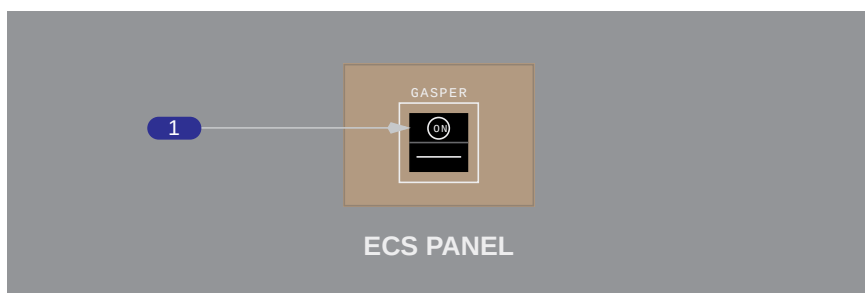
ON -

- all operating packs provide high air flow
- for three packs on highflow, turns off two recirculation fans to maintain a constant ventilation rate
- EICAS memo message PACKS HIGH FLOW displays

Off -

- pack air flow controlled automatically
- provides the best fuel economy

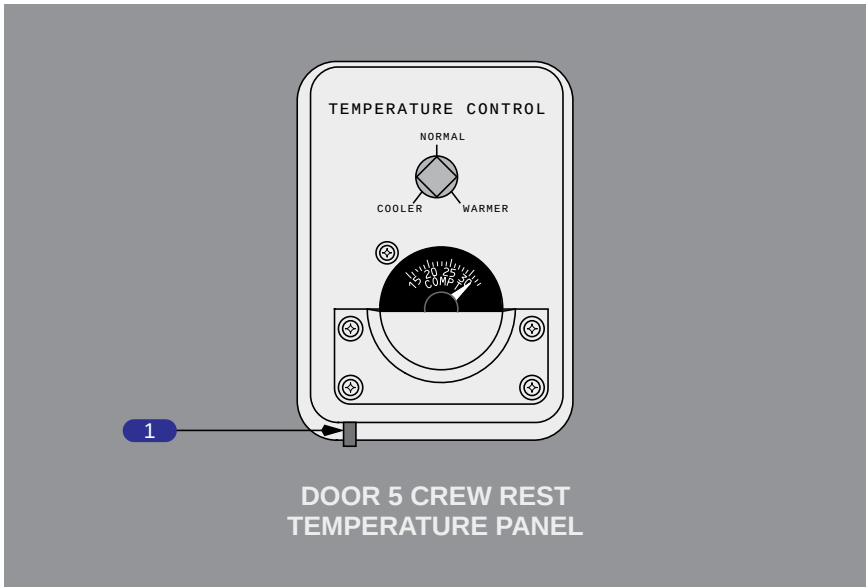
Gasper Switch



1 Gasper Switch

ON - gasper system operates

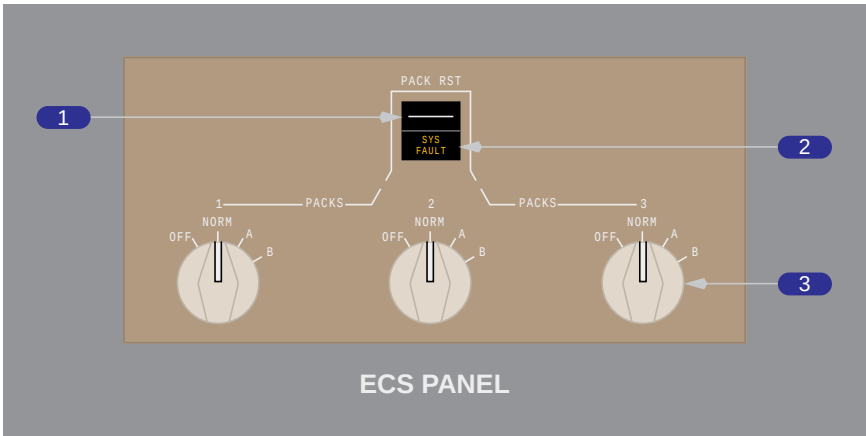
Crew Rest Reset Switch



1 Door 5 Crew Rest Reset Switch

Push - opens door 5 crew rest air supply valves, and resets recirculation fans and valves, if recirculation fans were shut down and valves were closed by crew rest smoke detection system and smoke is no longer detected.

Pack Control



1 PACK Reset (RST) Switch

Push -

- resets pack fault protection system
- restarts pack after automatic shutdown if fault no longer exists

2 Pack System (SYS) FAULT Light

Illuminated (amber) -

- pack overheat or other system fault has occurred
6311 - 6316
- may illuminate briefly when automatically or manually switching from pack temperature controller A to B or B to A

3 PACK Control Selectors

OFF -

- pack valve closed
- extinguishes SYS FAULT light for pack selected off
- resets pack fault protection system

Normal (NORM) -

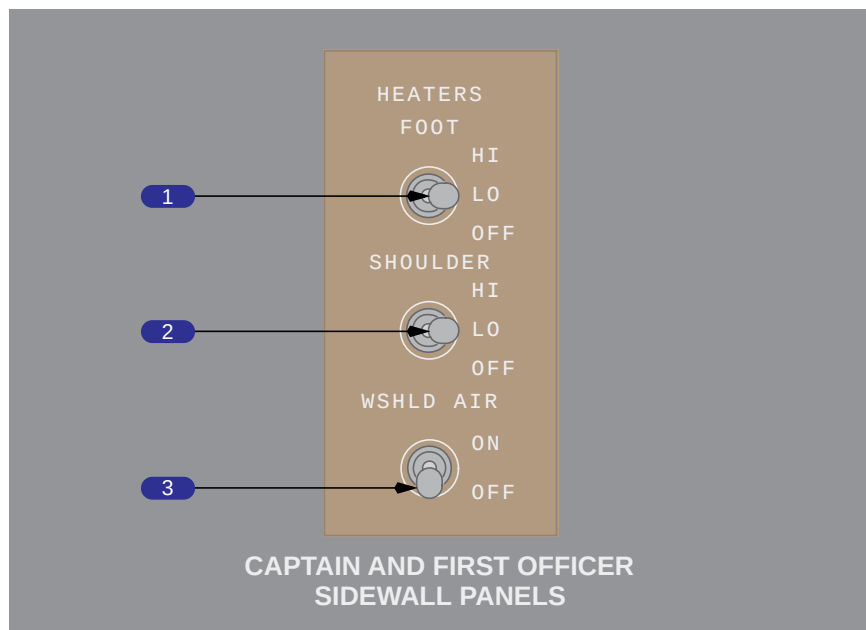
- pack controller A or B selected automatically on alternate flights
- selected controller is primary controller; selects secondary controller if primary controller fails

A - selects pack controller A as primary controller; selects B if A fails.

B - selects pack controller B as primary controller; selects A if B fails.

Pilot Auxiliary Heat and Windshield Air

Electric shoulder heater and foot heater operate only in flight.



1 FOOT Heater Switch

Control temperature is the same in HI and LO. Heater is inhibited when temperature of foot heater plate is warmer than 65°F (18°C).

HI - under-floor electric heater operates at high heating rate.

LO - under-floor electric heater operates at low heating rate.

OFF - under-floor electric heater off.

Note: The Foot Heater switches are inoperative on the ground.

2 SHOULDER Heater Switch

HI - electric heater adds heat at high setting to conditioned air flow to side windows.

LO - electric heater adds heat at low setting to conditioned air flow to side windows.

OFF - electric heater off.

Note: The Shoulder Heater switches are inoperative on the ground.

3 Windshield (WSHLD) AIR Switch

ON - supplemental anti-fogging air supplied to windshield.

OFF - anti-fogging air off.

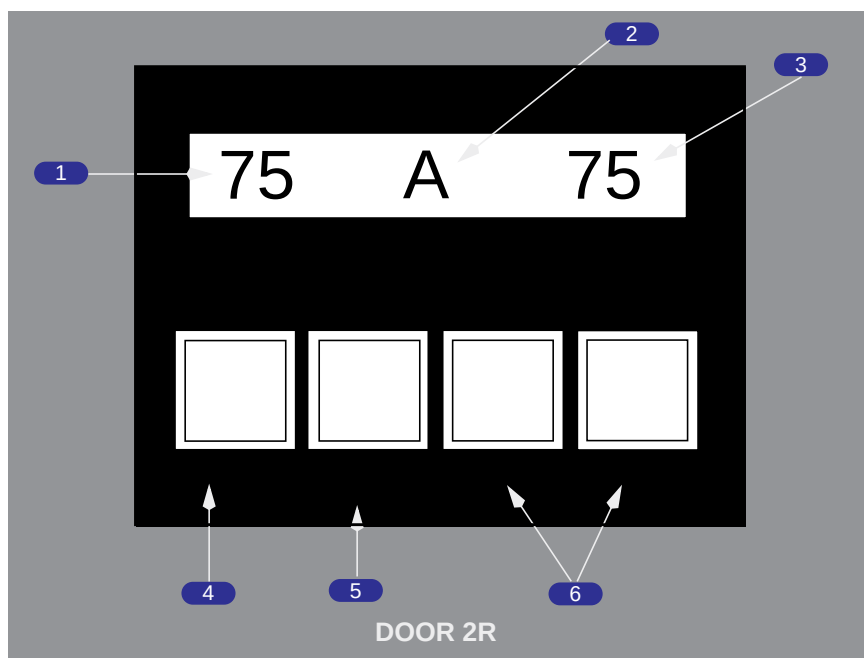
6311 - 6316



1 Side Window Air Flow Control

Rotate - sets air flow to side window shoulder air outlet.

Cabin Temperature Control Panel



1 Actual Temperature

- displays actual temperature of zone selected

2 Zone

- displays zone selected

3 Target Temperature

- displays target temperature for zone selected

4 Reset Switch

- resets all inputs from cabin temperature selector for all zones, except flight deck, to the Master Target temperature set by the PASS TEMP selector in the flight deck

5 Zone Select Switch

- selects zone for display and for temperature modification

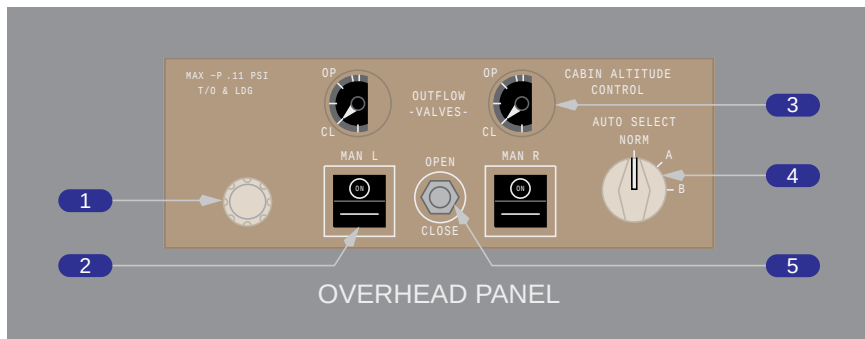
6 Cooler And Warmer Switch

- sets target temperature cooler or warmer for zone selected
- changes displayed target temperature

Pressurization System

Cabin Altitude Control

6301-6310



1 Landing Altitude Switch/Selector

PULL ON/ ROTATE-

- overrides any landing altitude inputs to cabin altitude controllers from the FMS
- when pulled ON, landing altitude must be set manually and is displayed on EICAS followed by MAN in amber

PUSH OFF -

- landing altitude is sent to cabin altitude controllers (AUTO) from FMS
- landing altitude information from the FMS is displayed on EICAS followed by AUTO in white

2 Outflow Valve Manual (MAN) Switches

ON -

- outflow valve in controlled manually
- bypasses automatic outflow valve control and cabin altitude limiter

Off - outflow valve controlled automatically.

3 OUTFLOW VALVES Position Indicators

OP (Open) - outflow valve open.

CL (Closed) - outflow valve closed.

4 Cabin Altitude AUTO Selector (SELECT)

NORM -

- cabin altitude controller A or B selected automatically on alternate flights
- selected controller is the primary controller.
- Selects secondary controller if primary controller fails

A - selects cabin altitude controller A as primary controller; selects B if A fails.

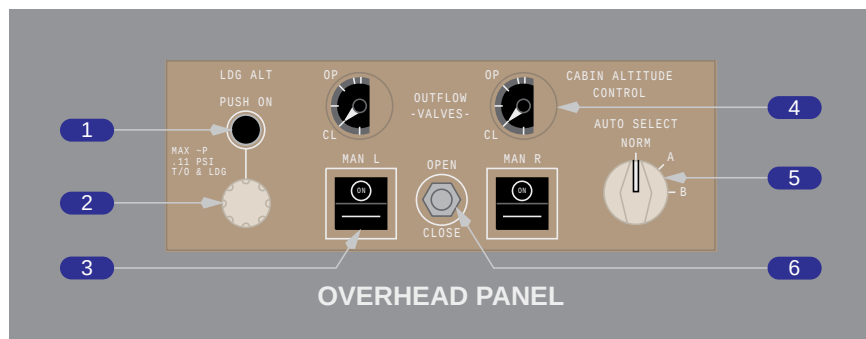
B - selects cabin altitude controller B as primary controller; selects A if B fails.

5 Outflow Valves Manual Control

OPEN - moves the outflow valves toward open.

CLOSE - moves the outflow valves toward closed.

6311-6316



1 Landing Altitude (LDG ALT) Switch)

Push - alternately changes landing altitude control between Automatic and Manual.

Manual -

- landing altitude set by rotating Landing Altitude selector
- landing altitude followed by MAN displayed on primary EICAS
- the EICAS advisory message LANDING ALT is displayed

Automatic -

- landing altitude set automatically from FMC - Refer to Chapter 11, Flight Management Navigation, Approach
- landing altitude followed by AUTO displayed on primary EICAS

2 Landing Altitude (LDG ALT) Selector

Rotate - sets landing altitude when MAN displayed on primary EICAS.

3 Outflow Valve Manual (MAN) Switches

ON -

- outflow valve in controlled manually
- bypasses automatic outflow valve control and cabin altitude limiter

Off - outflow valve controlled automatically.

4 OUTFLOW VALVES Position Indicator

OP (Open) - outflow valve open.

CL (Closed) - outflow valve closed.

5 Cabin Altitude AUTO Selector (SELECT)

NORM -

- cabin altitude controller A or B selected automatically on alternate flights
- selected controller is the primary controller.
- Selects secondary controller if primary controller fails

A - selects cabin altitude controller A as primary controller; selects B if A fails.

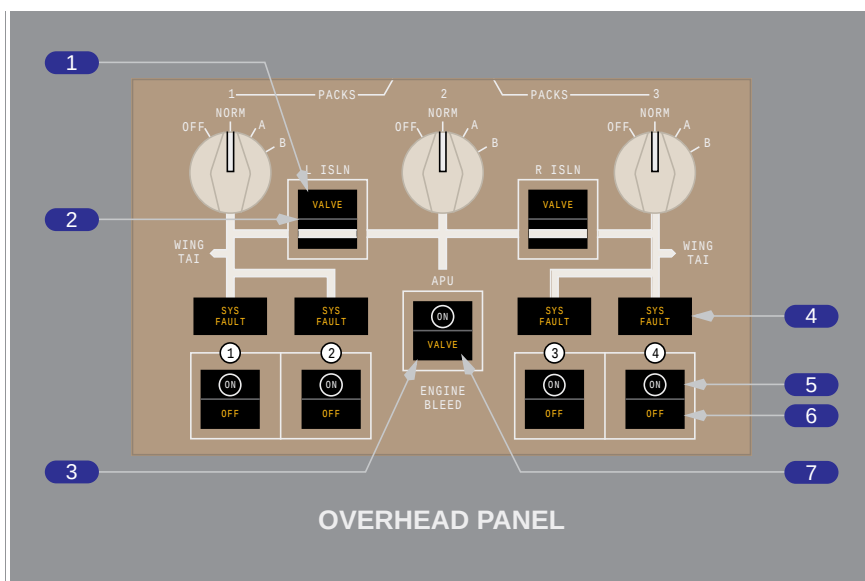
B - selects cabin altitude controller B as primary controller; selects A if B fails.

6 Outflow Valves Manual Control

OPEN - moves the outflow valve toward open.

CLOSE - moves the outflow valve toward closed.

Bleed Air Control



1 Isolation (ISLN) VALVE Lights

Illuminated (amber) - isolation valve position disagrees with switch position

2 Isolation (ISLN) Valve Switches

ON (bar in view) - valve open.

Off - valve closed.

3 APU Bleed Air Switch

ON - valve commanded open when EICAS memo message APU RUNNING displayed.

Off - valve closed.

4 Engine Bleed Air System (SYS) FAULT Lights

Illuminated (amber) -

- bleed air overheat, or
- bleed air overpressure, or
- HP bleed valve open when commanded closed, or
- PRV open when commanded closed

5 ENGINE BLEED Air Switches

ON -

- engine bleed air valve opens for engine start
- engine bleed air valve (PRSOV), PRV, and HP bleed valve open by system logic when bleed air pressure available

Off -

- engine bleed air valve (PRSOV), PRV, and HP bleed valve closed
- PRV opens when Nacelle Anti-ice switch ON, unless PRV closed by:
 - prior or present bleed air overheat, or
 - start valve not closed, or
 - HP bleed valve failed open

6 ENGINE BLEED Air OFF Lights

Illuminated (amber) - engine bleed air valve closed.

Supply of bleed air regulated by system logic.

7 APU Bleed Air VALVE Light

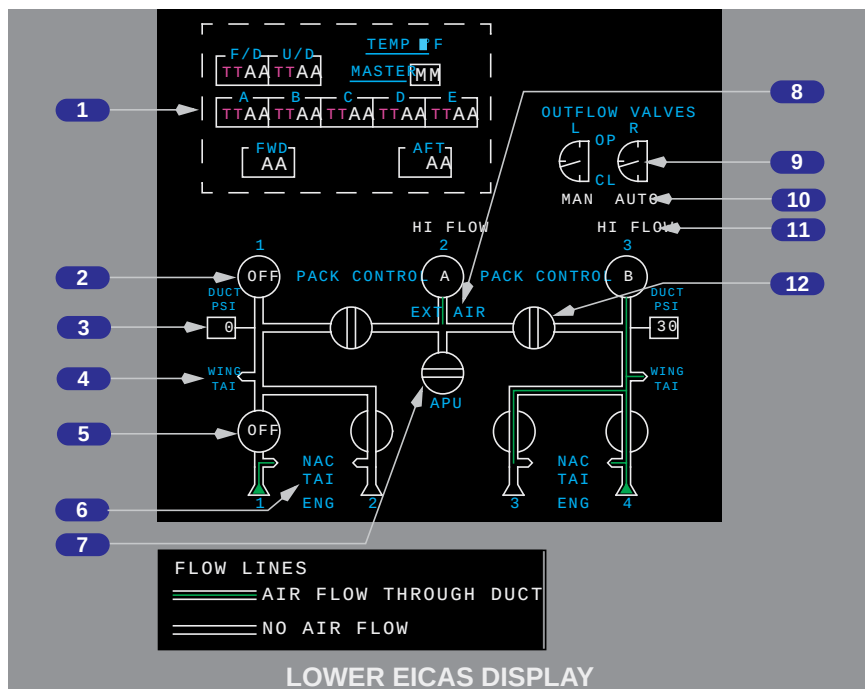
Illuminated (amber) - APU bleed air isolation valve position disagrees with switch position.

ECS Displays and Indications

ECS Synoptic Display

The ECS synoptic is displayed by pushing the ECS switch on the display select panel. Display select panel operation is described in Chapter 10, Flight Instruments, Displays.

Air flow displayed is generated by displayed valve positions, switch positions, and pack status. It does not display actual air flow, therefore the display may not represent actual system operation.



1 Zone Temperature

F/D, U/D, A, B, C, D, and E - zone target and actual temperatures for respective air conditioning zone:

- (TT) target temperature on left; displayed when:
 - at least one pack is operating, and
 - Passenger Temperature selector in AUTO, and
 - temperature control is not in backup mode
- (AA) actual temperature on right

MASTER - (MM) temperature setting of Passenger Temperature selector.

FWD, AFT - (AA) actual temperature of cargo compartment.

2 Pack Control

A - pack controller A is controlling the pack.

B - pack controller B is controlling the pack.

OFF - pack valve is closed.

3 Bleed Air Duct Pressure

White - 12 psi or greater.

Amber - 11 psi or less.

4 Wing Anti-Icing

Wing anti-icing valve is open.

5 Engine Bleed Air Valve

Position of the engine bleed air valve.

6 Nacelle Anti-Icing

Nacelle anti-icing valve is open.

7 APU Bleed Air Isolation Valve

Position of the isolation valve.

8 External Air Indication

- displayed if a pack is operating with APU and engines off, or
- bleed air ducts are pressurized with APU and engines off
- remains displayed momentarily after external air source is removed

9 Outflow Valves Position

OP - open.

CL - closed.

10 Outflow Valve

AUTO - outflow valve is controlled automatically.

MAN - outflow valve is controlled manually.

11 High Flow

HI FLOW - pack is in high flow.

Blank - pack is in normal flow or pack is off.

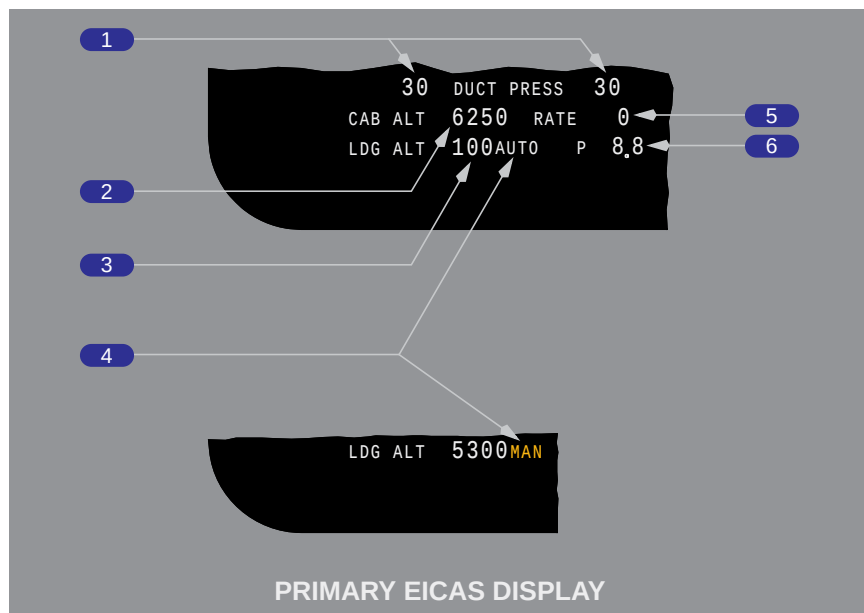
12 Isolation Valve

Position of isolation valve

Duct Pressure and Cabin Altitude Indications

Duct pressure, cabin altitude, rate, landing altitude, and differential pressure are displayed when:

- landing altitude MAN
- cabin altitude in caution (amber) or warning (red) range
- cabin differential pressure in caution (amber) or warning (red) range
- ECS or ENG synoptic selected on secondary EICAS display
- either duct pressure 11 PSI or less
- one of the following EICAS messages displayed:
 - CAB ALT AUTO
 - LANDING ALT
 - OUTFLOW VLV
 - BLEED DUCT LEAK



1 Bleed Air Duct Pressure

White - 12 psi and above.

Amber - 11 psi and below.

2 Cabin Altitude

White - normal range.

Amber - above normal range.

Red - excessive cabin altitude (above 10,000 feet).

3 Landing Altitude

- inhibited if both cabin altitude controllers A and B fail
- inhibited if both outflow valves are in MAN

4 Landing Altitude Selection

AUTO (white) - altitude set automatically from FMC - Refer to Chapter 11, Flight Management Navigation, Arrivals Page - IFR Approaches.

MAN (amber) - altitude set by Landing Altitude selector.

5 Cabin Altitude Rate

+ (plus) - rate of climb.

- (minus) - rate of descent.

6 Cabin Differential Pressure

White - normal range.

Amber - above normal range.

Red - excessive cabin differential pressure.

Intentionally
Blank

Air Systems

Air Conditioning System Description

Chapter 2

Section 20

Introduction

The air conditioning system supplies conditioned bleed air and recirculated cabin air at controlled temperature throughout the airplane.

The system supplies conditioned air to the flight deck shoulder heaters.

The system supplies ventilation for the passenger cabin:

- lavatories
- galleys
- flight deck crew rest
- individual passenger seat gaspers
- door 5 crew rest

Pack control, zone temperature control, cabin air recirculation, fault detection, and overheat protection are all automatic. Backup system control modes operate in the event of system failures.

The airplane is divided into seven temperature zones:

- flight deck
- upper deck
- five main deck cabin zones A through E

Pack Flow

Each pack valve has two flow settings, normal and high. The normal setting minimizes bleed air demands on the engine while in cruise. Fuel consumption is reduced approximately 0.3% for each pack in normal flow. The pack high flow setting provides the flow needed to meet maximum air exchange requirements. When the Recirculation Fan switches are ON, the packs are operating, and the High Flow switch is OFF, system logic reconfigures the pack flow and recirculation fan operating combination to maintain proper ventilation.

On the ground, during climb, and during descent, all three packs are normally at high flow, with two of the four recirculating fans operating.

To reduce bleed air demands, the packs automatically change to normal flow and all four recirculation fans operate during cruise.

The packs may be set manually to high flow by pushing the High Flow switch ON. An EICAS Memo message is displayed indicating the HIGH FLOW switch is in the ON position and the pack flow setting is not being controlled automatically.

Air Conditioning Packs

Three identical air conditioning packs cool bleed air from the engines, APU, or high pressure air from a ground source. Bleed air is precooled before entering the pack. The packs are controlled by two identical pack temperature controllers (PTCs), A and B. Each PTC has three separate channels, one for each pack. Control of the packs switches automatically to the other PTC at touchdown. If a PTC detects a fault in a pack channel, control of the respective pack switches to the other PTC.

When a PACK Control selector is placed in NORM, A, or B, the respective pack valve opens, which allows bleed air to flow into the pack. The pack valve is controlled electrically by the PTC and opens by bleed air pressure.

Each pack valve has two flow settings, normal and high. During cruise, normal flow minimizes bleed air demand on the engine to reduce fuel consumption. Fuel consumption is reduced approximately 0.3% for each pack in normal flow.

In cruise, pushing the Pack High Flow switch ON configures all three packs to high flow.

Pack Non-Normal Operation

Pack control, fault detection, and overheat protection are all automatic. When an overheat or PTC fault is detected, the respective pack valve closes resulting in a pack shut down.

If a PTC does not switch automatically to the other PTC, selecting A or B manually selects the respective PTC when the Trim Air switch is ON. An attempt to restore pack operation may be made by pushing the Pack Reset switch.

If the pack cannot be reset, placing the respective Pack Control Selector to OFF extinguishes the Pack System Fault light for use by the operating packs.

If both PTCs A and B fail, air conditioning packs continue to operate and the pack overheat protection system continues to operate normally. A pack overheat results in a shut down.

Recirculation Fans

Recirculation fans assist the packs to maintain a constant ventilation rate throughout the passenger cabin. The fans draw cabin air through filters, then reintroduce the air into the conditioned air distribution system. Two fans are located above the main passenger compartments and two fans are located below the main passenger cabin floor. If a fan overheat is detected, electrical power is removed.

Pack flow rate and recirculation fan operation are configured by:

- the phase of flight,
- the number of air conditioning packs operating, and
- the number of recirculation fans operating.

The system reconfigures pack flow rate and recirculation fan operation automatically when fans or packs are shut down or fail.

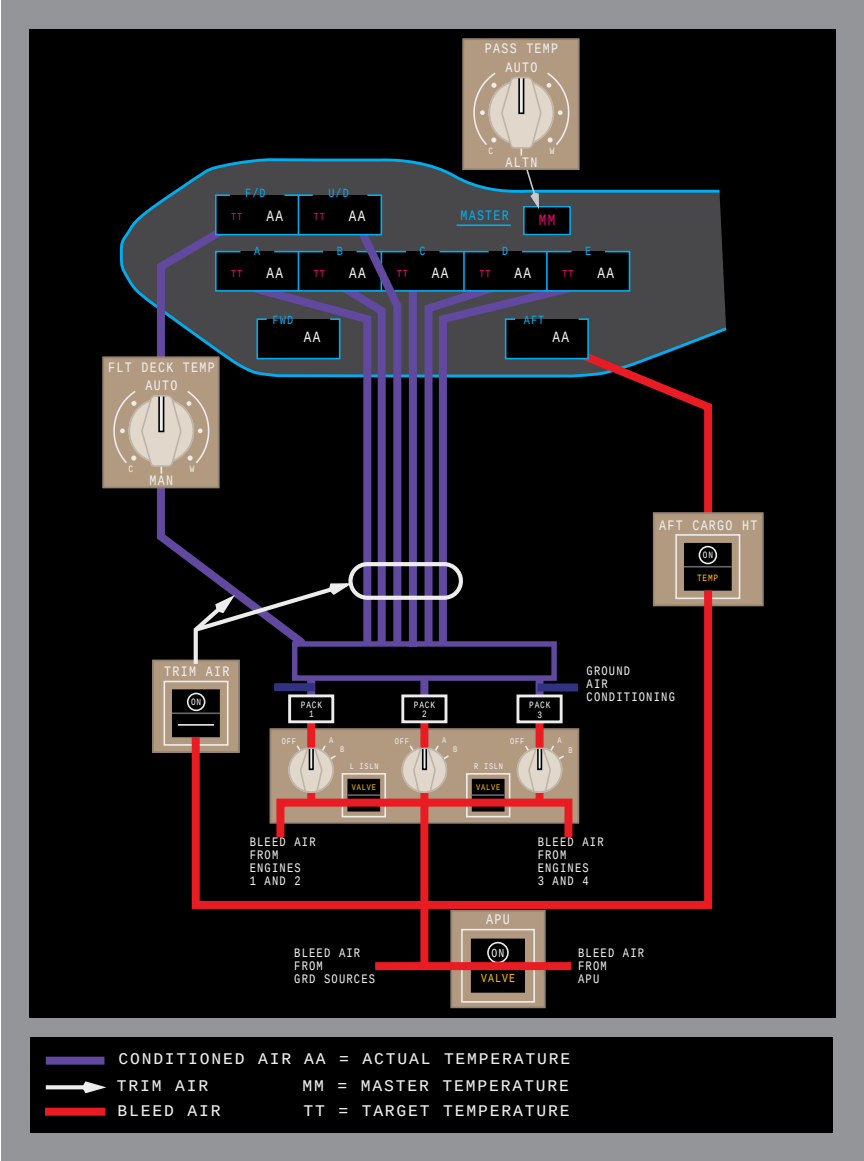
Cargo Fire Arm

When a Cargo Fire Arm switch is pushed, pack 3 shuts down automatically. In addition, pack 1 and 2 change to HI FLOW. As a result, air distribution is configured to starve the affected zone of fresh air, minimize air movement, purge smoke from the flight deck and passenger cabin, and assure the supply of fresh air to the flight deck.

Crew Rest Smoke Detection Mode

If smoke is detected in the door five crew rest, the crew rest air supply valves close and the recirculation fans shutdown. The valves remain closed and the fans remain shutdown until reset. Pushing the Door 5 Crew Rest Reset switch opens and resets the valves and resets the recirculation fans if smoke is no longer detected.

Air Distribution Diagram



Temperature Control

Zone temperatures are controlled by the zone temperature controller (ZTC).

Hot trim air from the bleed air system is added through trim air valves in the zone conditioned air supply ducts. The ZTC modulates the zone trim air valves to regulate the temperature of the conditioned air in each zone.

The temperature zone requiring the coolest temperature controls pack outlet temperature.

Passenger Zone Target Temperatures

The Passenger Temperature selector sets the master passenger cabin temperature to between 65°F (18°C) and 85°F (29°C). The master passenger cabin temperature for all passenger temperature zones is automatically increased or decreased and manually modified to set target temperatures for each passenger temperature zone.

Automatic Passenger Comfort Compensation Of Zone Target Temperatures

For passenger comfort, the ZTC compensates for temperature changes as cabin air humidity and passenger activity decrease during flight. The passenger cabin zone target temperatures slowly increase automatically during the early part of the flight (+ 2° F/hour, max increase of 4°F). The flight crew does not have to manually increase target temperatures to compensate for the increase in humidity and decrease in passenger activity. Target temperatures decrease slowly automatically during descent until all passenger comfort temperature compensation is removed.

Manual Modifications To Zone Target Temperatures

The target temperatures of each passenger zone may be further modified plus or minus 10°F (6°C) within the range of 65°F (18°C) to 85°F (29°C) from the comfort compensated master temperature. This is accomplished with the cabin temperature panel located at door two right.

The cabin temperature panel accepts temperature modifications when at least two engines are operating.

Temperature Control With Loss of Trim Air System

Trim air is not available to the flight deck and main deck conditioned air distribution system if:

- the EICAS advisory message TEMP ZONE is displayed,
- the center section of the bleed duct is isolated,
- the EICAS advisory message TRIM AIR OFF is displayed, or
- the Master Trim Air switch is OFF.

If trim air is not available to the distribution system, backup modes control temperature in the passenger temperature zones of the cabin:

- if the Passenger Temperature selector setting is available to the PTC, pack outlet temperature is regulated to achieve an average temperature between 65°F (18°C) and 85°F (29°C), as set by the Passenger Temperature selector, or
- if the Passenger Temperature selector setting is unavailable to the PTC, pack outlet temperature is regulated to achieve the last passenger temperature set, or
- if the last passenger temperature set is unavailable to the PTC, pack outlet temperature is regulated to achieve an average cabin temperature of 75°F (24°C)

Temperature Control Non-Normal Operation

If a system fault or overheat occurs in the flight deck or a passenger zone, the master trim air valve closes and a backup mode controls cabin temperature. An attempt to restore zone temperature control can be made by pushing the Zone Reset switch.

Cargo Heat

Forward Cargo Heat

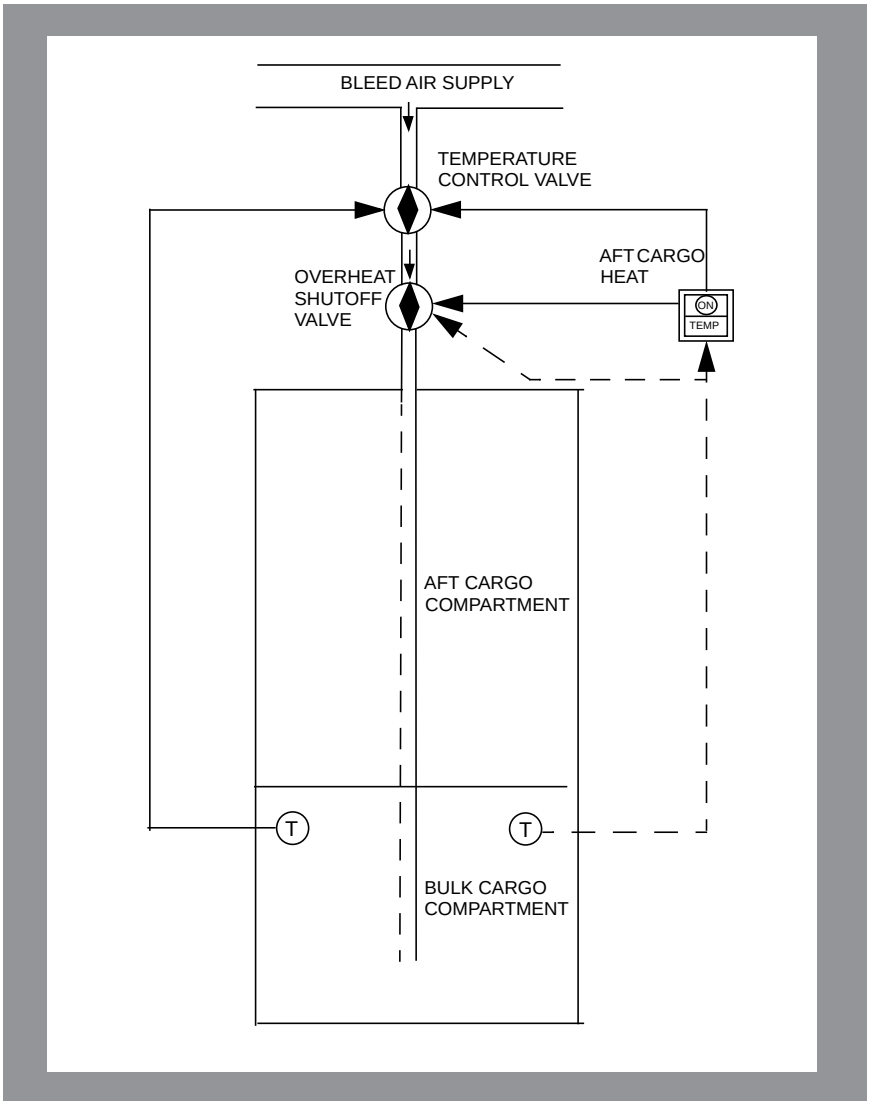
When the equipment cooling system inboard exhaust valve is open, the heated air exhausted from the electrical and electronic (E & E) compartment heats the forward cargo compartment. Two electric heaters augment heating.

Aft Cargo Heat

Aft cargo heat is provided by bleed air from the center section of the bleed air duct. A thermal switch in the compartment opens and closes the temperature control valve. When the compartment is cool, the thermal switch opens the valve. When the compartment warms, the thermal switch closes the valve. The pilot cannot regulate the temperature.

An overheat thermal switch provides overheat protection by opening and closing an overheat/shutoff valve at higher temperatures.

Aft Cargo Heat Diagram



Gasper System

The gasper system supplies recirculated air drawn from the upper passenger cabin area. Gasper air is distributed to the passenger service unit air gasper outlets above each passenger seat.

Pilot Auxiliary Heat

Flight crew shoulder heat is provided by electric elements in the side window and pilot shoulder air diffusers. The foot heaters have electric heating elements under the pilot foot area. Shoulder heat and foot heat are available in flight.

Lavatory and Galley Ventilation

Two ventilation fans, a primary and a backup, draw air from the galleys and lavatories. If the primary fan fails, the backup fan operates automatically.

Conditioned air is provided to the galleys from the air distribution system.

Equipment Cooling

The equipment cooling system provides cooling air for flight deck equipment and the electrical and electronic (E & E) compartment equipment racks. The system uses internal fans and valves to direct cool cabin air from inside the lower fuselage into the equipment racks. The warm exhaust air is ducted into the forward cargo compartment, recirculated in a closed loop mode through the E & E compartment cooling racks, or ducted overboard.

On the ground, with the engines not operating, the Equipment Cooling selector in NORM, and ambient temperatures above 45°F, the warm exhaust air is ducted overboard through the ground exhaust valve. With lower ambient temperatures (less than 45°F), the ground exhaust valve is closed and the system is configured for flight.

On the ground, when one or more engines on each wing are operating, the system configures for flight to allow cabin pressurization. Positioning the Equipment Cooling selector to STBY closes the ground exhaust valve to manually configure the airplane for flight.

In flight configuration, the inboard exhaust valve is open and the warmed equipment cooling exhaust air discharges into the forward cargo compartment.

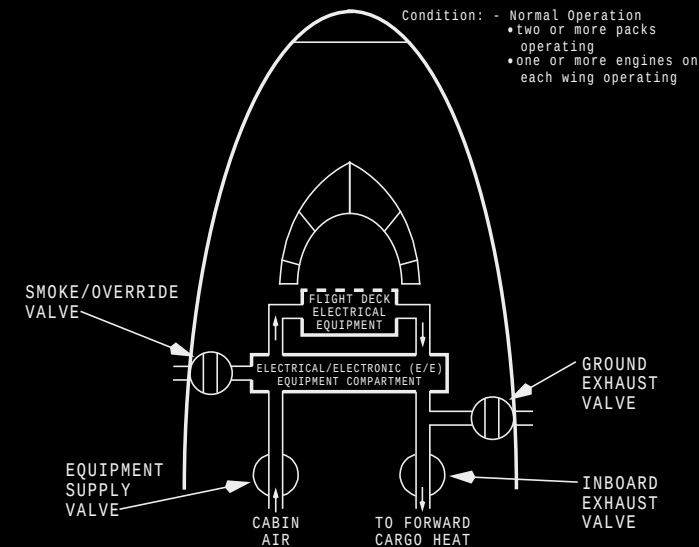
With the Equipment Cooling selector in NORM or STBY, the system normally configures to closed loop mode if a single internal fan fails. In closed loop mode, the inboard exhaust valve is closed.

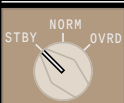
Equipment Cooling Non-Normal Operation

With the Equipment Cooling selector in NORM, the airplane on the ground, and with one or more engines on each wing operating, the EICAS alert message EQUIP COOLING is displayed if the equipment cooling system is not configured for flight. Positioning the selector to STBY configures the system for flight.

An override mode provides equipment cooling in flight if internal fans are inoperative. With the Equipment Cooling selector in OVRD, the internal fans are not powered and the smoke/override valve opens with all other valves closed. The smoke/override valve opens to an overboard vent allowing cabin differential pressure to draw air from the panels area on the flight deck, through the equipment cooling ducts to the E & E compartment equipment racks, to create a reverse flow of air across the equipment, then through the supply duct, and overboard. In addition, the Nitrogen Generating System (NGS) is shutdown.

Equipment Cooling Control Diagram



EQUIPMENT COOLING SWITCH POSITION	SYSTEM OPERATION	EQUIPMENT COOLING VALVE CONFIGURATION
	• Normal Operation • Normal Operation includes reconfiguring after supply and exhaust fan failure to maintain E/E equipment cooling: - Inboard Exhaust valve closes - no airflow to forward cargo - no EICAS message displayed	Above 45°F (7°C), Ground Exhaust valve opens and Inboard Exhaust valve closes. Below 45°F (7°C), Ground Exhaust valve closes and Inboard Exhaust valve opens.
		Ground Exhaust valve closes and Inboard Exhaust valve opens
	• Cooling system operates in reverse flow using differential pressure to exhaust cooling air through Smoke/Override valve • No cooling exhaust airflow to forward cargo • The NGS is inoperative	Smoke/Override valve opens. Equipment Supply valve, Inboard Exhaust valve, and Ground Exhaust valve close.

Introduction

Cabin pressurization is controlled by regulating the discharge of conditioned cabin air through the outflow valves.

Two outflow valves are installed at the rear of the cabin. The valves normally operate in parallel. Cabin altitude and full ventilation rates can be maintained by either valve.

There are two cabin altitude controllers, A and B. Each controller controls both outflow valves.

Positive and negative pressure relief valves protect the fuselage against excessive pressure differential.

The pressurization system has automatic and manual operating modes. Other than accomplishing normal procedures for entering FMC data, no specific flight crew action is required for fully automatic operation for all flights with a landing below 8,000 feet.

Pressurization System Automatic Operation

In flight, the cabin altitude controllers operate in a climb mode, a cruise mode, or a descent mode.

The controllers use ambient pressure and flight plan data from the FMC to calculate a cabin pressurization schedule. The schedule provides a comfortable cabin climb to cruise altitude.

For takeoff, the system provides a small positive pressurization prior to rotation to cause a smooth transition to the cabin altitude climb schedule.

In cabin altitude controller climb mode, cabin altitude increases on a schedule related to airplane climb rate and flight plan cruise altitude. When the FMC climb path has a planned level segment, it is included in the total time required for the airplane to reach the top of climb. Cabin altitude continues to increase during the level segment. When the airplane climb flight path is above the FMC climb path and maximum cabin pressure differential is reached during the climb, cabin rate then becomes a function of airplane climb rate so maximum cabin differential pressure is not exceeded.

If cruise altitude is unavailable from the FMC in AUTO, the cabin altitude controllers assume a cruise altitude of 39,000 feet.

In cabin altitude controller cruise mode, maximum cabin altitude is 8,000 feet. When the takeoff field elevation is higher than 8,000 feet, the cabin descends to the cabin cruise altitude while the airplane is climbing.

The cabin altitude controllers enter cabin altitude controller descent mode at T/D or at initial descent of approximately 1,000 feet from cruise altitude, regardless of T/D.

In cabin altitude controller descent mode, cabin altitude decreases or increases to slightly below the FMC planned landing altitude in AUTO or the landing altitude set in MAN. The slight altitude difference assures a small positive pressurization at touchdown. In MAN, FMC altitude information is bypassed and the cabin altitude controller uses internal rate schedules to control cabin altitude.

Landing elevation limits are 1,000 feet below sea level to 14,000 feet above sea level. The captain altimeter setting provides landing altitude barometric pressure correction.

At touchdown, the outflow valves open to depressurize the cabin.

The cabin altitude limiter closes both outflow valves if cabin altitude exceeds 11,000 feet.

Full automatic operation of cabin altitude is possible with one outflow valve operating automatically and the other outflow valve not operating. For this configuration, one pack is selected off to ensure cabin doors may be opened regardless of the position of the outflow valves if an emergency evacuation is required immediately after landing.

Supplemental Procedure Landing Airport Between 8,000 Feet and 10,000 Feet

To avoid the cabin altitude controllers inadvertently entering descent mode during cruise, which would allow cabin altitude to immediately begin increasing to FMC landing altitude, the landing altitude is set to 8,000 feet or in MAN during climb and cruise.

Cabin Altitude Controller Automatic Operation With Loss of Landing Altitude

If landing altitude is unavailable from the FMC and not set in MAN, the EICAS advisory message LANDING ALT is displayed and the cabin altitude controllers assume a landing altitude of 2,000 feet.

Pressurization System Manual Operation

If both Outflow Manual switches are ON, all automatic cabin altitude control functions are bypassed. For this configuration, one pack is selected off to ensure cabin doors may be opened regardless of the position of the outflow valves if an emergency evacuation is required immediately after landing.

Pressurization Relief

Two mechanical positive pressure relief valves prevent overpressurization of the airplane. One or both valves open if cabin pressure becomes excessive, and close when cabin pressure is no longer excessive. Pack two shuts down to assist in relieving excess cabin pressure. Pack two resets when both cabin pressure relief valves close.

Negative pressure relief valves in the forward and aft cargo doors open when the airplane cabin pressure is slightly less than outside air pressure. The valves also open to relieve any existing differential pressure when a cargo door is unlatched.

Intentionally
Blank

Air Systems

Bleed Air System Description

Chapter 2

Section 40

Introduction

Bleed air can be supplied by the engines, APU, or a ground air source.

Bleed air is used for:

- air conditioning
- pressurization
- wing and engine anti-ice
- engine start
- leading edge flaps
- aft cargo heat
- cargo smoke detection
- hydraulic reservoir pressurization
- potable water tank pressurization
- air driven hydraulic demand pumps

Engine Bleed Air Supply

Engine bleed air is supplied from either intermediate pressure (IP) or high pressure (HP) engine sections. IP air is used during high power setting operations. HP air is used during descent and other low power setting operations.

To prevent damage to ducting and equipment downstream, the pressure regulating valve (PRV) limits bleed air pressure. The fan air precooler regulates bleed air temperature.

With an Engine Bleed Air switch ON, system logic allows bleed air to open the HP bleed valve and the PRV and allows bleed air to open the respective engine bleed air valve and flow into the bleed air duct. The bleed air valves are pressure actuated and remain closed until engine bleed air pressure causes forward flow.

The engine bleed air valve regulates the engine bleed air to provide normal bleed air system pressure. It also prevents reverse flow of bleed air from the duct, except during the engine start sequence. When air pressure in the bleed air duct from the APU, ground air, or another engine is higher than the bleed air from an engine, the engine bleed air valve closes to prevent reverse flow.

During engine start, the engine bleed air valve opens and allows reverse flow of air from the bleed air duct to open the start valve. The PRV is positively closed to prevent reverse air flow into the engine compressor sections. Any time the engine start valve is not fully closed, the PRV remains positively closed. After N2 increases past 50%, the start valve closes which enables the PRV to open and the engine bleed air valve reverse flow prevention is enabled.

If the engine start valve fails to close, bleed air is isolated from the engine starter because both the PRV and the engine bleed air valve remain closed. Nacelle anti-ice is not available for the respective engine.

If an Engine Bleed Air switch is off, the respective engine bleed air valve, PRV, and HP bleed valve are closed.

If a bleed air overheat is detected, the PRV and HP bleed valves close. Pushing an Engine Bleed Air switch from off to ON resets the engine bleed fault detection system.

Bleed air is available for nacelle anti-ice operation with the Engine Bleed Air switch ON except when:

- the PRV has failed closed, or
- the PRV has been closed due a bleed air overheat, or
- the start valve is not closed

Bleed air is available for nacelle anti-ice operation with the Engine Bleed Air switch off except when:

- the PRV has failed closed, or
- the PRV has been closed due a bleed air overheat, or
- the start valve is not closed, or
- the HP bleed valve is failed open

APU Bleed Air Supply

APU bleed air is used primarily during ground operations for pack operation and engine starting. APU bleed air is available in flight.

With the APU bleed air switch ON, the APU bleed valve opens when the APU can supply bleed air. The EICAS memo message APU RUNNING is displayed when APU N1 is 95% and higher. APU bleed air is supplied through the center section of the bleed air duct. The check valve in the APU supply line prevents reverse flow of bleed air from the duct into the APU.

Bleed duct overheat protection is provided in the APU bleed air system to detect leaks. If the APU shuts down for an overheat, it cannot be restarted.

Ground Bleed Air Supply

External connectors are provided to connect a ground source of high pressure air directly to the bleed air duct. High pressure air is used to start the engines when APU air is not available. Check valves prevent reverse flow of bleed air from the bleed air duct to the connectors.

Ground Source of Air Conditioning

When a ground source of conditioned air is available, it may be used to supply conditioned air directly to the cabin distribution system, eliminating the need for pack operation.

CAUTION: Do not operate a cooling pack and a ground air source of conditioned air for an extended period of time. A cooling pack cannot control the air temperature if a ground air source is operated simultaneously and may cause damage to equipment.

Bleed Air Duct System

The left and right isolation valves separate the bleed air duct into three sections: left, center, and right. The system normally operates with the isolation valves open. The valves are controlled by the left and right isolation valve switches.

Duct Leak and Overheat Detection System

A bleed duct overheat system is provided to detect leaks. If a duct leak is detected, the bleed air duct section affected can be isolated by closing the respective isolation and engine bleed air valves.

Bleed Air System Non-normal Operations

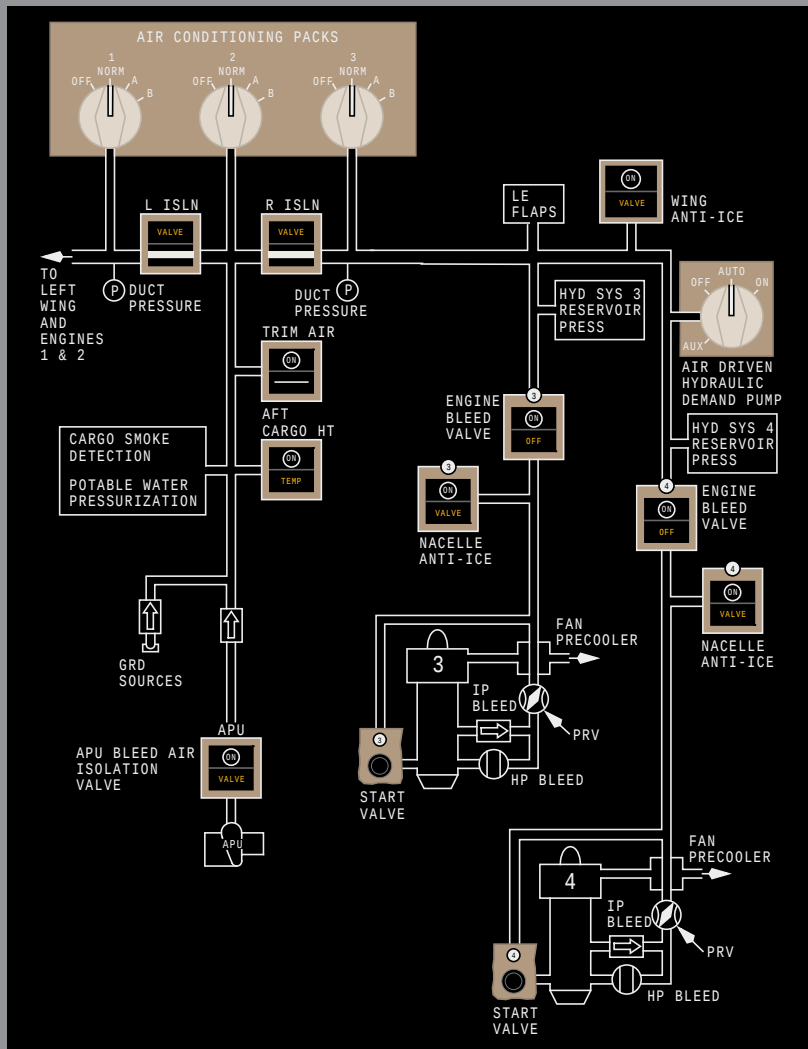
If a bleed duct leak is detected, closing the respective isolation and engine bleed valves prevents further air loss.

If the center duct section is isolated, pushing the Aft Cargo Heat switch off closes the electrically operated aft cargo heat valves to prevent cabin air flowing in reverse through the aft cargo heat supply duct and into the leaking center duct section. All temperature zones operate in backup temperature control mode without trim air. In addition, cargo smoke detection is not available. An electric compressor provides backup potable water pressurization.

If the left or right duct section is isolated, the respective leading edge flaps operate electrically in secondary mode. The respective hydraulic demand pump one or four is selected OFF to avoid the EICAS alert message HYD PRESS DEMAND from being displayed during approach. A maximum of one air conditioning pack on assures sufficient thrust is available from the two engines which supply air to the unaffected duct sections. The Nitrogen Generating System (NGS) is shutdown when the right bleed duct is isolated.

The EICAS alert message BLEED is displayed for bleed overpressure, or PRV or HP bleed valve failed to close when commanded. If the respective NAI VALVE message is displayed after pushing the related Nacelle Anti-ice switch ON, the PRV is closed because the HP bleed valve failed open and nacelle anti-ice is not available.

Bleed Air System Schematic



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Air Systems

EICAS Messages

Chapter 2

Section 50

EICAS Alert Messages

Message	Level	Aural	Message Logic
BLD DUCT LEAK L, C, R	Caution	Beeper	Bleed air leak or overheat along left, center, or right duct section.
BLD 1, 2, 3, 4 OVHT/PRV	Advisory		Engine bleed air overheat or PRV failed closed.
BLEED 1, 2, 3, 4	Advisory		Engine bleed air overpressure, or HP bleed valve or PRV failed to close when commanded.
>BLEED 1, 2, 3, 4 OFF	Advisory		Engine Bleed Air switch OFF, engine operating, and engine bleed air valve closed.
BLEED HP ENG 1, 2, 3, 4	Advisory		HP bleed valve failed closed.
>BLEED ISLN APU	Advisory		APU bleed isolation valve position disagrees with commanded position.
BLEED ISLN L, R	Advisory		Isolation Valve switch position and valve position disagree.
CABIN ALT AUTO	Caution	Beeper	Both cabin altitude controllers failed or both Outflow Valve Manual switches ON.
CABIN ALTITUDE	Warning	Siren	Cabin altitude excessive.
>E/E CLNG CARD	Advisory		Fault in equipment cooling system and system not fully functional. Message inhibited in flight.
EQUIP COOLING	Caution	Beeper	With Equipment Cooling selector in NORM or STBY, airflow inadequate, or overheat or smoke detected; or with selector in OVRD, differential pressure for reverse flow cooling inadequate; or ground exhaust valve not in commanded position.

Message	Level	Aural	Message Logic
LANDING ALT	Advisory		Disagreement between controller landing altitude and FMC landing altitude, or landing altitude in MAN.
OUTFLOW VLV L, R	Advisory		Automatic control of outflow valve inoperative, or respective Outflow Valve Manual switch ON.
PACK 1, 2, 3	Advisory		Pack controller fault, or pack operation fault, or pack overheat, or pack 2 shutdown with either cabin pressure relief valve open.
PACK CONTROL	Advisory		Automatic control of outlet temperature of all packs has failed.
PRESS RELIEF	Advisory		Either pressure relief valve opens with all packs operating and Pack 2 not shutdown.
TEMP CARGO HEAT	Advisory		Overheat detected in aft cargo compartment when aft cargo heat system operating. Inhibited on the ground.
TEMP ZONE	Advisory		Zone duct overheat, or master trim air valve failed closed, or zone temperature controller failed. Master trim air valve driven closed and temperature controlled in backup mode.
>TRIM AIR OFF	Advisory		Master trim air valve closed. Flight deck and passenger cabin temperature controlled in backup mode.

EICAS Memo Messages

Message	Level	Aural	Message Logic
PACK 1, 2, 3 OFF	Memo		Pack switch off. Inhibited by Pack 1, 2, 3 advisory message.
PACKS 1 + 2, 1 + 3, 2 + 3 OFF	Memo		Pack switches off.
PACKS HIGH FLOW	Memo		High flow switch ON. Pack flow setting not controlled automatically.
PACKS OFF	Memo		All pack switches off.

Anti-Ice, Rain
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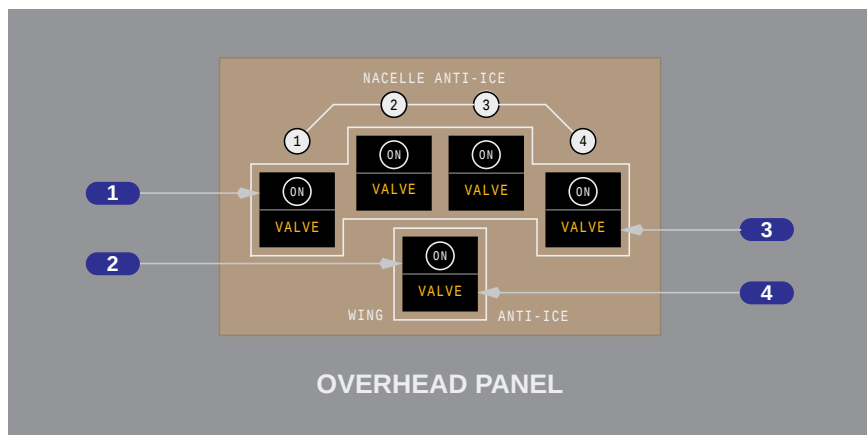
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Nacelle and Wing Anti-Icing

Nacelle and Wing Anti-Ice Panel



1 NACELLE ANTI-ICE Switches

Off - nacelle anti-icing valves commanded closed

ON -

- nacelle anti-icing valve opens when bleed air pressure is available
- engine igniters selected by Auto Ignition selector and EEC operate continuously
- approach idle is selected (when aircraft is in flight)
- PRV opens when nacelle anti-icing valve is open, unless PRV closed by:
 - prior or present bleed air overheat, or
 - start valve not closed, or
 - HP bleed valve failed open

2 WING ANTI-ICE Switch

Off - wing anti-icing valves commanded closed

ON -

- in flight, the wing anti-icing valves open to supply bleed air to the left and right wing leading edges
- on the ground, the system is off and wing anti-icing valves are closed

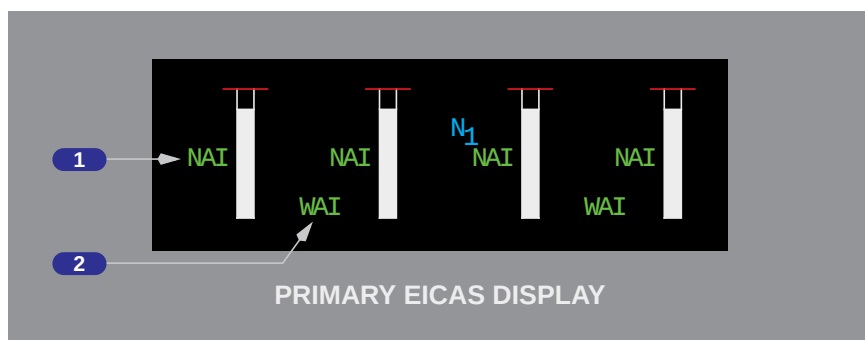
3 ENGINE ANTI-ICE VALVE Lights

Illuminated (amber) - nacelle anti-icing valve position disagrees with switch position

4 WING ANTI-ICE VALVE Light

Illuminated (amber) – the position of either wing anti-icing valve disagrees with the switch position.

Anti-Icing Indications on EICAS Display



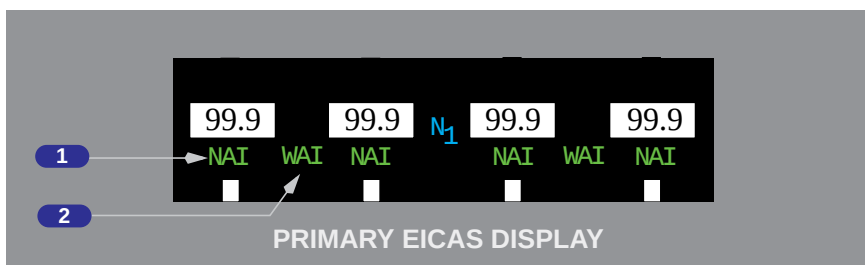
1 Nacelle Anti-icing Indication

Displayed (green) - nacelle anti-icing valve is open.

2 Wing Anti-Icing Indication

Displayed (green) - wing anti-icing valve is open.

Anti-Icing Indications in Compact Mode



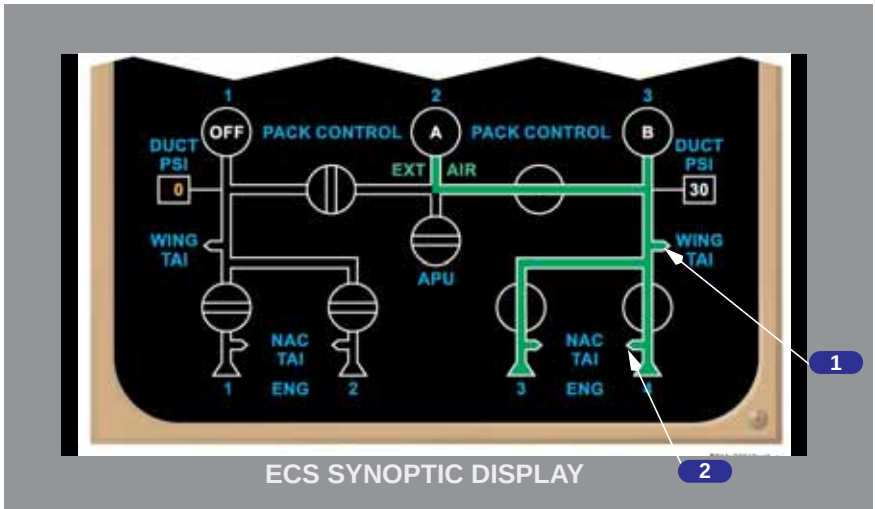
1 Nacelle Anti-icing Indication

Displayed (green) - nacelle anti-icing valve is open.

2 Wing Anti-Icing Indication

Displayed (green) - wing anti-icing valve is open.

Nacelle Anti-Ice and Wing Anti-Ice Indications, Secondary EICAS



1 Wing TAI (Wing Anti-Ice Indication)

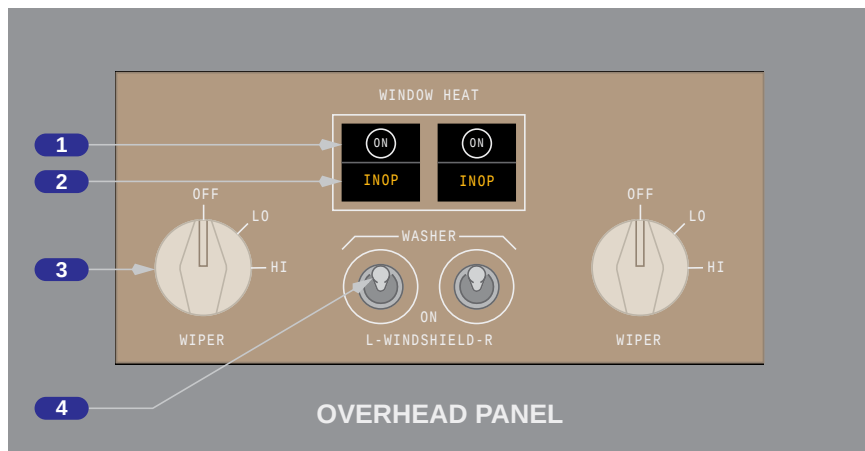
Displayed (green) - wing anti-ice switch is on and wing anti-ice valve is open.

2 NAC TAI (Nacelle Anti-Ice Indication)

Displayed (green) - nacelle anti-ice switch is on and NAI valve is open.

Windshield Heat and Washers

Windshield Heat and Washers Panel



1 WINDOW HEAT Switches

ON - controlled heat applied to the windshield.

2 WINDOW HEAT Inoperative (INOP) Lights

Illuminated (amber) -

- windshield overheat or controller fault has been detected
- power removed from windshield

3 Windshield WIPER Selectors

OFF - wipers off and sequenced to stowed position.

LO - wipers operate at low speed.

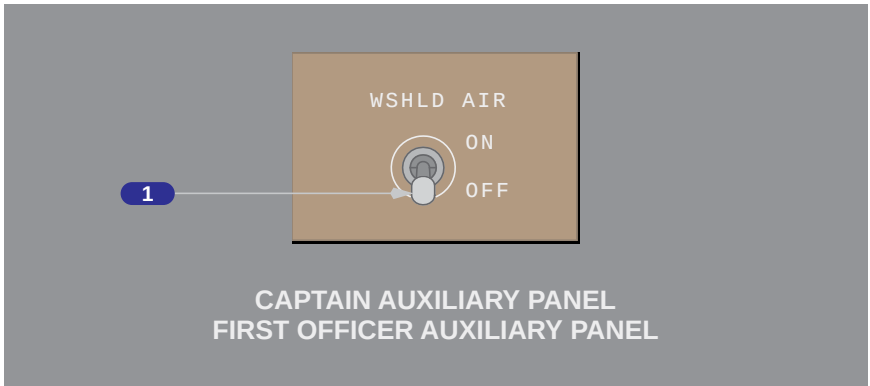
HI - wipers operate at high speed.

4 WINDSHIELD L, R WASHER Switches

Spring loaded to neutral.

ON - applies washer fluid.

Windshield Air Switch

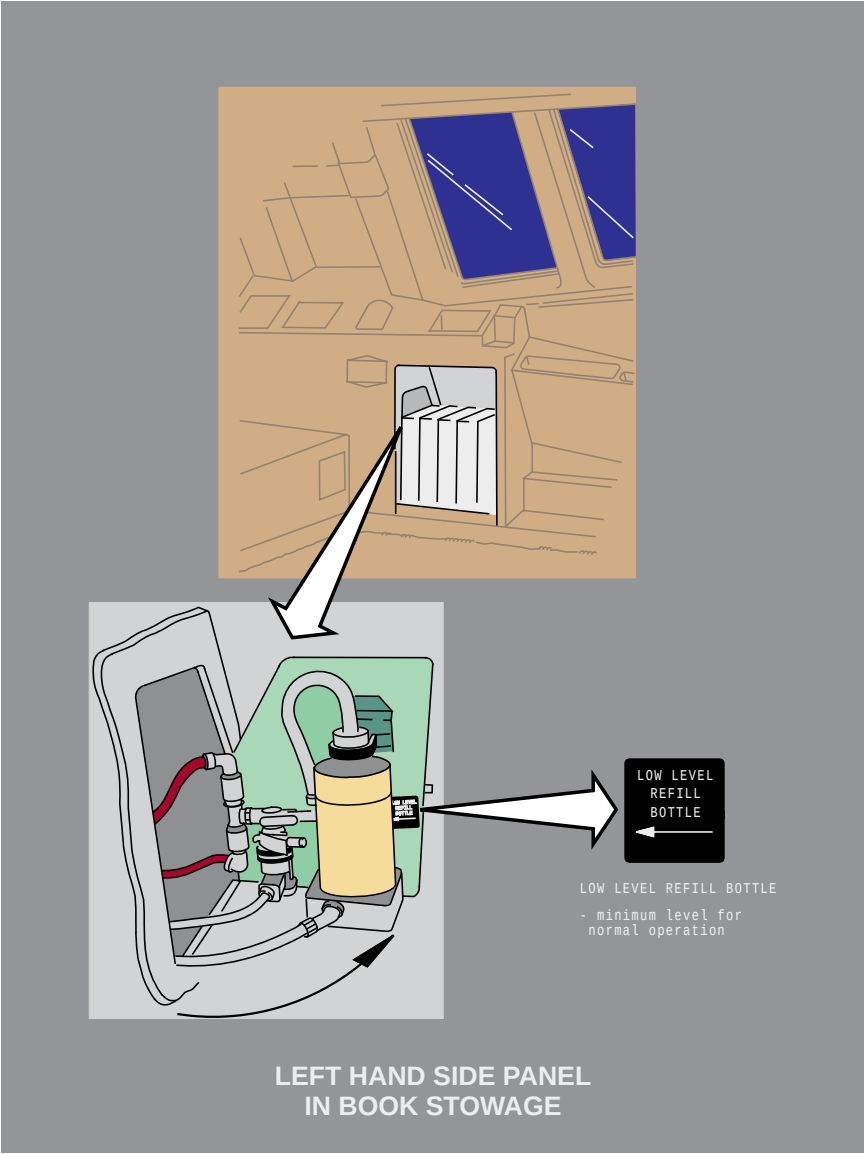


1 Windshield (WSHLD) AIR Switch

ON - provides air to windshield

OFF - windshield air off

Windshield Washer Fluid



Anti-Ice, Rain System Description

Chapter 3 Section 20

Introduction

The anti-icing and rain systems include:

- engine nacelle inlet anti-icing
- wing anti-icing
- flight deck window heat
- windshield wipers
- probe heat

Anti-Ice Systems

Nacelle and wing anti-icing is provided by distributing engine bleed air to the nacelle inlets and to the wing leading edges.

Nacelle Anti-Ice System

The nacelle anti-ice valves are opened by engine bleed air pressure. When a nacelle anti-icing valve is open, NAI is displayed on the primary EICAS display. When a Nacelle Anti-Ice switch is ON, the respective nacelle anti-icing valve is commanded open.

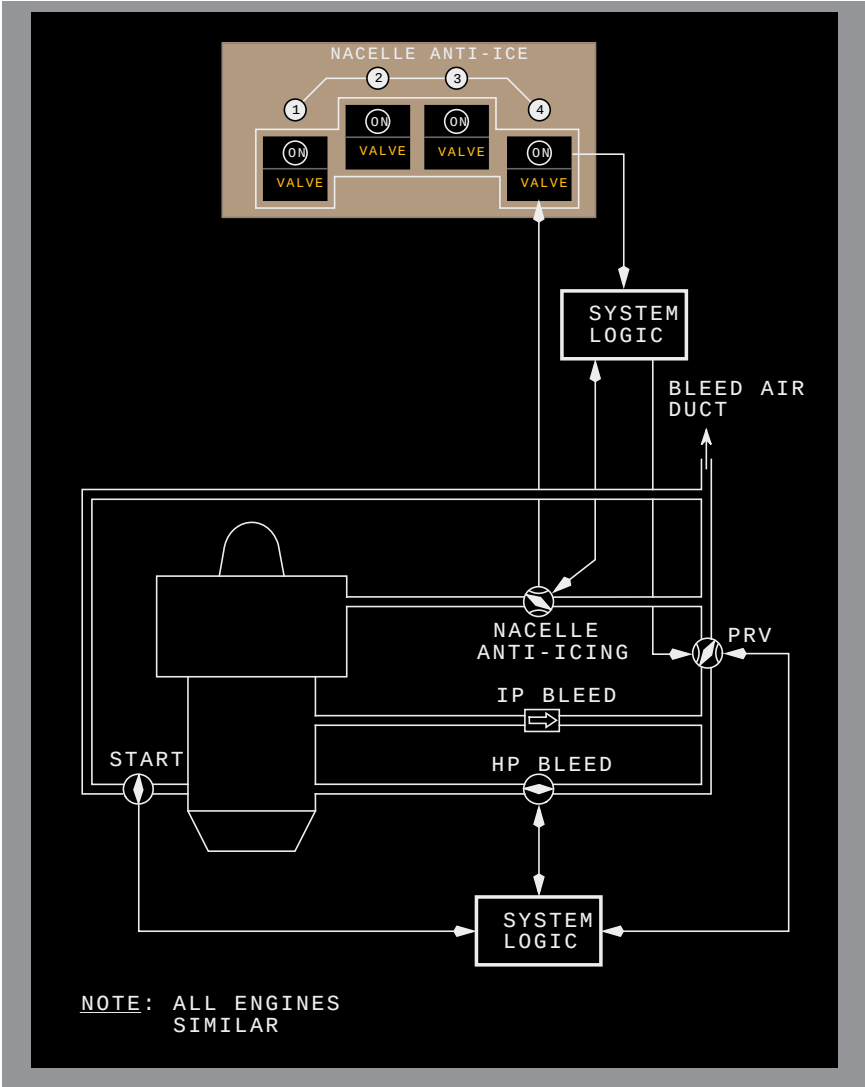
When the Nacelle Anti-Ice switch is commanded ON the engine igniters selected by the Auto Ignition selector and EEC operate continuously.

Bleed air is not available for nacelle anti-icing if the PRV is closed because of:

- a prior or present bleed air overheat, or
- the start valve is not closed, or
- the HP bleed valve is failed open

When nacelle anti-icing is commanded ON with the engine bleed valve closed, the HP bleed valve remains closed. Bleed air is supplied by IP bleed only.

Nacelle Anti-ice System Diagram



Wing Anti-Icing

When a wing anti-icing valve is open, WAI is displayed on the primary EICAS display.

In flight, when the Wing Anti-Ice switch is ON, the wing anti-icing valves open. Only the leading edge midspan and outboard sections are anti-iced. Wing anti-icing is ineffective when the leading edge flaps are not retracted.

Flight Deck Windows

Flight deck windows are electrically heated. The forward windshields have anti-icing protection on the exterior surfaces, and anti-fogging heating on the interior surfaces. The side windows have controlled anti-fogging heating on the interior surfaces.

The Window Heat switches control heating for the forward windshields only. When the Window Heat switches are ON, electric power is supplied to the forward windshields.

Side window heating is automatic and no flight deck controls are provided. The system is powered whenever the AC electrical system is powered.

If a fault or overheat condition is sensed, power is disconnected from the respective forward windshield or side window system. Pushing a Window Heat switch off for 10 seconds, then ON, resets a forward windshield heat controller fault.

Windshield Wipers and Washers

The two speed windshield wipers are independently controlled. When a wiper selector is OFF, the wiper is off and stowed.

If the wipers are used on a dry windshield, the wipers may scratch the windshield.

The Windshield Washer switches command a continuous application of washer fluid while held ON. The washer fluid reservoir is located behind the door in the book storage area on the captain side panel. The reservoir has a sight gage and a refill reference mark.

Windshield Air

Windshield Air switches on the captain and first officer auxiliary panels control anti-fogging air flow from the flight deck conditioned air supply.

Probe Heat

Four pitot-static probes and two angle of attack probes are electrically heated for anti-icing protection when any engine is operating. Two total air temperature probes are electrically heated for anti-ice protection in flight.

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Anti-Ice, Rain EICAS Messages

Chapter 3 Section 30

EICAS Alert Messages

The following EICAS messages can be displayed.

Message	Level	Aural	Message Logic
>ANTI-ICE	Advisory		A Nacelle Anti-ice switch or the Wing Anti-ice switch is ON, and TAT is more than 12°C.
HEAT L, R AOA	Advisory		AOA probe heat is failed.
HEAT L, R TAT	Advisory		TAT probe heat is failed, or on the ground, TAT probe is heated.
HEAT P/S CAPT, FO, L AUX, R AUX	Advisory		Pitot static probe heat is failed.
HEAT WINDOW L, R	Advisory		Forward window heat is not operating.
NAI VALVE 1, 2, 3, 4	Advisory		Nacelle anti-icing valve is not in the commanded position.
WAI VALVE LEFT, RIGHT	Advisory		Wing anti-ice valve not in commanded position.

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Automatic Flight

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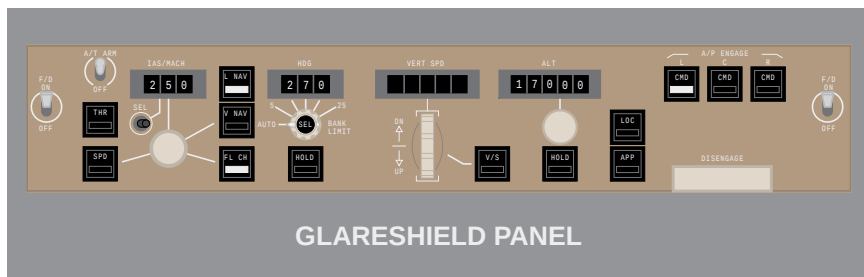
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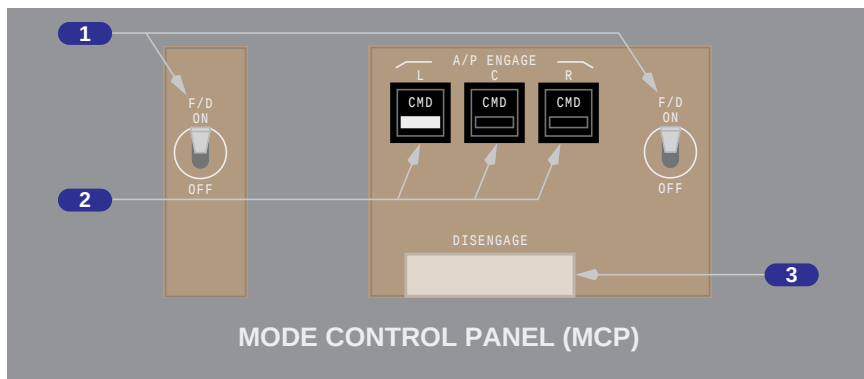
Automatic Flight Controls and Indicators

Chapter 4 Section 10

Mode Control Panel (MCP)



Autopilot Flight Director System (AFDS) Controls



1 Flight Director (F/D) Switches

The left F/D switch activates F/D steering indications on the left primary flight display (PFD). The right F/D switch activates F/D steering indications on the right PFD.

ON -

- on the ground with no autopilot (A/P) engaged and both F/D switches OFF, the first F/D switch positioned ON arms the F/D in the takeoff go-around (TO/GA) roll and pitch modes. Positioning the second F/D switch ON displays the flight direction steering indications on the second PFD
- in flight, with the A/P disengaged and both F/D switches OFF, the first F/D switch positioned to ON activates the F/D in:
 - vertical speed (V/S) as the pitch mode, and

- heading hold (HDG HOLD) as the roll mode, or if bank angle greater than five degrees, attitude hold (ATT)
- in flight, with the A/P engaged and both F/D switches OFF, the first F/D switch positioned to ON activates the F/D in the selected A/P mode(s)

OFF -

- F/D steering indications do not display, unless
- a TO/GA switch is pushed when airspeed is greater than 80 knots and flaps out of up

2 Autopilot (A/P) ENGAGE Switches

Push (any switch engages the autopilot) -

- when either F/D switch is ON, the A/P engages in the selected F/D mode(s)
- when both F/D switches are OFF, the A/P engages in:
 - vertical speed (V/S) as the pitch mode and
 - heading hold (HDG HOLD) or attitude hold (ATT) as the roll mode

3 Autopilot DISENGAGE Bar

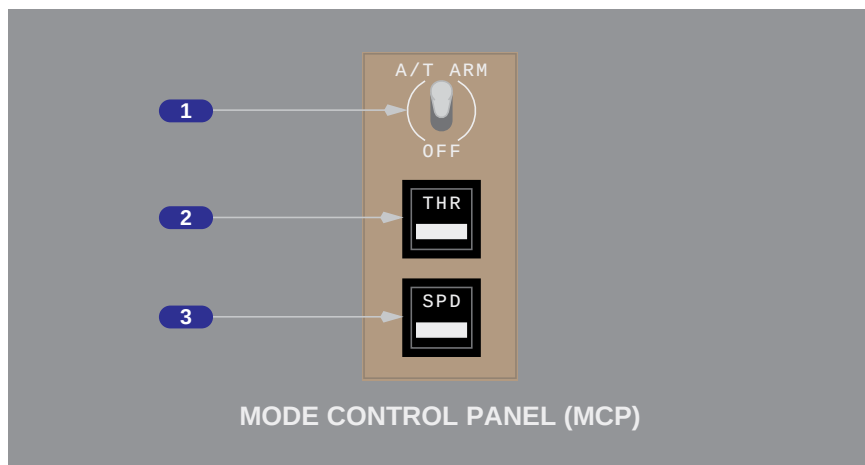
Push down -

- disengages all three A/Ps
- prevents A/P engagement
- exposes amber stripe

Lift up -

- enables A/P engagement
- conceals amber stripe

Autothrottle (A/T) System Controls



1 Autothrottle (A/T) ARM Switch

ARM -

- disconnects if more than one engine inoperative
- arms A/T system for mode selection
- A/T activates when VNAV, FLCH, or TO/GA switch pushed
- A/T activates when speed switch pushed and pitch mode is ALT, V/S, or G/S
- when A/T flight mode annunciation blank and pitch mode is VNAV XXX or FLCH SPD, cycling the A/T ARM switch to OFF and back to ARM activates the A/T

OFF -

- disconnects A/T
- disables A/T activation
- disables engine trim equalization

2 Thrust (THR) Switch

Operative from 400 feet after takeoff until landing; used to select climb thrust after takeoff or go-around.

Push -

Light remains extinguished (thrust limit function) -

- after takeoff with VNAV or FLCH selected, changes reference thrust limit to armed climb thrust limit, or CON if engine inoperative
- after go-around, changes reference thrust limit to CLB, or CON if engine inoperative or CON selected

Note: Reference thrust limit remains G/A when flaps in landing position or pitch mode is G/S.

Light illuminates (A/T mode function) - Changes A/T mode to THR REF when:

- reference thrust limit is CLB, CLB1, CLB2, CRZ, or CON and pitch mode is ALT or V/S
- reference thrust limit is G/A and pitch mode is G/S or FLARE, or pitch mode is ALT or V/S and flaps in landing position

3 Speed (SPD) Switch

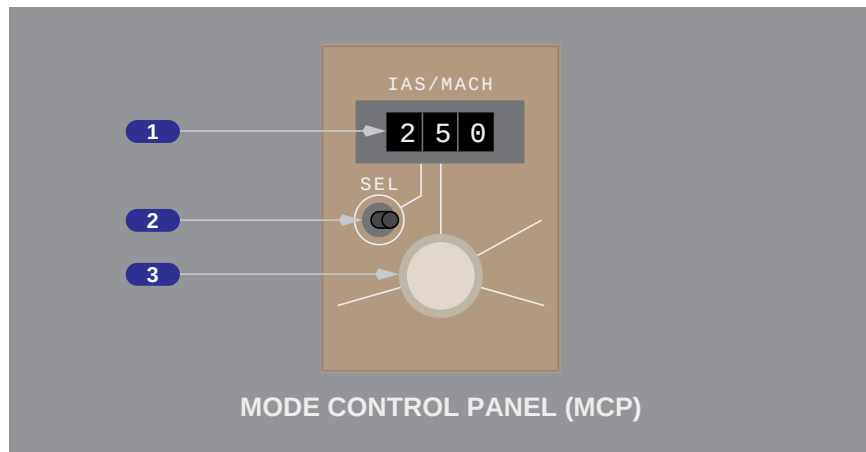
Operative from 400 feet after takeoff until landing.

Push (light illuminates) -

- selects A/T SPD mode
- displays SPD on both PFDs

- A/T controls thrust to maintain IAS or Mach displayed in IAS/MACH window subject to minimum and maximum speed limits
- inactive in VNAV XXX, FLCH SPD, or TO/GA pitch modes

Autopilot Flight Director IAS/Mach Controls



1 IAS/MACH Window

Displays selected speed when IAS/MACH selector controls command speed.

Blank when FMC controls command speed.

IAS/Mach window and PFD speeds set to 200 knots when power first applied.

Display range:

- 100 - 399 KIAS
- .40 - .95 Mach

Displays selected speed on PFD.

In climb, changes from IAS to Mach at approximately .84 Mach.

In descent, changes from Mach to IAS at approximately 310 knots.

2 IAS/MACH Select (SEL) Switch

Push -

- alternately changes the IAS/MACH window between IAS and Mach displays (Mach must be 0.4 or greater to switch from IAS to Mach)
- inoperative when the IAS/MACH window is blank

3 IAS/MACH Selector

Rotate -

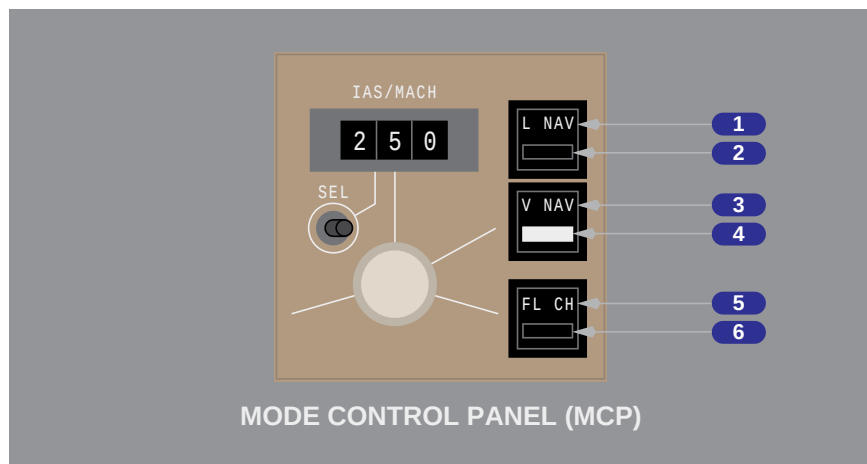
- sets speed in IAS/MACH window and command speed on both PFDs
- inoperative when IAS/MACH window blank

Push - with VNAV active, alternately opens or closes the IAS/MACH window:

- when window closed, FMC computed target speed is active and displays on PFDs
- when window open, FMC speed-intervention is active and IAS/MACH selector may be used to set command speed. Pitch mode annunciator changes to VNAV SPD when descending in VNAV PTH. Selected speed maintained by pitch until airplane intercepts an altitude constraint and VNAV PTH annunciates. When inside the Key Waypoint, pitch mode remains VNAV PTH and A/T controls speed

IAS/MACH window open if pitch mode is FLCH SPD, V/S, TO/GA, ALT, or G/S.

Autopilot Flight Director Roll and Pitch Controls



1 Lateral Navigation (LNAV) Switch

Push -

- arms, selects, or disarms LNAV as roll mode
- displays LNAV in white (armed) on both PFD roll flight mode annunciations when armed. The previous roll mode remains active
- Active route required to arm LNAV
- LNAV activates when the airplane is 50 feet above runway elevation and:
 - within 2.5 NM of the active leg
 - when not within 2.5 NM of the active leg but on an intercept heading to the active leg, remains armed then activates when approaching the active leg

- when active, displays LNAV in green on PFD roll flight mode annunciator
- selection of LNAV with the airplane not on a heading to intercept the active leg, displays NOT ON INTERCEPT HEADING in the CDU scratch pad
- LNAV maintains current heading when:
 - passing the last active route waypoint
 - passing the last waypoint prior to a route discontinuity
 - passing the last route offset waypoint
 - activating the inactive route or activating an airway intercept and not within LNAV engagement criteria
- LNAV deactivated:
 - by selecting heading select (HDG SEL) or heading hold (HDG HOLD)
 - by selecting TO/GA
 - by disengaging autopilot and selecting both FDs OFF
 - when localizer captures
 - with dual FMC failure
- LNAV is disarmed by pushing LNAV switch a second time or by selecting LOC or APP.

2 LNAV Light

Illuminated - LNAV roll mode armed or active.

3 Vertical Navigation (VNAV) Switch

Push -

- arms, selects, or disarms VNAV as pitch mode
- displays VNAV in white (armed) on both PFD pitch flight mode annunciators below 400 feet (gross weight, cruise altitude, and cost index must be entered)
- VNAV activates 400 feet above runway elevation
- when VNAV selected and FMC has insufficient data to provide VNAV guidance (such as invalid gross weight or there is no end-of-descent point in descent) displays PERF/VNAV NOT AVAILABLE in CDU scratchpad
- VNAV SPD, VNAV PTH, or VNAV ALT pitch mode displays in green (active) on PFD pitch flight mode annunciator
- in VNAV SPD pitch mode, AFDS commands pitch to hold target airspeed. The A/T operates in THR REF, THR, IDLE or HOLD mode, as required by phase of flight
- in VNAV PTH pitch mode, AFDS commands pitch to maintain FMC target altitude or VNAV path; A/T operates in speed (SPD) mode

- in VNAV ALT pitch mode, AFDS commands pitch to maintain MCP selected altitude; A/T operates in SPD mode
- VNAV pitch guidance available with one or two engines inoperative

Note: In VNAV, if a conflict exists between the VNAV profile and the MCP altitude, the airplane levels and the pitch flight mode annunciation becomes VNAV ALT. Resetting the MCP altitude window and pushing the altitude selector continues the climb or descent. If below the VNAV path, resetting the MCP altitude window and intercepting the VNAV path will also continue the descent.

VNAV deactivated:

- by selecting TO/GA, FLCH SPD, V/S, ALT, or G/S pitch mode
- by disengaging autopilot and selecting both FDs OFF
- with a dual FMC failure

VNAV is disarmed by pushing VNAV switch a second time.

4 VNAV Light

Illuminated - VNAV pitch mode armed or active.

5 Flight Level Change (FLCH) Switch

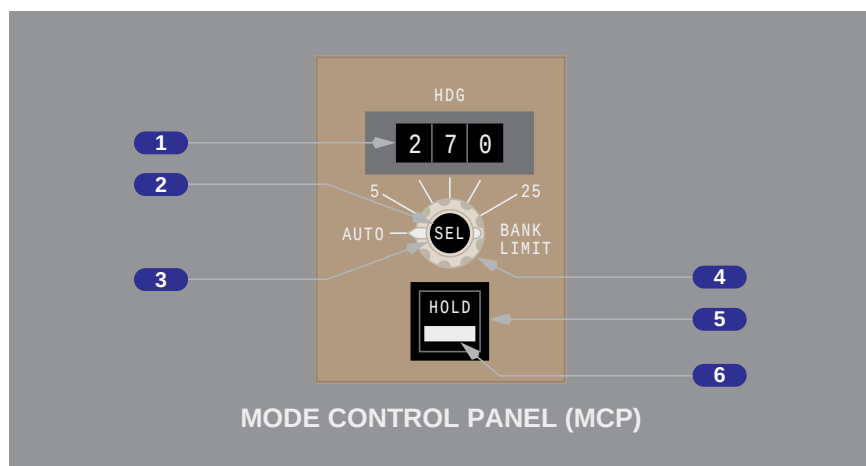
Push -

- selects FLCH SPD pitch mode
- FLCH SPD pitch mode displays in green (active) on PFD flight mode annunciator
- when IAS/MACH window blank, IAS/MACH window opens to FMC target speed, if valid. If not valid, IAS/MACH window opens to current speed
- when IAS/MACH window open, displays command speed
- when changing from TO/GA to FLCH, IAS/MACH window displays highest value of current airspeed or selected speed
- AFDS pitch holds selected speed. When selected altitude captured, pitch flight mode annunciator changes to ALT
- A/T operates in THR, followed by HOLD mode in descent. When selected altitude captured, A/T mode changes to SPD. A/T advances or retards thrust levers to maintain a vertical speed proportional to the altitude change requested
- with higher altitude set in the ALT window, reference thrust limit changes to CLB when CRZ displayed and to CON with an engine inoperative

6 Flight Level Change Light

Illuminated - flight level change pitch mode active.

Autopilot Flight Director Heading and Bank Angle Controls



1 Heading (HDG) Window

Displays selected heading.

Displays selected heading on PFDs and NDs.

HDG window, PFD, and ND headings set to 000 when power first applied.

Changes to ILS front course at LOC capture.

Note: Heading slews to final approach course during ILS or LOC approaches only.

2 Heading Select (HDG SEL) Switch

Push -

- selects HDG SEL roll mode
- HDG SEL roll mode displays in green (active) on PFD roll flight mode annunciation
- AFDS controls roll to acquire and hold selected heading
- bank is limited by bank limit selector

3 Heading (HDG) Selector (inner)

Rotate - sets heading in HDG window and selected heading on PFDs and NDs.

4 BANK LIMIT Selector (outer)

Rotate - sets AFDS commanded bank limit when in heading select (HDG SEL) roll mode as follows:

- AUTO - varies between 15 - 25 degrees, depending on TAS, flap position, and V2
- 5, 10, 15, 20, or 25 - selected value is maximum, regardless of airspeed

5 Heading (HDG) HOLD Switch

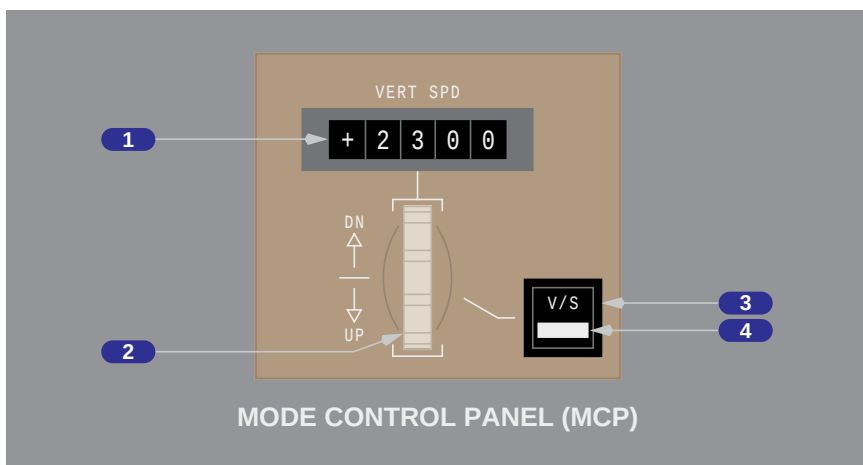
Push -

- selects HDG HOLD roll mode
- HDG HOLD roll mode displays in green (active) on PFD roll flight mode annunciation
- AFDS rolls wings level, then holds present heading

6 Heading Hold Light

Illuminated - HDG HOLD roll mode active.

Autopilot Flight Director Vertical Speed (V/S) Controls



1 Vertical Speed (VERT SPD) Window

Blank when vertical speed (V/S) pitch mode not selected.

Displays current V/S when V/S pitch mode selected.

Displays selected V/S in 100 fpm increments.

Display range is -8000 to +6000 fpm.

Vertical speed displays on the PFD V/S indication.

2 Vertical Speed (V/S) Selector

UP or Down (DN) - sets V/S in VERT SPD window and on both PFDs.

3 Vertical Speed (V/S) Switch

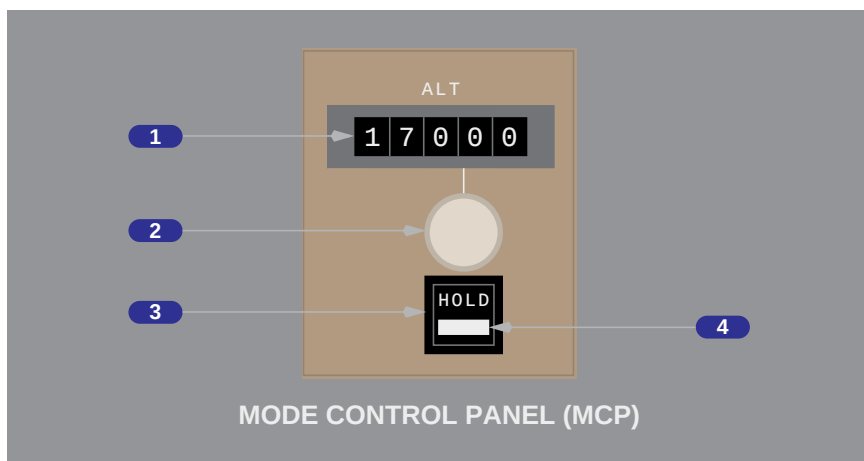
Push -

- selects V/S pitch mode
- V/S pitch mode displays in green (active) on PFD pitch flight mode annunciation
- displays current V/S in V/S window
- AFDS pitch maintains V/S displayed in the V/S window. When selected altitude reached, pitch flight mode annunciation changes to ALT
- A/T operates in speed (SPD) mode, if armed

4 Vertical Speed (V/S) Light

Illuminated - vertical speed pitch mode is active.

Autopilot Flight Director Altitude Controls



1 Altitude Window

Displays selected altitude in 100 feet increments. Display range is 0 to 50000 feet.

Displays selected altitude on PFDs.

Displayed altitude is reference altitude for altitude alerting and level off.

ALT window and PFD altitudes set to 10000 feet when power first applied.

2 Altitude Selector

Rotate - sets altitude in ALT window and selected altitude on both PFDs.

Push -

- during climb or descent with altitude constraints, each push deletes the next waypoint constraint between the airplane altitude and the altitude window setting
- during climb with no altitude constraints, and the altitude window set above the FMC cruise altitude, changes cruise altitude to the altitude window value
- during cruise:
 - with the altitude window set above or below FMC cruise altitude, resets the FMC cruise altitude to the altitude window altitude
 - when in VNAV PTH or VNAV ALT pitch mode, initiates a climb or descent toward the altitude window altitude
 - within 50 NM of the top-of-descent (T/D) point, with the altitude window set below cruise altitude, initiates descent now (DES NOW) with a reduced descent rate

3 Altitude HOLD Switch

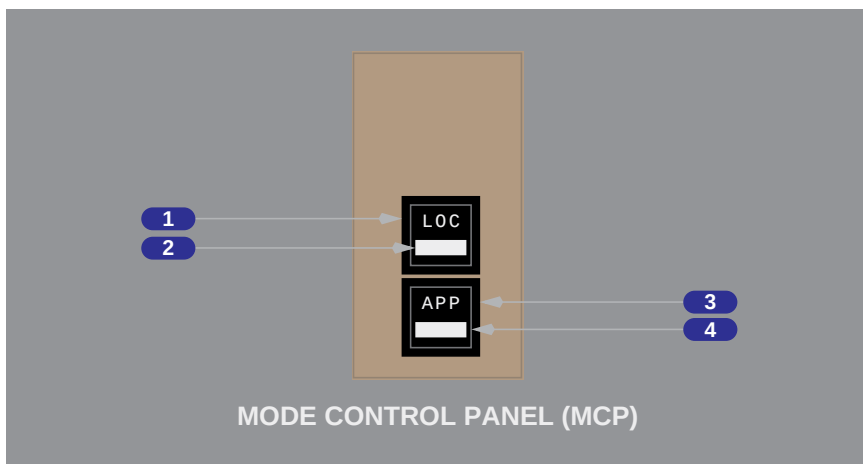
Push -

- selects altitude (ALT) pitch mode
- ALT pitch mode displays in green (active) on PFD pitch mode annunciation
- AFDS commands pitch to maintain the altitude when the switch was pushed

4 Altitude Hold Light

Illuminated - altitude hold mode active.

Autopilot Flight Director Approach Mode Controls



1 Localizer (LOC) Switch

Push -

- arms, disarms, or captures localizer (LOC) as roll mode
- displays LOC in white (armed) on PFD roll flight mode annunciations before localizer capture; current roll mode remains active until LOC capture
- displays LOC in green (active) on PFD roll flight mode annunciations after localizer capture
- arms AFDS to capture and track inbound on front course
- capture point varies based on range and intercept angle
- localizer capture can occur when intercept track angle is within 120 degrees of the localizer course

Note: After localizer capture, flight director roll commands may appear inconsistent with A/P roll maneuvers for one to two minutes.

Localizer mode can be disarmed before localizer capture by:

- pushing localizer switch a second time, or
- selecting LNAV

Localizer mode can be deactivated after localizer capture by:

- selecting a roll mode other than LNAV
- pushing a TO/GA switch
- disengaging the autopilot and positioning both F/D switches off

2 Localizer Light

Illuminated - localizer roll mode armed or active.

3 Approach (APP) Switch

Push -

- arms, disarms, or captures localizer (LOC) as roll mode and glideslope (G/S) as pitch mode
- displays LOC and G/S in white (armed) on PFD roll and pitch flight mode annunciations before localizer and glideslope capture
- displays LOC and G/S in green (active) on PFD roll and pitch flight mode annunciations after each is captured
- arms other A/P systems (CMD switch lights illuminated) for engagement at localizer and glideslope capture and radio altitude less than 1,500 feet
- A/P systems are powered by separate sources
- either localizer or glideslope can be captured first

- localizer captures when intercept track angle is within 120 degrees of localizer course
- glideslope captures when intercept track angle is within 80 degrees of localizer course

Note: After localizer capture, flight director roll commands may appear inconsistent with A/P roll maneuvers for one to two minutes.

Approach mode can be disarmed before localizer or glideslope capture by:

- pushing approach switch a second time, or
- selecting LOC, LNAV, or VNAV

Approach mode deselects:

- with localizer captured and glideslope armed, by selecting another roll mode other than LNAV; selecting LOC mode initiates a localizer approach
- with glideslope captured and localizer armed, by selecting another pitch mode other than VNAV
- after localizer and/or glideslope are captured, by selecting TO/GA mode or disengaging autopilot and positioning both F/D switches off

4 Approach Light

Illuminated - approach modes (LOC and G/S) armed or active.

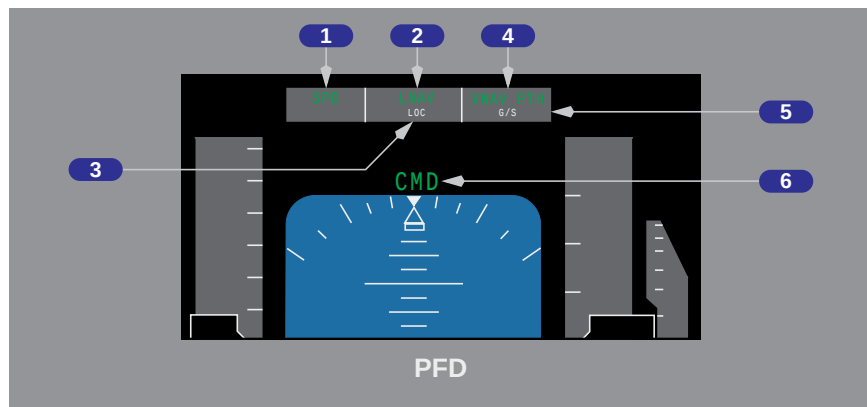
PFD Flight Mode Annunciations (FMAs)

Note: A/T, roll, or pitch mode changes are emphasized for 10 seconds by a green box around the mode.

Note: An amber horizontal line displays through the affected ACTIVE pitch or roll mode when a flight mode fault is detected.

Note: NO AUTOLAND displays on the PFD if failures cause the system to degrade from multi-channel engage status (LAND 3 or LAND 2) to single channel status during an autoland. The mode change is emphasized for 10 seconds by an amber box.

NO AUTOLAND also displays on PFD if multi-channel approach selected but multi-channel engage status (LAND 3 or LAND 2) has not been annunciated by 600 feet AGL. Under these conditions, flare and rollout modes are not armed.



1 Autothrottle Modes (Active)

Displayed (green) -

- THR
- THR REF
- HOLD
- IDLE
- SPD

2 AFDS Roll Modes (Active)

Displayed (green) -

-
• HDG HOLD	• LOC
• HDG SEL	• ROLLOUT
• LNAV	• TO/GA
• ATT	

3 AFDS Roll Modes (Armed)

Displayed (white) -

• LOC	• LNAV
• ROLLOUT	

4 AFDS Pitch Modes (Active)

Displayed (green) -

• TO/GA	• VNAV ALT
• ALT	• G/S
• V/S	• FLARE
• VNAV PTH	• FLCH SPD
• VNAV SPD	

5 AFDS Pitch Modes (Armed)

Displayed (white) -

• G/S	• VNAV
• FLARE	

6 AFDS (Active)

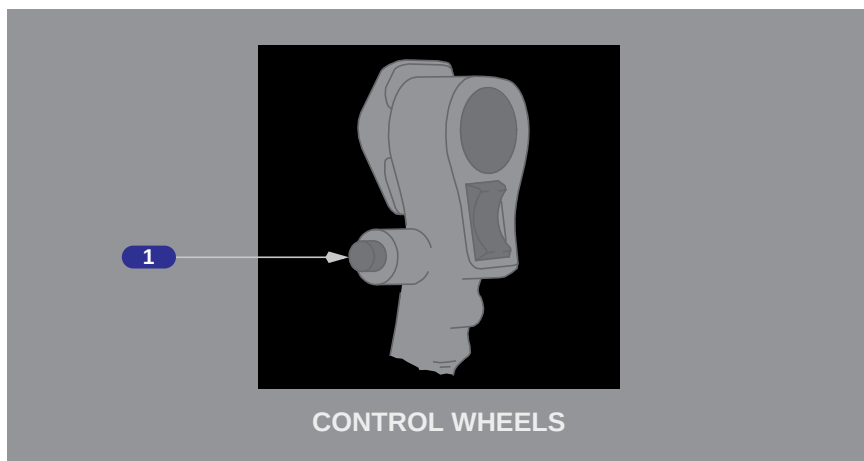
Displayed (green) -

• FD	• LAND 3
• CMD	• TEST

Displayed (green with white triangles) - ▷LAND2◁

Displayed (amber) - NO AUTOLAND

Autopilot Disengage Switch



1 Autopilot Disengage Switch

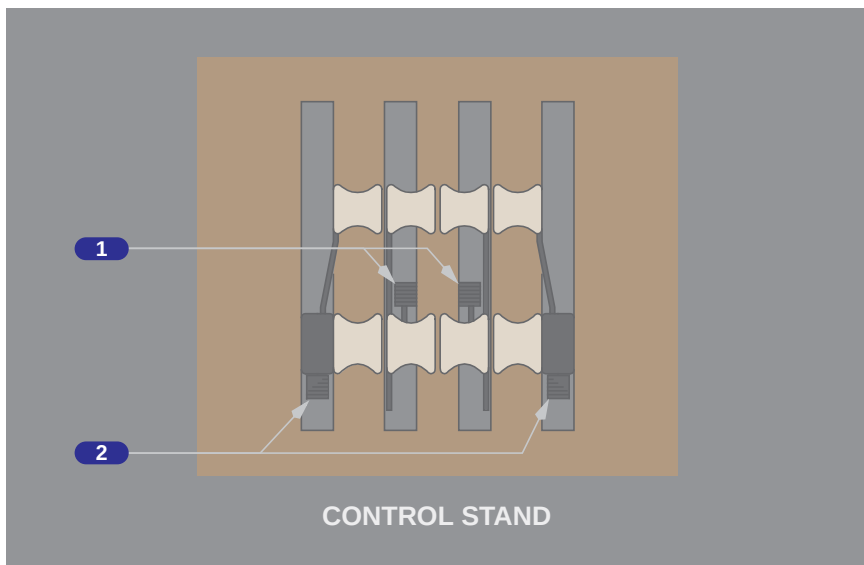
First push (either switch) -

- disengages all autopilots
- master warning lights illuminate
- displays the EICAS warning message >AUTOPILOT DISC
- if A/P automatically disengages, resets master warning lights, EICAS warning message, and aural warning
- sounds a siren aural warning

Second push - resets:

- master warning lights
- EICAS warning message
- aural warning

Autothrottle Disconnect and TO/GA Switches



1 Takeoff/Go-around (TO/GA) Switch

On the ground:

Push -

- below 50 knots and flaps out of up, activates A/T in THR REF mode at reference thrust limit selected on THRUST LIMIT page. If not pushed below 50 knots, A/T operation is inhibited until reaching 400 feet altitude
- updates FMC position to runway landing threshold or position shift point if GPS updating not active

In flight:

Push (after lift-off with takeoff reference thrust limit displayed) -

- removes takeoff derates
- A/T in HOLD, activates A/T in THR REF mode
- between 50 feet and 400 feet, selects TO/GA roll mode
- above 400 feet, selects TO/GA roll and pitch modes

Push (on approach with flaps out of up or glideslope captured) -

- activates A/T in THR mode with GA reference thrust limit displayed. Thrust adjusts to provide a 2000 feet per minute climb
- selects TO/GA roll and pitch modes
- with no A/P or F/D active and TO/GA armed for Go Around, activates A/T in THR mode with GA reference thrust limit displayed. Thrust adjusts to provide a 2000 feet per minute climb

Second push - activates autothrottle in THR REF using GA reference thrust.

2 Autothrottle Disconnect Switches

Push (either switch) -

- disconnects A/T
- illuminates master caution lights
- displays EICAS message >AUTOTHROT DISC
- if A/T automatically disconnects, resets master caution lights and EICAS message

Second push - resets master caution lights and EICAS message.

Autothrottle remains armed.

Automatic Flight System Description

Chapter 4 Section 20

Introduction

The automatic flight control system consists of the autopilot flight director system (AFDS) and the autothrottle system (A/T). The mode control panel (MCP) and flight management computer (FMC) control the AFDS and the autothrottle system to perform climb, cruise, descent, and approach.

Autopilot Flight Director System

The AFDS consists of three flight control computers (FCC) and the MCP.

The MCP provides control of the autopilot, flight director, altitude alert, and autothrottle systems. The MCP selects and activates AFDS modes, and establishes altitudes, speeds, and climb/descent profiles.

The three FCCs, left, center, and right, control separate hydraulically powered A/P control servos to operate flight controls. The A/P controls ailerons and elevators. Rudder commands are added 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, separate electrical sources power the three FCCs.

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

MCP Switches

MCP switches select automatic flight control and flight director modes. A light in the lower half of the switch illuminates PFD roll and pitch flight mode annunciations to indicate the mode is armed or active. Autothrottle modes are discussed later in this section.

Most modes activate with a single push. These modes include:

- flight level change (FLCH SPD)
- heading hold (HDG HOLD)
- heading select (HDG SEL)
- vertical speed (V/S)
- altitude hold (ALT)

Other modes arm or activate with a single push. These modes are:

- lateral navigation (LNAV)
- vertical navigation (VNAV)
- localizer (LOC)
- approach (APP)

All modes deactivate by disengaging the autopilot and turning both flight directors off. After localizer and glideslope capture, the localizer and glideslope modes can only be deactivated by disengaging the autopilot and turning both flight directors off or by selecting TO/GA mode. VNAV, LNAV, LOC, and APP modes can be disarmed by pushing the mode switch a second time.

Desired target values can be selected on the MCP for:

- airspeed
- vertical speed
- Mach
- altitude
- heading

All parameters except vertical speed can be preselected before autopilot and/or flight director engagement.

Autopilot Engagement

The autopilot is engaged by pushing one of the MCP autopilot engage switches.

Autopilot Disengagement

Normal autopilot disengagement is through either control wheel autopilot disengage switch. The autopilots can also be disengaged by the MCP autopilot disengage bar. The EICAS warning message >AUTOPILOT DISC displays when the autopilot has been manually or automatically disengaged.

AFDS Failures

During autopilot operation, failures affecting the active mode annunciate on the PFD. If the failure affects only the active mode:

- the autopilot remains engaged in an attitude stabilizing mode
- an amber line is drawn through the mode annunciation
- the EICAS caution message >AUTOPILOT displays

Failures affecting all autopilot modes result in an autopilot disengagement accompanied by an aural warning. Depending on the system failure, it may be possible to reengage an autopilot by pushing the autopilot engage switch.

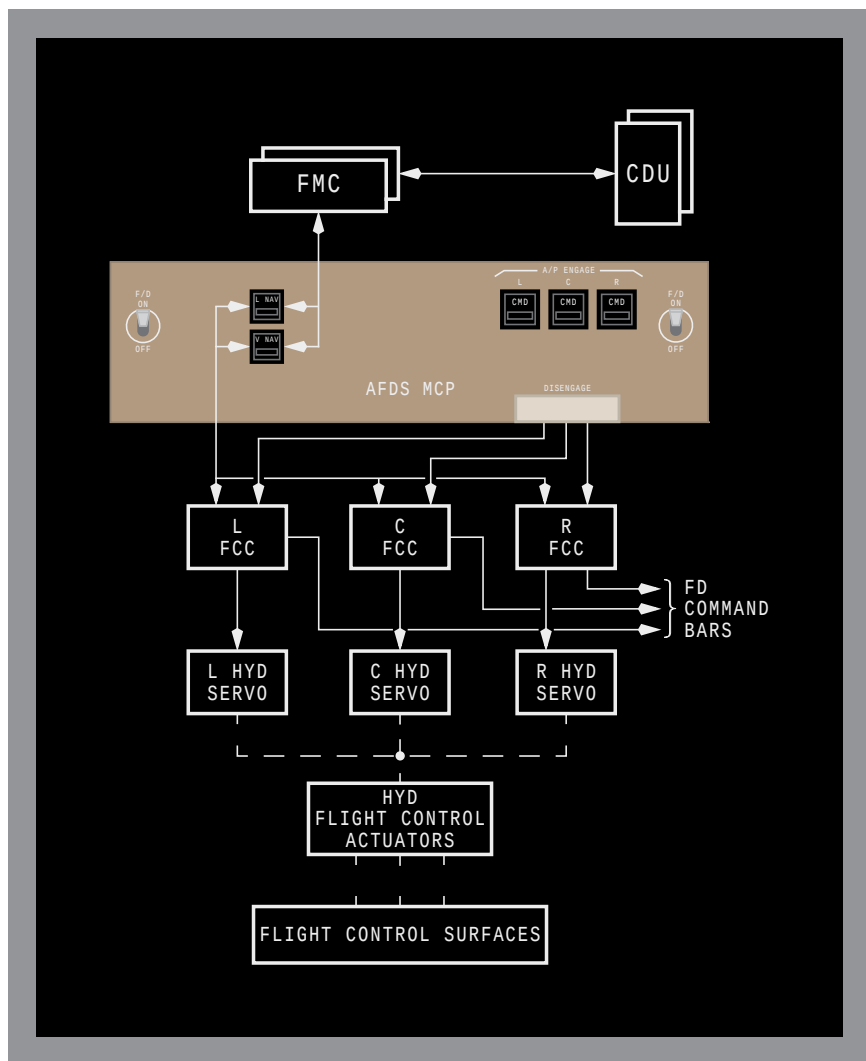
A flight director mode failure, in either pitch or roll, causes the command bars to disappear.

Flight Director Display

The flight director steering indications normally display any time the related Flight Director switch is ON.

Pushing a TO/GA switch when airspeed is greater than 80 knots and the flaps are out of up displays steering indications when the Flight Director switch(es) is OFF. In this case, steering indications can be removed by cycling the flight director switch(es) ON and OFF.

Autopilot Flight Director System Schematic



AFDS Status Annunciation

The following AFDS status annunciations display above the attitude display:

- **FD** - flight director ON and autopilots not engaged
- **CMD** - autopilot engaged
- **LAND 3** - three autopilots engaged and operating normally for an automatic landing

- ▷LAND2◁ - AFDS redundancy reduced; in some cases, only two autopilots available
- NO AUTOLAND - AFDS unable to make an automatic landing

With a LAND 3 indication, the autopilot system level of redundancy is such that a single fault cannot prevent the autopilot system from making an automatic landing (fail operational).

With a ▷LAND2◁ indication, the level of redundancy is such that a single fault cannot cause a significant deviation from the flight path (fail passive).

An EICAS message displays for any fault limiting the capability of the automatic landing system. Below 200 feet RA, a change from LAND 3 to ▷LAND2◁ is not annunciated. Faults not requiring immediate crew action or awareness are annunciated after touchdown.

AFDS Flight Mode Annunciations

Flight mode annunciations display above AFDS status annunciations. Mode annunciations, from left to right, are:

- autothrottle
- roll
- pitch

Active modes display at the top of the flight mode annunciation boxes in large green letters. Armed modes (except for TO/GA in flight) display in smaller white letters at the bottom of the flight mode annunciator boxes.

Autothrottle Modes

Autothrottle annunciations are:

THR - autothrottle applies thrust to maintain the climb/descent rate required by the pitch mode.

THR REF - thrust set to the reference thrust limit displayed on EICAS.

IDLE - displays while the autothrottle moves thrust levers to idle; IDLE mode is followed by HOLD mode.

HOLD - thrust lever autothrottle servos are inhibited. The pilot can set the thrust levers manually.

SPD - autothrottle maintains command speed. Command speed can be set using the MCP IAS/Mach selector or, by the FMC, as displayed on the CDU CLIMB, CRUISE, or DESCENT page. Autothrottle will not exceed thrust limits displayed on EICAS. Speed protection is not provided when the pitch mode is V/S.

Roll Modes

Roll annunciations are:

LNAV -

Arm LNAV by pushing the LNAV switch (the light illuminates and LNAV annunciates on the PFD roll mode annunciator in white characters below the current roll mode).

- LNAV (armed) - LNAV is armed to activate when parameters are met
- LNAV (active) - LNAV activates when above 50 feet and in position to turn onto the active route leg. In flight, selection causes immediate activation if within 2.5 NM of the active leg

HDG -

- HDG SEL (active) - airplane turns to or maintains the heading set in the MCP heading window
- HDG HOLD (active) - AFDS holds present heading. When turning, AFDS holds the heading reached after rolling wings level

ATT - (active) - when the autopilot is first engaged or the flight director is first turned on in flight, AFDS holds a bank angle between 5 and 30 degrees and will not roll to wings level. When the bank angle is less than 5 degrees, AFDS rolls to wings level (HDG HOLD). When the bank angle is greater than 30 degrees, AFDS rolls to 30 degrees of bank.

LOC -

- LOC (armed) - AFDS captures the localizer when within range and within 120 degrees of the localizer course
- LOC (active) - AFDS follows the localizer course

TO/GA -

- On the ground, TO/GA annunciates by positioning either flight director switch ON when both flight directors are OFF. TO/GA roll guidance becomes active at lift-off
- In flight, TO/GA is armed when flaps are out of up or glideslope is captured. There is no flight mode annunciation for TO/GA armed. TO/GA is activated in flight by pushing a TO/GA switch. The roll steering indication provides guidance to maintain the ground track present at mode engagement

ROLLOUT -

- ROLLOUT (armed) - displays below 1,500 feet radio altitude and activates below 5 feet
- ROLLOUT (active) - after touchdown, AFDS uses rudder and nosewheel steering to steer the airplane on the localizer centerline

Pitch Modes

Pitch annunciations are:

TO/GA -

- On the ground, TO/GA annunciates by positioning either flight director switch ON when both flight directors are OFF. The flight director pitch bar indicates an initial pitch of eight degrees up. TO/GA pitch guidance becomes active at rotation.
- After takeoff, the AFDS commands a pitch attitude less than the pitch limit indicator to maintain:
 - a target speed of V2 plus 10 knots or airspeed at rotation (pitch attitude greater than two degrees) plus 10 knots, whichever is greater
 - if current airspeed remains above the target speed for 5 seconds, target airspeed resets to current airspeed, to a maximum of V2 plus 25 knots
 - IAS/MACH window speed if IAS/MACH window speed is changed to a speed greater than the target speed

Note: AFDS uses the speed set in the IAS/MACH window for V2.

- In flight, TO/GA is armed when flaps are out of up or glideslope is captured
- When a go-around is initiated, the command speed is the MCP IAS/Mach window or current airspeed, whichever is higher. If the airspeed increases and remains above the initial target airspeed for five seconds, target airspeed resets to current airspeed to a maximum of the IAS/MACH window speed plus 25 knots. If airspeed at initiation of go-around is greater than IAS/Mach window plus 25 knots, that speed is maintained. GA displays as the reference thrust limit on the primary EICAS engine display

VNAV -

- Arm VNAV by pushing the VNAV switch (the light illuminates and VNAV annunciates on the PFD pitch mode annunciator in white characters below the current pitch mode).
- VNAV activates at 400 feet and provides pitch commands to maintain the FMC computed airspeed/path:
 - VNAV SPD (active) - AFDS maintains the FMC speed displayed on the PFD and/or the CDU CLIMB, CRUISE, or DESCENT pages. During speed intervention, use the MCP IAS/MACH selector to manually set the speed
 - when a VNAV descent is initiated before the top of descent (T/D) and the airplane subsequently intercepts the VNAV descent path, the pitch annunciation may change from VNAV SPD to VNAV PTH
 - VNAV PTH (active) - AFDS maintains FMC altitude or descent path with pitch commands. For a non-entered headwind, thrust may increase to maintain the VNAV descent path. If the MCP altitude window remains set to the current cruise altitude and the airplane is within two minutes of the top of descent, the CDU scratchpad message RESET MCP ALT displays

- VNAV ALT (active) - If a conflict occurs between the VNAV profile and the MCP altitude, the airplane levels and the pitch flight mode annunciation becomes VNAV ALT. The airplane maintains altitude. To continue the climb or descent, change the MCP altitude and push the altitude selector or change the pitch mode. If below the VNAV path, resetting the MCP altitude window and intercepting the VNAV path will also continue the descent

V/S -

Pushing the V/S switch opens the vertical speed window and displays the current vertical speed. It also opens the IAS/MACH window (if blanked). Pitch commands maintain the rate of climb or descent selected in the V/S window.

FLCH SPD -

Pushing the FLCH switch opens the IAS/MACH window (if blanked). Pitch commands maintain IAS/MACH window airspeed or Mach.

ALT -

Altitude hold mode is activated by:

- pushing the MCP altitude HOLD switch, or
- capturing the selected altitude from a V/S or FLCH climb or descent

G/S -

AFDS follows the ILS glideslope.

FLARE -

- FLARE (armed) - during autoland, FLARE displays below 1,500 feet RA
- FLARE (active) - during autoland, flare activates between 60 and 40 feet RA. FLARE deactivates at touchdown and the nosewheel smoothly lowers to the runway

Autothrottle System

The autothrottle system provides thrust control from takeoff through landing.

Autothrottle operation is controlled from the MCP and the CDUs. The MCP allows mode and speed selection. The CDU allows FMC reference thrust limit selection. When a pitch mode is active, FMC selects autothrottle modes and target thrust values. Refer to Chapter 11, Flight Management, Navigation, for FMS and CDU operation.

The autothrottle can be operated without using the flight director or the autopilot.

Autothrottle Thrust Lever Operation

The autothrottle (A/T) system provides automatic thrust control from start of takeoff through climb, cruise, descent, approach and go-around, or landing.

The autothrottle system consists of:

- thrust management function and performance data base of the FMC
- specific controls and indicators on the MCP (A/T ARM switch, A/T modes)
- TO/GA switches
- A/T disconnect switches
- autothrottle servo

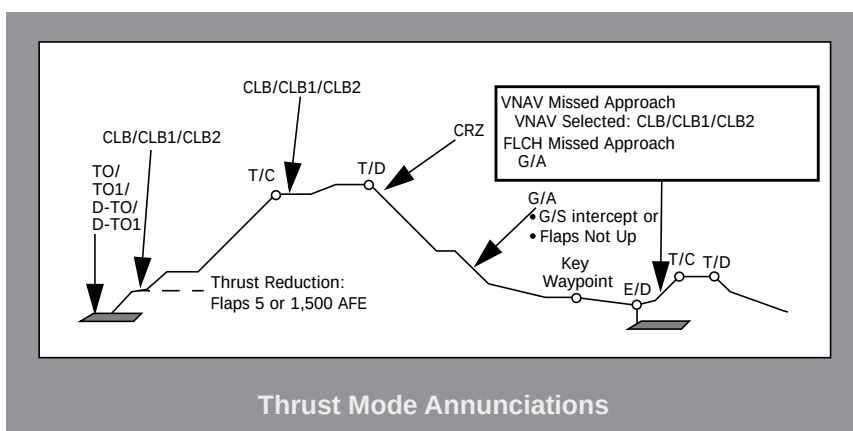
The autothrottle system moves thrust levers to control speed or thrust, depending on the active mode.

Thrust levers can be manually positioned without disconnecting the autothrottle. After manual positioning and release, the autothrottle repositions thrust levers to comply with the active mode. The autothrottle system does not reposition thrust levers while in HOLD mode.

Thrust Limits

Autothrottle operation is controlled through mode and speed selection on the MCP, and thrust reference mode selection from the THRUST LIMIT page of the CDU. The FMC computes and displays thrust limits for all modes and controls full-throttle operation to provide maximum thrust without exceeding EPR limits. The A/T system also controls thrust to avoid exceeding limits related to flap, landing gear, angle of attack and VMO/MMO speeds. When VNAV is engaged, the FMC automatically selects the appropriate autothrottle modes, thrust reference modes and reference EPR. This diagram depicts reference thrust limits automatically scheduled by phase of flight

Thrust Mode Annunciations Diagram



Note: CLB, CLB1, and CLB2 thrust values are equivalent above 15,000 feet. CLB1 and CLB2, if selected, will not change to CLB above this altitude.

Autothrottle Disconnect

The autothrottle system can be disconnected manually by positioning the Autothrottle Arm switch to OFF or by pushing either Autothrottle Disconnect switch. The EICAS caution message >AUTOTHROT DISC displays when the autothrottle has been manually or automatically disconnected.

Autothrottle disconnect occurs if a fault in the active autothrottle mode is detected, or when a reverse thrust lever is raised to reverse idle. The autothrottle also disconnects and cannot be reactivated if both FMCs fail or two or more engines are shut down. The autothrottle disconnects when the FMC Master switch is switched, but can be reactivated.

Automatic Flight Operations

Automatic Flight - Takeoff and Climb

Takeoff is a flight director only function of the takeoff/go-around (TO/GA) mode. The autopilot may be engaged after takeoff.

During preflight:

- with the autopilot disengaged and both Flight Director switches OFF, activation of TO/GA roll and pitch mode occurs when the first Flight Director switch is positioned ON
- PFD displays FD as AFDS status and TO/GA as the pitch and roll flight mode annunciations
- pitch command is set to approximately eight degrees up
- roll command is wings level

During takeoff prior to lift-off:

- with speed less than 50 KIAS, pushing a TO/GA switch activates the autothrottle in thrust reference (THR REF) and advances thrust levers to the selected reference thrust limit. If the autothrottle is not active by 50 knots, it cannot be activated until above 400 feet
- at 65 knots, autothrottle annunciation changes to HOLD
- during takeoff, the FMC records barometric altitude as the airplane accelerates through 100 knots. This altitude is used to activate LNAV and VNAV, enable autothrottle activation (if not active), command acceleration for flap retraction, and set climb thrust if an altitude has been selected

At lift-off:

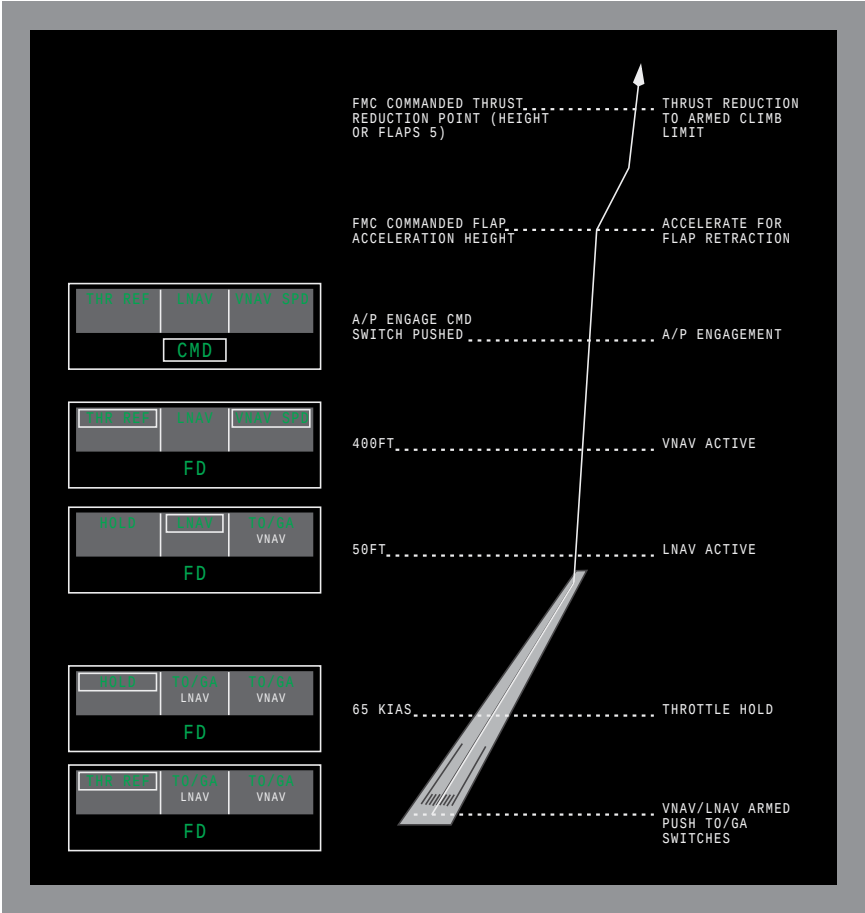
- pitch command target speed is $V_2 + 10$. If current airspeed remains above target speed for 5 seconds, target airspeed is reset to current airspeed (limited to a maximum of $V_2 + 25$)
- if an engine failure occurs on the ground, the pitch command target speed at lift-off is V_2 or airspeed at lift-off, whichever is greater (limited to a maximum of $V_2 + 10$)
- roll command maintains ground track

After lift-off:

- if an engine failure occurs, the pitch command target speed is:
 - V_2 , if airspeed is below V_2
 - existing speed, if airspeed is between V_2 and $V_2 + 10$
 - $V_2 + 10$, if airspeed is above $V_2 + 10$
- if a TO/GA switch is pushed with the takeoff reference thrust limit displayed:
 - takeoff and climb derates are removed
 - A/T in HOLD, autothrottle annunciation is THR REF
 - between 50 feet and 400 feet, selects TO/GA roll mode
 - above 400 feet, selects TO/GA roll and pitch modes
- at 50 feet, LNAV activates when armed. Roll commands bank to track the active route
- at 400 feet, VNAV activates when armed. Pitch commands the current airspeed. Autothrottle sets the selected reference thrust and annunciates THR REF
- at acceleration height, pitch commands speed to 5 knots below takeoff flap placard speed. As flaps are retracted, pitch commands an acceleration to 5 knots below the placard speed of the commanded flap position
- When flaps are up, pitch commands an acceleration to VNAV climb speed. VNAV climb speed is the greater of:
 - $V_{REF} + 100$ knots, or
 - speed transition associated with origin airport
- at thrust reduction point (either an altitude or flaps 5), the FMC changes the reference thrust limit to the armed climb limit (CLB, CLB 1, or CLB 2)

TO/GA mode terminates by selecting any other pitch and roll mode, or by activation of LNAV/VNAV modes

Automatic Flight Takeoff Profile



Automatic Flight - Cruise

The autopilot and/or flight director can be used after takeoff to fly a lateral navigation track (LNAV) and a vertical navigation track (VNAV) provided by the FMC. Using LNAV and VNAV ensures the most economical operation.

Profile illustrations show the use of LNAV and VNAV.

Automatic Flight - Approach and Landing

The AFDS provides guidance for single or multiple autopilot ILS approaches.

Pushing the APP switch arms localizer in roll mode and glideslope in pitch mode. Either localizer or glideslope can be captured first.

Pushing the LOC switch arms only the localizer. Localizer capture can occur when the intercept angle is less than 120 degrees.

Runway Alignment and Asymmetric Thrust Compensation

AFDS controls the rudder during multiple A/P approaches to compensate for crosswind landings and engine-out asymmetric thrust conditions.

With ▷LAND 2◁ or LAND 3 annunciated, A/P control of the rudder is active.

For crosswinds requiring more than 10 degrees of crab angle, runway alignment occurs at 500 feet AGL. A sideslip of 5 degrees is established to reduce the crab angle. This configuration is maintained until touchdown. The airplane lands with the upwind wing low.

For crosswinds requiring a crab angle of between 5 and 10 degrees, an initial alignment occurs at 500 feet AGL, followed by a second alignment at 200 feet AGL. The initial alignment initiates a sideslip to reduce the crab angle to 5 degrees. This configuration is maintained to 200 feet AGL, where a second sideslip alignment increases the sideslip to further reduce the touchdown crab angle.

For crosswinds requiring a crab angle of less than 5 degrees, runway alignment occurs at 200 feet AGL, where a sideslip is introduced to align the airplane with the runway.

If an engine fails prior to the approach, AFDS introduces a sideslip at 1,300 feet AGL. This establishes a wings level configuration. If an engine fails during the approach, the wings level configuration is established when the engine failure is detected.

If moderate or strong crosswinds are from the side opposite the failed engine, no wings level sideslip is commanded, since the airplane is already banked into the wind.

If the A/Ps are disengaged, manually or automatically, in an asymmetric thrust condition with rudder control active, the rudder moves to the trimmed position. The pilot may need to exert rudder pedal force to maintain a smooth transition to manual flying.

Flare

The flare maneuver brings the airplane to a smooth automatic landing touchdown. The flare mode is not intended for single autopilot or flight director only operation.

FLARE arms when LAND 3 or ▷LAND 2◁ annunciates. At approximately 50 feet radio altitude, the autopilots start the flare maneuver. FLARE replaces the G/S pitch flight mode annunciation.

During flare:

- at 25 feet radio altitude, the autothrottle retards thrust levers to idle
- IDLE replaces the SPD autothrottle flight mode annunciation
- at touchdown, the FLARE annunciation no longer displays, and the nose lowers to the runway

Rollout

Rollout provides localizer centerline rollout guidance. Rollout arms when LAND 3 or ▷LAND 2◁ annunciates.

At approximately five feet radio altitude, rollout activates. ROLLOUT replaces the LOC roll flight mode annunciation.

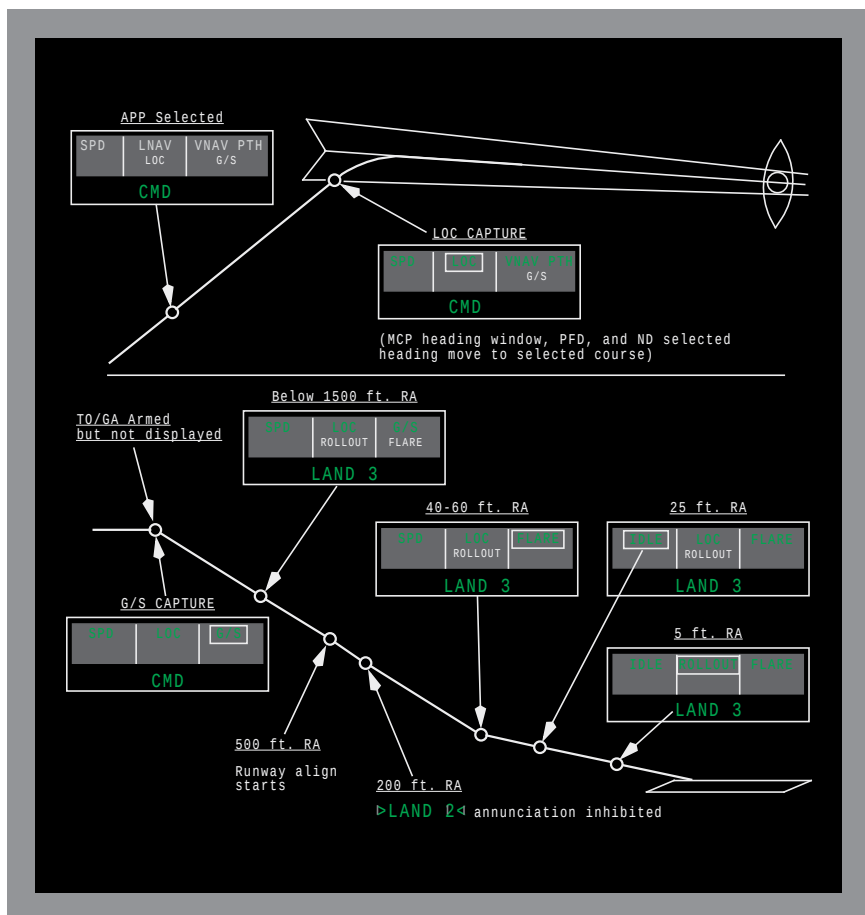
The autopilot controls rudder and nose wheel steering to track the localizer centerline.

During rollout, autothrottle IDLE mode remains active until the autothrottle disconnects with thrust levers in reverse.

Rollout guidance continues until the autopilots are disengaged.

Note: Ten seconds after reverse thrust levers are down, autothrottle is armed until flaps are UP. Pushing a TO/GA switch while the autothrottle is armed activates the autothrottle in THR REF mode.

Automatic Flight Approach Profile



Automatic Flight - Go-Around

TO/GA is armed when flaps are out of UP or glideslope is captured. The reference thrust limit changes to G/A when flaps are extended out of UP, flaps are extended to landing position, or glideslope is captured. The reference thrust limit is locked in G/A when flaps are in landing position or glideslope is captured.

Pushing either TO/GA switch activates a go-around. The mode remains active even if the airplane touches down while executing the go-around.

When the flight director switches are not on, pushing either TO/GA switch displays the flight director bars.

The TO/GA switches are inhibited two seconds after radio altitude decreases through five feet on landing. TO/GA is enabled again three seconds after radio altitude increases through five feet for a rejected landing or touch and go.

With the first push of either TO/GA switch:

- roll and pitch activate in TO/GA
- autothrottle activates in thrust (THR) to establish a 2000 FPM climb
- if current airspeed remains above the target speed for 5 seconds, the target airspeed is reset to current airspeed, (to a maximum of the IAS/MACH window speed plus 25 knots)

With the second push of either TO/GA switch:

- autothrottle activates in thrust reference (THR REF) at full go-around thrust

TO/GA level-off:

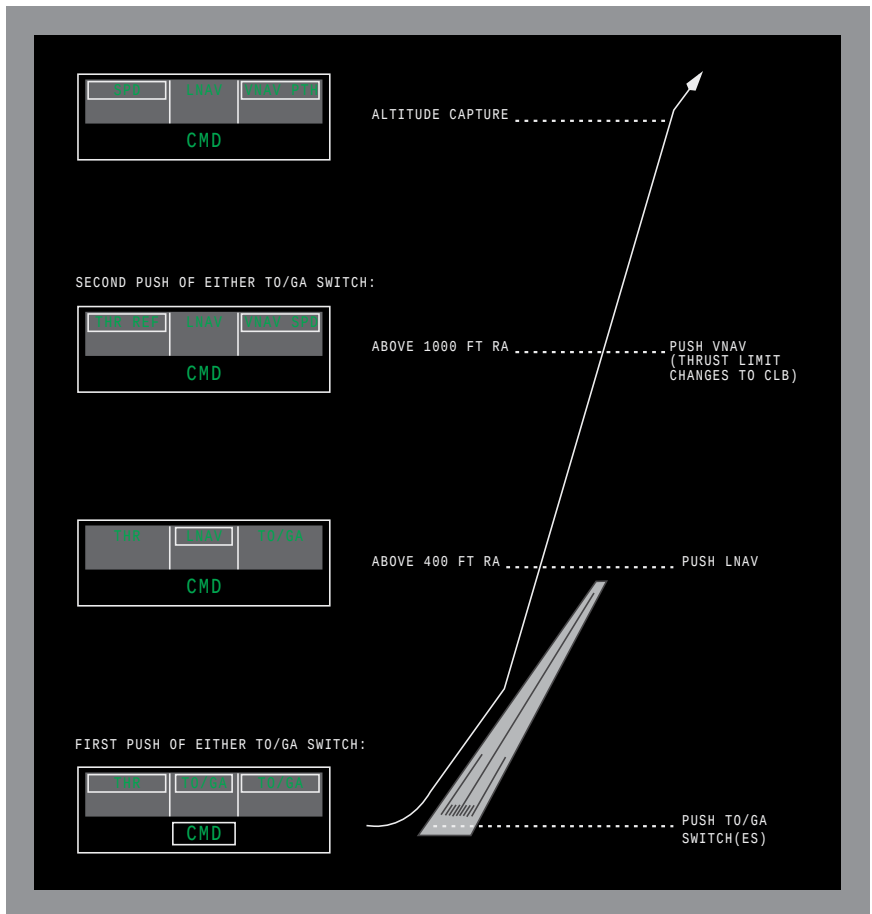
- at the set altitude, the AFDS pitch flight mode annunciation changes to altitude hold (ALT); all autopilots, except first in CMD, disengage
- A/T remains in THR or THR REF until SPD mode is selected. Speed protection prevents exceeding the maximum operating, gear extended, or flap placard speed
- TO/GA remains the active roll mode until another mode is selected

TO/GA mode termination:

- below 400 feet radio altitude, disengage autopilot and turn off both flight directors
- above 400 feet radio altitude, select a different roll or pitch mode; all autopilots, except first in CMD, disengage

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 returns to the trimmed position unless the pilot exerts the rudder pedal force required to maintain the rudder position.

Automatic Flight Go-Around Profile



Automatic Flight Windshear Recovery

The AFDS provides windshear recovery guidance by means of the normal go-around pitch and roll modes. With go-around armed, pushing a TO/GA switch commands a pitch-up of 15 degrees or slightly below the pitch limit, whichever is lower.

As rate of climb increases from 600 to 1200 feet per minute (0 to 600 feet per minute with engine out), AFDS gradually transitions from pitch to airspeed control. The target airspeed is IAS/MACH window airspeed or current airspeed, whichever is greater when TO/GA is activated. If current airspeed remains above the selected speed for 5 seconds, the selected airspeed is reset to current airspeed, (to a maximum of the IAS/MACH window speed plus 25 knots).

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

Flight Envelope Protection

The automatic flight control system provides stall and overspeed protection. Stall protection prevents speed reduction below the minimum maneuvering speed. Overspeed protection prevents exceeding the maximum operating, gear extended, or flap placard speed.

The FMC supplies minimum and maximum speeds to the automatic flight control system. To minimize transient speed overshoots of maximum operating, gear extended, or flap placard speed, and undershoot of flaps extended minimum speed, the FMC uses a five knot margin.

The autothrottle and AFDS independently provide speed protection for all operations except during V/S pitch mode or engine failure above maximum engine-out altitude. Autothrottle speed protection is limited by the reference thrust limit (CLB, CRZ, CON, etc.) and idle. AFDS speed protection is provided through the elevators in the following pitch modes: VNAV SPD, FLCH SPD, or TO/GA.

If FMC data is invalid, VNAV is unavailable and internal FCC speed limits are used for FLCH SPD or TO/GA. FCC minimum speed is a function of flap setting. FCC maximum speed is the air data computer VMO/MMO for flaps up and flap placard speed for flaps down.

During cruise, the AFDS maintains level flight. If an engine fails above maximum engine-out altitude, delaying descent results in a gradual airspeed loss.

Refer to Chapter 15, Warning Systems, for a description of stall and speed related warnings.

Automatic Flight EICAS Messages

Chapter 4 Section 30

Automatic Flight EICAS Messages

The following EICAS messages can be displayed.

Message	Level	Aural	Message Logic
>AUTOPILOT	Caution	Beeper	Selected autopilot operating in degraded mode. Active roll and/or pitch mode may have failed.
>AUTOPILOT DISC	Warning	Siren	All engaged autopilots have disengaged.
>AUTOTHROT DISC	Caution	Beeper	Autothrottle has disconnected. Message and aural inhibited when disconnect occurs due to selection of reverse thrust.
>NO AUTOLAND	Caution	Beeper	Autoland not available. Message is a caution if fault occurs after LAND 3 or LAND 2 annunciates.
	Advisory		Message is an advisory if fault occurs before LAND 3 or LAND 2 annunciates.
>NO LAND 3	Caution	Beeper	Autoland system does not have redundancy for triple channel autoland. Message is a caution if fault occurs after LAND 3 annunciates.
	Advisory		Message is an advisory if fault occurs before LAND 3 annunciates.

Intentionally
Blank

Communications

Chapter 5

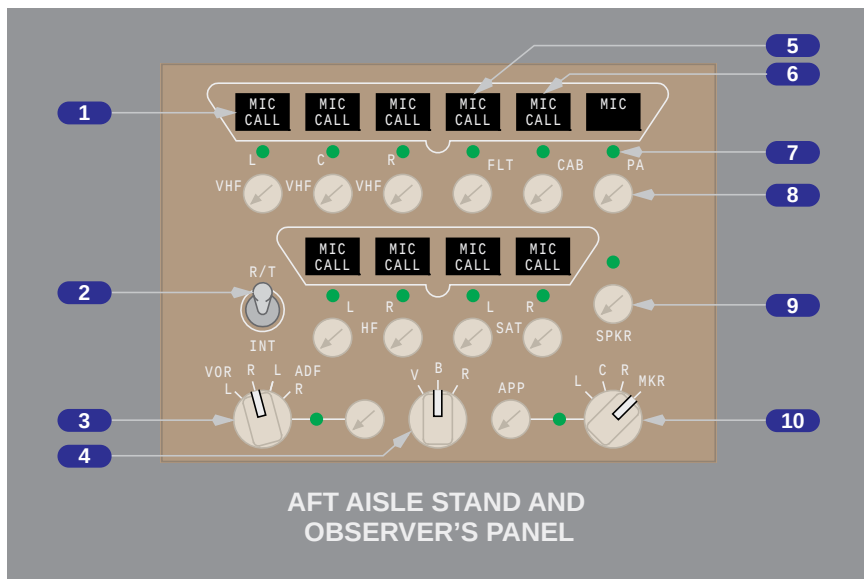
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Audio Control Panel



1 Transmitter Select Switches

Push –

- MIC light illuminates
- MIC light for any other transmitter extinguishes
- selects respective transmitter (radio or intercommunications) for transmission from this crew station (only one can be selected at a time for each crew station)
- selects receiver audio on, if not previously selected on manually
- pushing CAB transmitter select switch twice within three seconds places a priority call to a selected cabin station

Note: Do not select VHF C for ATC voice communication with ACARS operational.

2 Push to Talk Switch

R/T – keys boom microphone or oxygen mask microphone on the selected radio transmitter or interphone system.

Center - off.

INT - keys boom microphone or oxygen mask microphone on flight interphone.

Note: Oxygen mask microphone active when oxygen mask stowage box left-hand door open. Boom microphone active when oxygen mask stowage box left-hand door closed and RESET/TEST switch pushed and released.

3 VOR/ADF Receiver Selector

Selects VOR or ADF receiver to be monitored:

- VOR L - left VOR
- VOR R - right VOR
- ADF L - left ADF
- ADF R - right ADF

4 Navigation Filter Selector

Filters VOR, ADF, or ILS audio:

- V (voice) – voice audio is heard
- B (both) – voice and range audio are heard
- R (range) – range audio (navigation aid Morse code identifier) is heard

5 MIC Lights

Illuminated (white) – indicates respective transmitter is selected.

Note: Only one MIC light can be illuminated at a time.

6 CALL Lights

Illuminated (white) - with aural chime, indicates a call on:

- cabin interphone (CAB)
- flight interphone (FLT)
- ACARS (VHF C, HF-L, or SAT-L)
- SELCAL (HF-L, HF-R, VHF-L, or VHF-R)

Resets when respective transmitter select switch pushed or; when already pushed, by pressing a MIC/INTERPHONE switch.

PA does not have a call indication.

7 Receiver Lights

Illuminated (green) - indicates respective receiver audio manually selected on.

Automatically illuminates when 121.50 is tuned on a VHF radio.

8 Receiver Volume Controls

Push - selects respective receiver audio on.

Rotate - controls receiver volume.

Second push - deselects respective receiver audio.

Note: Will not select off when respective transmitter selected on, or 121.500 tuned in radio tuning panel Active Frequency indicator.

9 Captain's and First Officer's Speaker (SPKR) Volume Control

Push - turns respective flight deck speaker on.

Rotate - controls flight deck speaker volume.

Second push - deselects respective receiver audio.

Note: Speaker volume control on center audio panel is inoperative.

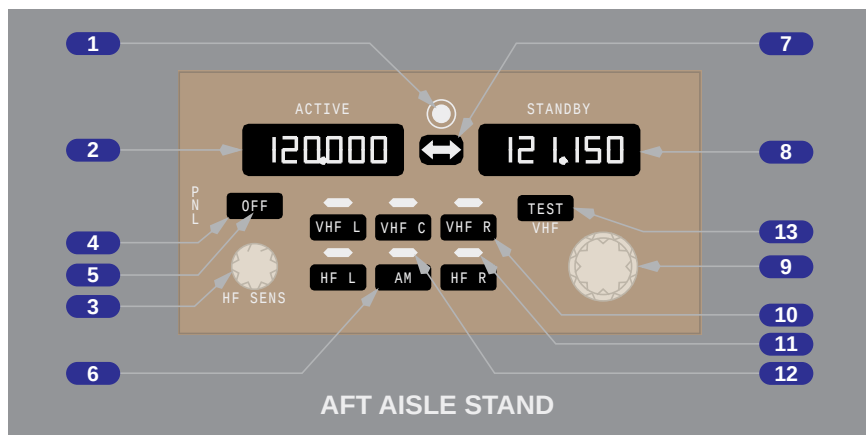
10 Approach (APP) Receiver Selector

Selects approach receiver to be monitored:

- APP L - left ILS
- APP C - center ILS
- APP R - right ILS
- MKR - marker beacon

Radio System

Radio Tuning Panel



1 Offside Tuning Light

Illuminated – indicates one of the following conditions:

- the radio tuning panel is being used to tune a radio not normally associated with this radio tuning panel
- the radio normally associated with this panel is being tuned by another radio tuning panel

Note: The left radio tuning panel is normally associated with VHF L and HF L.
The right radio tuning panel is normally associated with VHF R and HF R.
The center radio tuning panel is normally associated with VHF C.

2 ACTIVE Frequency Window

Displays tuned frequency of selected radio.

Displays DATA on VHF C, HF-L, or HF-R when ACARS selected.

3 HF Sensitivity (SENS) Control

Rotate – adjusts sensitivity of respective HF receiver.

CW - increase sensitivity for reception of weak or distant stations.

CCW - decreases sensitivity to reduce noise static.

Note: Decreasing the sensitivity too far prevents reception, including SELCAL monitoring of HF radios. Center radio tuning panel HF SENS control inoperative

Control not affected by radio tuning panel failure or by OFF switch.

4 Radio Tuning Panel OFF Switch

Push – disconnects panel from communication radios.

5 Radio Tuning Panel OFF Light

Illuminated (white) – radio tuning panel is disconnected from communication radios.

6 AM Switch

Push – sets AM (amplitude modulation) or USB (upper side band) mode for selected HF.

7 Frequency Transfer Switch

Push –

- transfers STANDBY window frequency to ACTIVE window and tunes selected radio to new active frequency
- transfers ACTIVE window frequency to STANDBY window

8 STANDBY Frequency Window

Displays preselected or previously tuned frequency of selected radio.

Displays DATA on VHF C, HF-L, or HF-R when selection of the frequency transfer switch would reconfigure VHF C, HF-L, or HF-R to the data mode.

9 Frequency Selector

Rotate – to set frequency in the STANDBY window:

- outer knob – selects the portion of the frequency to the left of the decimal point
- inner knob – selects the portion of the frequency to the right of the decimal point

10 Radio Tuning Switches

Push –

- selects radio to be tuned
- tuned frequency displays in ACTIVE frequency window
- standby frequency displays in STANDBY frequency window

Note: Do not select VHF C for ATC voice communication with ACARS operational.

11 Radio Tuning Lights

Illuminated (white) – indicates selected radio.

12 AM Light

Illuminated (white) – HF AM selected.

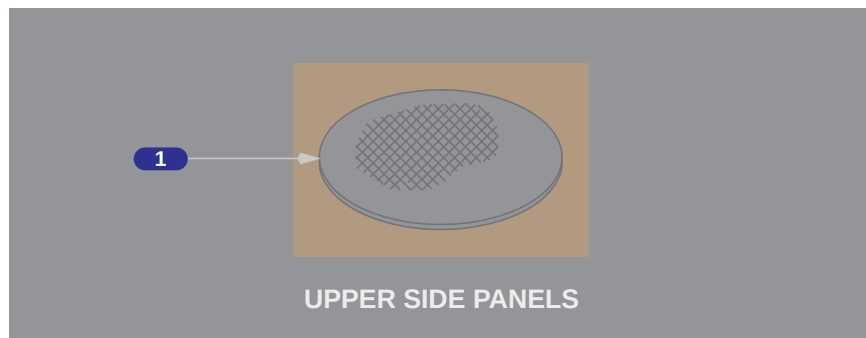
Extinguished – HF USB is selected.

13 VHF Test Switch

Push – removes automatic squelch and permits reception of background noise verifying VHF receiver operable.

Miscellaneous Communication Controls

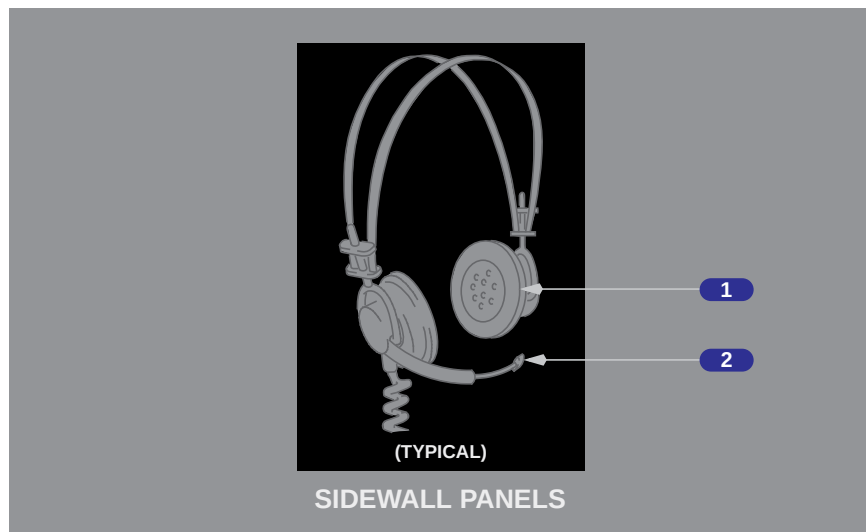
Flight Deck Speaker



1 Flight Deck Speaker

Controlled by speaker volume control on respective audio control panel.

Headphone/Boom Microphone



1 Headphone

Used to monitor audio from respective audio control panel.

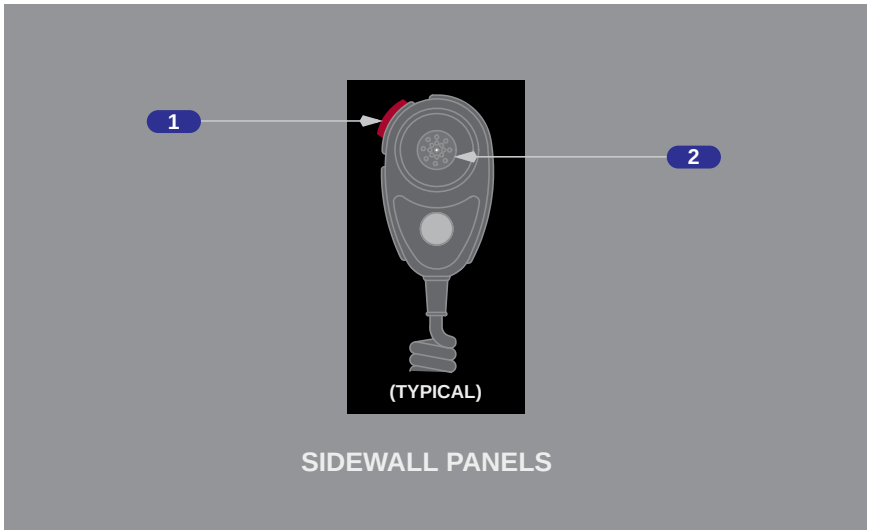
Audio volume adjusted using audio control panel controls for the respective station.

Available at all four flight deck stations.

2 Boom Mic

Activation of a control wheel, glareshield, or audio control panel mic/interphone switch transmits on the system selected for use at that station.

Hand Microphone



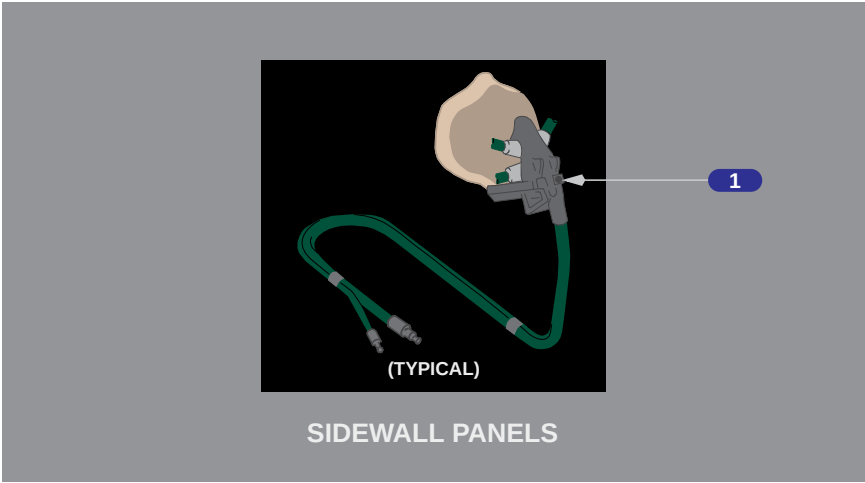
1 Hand Microphone Push To Talk Switch

Push – activates hand microphone.

2 Hand Microphone

Transmits on system selected by audio control panel.

Oxygen Mask Microphone

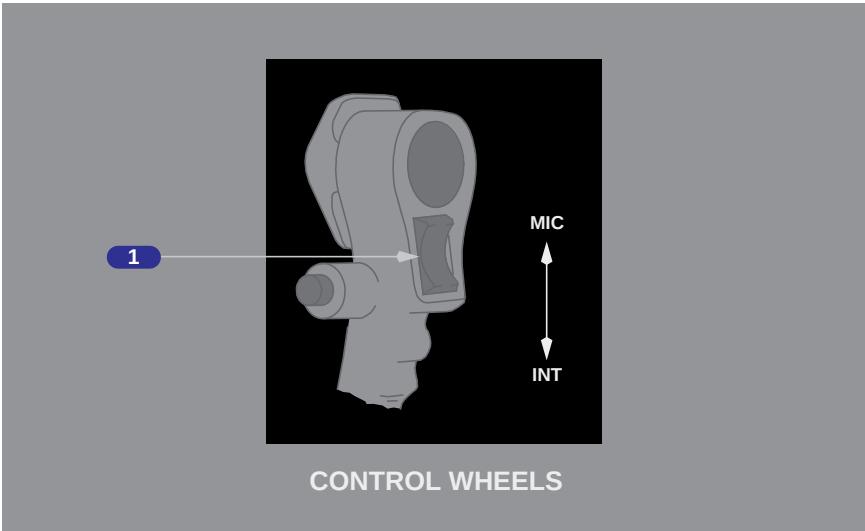


1 Oxygen Mask Microphone

Enabled when oxygen mask doors open. Boom microphone is disabled.

Activation of a control wheel, glareshield, or audio control panel mic/interphone switch transmits on the system selected for use at that station.

Control Wheel Microphone/Interphone Switch



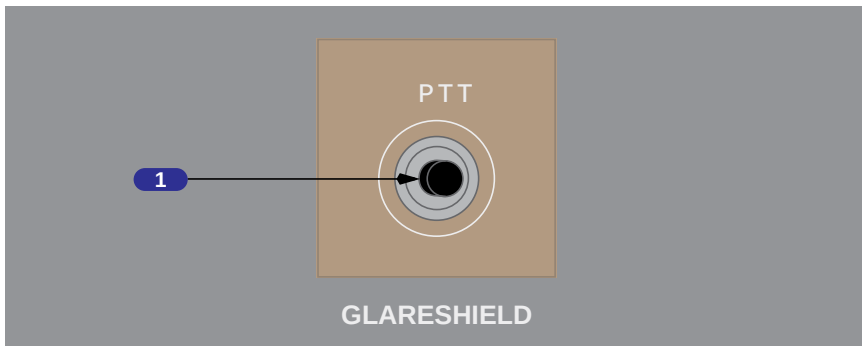
1 Control Wheel Mic/Interphone Switch

MIC – allows oxygen mask or boom microphone transmission on selected transmitter. Spring-loaded to center.

CENTER – off position.

INT – allows oxygen mask or boom microphone transmission on flight interphone system. Spring-loaded to center.

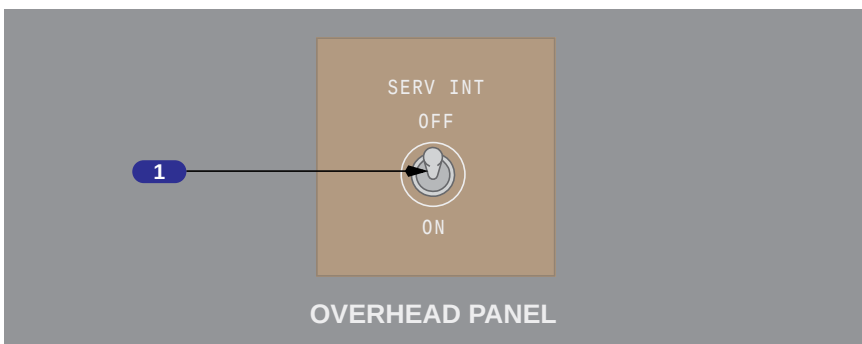
Glareshield Microphone Switch



1 Glareshield Microphone (PTT) Switch

Push – allows oxygen mask or boom microphone transmission on selected transmitter.

Service Interphone Switch



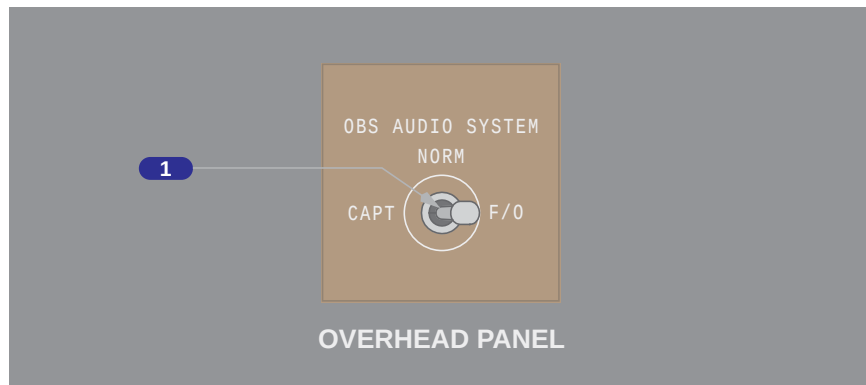
1 Service Interphone (SERV INT) Switch

OFF – allows independent operation of service and flight interphone systems.

ON – connects service and flight interphone systems.

Observer Audio System Switch

6301 - 6310



1 Observer (OBS) AUDIO SYSTEM Switch

Allows Captain or First Officer to use Observer's audio control panel.

CAPT - connects Observer audio panel to Captain audio control panel:

- hand mic
- boom mic/headset
- headphone
- oxygen mask mic
- speaker
- push to talk switches

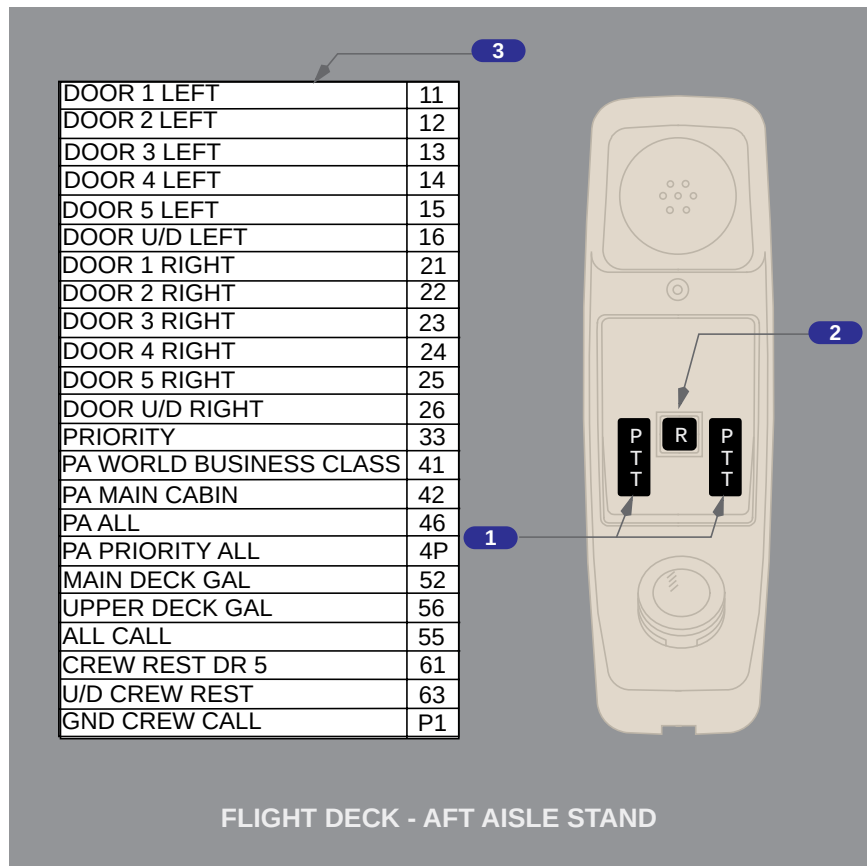
NORM - audio control panel normal operation

F/O - connects Observer's audio control panel to First Officer's:

- hand mic
- boom mic/headset
- headphone
- oxygen mask mic
- speaker
- push to talk switches

Handset

Handset provides communication with other handsets or PA system.



1 PA Push to Talk (PTT) Switches

Push – in PA mode connects handset mic to selected PA area.

2 Reset Switch

Push – cancels call.

3 Directory

Located on the back of the handset.

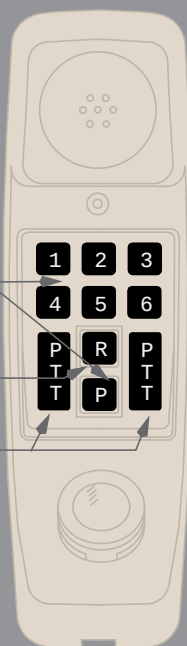
DOOR 1 LEFT	11
DOOR 2 LEFT	12
DOOR 3 LEFT	13
DOOR 4 LEFT	14
DOOR 5 LEFT	15
DOOR U/D LEFT	16
DOOR 1 RIGHT	21
DOOR 2 RIGHT	22
DOOR 3 RIGHT	23
DOOR 4 RIGHT	24
DOOR 5 RIGHT	25
DOOR U/D RIGHT	26
PILOT	31
PRIORITY CABIN	32
PRIORITY PILOT	33
PA WORLD BUSINESS CLASS	41
PA MAIN CABIN	42
PA ALL	46
PA PRIORITY ALL	4P
MAIN DECK GAL	52
UPPER DECK GAL	56
ATT ALL CALL	54
ALL CALL	55
CREW REST DR 5	61
CABIN READY	6P
PILOT ALERT	PP

4

1

3

2



CABIN - FLIGHT ATTENDANT PANELS

1 Interphone Keys

Push – selecting two digit code calls respective station or PA area.

2 PA Push to Talk (PTT) Switches

Push – in PA mode connects handset mic to selected PA area.

3 Reset Switch

Push – cancels call or incorrectly selected code.

4 Directory

Located on the back of the handset.

Call Panel

Provides control for either PA (passenger address) or CAB (cabin) interphone communications using either the handset or an audio control panel.



1 Next (NXT) Switch

Push -

- reviews stored call locations
- when no other calls, scrolls through directory

2 Call Switches

Push -

- selecting two digit code calls respective station or PA area
- speak by selecting CAB (cabin) transmitter switch on audio control panel or handset

3 Reset (RST) Switch

Push - cancels call or incorrectly selected code, or displays DIRECTORY when scrolling through directory.

4 Call Station Indicator

Indicator displays:

- location and code of station calling or being called
- number of stored call locations
- station code and location when reviewing directory or other calls to the flight deck

Other call panel displays are:

- CABIN READY
- PA IN USE
- PILOT ALERT
- VIDEO IN USE

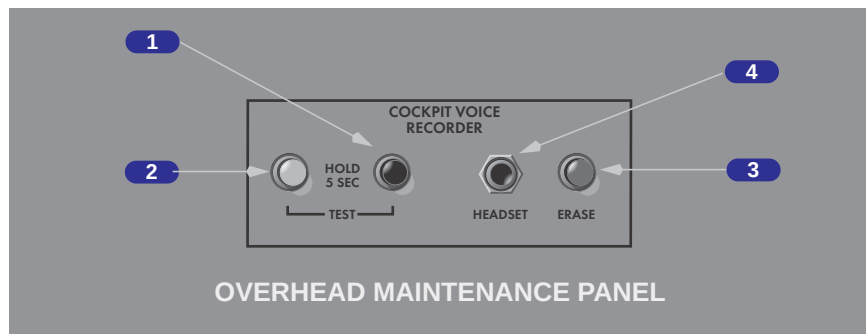
6311 - 6316

- PARTY LINE

Note: Call station directory located on handset. Light sensor adjusts intensity of call station indicator.

Cockpit Voice Recorder System

Cockpit Voice Recorder Panel



1 STATUS Indicator

Illuminated (green) – test completed successfully. Extinguished after button is released.

2 Cockpit Voice Recorder TEST Switch

Push and hold for five seconds – tests all four cockpit voice recorder channels (1 per second).

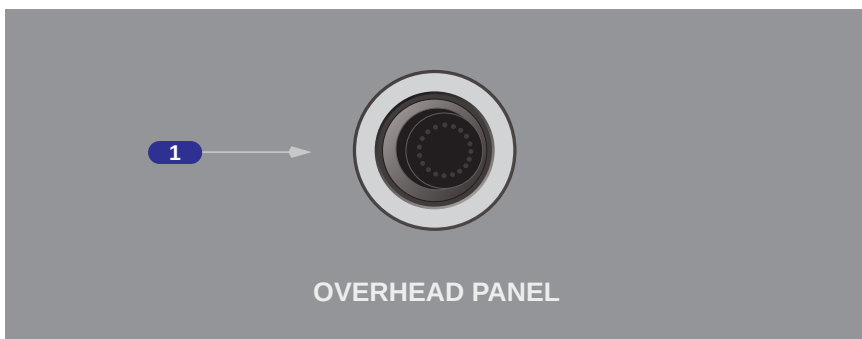
3 Cockpit Voice Recorder ERASE Switch

Push and hold for three seconds – erases voice recorder if on the ground, AC power on, and parking brake set.

4 Cockpit Voice Recorder Headset Jack

A headset may be plugged in to monitor playback of voice audio, or to monitor tone transmission during test.

Cockpit Voice Recorder Microphone

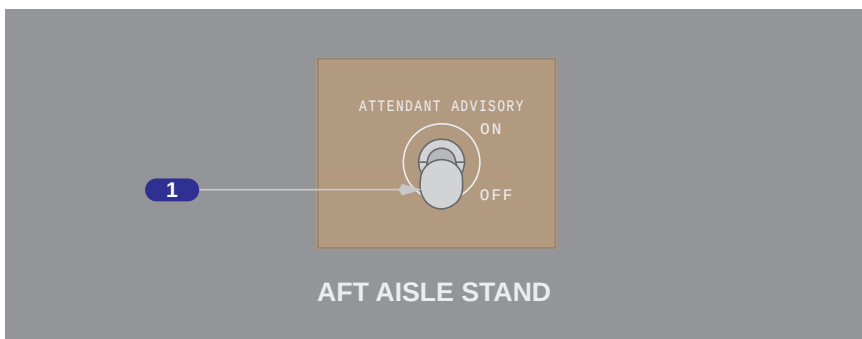


1 Cockpit Voice Recorder Microphone

Area microphone for the voice recorder.

Miscellaneous Communication Switches

Attendant Advisory Switch

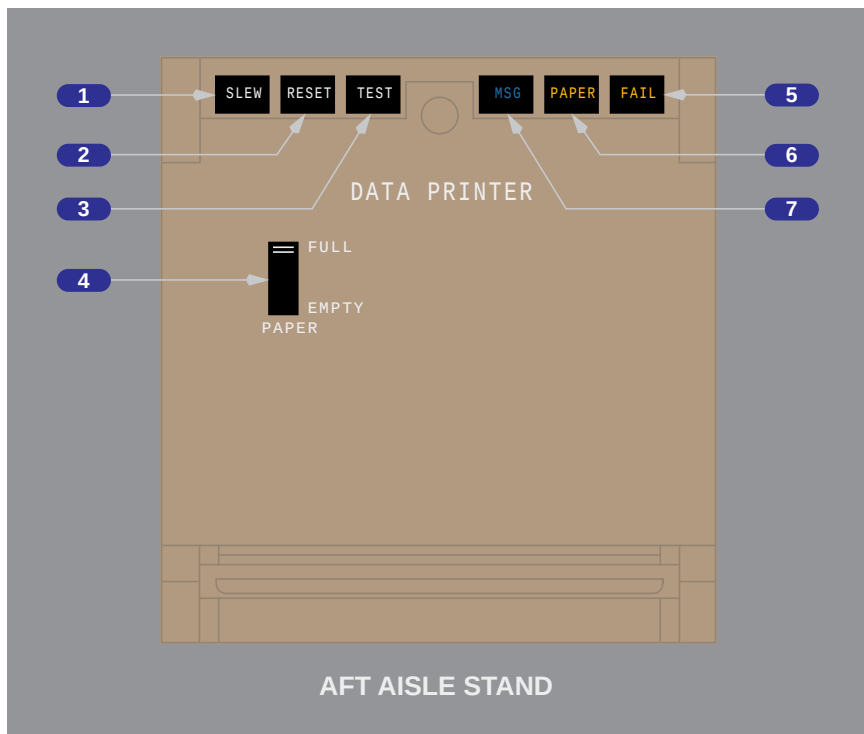


1 ATTENDANT ADVISORY Switch

ON - illuminates green advisory lights at flight attendant's stations.

OFF - extinguishes green advisory lights at flight attendant's stations.

Printer Controls



1 SLEW Switch

Push and hold - advances paper.

2 RESET Switch

Push - resets Message (MSG) light.

3 TEST Switch

Push –

- tests printer
- when pushed with RESET switch, prints test pattern

4 PAPER Indicator

Indicates amount of paper in printer.

5 FAIL Light

Illuminated (amber) - indicates printer failure.

6 PAPER Light

Illuminated (amber) - indicates printer out of paper.

7 Message (MSG) Light

Illuminated (blue) - indicates message sent to printer.

Intentionally
Blank

Communications System Description

Chapter 5 Section 20

Introduction

The communication system includes:

- radio communication system
- cockpit voice recorder system
- interphone communication system
- SATCOM communication system

FANS/CPDLC Equipped Aircraft

- company data communications
- air traffic services datalink communications

The radio tuning and audio panels control the communications system.

Audio Control Panels

The audio control panels control radio and interphone communication systems. Navigation receiver audio can also be monitored.

The captain, first officer, and first observer audio control panels are installed on the aft aisle stand.

The second observer audio control panel is installed on the sidewall panel.

Microphones are keyed by pushing the desired audio control panel transmitter select switch and then selecting one of the following:

- the MIC position of a control wheel switch
- the R/T position of an audio control panel PTT (Push to Talk) switch
- the PTT position of a glareshield microphone switch
- the PTT position of a hand microphone switch

Systems are monitored using headphones or speakers.

An oxygen mask microphone is enabled and the boom microphone is disabled when the oxygen mask left stowage door is open. The oxygen mask microphone is disabled and the boom microphone is enabled when the left oxygen mask stowage box door is closed and the RESET/TEST switch is pushed.

Cockpit Voice Recorder System

The cockpit voice recorder records any transmitted or received flight deck audio as selected on the audio control panels. It also records flight deck area conversations using an area microphone and crew member boom, oxygen mask, and hand microphones, independent of microphone/interphone switch position. All inputs are recorded continuously.

Radio Tuning Panels

The radio tuning panels tune the VHF and HF radios. The panels are designated left, center, and right, and are normally associated with the respective VHF and HF radios.

If a radio tuning panel fails, the panel can be disconnected from the communication radios using the Off switch.

An offside tuning indicator on each radio tuning panel indicates one of the following conditions when illuminated:

- the panel is selected to a radio normally associated with another radio tuning panel
- a communication radio not normally associated with that radio tuning panel has been selected and may be tuned by another radio tuning panel

Radio Communication System

The radio communication system consists of:

- Very High Frequency (VHF)
- High Frequency (HF)
- Aircraft Communication Addressing and Reporting System (ACARS)
- Selective Calling (SELCAL)
- Satellite Communications (SATCOM)

VHF and HF

There are three VHF radios (VHF L, C, R) and two HF radios (HF L, R). Any VHF or HF radio can be controlled by any radio tuning panel. The audio panels control voice transmission and receiver monitoring.

VHF L and VHF R are configured for voice communication only. VHF C can be configured for voice or ACARS data communication. Normally, VHF C is configured for ACARS data communication.

6315, 6316

HF L or HF R can be configured for voice or ACARS data communication.

The two HF radios share a common antenna. An HF voice transmission disables the opposite side HF radio during transmission. Simultaneous use of both HF radios is limited to receive only. HF Datalink is inhibited on the ground.

HF radio sensitivity can be adjusted using any radio tuning panel with the receiver selected. Sensitivity control is rendered inoperative by radio tuning panel failure or by pushing the OFF switch.

6301 - 6314

When an HF transmitter is keyed after a frequency change, the antenna tunes while a continuous tone can be heard through the audio system. A tone lasting longer than 7 seconds indicates failure of the system to tune.

6315, 6316

When an HF transmitter is keyed after a frequency change, the antenna tunes while a continuous or intermittent tone may be heard through the audio system. A tone lasting longer than 7 seconds indicates failure of the system to tune. Data is stored in memory for the last 100 tuned frequencies. Stored frequencies may tune quickly and a tone may not be noticeable.

Stuck Mic Protection

On the ground, any VHF radio transmitting for longer than 35 seconds is disabled following annunciation of a warning beep. The radio is enabled when the microphone switch for that radio is released.

Aircraft Communication Addressing and Reporting System (ACARS)

Pre FANS/CPDLC Equipped Aircraft

ACARS datalink provides automatic and manual means to transmit and receive operational, maintenance, and administrative information between the airplane and a ground station. ACARS is operational when electrical power is established and is accessed by selecting the ACARS prompt on all 3 CDU main menus.

FANS/CPDLC Equipped Aircraft

ACARS datalink provides automatic and manual means to transmit and receive air traffic services, operational, maintenance, and administrative information between the airplane and a ground station. ACARS is operational when electrical power is established and is accessed by selecting the ACARS prompt on the CDU main menu.

ACARS communicates through either VHF C, HF-L, or SATCOM.

If ACARS is not available due to lost communication, information to be transmitted is stored and transmitted automatically when communication is regained.

VHF C, HF-L or HF-R data mode can be selected and deselected by pushing the frequency transfer switch on the radio tuning panel. VHF C, HF-L or HF-R is in data mode when the word DATA is displayed in the radio tuning panel active frequency window.

6301 - 6310

If the data mode is deselected, ACARS is still operational and an ACARS failure may cause interference with voice operation of the radio. Therefore, ATC voice communication on VHF C is prohibited.

6311 - 6314

When a VHF C standby frequency is transferred to the active window, DATA is displayed in the standby window. If a new frequency is subsequently selected in the standby window, DATA is replaced by the new frequency. DATA can be returned to the standby window by selecting a frequency higher or lower than the allowable VHF frequency range. When in the data mode, VHF C is not available for voice communications. VHF C can be returned to the voice communication mode by transferring a voice frequency into the active frequency window.

6315, 6316

When a VHF C or HF L/R standby frequency is transferred to the active window, DATA is displayed in the standby window. If a new frequency is subsequently selected in the standby window, DATA is replaced by the new frequency. DATA can be returned to the standby window by selecting a frequency higher or lower than the allowable VHF or HF frequency range. When in data mode, VHF C is not available for voice communications. HF datalink operation is inhibited on the ground. When an HF radio is in data mode during flight, the opposite side HF is available for voice communication and will preempt any HF datalink operation in progress. HF datalink resumes after a short period following completion of the voice transmission. VHF C or HF can be returned to voice communication mode by transferring a voice frequency into the active frequency window.

Selective Calling (SELCAL)

The SELCAL system monitors the VHF and HF radios. When the system receives a call from a ground station, the respective radio CALL light illuminates and a chime sounds. The CALL light is reset by selecting the respective transmitter selector, or transmitting on that radio.

Satellite Communications (SATCOM)

The SATCOM system provides ACARS data communications.

ACARS uses HF LEFT, then the SATCOM system when the airplane is beyond VHF communication range. Switching between VHF and SATCOM is automatic. ACARS data is controlled through the control display units (CDUs).

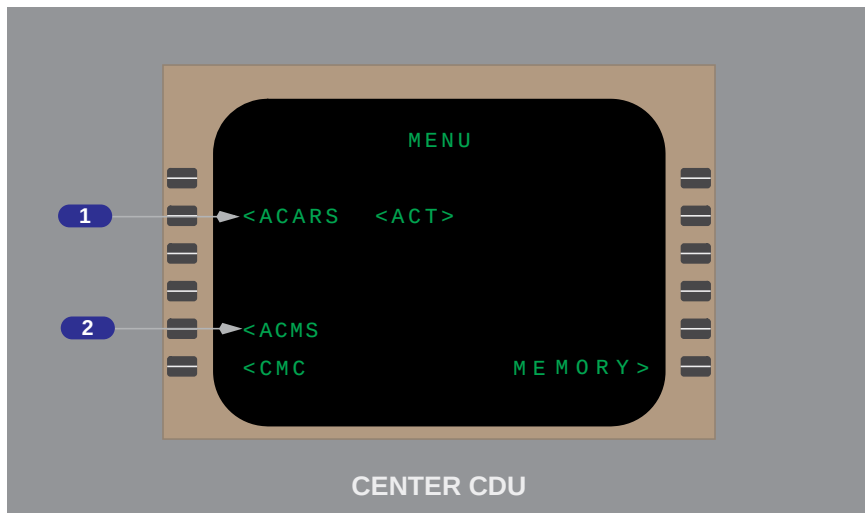
The SATCOM CDU control pages display by selecting <A-SAT on the left or right MENU page.

CDU Menu Page

Pushing the CDU MENU key displays the CDU MENU page.

CDU ACARS Access

Normally, ACARS displays are viewed on the center CDU. ACARS prompts are available on the MENU page of all CDUs.



1 ACARS

Push -

- displays ACARS page
- activates ACARS control of CDU

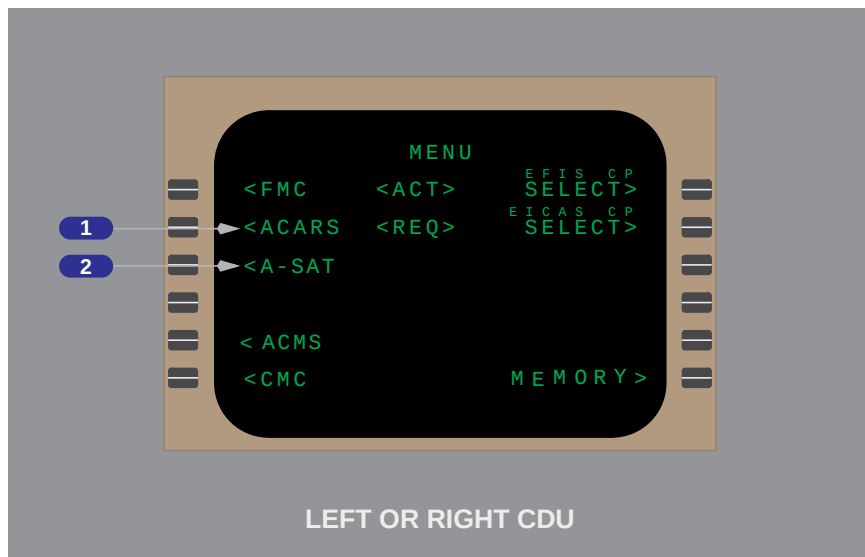
2 ACMS

6311-6316

To be developed.

CDU SATCOM Access

Normally, SATCOM is displayed on the left and right CDUs. SATCOM prompts are available on L or R CDU MENU pages.



1 ACARS

Push -

- displays ACARS page
- activates ACARS control of CDU

2 A-SAT

Push -

- displays SATCOM page
- activates SATCOM control of CDU
- CDU SATCOM access
- displayed on the left and right CDUs

Communications Interphone Systems

Chapter 5 Section 30

Interphone Communication System

The interphone communication system includes the:

- flight interphone system
- cabin interphone system
- passenger address (PA) system
- service interphone system

The flight interphone, service interphone, and PA systems are normally operated through the audio control panel.

The cabin interphone is operated through the audio control panel or flight deck handset.

Flight Interphone System

The flight interphone system provides communications between flight deck crew members. The flight interphone system also provides communications between the flight deck and ground crew through the flight interphone jack in the nose landing gear wheel well.

The system is used by selecting the INT (interphone) position of a control wheel switch or an audio control panel PTT (Push to Talk) switch. The interphone can also be used by selecting the FLT transmitter select switch on an audio control panel and then selecting one of the following:

- the R/T position of an audio control panel PTT switch
- the MIC position of a control wheel switch
- the PTT position of a hand microphone switch
- the PTT position of a glareshield microphone switch

Crew alerting of a ground crew initiated call is provided by an aural alert chime and illumination of the FLT call indication. The call indication is reset by selecting the FLT transmitter select switch or transmitting on that transmitter. The ground crew is called by selecting P-1 on the flight deck call panel.

Service Interphone System

The service interphone system provides voice communications between ground crew stations at various locations around the airplane. The system can be connected to the flight interphone system through the service interphone switch on the overhead panel.

Passenger Address System

The passenger address (PA) system is used by the flight crew to make cabin announcements. The PA system is accessed using the boom microphone, oxygen mask microphone, hand microphone, or flight deck handset.

The boom, oxygen mask, or hand microphone is used by pushing the PA transmitter select switch and activating a microphone or push to talk switch. The system is monitored by pushing the PA receiver volume control.

The PA system can also be selected through the cabin interphone system, as described in the Cabin Interphone System section.

Cabin PA announcement priorities are:

- flight deck announcements from an audio control panel
- cabin handset direct access announcements
- priority (all area) announcements
- normal announcements from flight attendant or flight deck handsets

Cabin Interphone System

The cabin interphone system provides voice communications between the flight deck and the flight attendant stations.

The cabin interphone system is accessed by using the boom microphone, oxygen mask microphone, hand microphone, or the flight deck handset located behind the aisle stand.

The boom or oxygen mask microphone is used by selecting the CAB transmitter select switch and using the R/T position of a push to talk switch. The hand microphone is also used with the CAB transmitter selected. The system is monitored by selecting the CAB receiver volume control.

Selecting the CAB transmitter select switch or removing the flight deck handset from the hook activates the flight deck call panel. The call panel is used to select the desired station to be called.

Interphone system calls from the flight deck to attendant stations are prioritized according to the code dialed (PA announcements, Priority 33, ALL CALL, and station to station). A higher priority call will override and disconnect a lower priority call.

A priority line can be established only to the primary station (normally primary DR 1L), by dialing 33 or pushing the CAB transmitter select switch on the audio control panel twice within three seconds. This action also joins an existing priority call between the primary and alternate station.

Any station may call the flight deck on Pilot Alert and override a Priority call but not a PA announcement.

Calls may be transferred to any other station by dialing the code of the station the call is to be transferred to and then hanging up. Up to four stations may be connected in a conference call by dialing the station to be added.

Flight attendants desiring communication with the flight deck use the flight attendant handsets. The incoming call illuminates the CAB call indication on the audio control panel, displays the location of the calling station on the call panel, and sounds a chime.

The CAB call indication is reset by selecting the respective transmitter select switch, or transmitting on that transmitter. The call indication is also reset by picking up the flight deck handset.

6301 - 6310

If more than one call is made to the flight deck at a time, the other callers get a busy signal, but the caller location is stored.

6311 - 6316

The flight deck can receive up to three incoming calls at the same time from callers using dial code 31. With a call in progress, up to two additional callers may access the same line and PARTY LINE displays on the flight deck call panel. When more than three calls are made to the flight deck at the same time from callers using dial code 31, the additional callers get a busy signal and the caller's location is stored.

When calls are stored, the call panel displays a "W" followed by the number of stored calls. After completing the call, stored locations can be reviewed with the NXT switch on the call panel.

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Satellite Communication

General

The Satellite Communication (SATCOM) system allows discrete telephone calls between the aircraft and ground stations via satellites. SATCOM is used for voice and data transmissions. SATCOM provides independent channels for voice and data transmissions.

Voice communications can be initiated by the flight crew or ground stations. There is a slight delay in communications using SATCOM voice.

The 747-400 SATCOM system uses the Iridium satellite constellation which provides worldwide coverage. SATCOM enables pilots to make satellite phone calls to Flight Dispatch to coordinate and resolve operational issues, where previously only ACARS or an HF phone patch may have been available. In addition, Dispatchers can make phone calls to the aircraft, and pilots can call ATC facilities directly during emergency to non-normal (loss of HF connectivity) communications situations. However, this new 744 SATCOM does not replace HF as the primary means for ATC contact.

SATCOM logs on to the Iridium satellite system automatically when AC power is established.

The 744 SATCOM system interfaces with the existing headsets, microphones, speakers, Left and Right CDUs (not Center), and Left SAT button on each Audio Panel. Use the Left SAT buttons and the left and right CDUs only. Since SATCOM voice is essentially just a phone call, there is no “party line” like VHF or HF communications where you can hear other aircraft communications. However, voice quality and connection time is much improved compared to HF voice communications.

The Iridium SATCOM system, uses a new generation of avionics that are smaller, lighter, and cheaper to purchase and operate than the Inmarsat system, and can be used while airborne or on the ground anywhere in the world including the polar regions. SATCOM should be used when reasonably necessary, but like any variable cost resource, should be used prudently (e.g. the Delta VHF radio network should be used to contact Dispatch when operating in the U.S. since those calls are free). Outside the U.S. SATCOM should be preferred method of voice communications with the OCC.

SATCOM avionics are provisioned for sending and receiving ACARS datalink messages. The transmit/receive mode is prioritized in this order: VHF DL, HF DL, SATCOM DL. ACARS use of SATCOM will be automatic and transparent to the flight crew. Beyond SATCOM additional avionics components are needed to send and receive Oceanic ATC Datalink messages. The 744 SATCOM facilitates ATC Datalink capability (CPDLC).

Communications EICAS Messages

The following EICAS messages can be displayed.

EICAS Alert Messages

Message	Level	Aural	Message Logic
>DATALINK AVAIL	Advisory		ACARS datalink is available after a temporary loss.
>DATALINK LOST	Advisory		ACARS datalink is temporarily lost.
>DATALINK SYS	Advisory		ACARS datalink is failed and is not available.
>HF DATA	Advisory		Selected HF radio failed and not available for ACARS data communication.
RADIO TRANSMIT	Advisory		VHF or HF radio keyed for 30 seconds or longer.
>SATCOM	Advisory		SATCOM system is failed.
>SATCOM DATA	Advisory		ACARS data communication through SATCOM system not available.

EICAS Memo Messages

Message	Message Logic
ATC MESSAGE	ATC uplinked message received.
ACARS MESSAGE	Crew required to access ACARS on CDU or when a message has been received for viewing on the CDU.
HF DATA OFF	Selected HF radio in voice mode and not available for ACARS data communication.
PRINTER MESSAGE	ACARS message printing.
VHF DATA OFF	VHF C radios in voice mode and not available for ACARS data communication.

ACARS Memo Messages

Message	Message Logic
ACARS ALERT	Displayed when crew input is required to enter missing data before ACARS transmits a report automatically.
ACARS CALL	Displayed when a request for voice mode has been received from a ground station. The CDU scratch pad message, VOICE GO AHEAD, will be displayed.
ACARS NO COMM	Displayed if VHF communication is lost. During the period communication is lost, information to be transmitted is stored and transmits automatically when communication is regained. The scratchpad message, NO COMMUNICATION, will be displayed.
ACARS MESSAGE	Displayed when a request for voice mode has been received from a ground station. The CDU scratch pad message, MESSAGE WAITING, LOAD REVISION, GATE REVISION, or VOICE GO AHEAD will be received.
VHF DATA OFF	Displayed when ACARS is in the voice mode (DATA deselected from the C VHF RTP). The CDU scratchpad message, ACARS VOICE, will be displayed.

FMC Messages

For FMC Message information, refer to Chapter 11.60.

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Blank

Electrical

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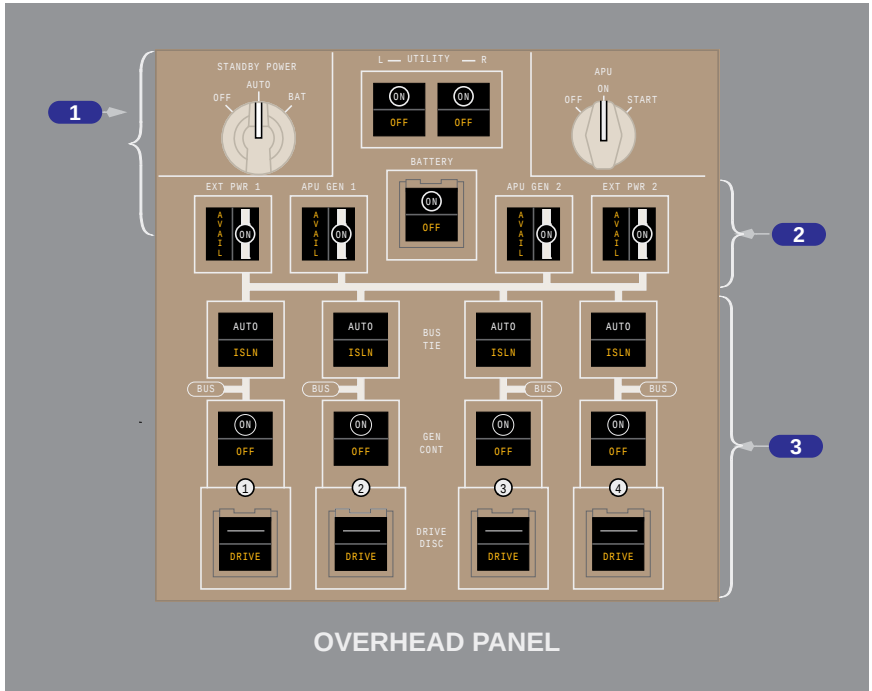
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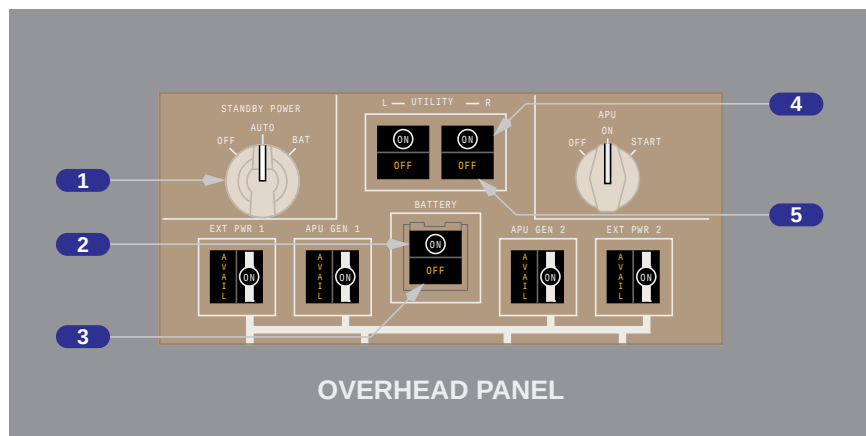
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Electrical Panel



- 1** Standby Power, Battery, and Utility Bus Controls
- 2** APU Generators and External Power Controls
- 3** AC Bus and Generator Controls

Standby Power, Battery, and Utility Bus Controls



1 STANDBY POWER Selector

Push to turn.

OFF -

- standby power not available
6301-6314
- standby bus disconnected from all power sources
6315, 6316
- main and APU standby busses disconnected from all power sources

6301-6314

AUTO - allows standby bus to be powered from available sources.

6315, 6316

AUTO - allows main and APU standby busses to be powered from available sources.

BAT -

- powers main battery bus from main battery through the main hot battery bus with battery switch ON
- powers APU battery bus from APU battery through the APU hot battery bus with battery switch ON
- disables main and APU battery chargers
6301-6314
- powers standby bus from the main battery through the main hot battery bus and the standby inverter with Battery switch ON

6315, 6316

- powers main and APU standby busses from their related batteries through their hot battery busses and standby inverters with Battery switch ON

Note: BAT position for ground maintenance use only.

2 BATTERY Switch

ON -

6301-6314

- main battery available as backup power source for main battery bus and standby bus
- APU battery available as backup power source for APU battery bus

6315, 6316

- main battery available as backup power source for main battery bus and main standby bus
- APU battery available as backup power source for APU battery bus and APU standby bus

Off (blank) - disconnects main and APU batteries from related battery busses.

3 BATTERY Switch OFF Light

Illuminated (amber) - Battery switch off

4 UTILITY Power Switches

ON - each switch powers two utility Electrical Load Control Units (ELCUs) and two galley ELCUs.

Off (blank) -

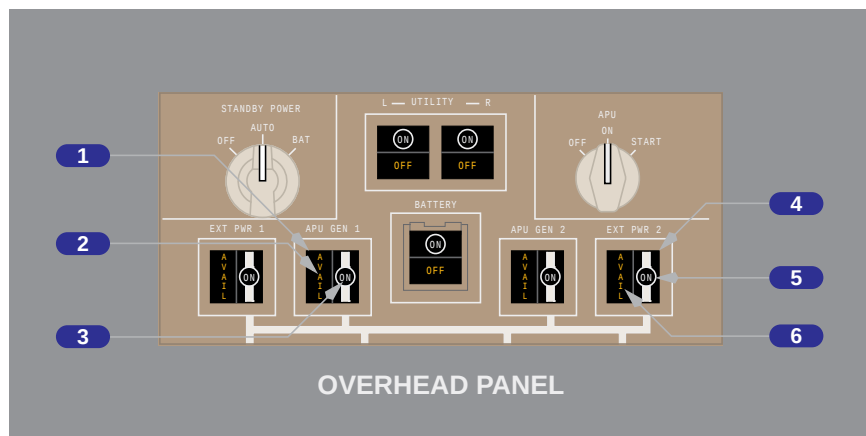
- removes power from related ELCUs
- resets fault logic circuitry

5 UTILITY Power OFF Lights

Illuminated (amber) -

- power removed from related ELCUs by fault protection logic, or
- related Utility Power switch OFF, or
- one or more Galley Emergency Power Off switches OFF
- not illuminated during load shedding

APU Generator and External Power Controls



1 APU Generator (APU GEN) Control Switches

Open or close the auxiliary power breaker if the AVAIL light is on

Push -

- if ON light illuminated, APU power is connected to the AC electrical system
- if ON light is extinguished, APU power is disconnected from the AC electrical system

2 APU Generator Power Available (AVAIL) Lights

Illuminated (white) -

- APU generator power quality acceptable
- extinguishes when ON light illuminates

3 APU Generator Power ON Lights

Illuminated (white) -

- related APU generator connected to AC electrical system
- extinguishes when AVAIL light illuminates

4 External Power (EXT PWR) Control Switches

Related external power connected to ac electrical system if the AVAIL light is illuminated

Push -

- if ON light illuminated, external power is connected to the AC electrical system
- if ON light extinguished, external power is disconnected from the AC electrical system

5 External Power ON Lights

Illuminated (white) -

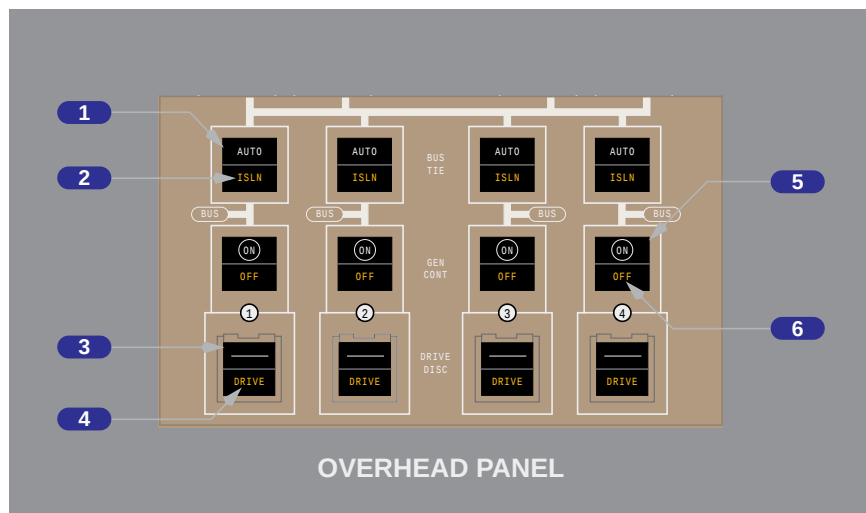
- related external power connected to AC electrical system
- extinguishes when AVAIL light illuminates

6 External Power Available (AVAIL) Lights

Illuminated (white) -

- related external power source plugged in, power quality acceptable
- extinguishes when ON light illuminates

AC Bus and Generator Controls



1 BUS TIE Switches

AUTO -

- arms automatic AC bus tie circuitry
- closes related DC isolation relay (DCIR)

Off (blank) -

- opens BTB and related DCIR
- resets fault logic circuitry

2 Bus Isolation (ISLN) Lights

Illuminated (amber) -

- BTB open
- AC bus isolated from synchronous bus

3 Generator Drive Disconnect (DRIVE DISC) Switches

Push -

- disconnects IDG from engine when above idle speed
- opens related Generator Control Breaker (GCB)
- switch is safety wire closed

Note: Ground maintenance action required to reconnect IDG.

4 Generator DRIVE Lights

Illuminated (amber) -

- IDG oil pressure low, or
- IDG oil temperature high, or

As Installed

- GCB open due to uncorrectable generator frequency fault

5 Generator Control (GEN CONT) Switches

ON -

- closed generator field
- arms GCB to close when generator power quality acceptable

Off (blank) -

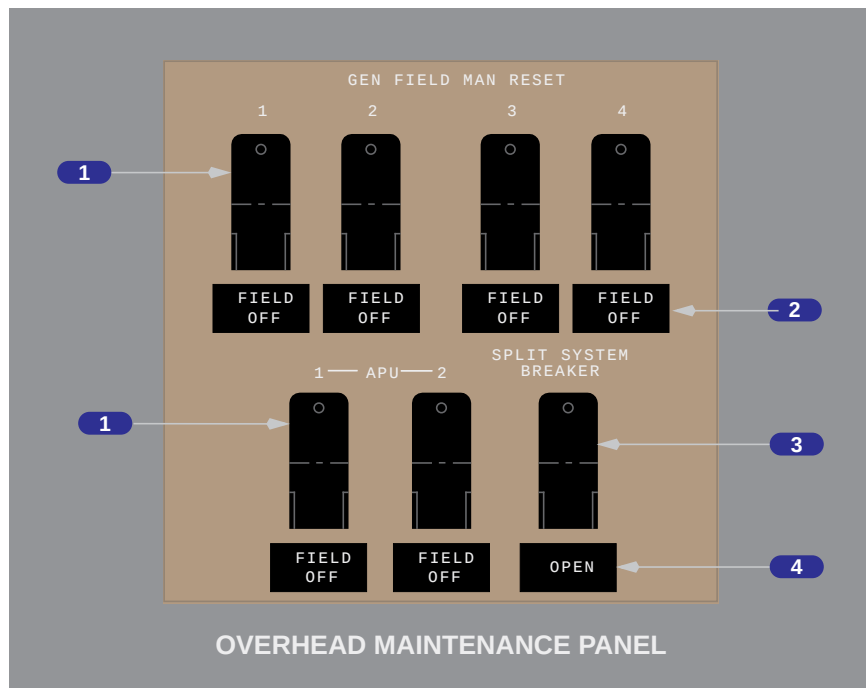
- opens generator field and GCB
- resets fault control logic circuitry
- isolates generator from its related AC bus

6 Generator OFF Lights

Illuminated (amber) - GCB open

Overhead Maintenance Panel

Generator Field Manual Reset and Split System Breaker Switches



1 Generator Field Manual Reset (GEN FIELD MAN RESET) Switches

Push - (spring-loaded toggle, guarded) opens or closes generator field if related Generator Control or APU Generator Control switch off

2 Generator FIELD OFF Lights

Illuminated (white) - generator field open.

3 SPLIT SYSTEM BREAKER Switch

Push - (spring-loaded toggle, guarded) opens or closes split system breaker

Note: Operative on ground only.

4 Split System Breaker OPEN Light

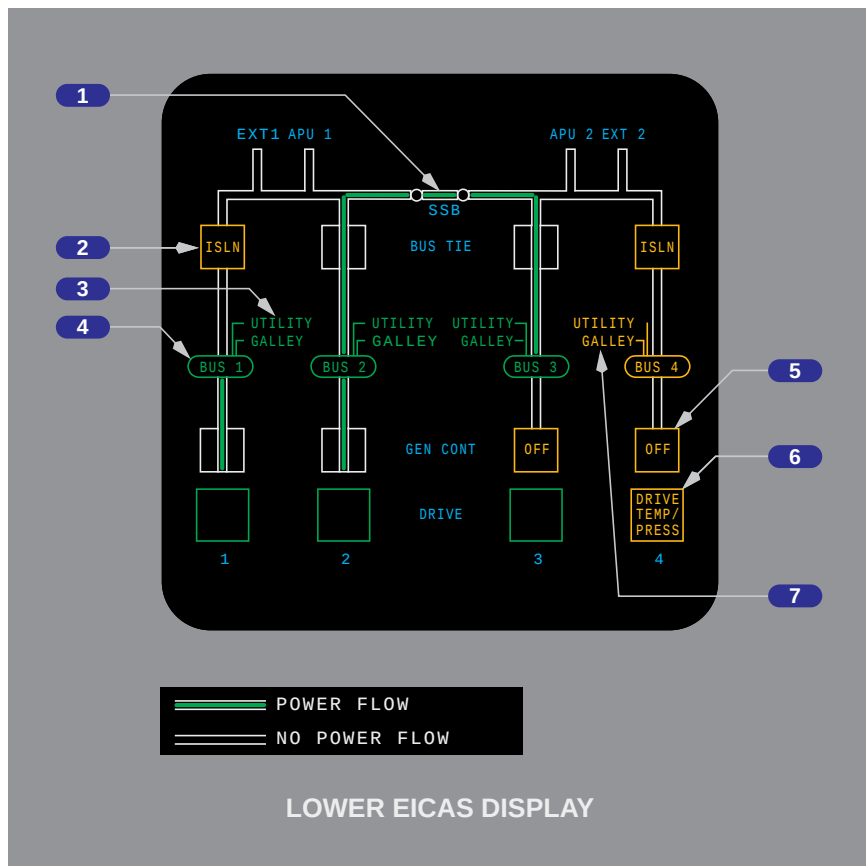
Illuminated (white) - split system breaker open

Electrical Synoptic Display

The electrical synoptic displays by pushing the ELEC Synoptic switch on the display select panel. Display select panel operation is described in Chapter 10, Flight Instruments, Displays.

The synoptic displays the configuration of the AC power system in a simplified schematic format. DC power flow is not represented. The depiction is generated by the status of various system breakers and conductors and does not represent actual power flow. Therefore, the display may not be an accurate representation of system operation. Symbols display in low intensity white when source data is invalid or unavailable.

During autoland, with bus tie breakers 1, 2, and 3 open, the message “ELECTRICAL SYNOPTIC INHIBITED FOR AUTOLAND” appears on the synoptic display.



1 SSB (Split System Breaker)

Closed - SSB closed, both sides of synchronous bus connected

Open - synchronous bus split.

2 BUS TIE

- power flow bar present - BTB closed
- ISLN (amber) - BTB open
 - associated AC Bus is isolated from the synchronous bus

3 UTILITY

- green - utility bus powered
- amber - utility bus not powered

4 BUS

- green - AC Bus powered
- amber - AC Bus not powered

5 GEN CONT

- power flow bar present - GCB closed
- OFF (amber) - GCB open

6 DRIVE

- blank (green) - normal operation
- DRIVE TEMP/PRESS (amber) - IDG has high oil temperature
 - low oil pressure

As Installed

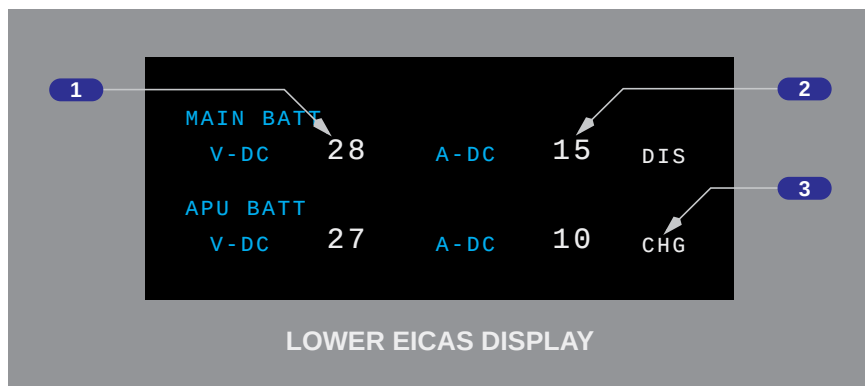
- GCB open due to uncorrectable generator frequency fault

7 GALLEY

- green - galley bus powered
- amber - galley bus unpowered

Battery Condition

Battery condition displays on the status page by pushing STAT Display switch on the display select panel. Display select panel operation is described in Chapter 10, Flight Instruments, Displays.



1 Battery Voltage (V-DC)

Main and APU battery voltage

2 Battery Current (A-DC)

Main and APU battery amperage

3 Battery Charge Status

DIS (Discharge) - battery discharging

CHG (Charge)

- battery charging
- if battery current is zero, charge status is blank

Intentionally
Blank

Electrical System Description

Chapter 6 Section 20

Introduction

The electrical system generates and distributes AC and DC power to other airplane systems and is comprised of main AC power, DC power, and standby power components. System operation is automatic. Electrical faults are automatically detected and isolated.

AC Electrical System

The AC electrical system is the main source of airplane electrical power.

Electrical Load Management and Load Shedding

Electrical system overload protection is provided by a load management system configured to ensure power is available to critical and essential equipment.

If electrical loads exceed power available (airplane or external), the load management system sheds AC loads by priority until the loads are within the capacity of airplane or ground power generators. Loads are shed one at a time through Electrical Load Control Units (ELCU) in a programmed sequence until the overload condition is relieved. Galley busses are shed first (order: 1,4,2,3), followed by utility busses (order: 1, 4, 2, 3). When an additional AC power source is available, loads are restored in reverse order (utility: 3, 2, 4, 1 then galley: 3, 2, 4, 1).

During load shedding, the ELEC UTIL BUS L and R messages and utility off lights are inhibited. However, the following EICAS alert messages may display in the order shown depending upon fuel system configuration and the extent of load shedding:

- FUEL PUMP 3 FWD
- FUEL OVRD 2 FWD
- FUEL OVRD 3 FWD
- FUEL PRESS CTR L
- FUEL PUMP 2 FWD

AC Electrical System Power Sources

The main AC electrical power sources are:

- four IDGs
- two auxiliary power sources (APU generators)
- two external power sources

During normal operation, IDG power output to the four AC busses is synchronized. Each bus is interconnected through a single synchronous bus, which distributes electrical power and allows individual AC busses to remain powered when their related generators are inoperative. The split system breaker (SSB) divides the synchronous bus allowing each side of the AC electrical system to be powered by separate auxiliary or external power sources.

IDGs

One IDG is mounted on each engine accessory gearbox. Each IDG incorporates an AC generator, drive unit with self-contained lubrication system, and automatic control and protection components.

When an engine is started with auxiliary or external power connected to each side of the electrical system (SSB open), the IDG powers its side of the synchronous bus when voltage and frequency are acceptable. The previous power source is disconnected. When an engine on the opposite side of the airplane is started, the IDG powers its side of the synchronous bus. The previous power source is disconnected and the SSB closes.

When a single auxiliary or external power source is powering the electrical system and an engine is started, the IDG powers the entire synchronous bus when voltage and frequency are acceptable. The SSB remains closed and the original power source is disconnected.

During power source transfers on the ground, such as switching from IDG to auxiliary or external power, output from IDG and another power source is momentarily synchronized before one source is disconnected. This provides smooth, uninterrupted electrical power switching.

Each IDG can be electrically disconnected from its related bus by pushing the Generator Control switch OFF. On the ground, an IDG can also be disconnected from its related bus by manually selecting an available auxiliary or external power source.

IDG Disconnect

Each IDG can be mechanically disconnected from its engine accessory gearbox by pushing the Generator Drive Disconnect switch. When an IDG is disconnected, generator power output is lost and cannot be restored by flight crew action.

The EICAS message ELEC DRIVE displays for low IDG oil pressure or high IDG oil temperature.

Uncorrectable Generator Frequency Fault - As Installed

The ELEC DRIVE message also displays if a GCB is open due to an uncorrectable generator frequency fault.

Automatic Drive Disconnect - As Installed

Excessively high drive oil temperature disconnects the IDG automatically if not manually disconnected by flight crew action. The resulting loss of generator power output opens the GCB and displays the EICAS message ELEC GEN OFF. Pushing the Generator Drive Disconnect switch after automatic disconnect replaces the ELEC DRIVE message with the >DRIVE DISC message.

Auxiliary and External Power

Auxiliary power is available only on the ground from generators mounted on the APU. External power is available from ground sources through two power receptacles located on the lower right forward fuselage. Either source can power main AC busses through connection to the synchronous bus. Auxiliary and external power sources cannot be connected to the same side of the synchronous bus simultaneously. The SSB is commanded open or closed to ensure all AC main busses are powered on the ground.

On an unpowered airplane with auxiliary and external power available, when a single power source is selected, the SSB closes and power is provided to the entire synchronous bus by the selected source. When the other same-type power source is selected on the opposite side, the SSB opens and each source powers its side of the synchronous bus. If one power source is disconnected or fails, the SSB closes maintaining power to the entire synchronous bus from the remaining source.

When IDGs are powering the electrical system with auxiliary or external power available, selecting a single power source disconnects IDGs on the same side and opens the SSB. The selected source powers its side of the synchronous bus, while the opposite side remains powered by IDGs. Selecting a second auxiliary or external power source on the opposite side disconnects the remaining IDGs and completes the power transfer from IDG to auxiliary/external power; the SSB remains open.

AC Electrical Power Distribution

AC power is distributed by the following busses:

- four main busses
- two transfer busses
- ground service and ground handling busses
- four galley busses
- four utility busses
- **6301 - 6314**
- one standby bus
- **6315, 6316**
- one main standby bus
- one APU standby bus

AC Main Busses

Each IDG normally powers its related AC bus through a GCB. Each AC bus is connected to the synchronous bus by a BTB. With the Bus Tie switch in AUTO, the related BTB controls the AC bus connection to the synchronous bus.

If power on an AC bus is unacceptable, the related BTB opens and the bus disconnects from the synchronous bus. However, the AC bus remains powered by its IDG. If the IDG is not able to maintain acceptable power quality, the GCB opens and the BTB closes to provide power from the synchronous bus.

The EICAS message ELEC BUS ISLN displays if the BTB is open. Pushing the Bus Tie switch OFF, then AUTO, resets logic circuitry and allows the BTB to close if the fault is corrected. The AC bus is reconnected to the synchronous bus.

The main AC busses power individual equipment items such as:

- TRUs
- navigation radios and flight control computers
- flight deck lighting
- pitot and window heat

The main AC busses also power other AC busses:

- AC bus 1 powers the ground service bus and provides back-up power for both transfer busses
- AC bus 2 powers the first officer transfer bus
- each AC bus powers a utility and galley bus
6301 - 6314
- AC bus 3 powers the captain transfer bus and the standby bus
6315, 6316
- AC bus 3 powers the captain transfer bus and the main standby bus

Ground Service Bus

The ground service bus is powered on the ground and in flight whenever AC bus 1 is powered. The ground service bus powers individual equipment items such as:

- main and APU battery chargers
- fuel pumps for APU start
- upper deck emergency doors
- flight deck flood, navigation, and service lights
- miscellaneous service outlets and equipment
- horizontal stabilizer fuel pump for defueling

On the ground when AC bus 1 is not powered, the ground service bus can be connected to the same source powering the ground handling bus by pushing the Ground Service switch on the flight attendant's panel at door 2L.

Ground Handling Bus

The ground handling bus is powered on the ground when APU generator 1 or external power 1 is available. If both are available, external power is automatically used. The ground handling bus powers individual equipment items such as:

- lower cargo door operation, handling equipment, and compartment lights
- fueling system
- auxiliary hydraulic pump 4
- flight deck access lights

Transfer Busses

Two transfer busses provide AC power to critical flight-related equipment. The transfer busses have a common back-up power source. Transfer to the back-up power source is automatic.

Captain Transfer Bus

6301-6314

The captain transfer bus is normally powered by AC bus 3. If AC bus 3 is unpowered, AC bus 1 powers the captain transfer bus.

6315, 6316

The captain transfer bus is normally powered by AC bus 3. If AC bus 3 is unpowered, AC bus 1 powers the captain transfer bus. The captain transfer bus powers the APU standby bus.

The captain transfer bus powers individual equipment items such as:

- center EFIS/EICAS Interface Unit (EIU)
- left HF
- center ADC
6301 - 6314
- left FMC, left ND, left PFD
6315, 6316
- APU standby bus

First Officer Transfer Bus

The first officer transfer bus is normally powered by AC bus 2. If AC bus 2 is unpowered, AC bus 1 powers the first officer transfer bus. The first officer transfer bus powers individual equipment items such as:

- autothrottle servo
- lower EICAS display
- right ADC, right EFIS control, right EIU, right FMC
- right CDU, right HF, right ND, right PFD

Utility and Galley Busses

Each main AC bus powers one utility bus and one galley bus. Each utility/galley bus is controlled by an Electronic Load Control Unit (ELCU) that protects the electrical system from utility and galley bus faults, and provides load management through automatic load shedding. With the Left Utility Power switch ON, utility busses 1 and 2 and galley busses 1 and 2 are powered according to ELCU logic. With the Right Utility Power switch ON, utility busses 3 and 4 and galley busses 3 and 4 are powered according to ELCU logic.

Utility busses power individual equipment items such as:

- forward main fuel pumps 2 and 3
- forward override/jettison pumps 2 and 3
- center override/jettison pump
- recirculating fans

Galley busses power the galleys located throughout the cabin.

The EICAS message ELEC UTIL BUS displays and the utility OFF light illuminates if one or more utility or galley bus become unpowered due to a fault. Cycling the Utility Power switch OFF, then ON restores power to the affected bus if the fault is corrected.

A guarded ON Galley Emergency Power Off switch is located at each galley. If a Galley Emergency Power Off switch is selected OFF, the related EICAS message ELEC UTIL BUS displays and utility OFF light illuminates. Cycling the flight deck Utility Power switch OFF, then ON will not reset the indications. The flight deck Utility Power switch should remain ON after cycling, which permits the remaining utility and galley busses to be powered and controlled by their related ELCU.

Electrical Bus Isolation During Autoland

During automatic ILS approach, AC and DC busses 1, 2, and 3 are isolated from the synchronous bus to provide independent power sources for the three autopilots. AC bus 4 continues to power the synchronous bus.

If any AC or DC source fails when busses are isolated for autoland, the system reconfigures automatically to maintain independent power sources for the three autopilots.

During autoland:

- AC bus isolation lights 1, 2, and 3 remain extinguished,
- the EICAS message ELEC BUS ISLN is not displayed,
- the message “ELECTRICAL SYNOPTIC INHIBITED FOR AUTOLAND” is displayed on the electrical synoptic.

The electrical system is no longer configured for autoland bus isolation when:

- all autopilots disengage, or
- TO/GA mode is annunciated and the airplane is higher than 100 feet radio altitude, or
- approach mode is disarmed or deselected, or
- the electrical system is unable to maintain a configuration for autoland bus isolation.

AC Standby Power System

The AC standby power system provides electrical power to critical flight deck equipment.

6301 - 6314

Major components of the system include:

- standby bus
- main battery
- standby inverter
- Standby Power selector

6315, 6316

Major components of the system include:

- main and APU standby busses
- main and APU batteries
- main and APU standby inverters
- Standby Power selector

Standby Bus

6301 - 6314

The standby bus is normally powered by AC bus 3. With the Battery switch ON, Standby Power selector in AUTO, and AC bus 3 not powered, the standby bus is powered by the standby inverter. The standby inverter, normally unpowered, is activated and receives power from the main battery charger through the main hot battery bus. The main battery charger is normally powered by AC bus 1 through the ground service bus.

With the Battery switch ON, Standby Power selector in AUTO, and both AC bus 1 and AC bus 3 not powered, the standby bus is powered by the standby inverter. The standby inverter, normally unpowered, is activated and receives power from the main battery through the main hot battery bus. With the main battery charger unpowered, the main battery can provide power to the standby bus for a minimum of 30 minutes.

The standby bus powers individual equipment items such as:

- left EIU, left CDU, left ILS, left VOR
- various flight control components
- standby ignition for all engines
- primary EICAS display, RMI, standby instrument lights
- left ADC, left EFIS control panel

Main Standby Bus

6315, 6316

The main standby bus is normally powered by AC bus 3. With the Battery switch ON, Standby Power selector in AUTO, and AC bus 3 not powered, the main standby bus is powered by the main standby inverter. The main standby inverter, normally unpowered, is activated and receives power from the main battery charger through the main hot battery bus. The main battery charger is normally powered by AC bus 1 through the ground service bus.

With the Battery switch ON, Standby Power selector in AUTO, and both AC bus 1 and AC bus 3 not powered, the main standby bus is powered by the main standby inverter. The main standby inverter, normally unpowered, is activated and receives power from the main battery through the main hot battery bus. With the main battery charger unpowered, the main battery can provide power to the main standby bus for a minimum of 30 minutes.

The main standby bus powers individual equipment items such as:

- left EIU, left CDU, left ILS, left VOR
- various flight control components
- standby ignition for all engines
- primary EICAS display, RMI, standby instrument lights
- left ADC, left EFIS control panel

APU Standby Bus

6315, 6316

The APU standby bus is normally powered by the captain transfer bus. With the Battery switch ON, Standby Power selector in AUTO, and the captain transfer bus not powered (loss of AC busses 1 and 3), the APU standby bus is powered by the APU standby inverter. The APU standby inverter, normally unpowered, is activated and receives power from the APU battery through the APU hot battery bus. With the APU battery charger unpowered, the APU battery can provide power to the APU standby bus for a minimum of 30 minutes.

The APU standby bus powers these equipment items:

- left FMC
- left ND
- left PFD

Standby Power Selector - BAT Position

6301 - 6314

With the Battery switch ON and Standby Power selector in BAT, the main and APU battery chargers are disabled. The standby bus is powered by the main battery through the main hot battery bus and standby inverter. The APU battery bus is powered by the APU battery through the APU hot battery bus. The main battery can provide power to the standby bus for a minimum of 30 minutes.

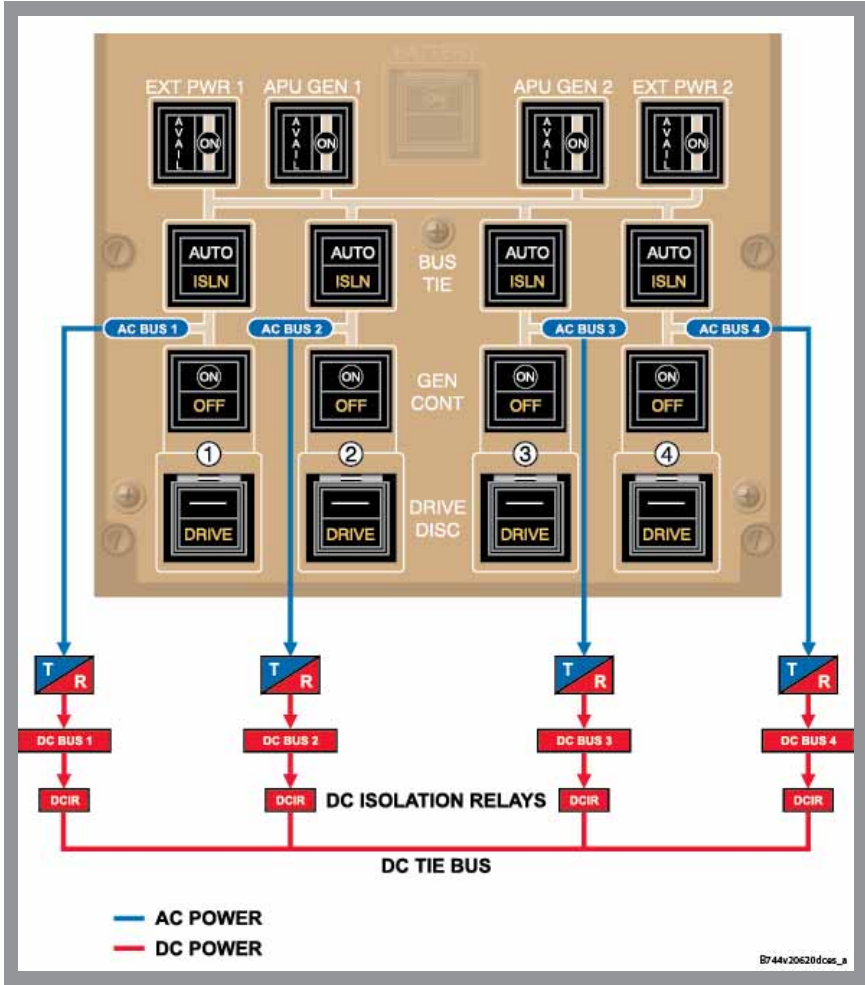
6315, 6316

With the Battery switch ON and Standby Power selector in BAT, main and APU battery chargers are disabled. Each AC standby bus is powered by its related battery and inverter. Each battery can provide power for a minimum of 30 minutes.

Note: The Standby Power selector must be in AUTO for flight. The BAT position is for ground maintenance use only.

DC Electrical System

The DC electrical system includes the main DC electrical system and the battery busses.



Main DC Electrical System

The main DC electrical system uses four transformer-rectifier units (TRUs) to produce DC power. Each TRU is powered by its related AC bus and provides DC power to a DC bus. The four DC busses are connected through DC isolation relays (DCIRs) to the DC tie bus, which allows each DC bus to remain powered if its related AC bus is unpowered or TRU fails. Pushing the Bus Tie switch to AUTO closes the related BTB and DCIR. Pushing the Bus Tie switch OFF opens the BTB and DCIR. This isolates the DC bus from the DC tie bus, leaving it powered by its AC bus and TRU. Automatic isolation of an AC bus due to an electrical fault opens the BTB, but does not open the DC isolation relay.

Main DC Power Distribution

TRU DC electrical power is distributed to four main DC busses. Main DC busses power individual equipment items such as:

- cabin pressure, fuel jettison, and pack temperature controllers
- wing anti-ice control
- engine-driven and hydraulic demand pump control
- fuel transfer and jettison valve control
- individual nacelle anti-ice control

Battery Busses

The following battery busses distribute DC power in addition to the four main DC busses:

- Main battery bus
- APU battery bus
- Main hot battery bus
- APU hot battery bus

The main and APU battery busses are normally powered by DC bus 3. If either AC bus 3 or DC bus 3 is unpowered, each battery bus is powered by its related hot battery bus.

The main battery bus provides power to individual equipment such as:

- APU controller (alternate), fuel valves (all engines), all crossfeed valves
- dome, storm, and selected indicator lights
- IDG disconnect (all engines), manual pressurization control, trailing edge flap control
- captain interphone, left radio tuning panel, left VHF

The APU battery bus powers individual equipment items such as:

- APU DC fuel pump, engine start air control
- cargo, first officer, and service interphones, PA system

- APU and engine fire/overheat detection loops A and B
- APU fire warning horn

Each hot battery bus is normally powered by the ground service bus through its related battery charger, which acts as a TRU for the hot battery bus while simultaneously maintaining its related battery fully charged. Each battery is directly connected to its related hot battery bus.

With the Battery switch ON, the main and APU hot battery busses power their related battery busses if either AC bus 3 or DC bus 3 is unpowered.

The main hot battery bus powers individual equipment items such as:

- APU fuel shutoff valve, spar valves (all engines)
- APU and lower cargo fire extinguishers
- engine fire extinguishers (all engines), fire switch unlock (all engines)

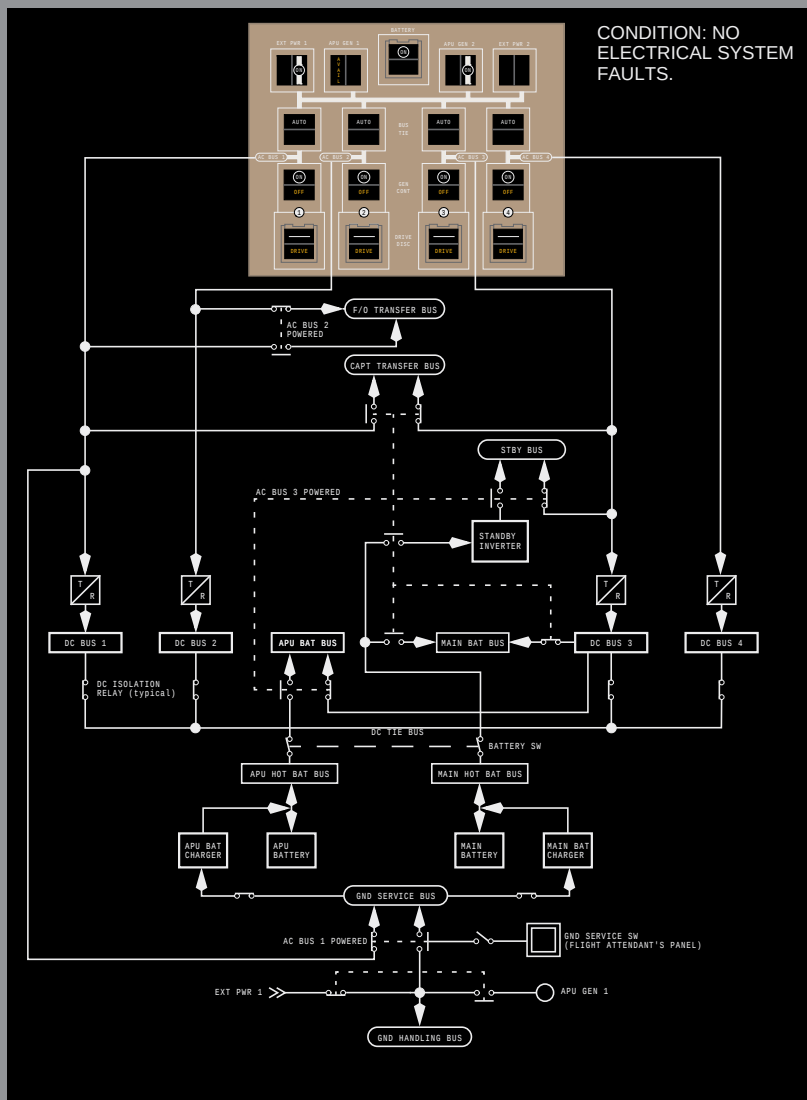
The APU hot battery bus powers individual equipment items such as:

- IRU left, center, right DC power
- left and right outflow valves
- APU inlet door, APU controller (primary)

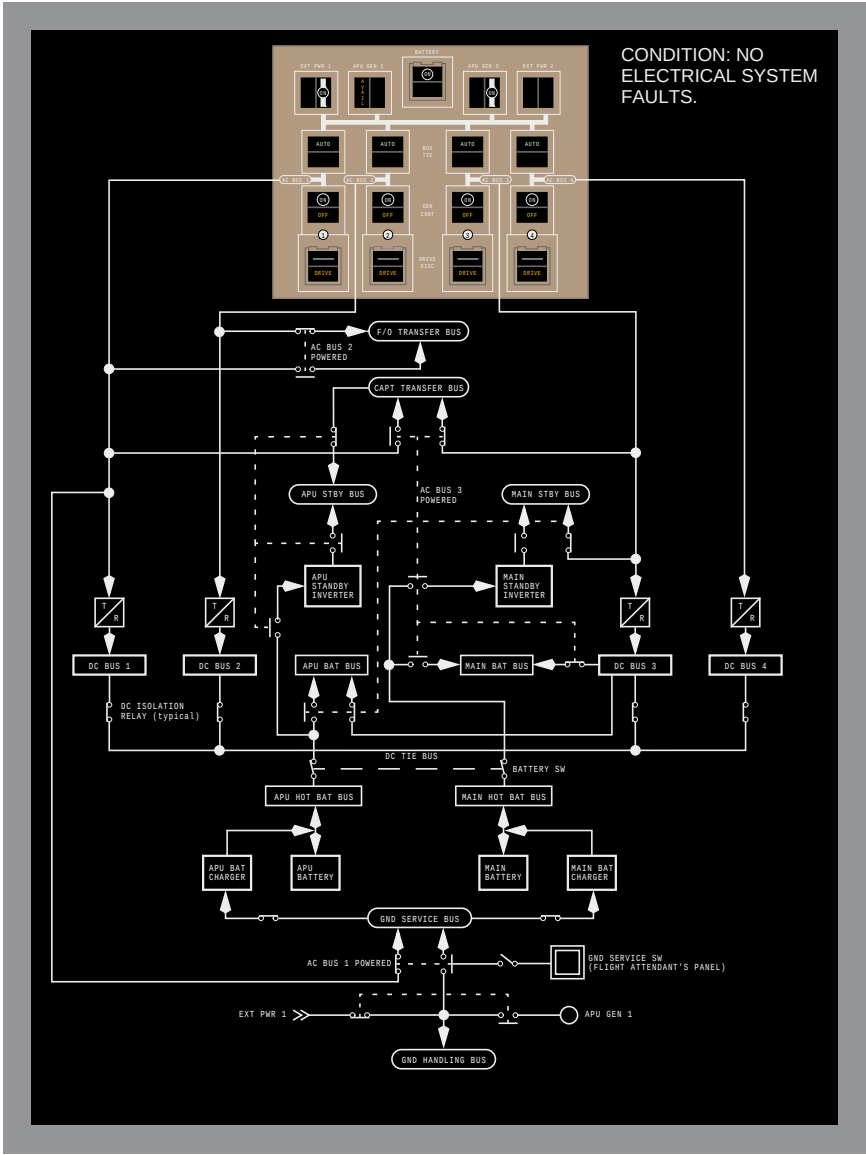
Electrical Power System Schematic

The Electrical Power System Schematic illustrates configuration of the electrical power system and functional relationships of its major components. System components not required for this purpose have been intentionally omitted.

6301 - 6314



6315, 6316



Electrical EICAS Messages

The following EICAS messages can be displayed.

Message	Level	Aural	Message Logic
>BAT DISCH APU	Advisory		APU battery discharging.
>BAT DISCH MAIN	Advisory		Main battery discharging.
>BATTERY OFF	Advisory		Battery switch OFF.
>DRIVE DISC 1, 2, 3, 4	Advisory		Generator Drive Disconnect switch pushed, IDG disconnected.
ELEC AC BUS 1, 2, 3, 4	Caution	Beeper	AC bus unpowered. Additional related messages displayed for unpowered equipment items.
ELEC BUS ISLN 1, 2, 3, 4	Advisory		Bus tie breaker open. Inhibited when ELEC AC BUS message displayed.

As installed

Message	Level	Aural	Message Logic
ELEC DRIVE 1, 2, 3, 4	Advisory		IDG oil pressure low or oil temperature high. Inhibited when Generator Drive Disconnect switch pushed.

As installed

Message	Level	Aural	Message Logic
ELEC DRIVE 1, 2, 3, 4	Advisory		IDG oil pressure low, oil temperature high, or GCB open due to uncorrectable generator frequency fault. Inhibited when Generator Drive Disconnect switch pushed.

Message	Level	Aural	Message Logic
ELEC GEN OFF 1, 2, 3, 4	Advisory		Generator control breaker open. Inhibited when ELEC AC BUS message displayed.

Message	Level	Aural	Message Logic
>ELEC SSB OPEN	Advisory		Split system breaker (SSB) open when commanded closed.

Message	Level	Aural	Message Logic
ELEC UTIL BUS L, R	Advisory		One or more galley or utility busses unpowered, or Galley Emergency Power switch off. Busses may be unpowered due to electrical fault, or related Utility Power switch or Galley Emergency Power switch off. Inhibited during load shedding.

6301 - 6314

Message	Level	Aural	Message Logic
>STBY POWER OFF	Advisory		Standby bus not powered.

6315, 6316

Message	Level	Aural	Message Logic
>STBY BUS APU	Advisory		APU standby bus not powered.
>STBY BUS MAIN	Advisory		Main standby bus not powered.

Engines, APU
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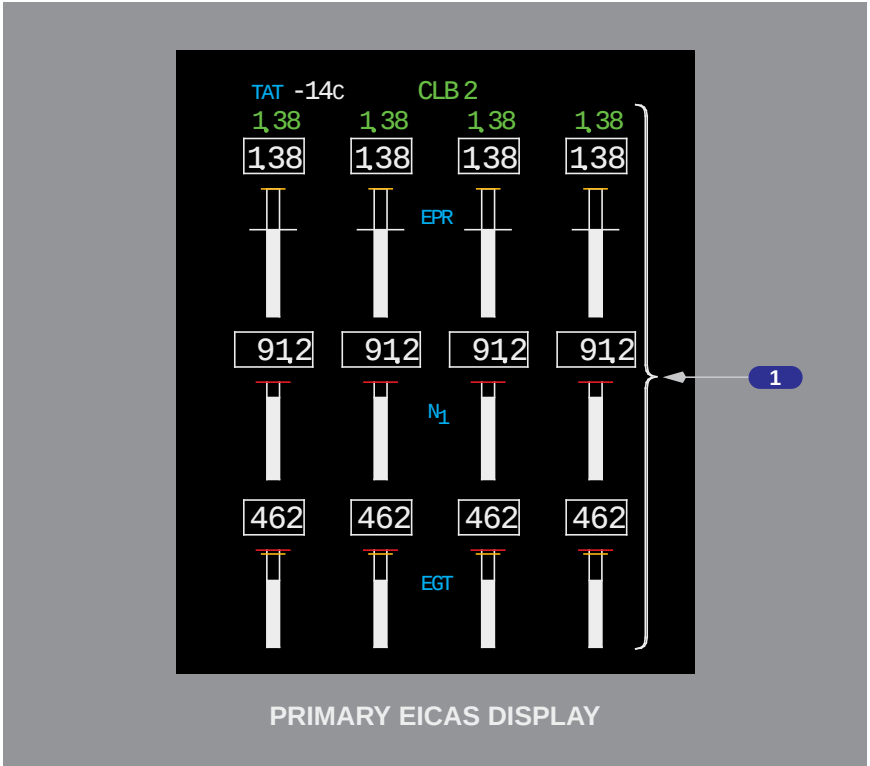
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Intentionally
Blank

Primary Engine Indications

Primary Engine Display



1 Primary Engine Indications

Displayed full time on EICAS display:

- EPR
- N1
- EGT

Mode Indications



1 Total Air Temperature (TAT)

Displayed (white) - TAT (degrees C).

2 Thrust Reference Mode

Displayed (green) - selected FMS thrust reference mode:

- TO - maximum rated takeoff thrust
- TO 1 - derate one takeoff thrust
- TO 2 - **Not used by Delta Air Lines.**
 - Derate two takeoff thrust
- D-TO - assumed temperature derated takeoff thrust
- D-TO 1 - derate one assumed temperature derated takeoff thrust
- D-TO 2 - **Not used by Delta Air Lines.**
 - Derate two assumed temperature derated takeoff thrust
- CLB - maximum rated climb thrust
- CLB 1 - derate one climb thrust
- CLB 2 - derate two climb thrust
- CON - maximum rated continuous thrust
- CRZ - maximum rated cruise thrust
- G/A - maximum rated go-around thrust

See Chapter 4, Automatic Flight, Autothrottle System for phase of flight displays.

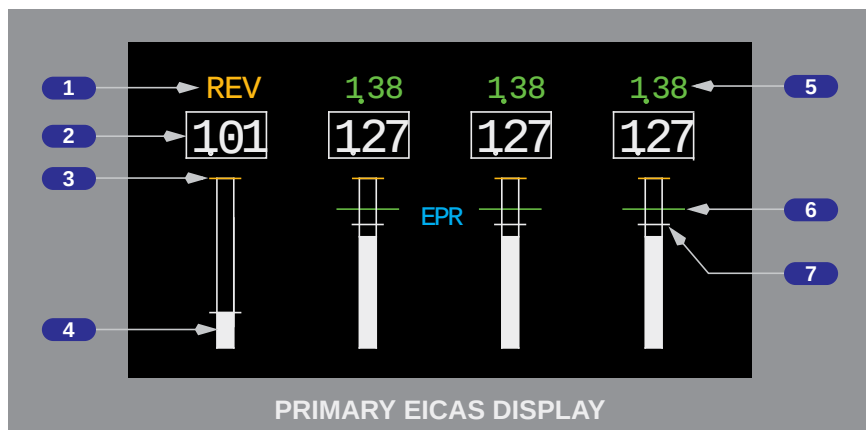
3 Assumed Temperature

Displayed (green) - selected assumed temperature (degrees C) for reduced thrust takeoff.

EPR Indications

Note: During tailwind conditions, slight EPR fluctuations may occur prior to five knots airspeed.

Note: When reverse thrust is activated, reference EPR is not displayed.



1 Thrust Reverser Indication

Displayed REV (amber) - reverser in transit.

Displayed REV (green) - reverser fully deployed.

2 EPR

Digital EPR displayed (white).

Visible after engine start is initiated.

3 Maximum EPR Line

Displayed (amber) - maximum allowable thrust.

Displayed (white) - maximum EPR is invalid.

4 EPR Indication

EPR displayed (white) - normal operating range.

5 Reference EPR

Displayed (digital, green) - reference thrust selected by FMC.

Not displayed when reverse thrust is selected.

6 Reference EPR Indicator

Displayed (green) - reference EPR.

Displayed (magenta) - target EPR commanded by FMC.

Magenta EPR displayed when:

- (1) Autothrottle engaged in THR REF.
- (2) Autothrottle engaged in THR.
- (3) During cruise mode with autothrottle disconnected.

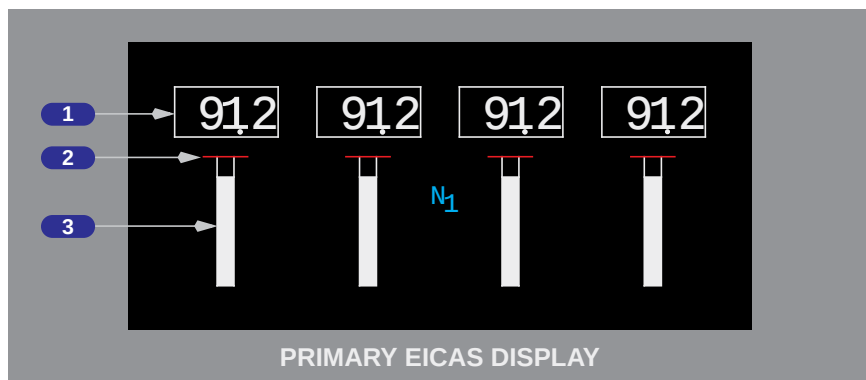
Not displayed when reverse thrust is selected.

7 Command EPR Indicator

Displayed (white) - EPR commanded by thrust lever position.

Visible after engine start is initiated.

N1 Indications



1 N1 RPM

Digital N1% RPM displayed:

- (white) - normal operating range
- (red) - operating limit reached

2 N1 Red Line

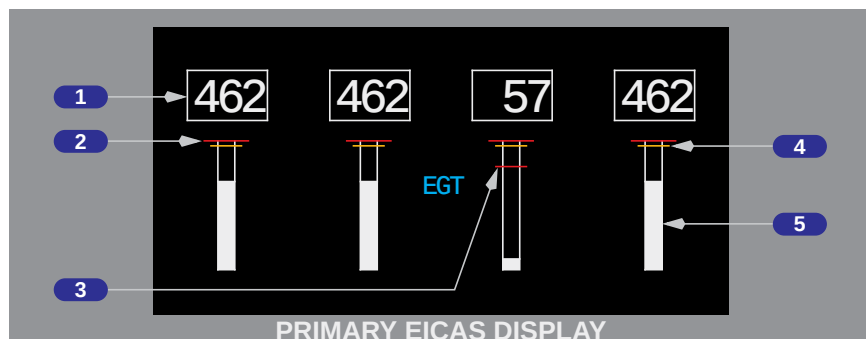
Displayed (red) - N1 RPM operating limit.

3 N1 RPM Indicator

N1 RPM, displayed:

- (white) - normal operating range
- (red) - operating limit reached

EGT Indications



1 EGT

EGT (degrees C), displayed:

- (white) - normal operating range
- (amber) - continuous limit reached
- (red) - start or takeoff limit reached

Visible after engine start is initiated.

Note: Indication remains white during takeoff or go-around for five minutes after TO/GA switch is pushed even though continuous EGT limit is reached.

2 EGT Red Line

Displayed (red) - takeoff EGT limit.

3 EGT Start Limit Line

Displayed (red):

- with Fuel Control switch in CUTOFF
- until N2 reaches a predetermined RPM (approximately 62%)

4 EGT Amber Band

Displayed (amber) - continuous EGT limit.

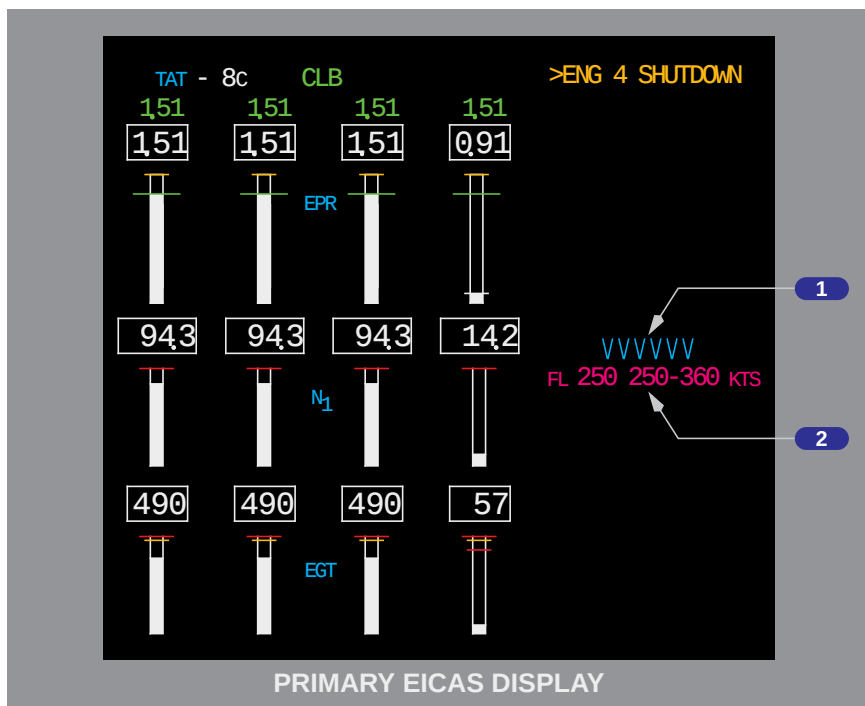
5 EGT Indication

Displayed:

- (white) - normal operating range
- (amber) - continuous limit reached
- (red) - start or takeoff limit reached

Note: Indication remains white during takeoff or go-around for five minutes after TO/GA switch is pushed even though continuous EGT limit is reached.

Secondary Exceedance Cue and In-flight Start Envelope



1 Secondary Engine Exceedance Cue

Displayed (cyan) -

- when a secondary engine parameter exceedance occurs
- until exceeding parameter returns to normal operating range
- uses same character field as status cue (replaces status cue if displayed)

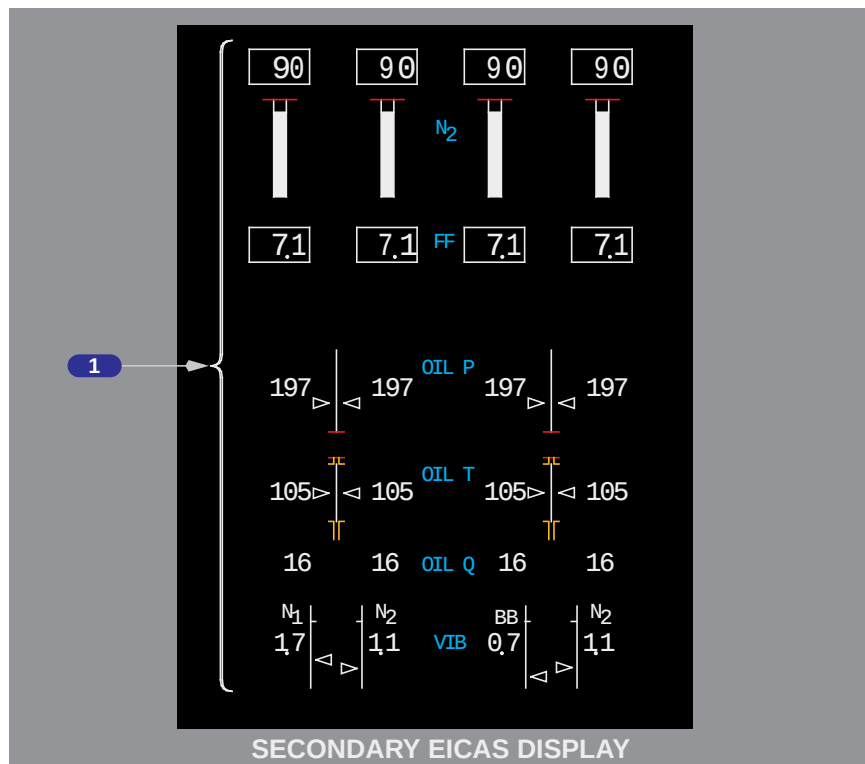
2 In-Flight Start Envelope

Displayed (magenta) - airspeed range for an in-flight start at the current flight level or maximum flight level (whichever is less) when the related Engine Fire switch is in and a Fuel Control switch is in CUTOFF.

Secondary Engine Indications

See Chapter 10, Flight Instruments, Displays, for display selection of Secondary Engine indications.

Secondary Engine Display



1 Secondary Engine Display

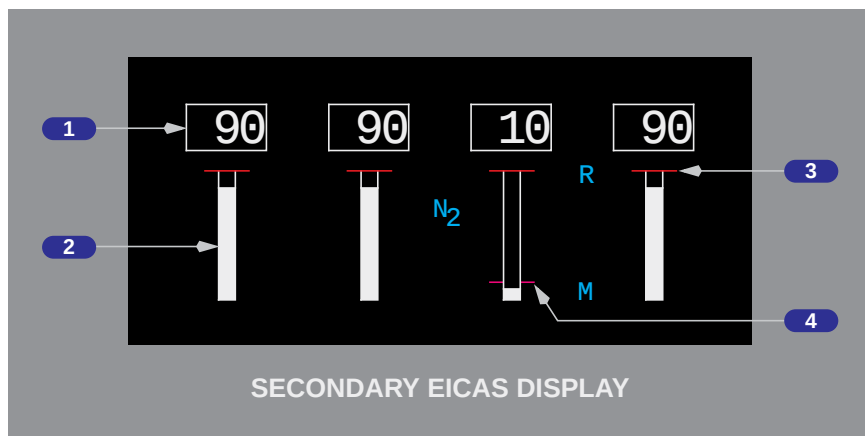
Displays:

- N₂ RPM
- fuel flow (FF)
- oil pressure (OIL P)
- oil temperature (OIL T)
- oil quantity (OIL Q)
- vibration (VIB)

Displays when:

- EICAS initially receives power
- in flight, when a Fuel Control switch is moved to CUTOFF

N2 Indications



1 N2

N2 RPM (%), displayed:

- (white) - normal operating range
- (red) - operating limit reached

2 N2 Indication

N2 RPM, displayed:

- (white) - normal operating range
- (red) - operating limit reached

3 N2 Red Line

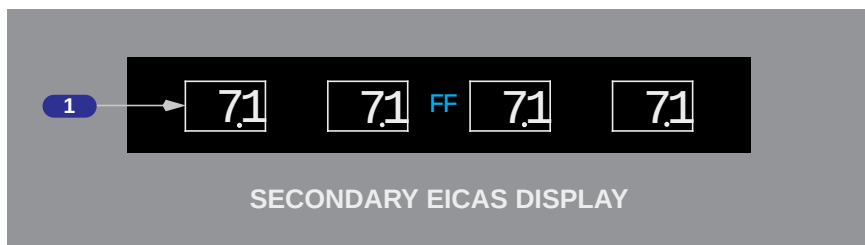
N2 RPM operating limit, displayed (red - R).

4 Fuel-On Indicator

Displayed (magenta - M) - minimum N2 RPM (15%) at which Fuel Control switch should be moved to RUN during start.

Displayed when Fuel Control switch in CUTOFF.

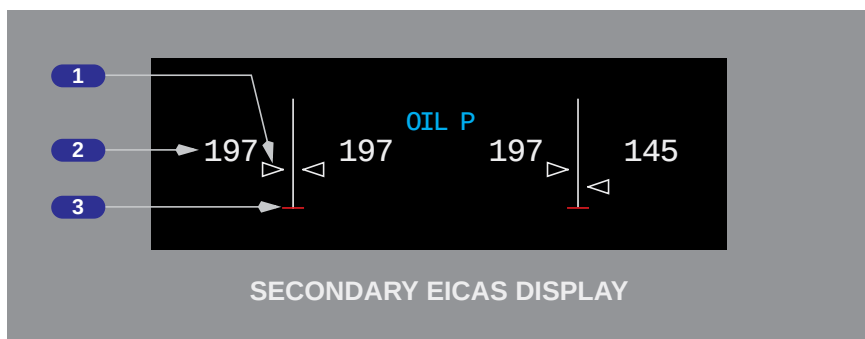
Fuel Flow Indications



1 Fuel Flow

Displayed (white) - fuel flow to the engine (pounds per hour x 1000).

Oil Pressure Indications



1 Oil Pressure Indicator

Engine oil pressure, displayed:

- (white) - normal operating range
- (red) - operating limit reached
- indication remains white when engine shutdown and during start

2 Oil Pressure

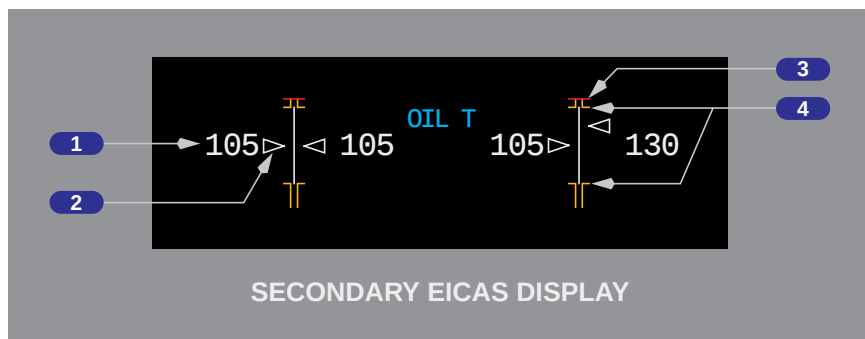
Engine oil pressure (psi), displayed:

- (white) - normal operating range
- (red) - operating limit reached
- indication remains white when engine shutdown and during start

3 Oil Pressure Red Line

Displayed (red) - oil pressure operating limit.

Oil Temperature Indications



1 Oil Temperature

Engine oil temperature (degrees C), displayed:

- (white) - normal operating range
- (amber) - caution range reached
- (red) - operating limit reached

Visible after engine start is initiated.

2 Oil Temperature Indicator

Engine oil temperature, displayed:

- (white) - normal operating range
- (amber) - caution range reached
- (red) - operating limit reached

Visible after engine start is initiated.

3 Oil Temperature Red Line

Displayed (red) - oil temperature operating limit.

4 Oil Temperature Amber Band

Displayed (amber) - oil temperature caution range.

Oil Quantity Indications



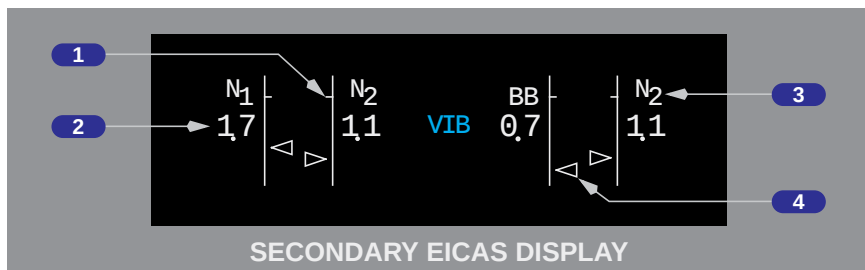
1 Oil Quantity

Usable oil quantity (U.S. quarts).

Displayed:

- (white) - normal quantity
- (magenta) - low quantity reached (< 4 quarts)

Engine Vibration Indications



1 Engine Vibration High Band

Displayed (white) - vibration level at which automatic display of vibration indications occurs.

2 Engine Vibration

Displayed (white) - engine vibration.

3 Engine Vibration Source

Identifies the vibration source being displayed.

Displayed (white) - vibration source with the highest vibration:

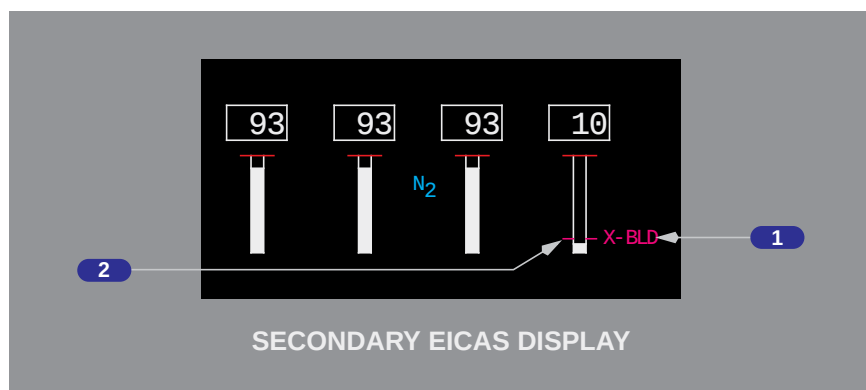
- N1 - N1 rotor vibration
- N2 - N2 rotor vibration

If vibration source BB (broad band vibration) displayed, source is unknown and average vibration displayed.

4 Engine Vibration Indicator

Displayed (white) - engine vibration.

Crossbleed Start Indications



1 Crossbleed (X-BLD) Start Indication

Indicates crossbleed air is recommended for in-flight start.

Displayed (magenta):

- in-flight start envelope displayed, and
- airspeed lower than for a windmilling start

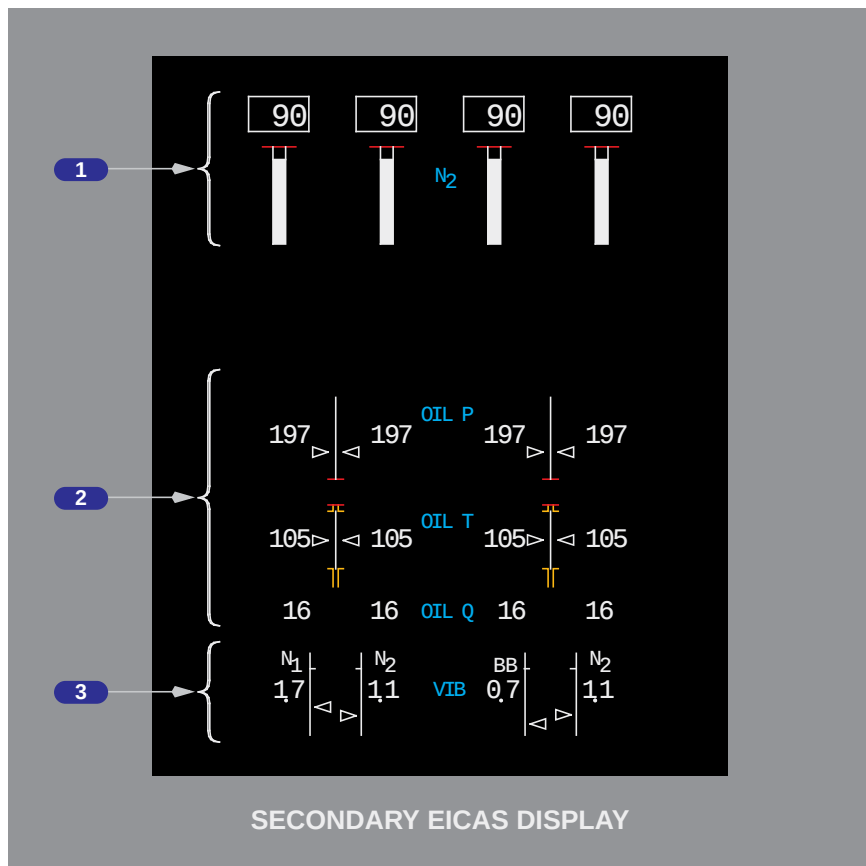
2 Fuel-on Indicator

Displayed (magenta):

- Displayed with cross bleed start.
- a Fuel Control switch is in CUTOFF
- minimum N₂ RPM at which Fuel Control switch should be moved to RUN during start

Partial Secondary Engine Indications

Partial secondary engine indications can display when the secondary engine display is not selected.



1 N2

Displays if an operating limit reached.

2 OIL P, OIL T, OIL Q

Displays if:

- a caution range or operating limit reached
- oil quantity low (< 4 quarts)

3 VIB

Displays if a display indicator reached.

Intentionally
Blank

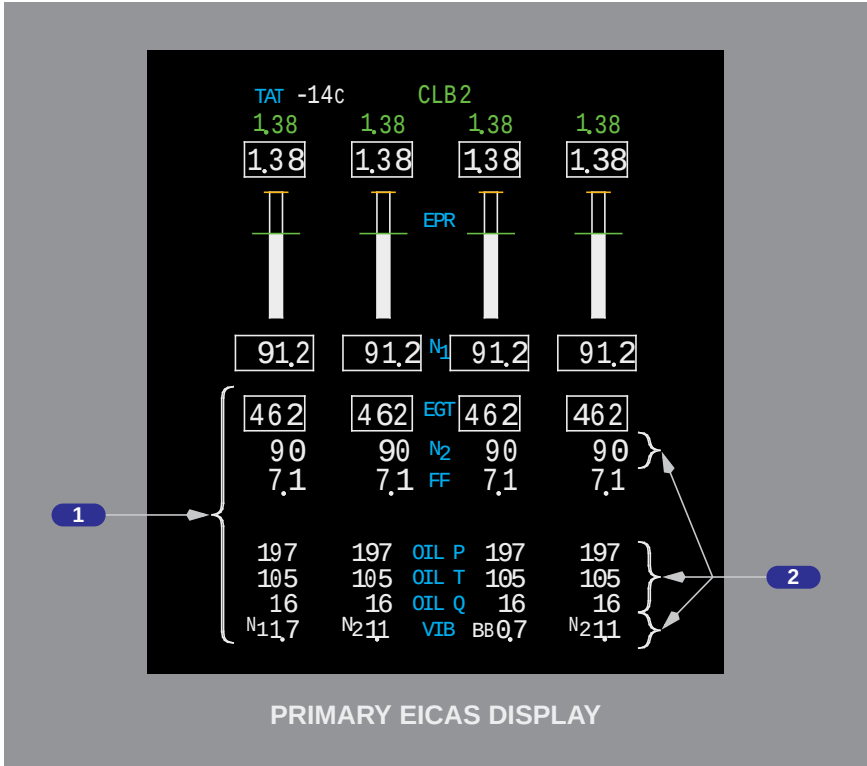
Engines, APU Compact Engine Indications

Chapter 7 Section 12

Compact Engine Indications

Compact engine indications are used when only one display unit is available for EICAS.

Compact Engine Display



1 Compact Engine Indications

Displayed continuously:

- EPR
- N1
- EGT

Displayed when selected by secondary engine display switch, or in flight if a Fuel Control switch is moved to CUTOFF:

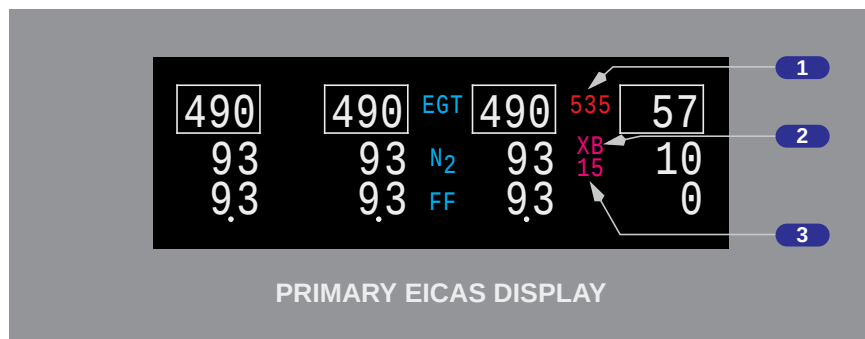
- N2
- FF
- OIL P
- OIL T
- OIL Q
- VIB

2 Partial Compact Engine Indications

N2, or OIL P, OIL T, OIL Q, or VIB display if:

- a secondary engine parameter exceedance occurs when secondary engine indications are not selected, or
- a secondary EICAS display other than secondary engine is selected when partial secondary engine indications are displayed on secondary EICAS

Compact Start Indications



1 EGT Start Limit

Displays red.

2 Crossbleed Start

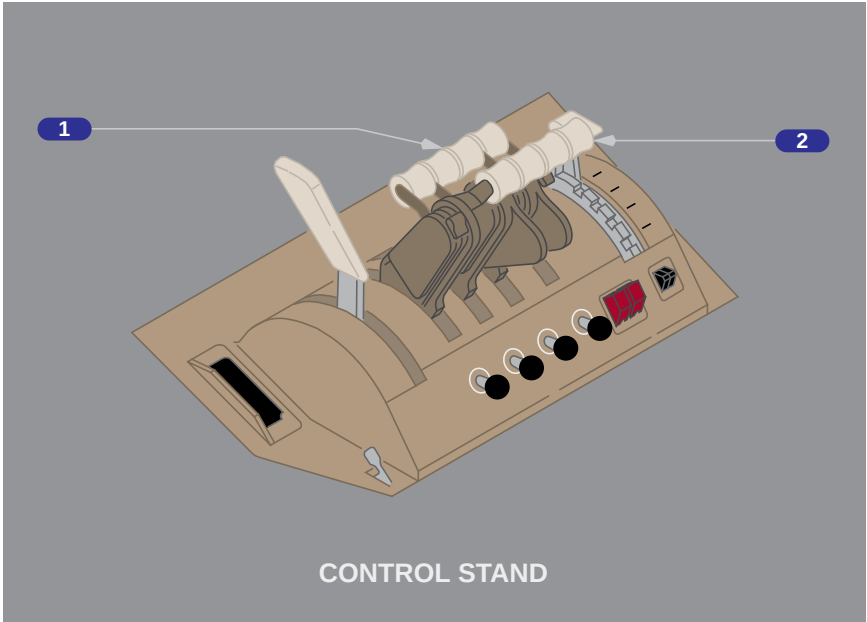
Displays magenta.

3 Fuel-on Indicator

Displays magenta.

Engine Controls

Thrust Levers



1 Reverse Thrust Levers

Control engine reverse thrust.

Reverse thrust can only be selected when Forward Thrust levers are closed.

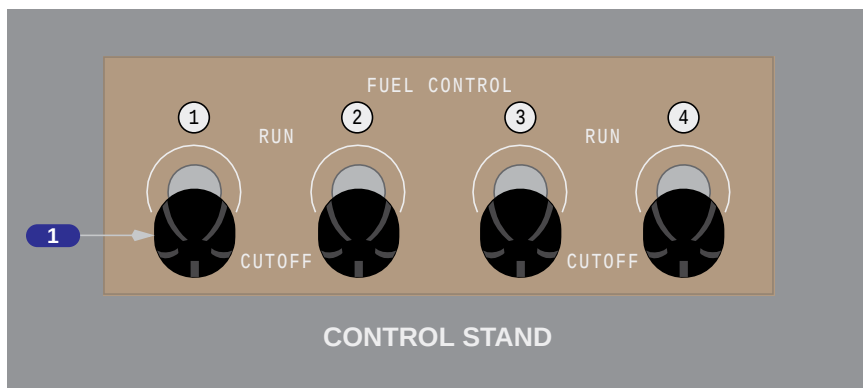
Actuates automatic speedbrakes (refer to Chapter 9, Flight Controls).

2 Forward Thrust Levers

Controls engine forward thrust.

Thrust levers can only be advanced when Reverse Thrust levers are down.

Fuel Control Switches



1 FUEL CONTROL Switches

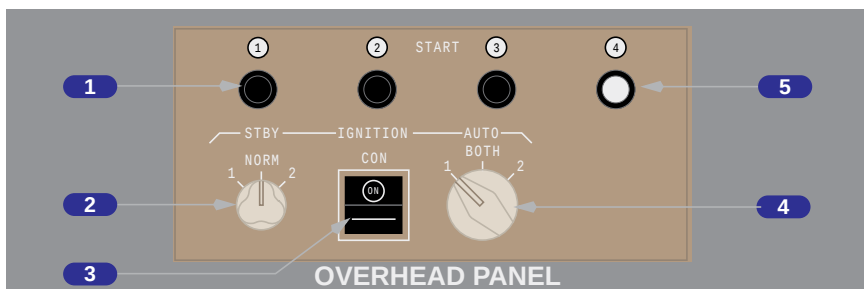
RUN -

- opens spar fuel valve
- opens engine fuel valve
- energizes igniter(s)

CUTOFF -

- closes fuel valves
- removes igniter power
- commands respective hydraulic demand pump to operate when Demand Pump selector in AUTO
- unlocks Engine Fire switch
- Nitrogen Generating System (NGS) is inoperative

Engine Start Panel



1 Engine START Switches

Pull -

- opens start valve
- opens engine bleed air valve

Releases at 50% N2 RPM -

- start valve closes
- engine bleed air valve closes

2 Standby (STBY) IGNITION Selector

NORM -

- AC power system supplies power to selected igniters
- standby power system supplies power continuously to number 1 igniters if AC power system is not powered

1 or 2 - standby power system supplies power continuously to respective igniters.

3 Continuous (CON) IGNITION Switch

ON -

- selected igniters operate continuously
- commands approach idle minimum

4 AUTO IGNITION Selector

1, BOTH, or 2 - selects respective igniters.

Selected igniters operate when any of the following occur:

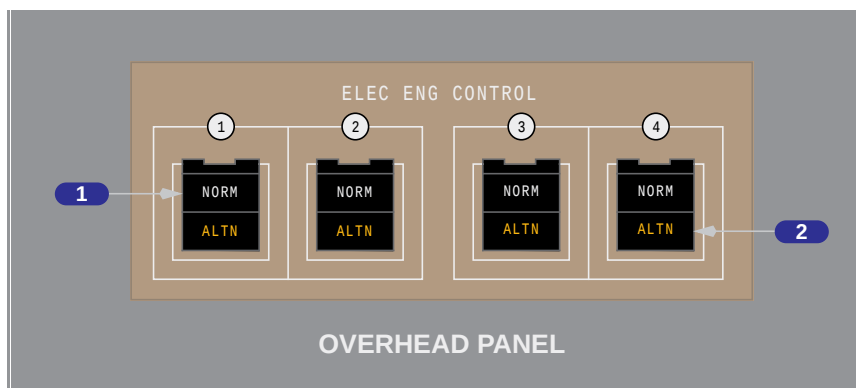
- during start when N2 RPM less than 50%
- trailing edge flaps out of up position (flaps 5 - 30)
- nacelle anti-ice ON

5 Engine Start Lights

Illuminated (white) - start valve is open.

Electronic Engine Control

Electronic Engine Control Panel



1 Electronic (ELEC) Engine (ENG) CONTROL Switches

NORM (Normal) -

- selects normal engine control mode
- electronic engine control sets thrust using EPR as the controlling parameter

Off (blank) -

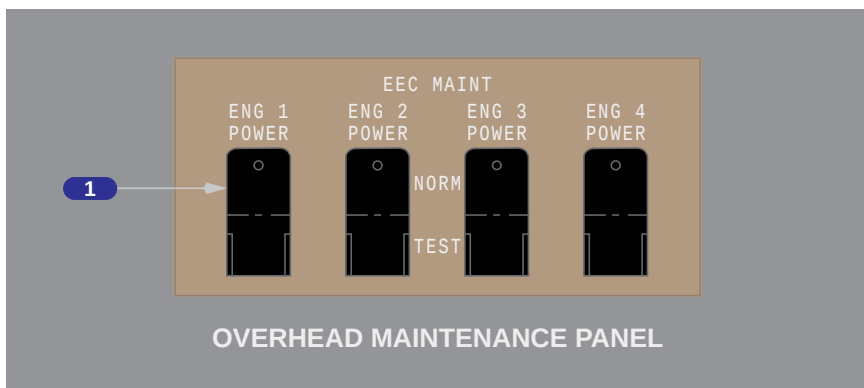
- alternate engine control mode manually selected
- thrust set using N1 RPM as controlling parameter

Note: Simultaneous display of NORM and ALTN indicates the respective EEC has automatically transferred to the alternate mode.

2 EEC Alternate (ALTN) Lights

Illuminated (amber) - alternate engine control mode selected.

Electronic Engine Control Maintenance Panel



1 EEC Maintenance (MAINT) POWER Switches

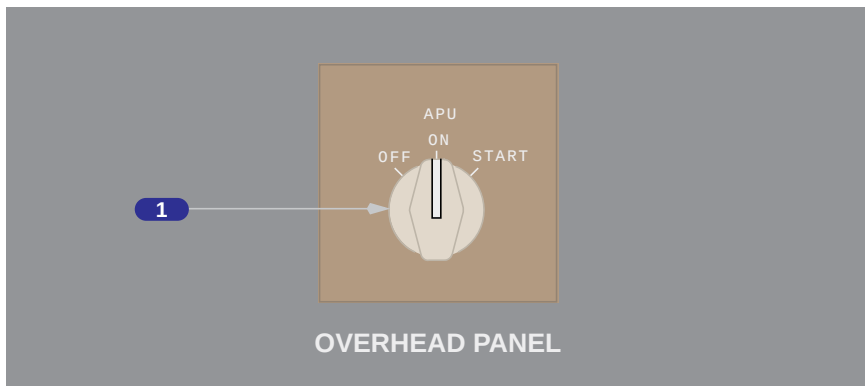
Normal (NORM) - supplies electrical power for normal EEC operation.

TEST - supplies electrical power for EEC maintenance testing when engine not running.

Intentionally
Blank

APU Controls and Indications

APU Selector



1 APU Selector

OFF -

- closes APU bleed air isolation valve
- initiates normal shutdown
- resets auto shutdown fault logic except when shutdown due to APU bleed duct leak

ON (APU operating position) -

- opens APU fuel valve and inlet door
- arms APU bleed air isolation valve

6301 - 6310

- activates DC or AC fuel pump (#2 AFT main fuel pump)

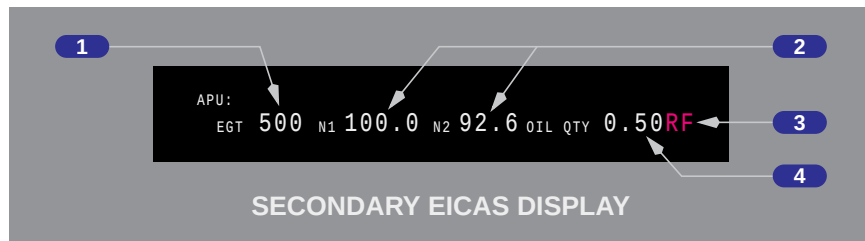
6311 - 6316

- activates DC or two AC fuel pumps (#2 and #3 AFT main fuel pumps)

START (momentary position, spring-loaded to ON) - initiates automatic start sequence.

APU Indications

Located on status (STAT) display.



1 EGT

APU exhaust gas temperature in degrees Celsius.

2 RPM

APU rotation speeds in percent.

3 Refill (RF)/Low (LO)

Displayed RF or LO (magenta) - oil quantity below prescribed level.

RF - oil quantity < 0.50

LO - oil quantity < 0.22

Note: The APU must be shut down in order to service the oil.

4 APU OIL Quantity

APU oil quantity (1.00 indicates full).

6301 - 6314

Quantity (and RF or LO indication) is not displayed until APU is running. ($N_1 \geq 95\%$)

6315 - 6316

Quantity (and RF or LO indication) is continuously displayed.

Engines, APU

Engine System Description

Chapter 7

Section 20

Introduction

The airplane is powered by four Pratt & Whitney PW-4056 engines. The engines are derated to 56,750 pounds takeoff thrust each.

The engines are dual rotor axial flow turbfans of high compression and bypass ratio. The N1 rotor consists of a fan, a low pressure compressor section, and a low pressure turbine section. The N2 rotor consists of a high pressure compressor section and a high pressure turbine section. The N1 and N2 rotors are mechanically independent. The N2 rotor drives the engine accessory gearbox.

Each engine has individual flight deck controls and an electronic engine controller (EEC). The Thrust levers are positioned by the autothrottle system or by the flight crew. See Chapter 11, Flight Management, Navigation, Section 32, for a description of FMC thrust management functions.

Engine Indications

Engine indications display on the engine indication and crew alerting system (EICAS) display.

Primary Engine Indications

EPR, N1, and EGT are primary engine indications and always display on the primary EICAS.

Secondary Engine Indications

N2, fuel flow, oil pressure, oil temperature, oil quantity, and engine vibration are secondary engine indications and normally display on secondary EICAS. The secondary engine indications display when:

- selected using the Secondary Engine Display switch (the ENG switch on the Display Select panel)
- the displays initially receive electrical power
- a Fuel Control switch is moved to CUTOFF in flight

The secondary engine parameters can be cleared by pushing the Secondary Engine Display switch.

Normal Display Format

Each engine indication consists of a digital indicator and, except for fuel flow and oil quantity, a moving vertical indicator. The digital readouts display numerical values while the moving indicators display relative value. The digital indicator for N1, EGT, N2, and fuel flow is enclosed in a box. The vertical indicator displays the normal operating range, caution range, and operating limit.

The normal operating range display on the vertical indicator is white. An indication is white when the engine parameter is in the normal operating range.

The oil temperature indicator has caution ranges displayed by amber bands. The indication changes color to amber if the parameter reaches the caution range.

The EGT indicator has a continuous limit displayed by an amber band. The indication changes color to amber if EGT reaches the continuous limit.

EGT indications are inhibited from changing color to amber during takeoff or go-around for five minutes after the TO/GA switch is pushed, even though EGT reaches the continuous limit.

The EGT indicator has a takeoff limit displayed by a red line. The indication changes color to red if EGT reaches the takeoff limit.

N1, N2, oil pressure, and oil temperature indicators have operating limits displayed by red lines. The indication changes color to red if the parameter reaches the operating limits.

An indication changes color back to white when the parameter returns to the normal operating range. The box enclosing the digital indicator remains red as a reminder of the exceedance. The red box color can be selectively canceled to white or recalled to red by pushing the cancel or recall switch on the EICAS Display Select panel.

The oil quantity indication changes color to magenta if low oil quantity (< 4 quarts) is detected.

Maximum EPR is displayed by an amber line. The EPR indication changes color to red when maximum EPR is reached. The reference EPR indicator displays the reference EPR selected by the FMC. The command EPR indicator displays EPR commanded by Thrust lever position. It equals actual EPR when the engine is stabilized. The command EPR indicator moves when the Thrust lever moves to display the new commanded EPR.

Compact Display Format

If only one display unit is available for use by EICAS, primary EICAS always displays. Primary engine indications display in the normal format. Secondary engine indications are selected by pushing the Secondary Engine Display switch. Pushing the switch displays the primary and secondary engine indications on primary EICAS in compact format. In compact format, EPR displays by digital and vertical indicators while all other engine indications display by digital indicators. Pushing the switch again removes the secondary engine indications and returns the primary engine indications to normal format.

Partial Display Format

Secondary engine indications display in partial format if a secondary engine parameter exceeds the normal operating range when the secondary engine display is not selected. The secondary engine exceedance cue displays on primary EICAS when an exceedance occurs.

If an N2 RPM increases to the operating limit, the N2 indications display. If an oil pressure decreases to the operating limit, if an oil temperature increases to the caution range or operating limit, or if an oil quantity decreases to the low level, the oil indications display. If an engine vibration increases to the display indicator, the vibration indications display.

Pushing the Secondary Engine Display switch while the secondary engine display is in the partial format displays the entire secondary engine display. Pushing the switch again returns the secondary engine display to partial format.

Selecting another secondary EICAS display while the secondary engine display is in partial format removes the secondary engine display from secondary EICAS. The partial secondary engine indications display with the primary engine indications on primary EICAS in compact format.

If only one display unit is available for use by EICAS and a secondary engine parameter exceedance occurs, the primary and partial secondary engine indications display on primary EICAS in compact format.

If the secondary engine exceedance cue displays and partial secondary engine indications are not displayed, pushing the Status Display switch displays the primary and partial secondary engine indications on primary EICAS in compact format.

In all cases, the partial secondary engine indications and secondary engine exceedance cue remain displayed until the exceeding engine parameter returns to the normal operating range.

Electronic Engine Control (EEC)

Each EEC has full authority over engine operation, there is no manual control capability for the engine. The EEC uses thrust lever inputs to control forward and reverse thrust. The EEC has two control modes: normal and alternate. In the normal mode, the EEC uses EPR as the controlling parameter for setting thrust. In the alternate mode the EEC uses N1 as the controlling parameter. Electrical power for each EEC is provided by an alternator mounted on the engine accessory gearbox.

The EEC provides the EICAS with EPR, EGT, and oil temperature for display. When the engine is shut down on the ground, the EEC alternator is not powered, so these values are not displayed. EPR, EGT, and oil temperature are displayed after engine start is initiated ($N_2 > 10\%$).

EEC Normal Mode

In normal mode, EEC sets thrust by controlling EPR based on Thrust lever position. EPR is commanded by positioning the Thrust levers either with the autothrottles, or by the flight crew. The EEC calculates an EPR value between idle and maximum EPR. Maximum EPR is the maximum allowable thrust available from the engine. The calculated EPR is compared to actual EPR. The EEC commands the fuel metering unit to adjust fuel flow until actual EPR equals calculated EPR.

When the engine is stabilized, EEC keeps thrust constant independent of outside air temperature and pressure. The EEC adjusts thrust for changes in nacelle and wing anti-ice and airplane pressurization bleed requirements. This allows a fixed Thrust lever position throughout a climb.

Maximum EPR represents the maximum rated thrust available from the engine. The EEC continuously computes maximum EPR. Thrust is limited to maximum EPR at the full forward thrust lever position. Maximum thrust is available during any phase of flight by moving the thrust lever to the full forward position.

EEC Alternate Mode

The EEC uses alternate mode as a backup to normal mode. If EEC detects a fault and can no longer control the engine using the normal mode, it automatically transfers control to the alternate mode. Alternate mode can also be selected manually using the EEC Mode switch.

Alternate mode does not provide thrust limiting at maximum EPR. Maximum EPR is reached at a Thrust lever position less than full forward. Thrust levers must be adjusted to maintain desired thrust as environmental conditions and bleed requirements change. N1 should be used to set or monitor the power.

Alternate mode provides equal or greater thrust than normal mode for the same Thrust lever position. Thrust does not change when EEC transfers control from normal mode to alternate mode. Thrust increases when alternate mode is selected manually. When thrust is greater than idle, the Thrust lever should be moved aft prior to manually selecting alternate mode so thrust does not exceed maximum EPR.

If the EECs are in the alternate mode, advancing the thrust levers full forward provides some overboost and should be considered only during emergency situations when all other actions have been taken and terrain contact is imminent.

If control for any EEC transfers from normal to alternate, the autothrottle disconnects. The autothrottle can be activated after all EECs are again in the normal mode.

The EEC selects an unannunciated alternate mode when reverse thrust is used due to EPR sensing inaccuracies during reverser operation.

EEC Idle Selection

The EEC selects minimum idle or approach idle. Minimum idle is a lower thrust than approach idle. Approach idle is selected in flight when:

- nacelle anti-ice is ON
- flaps are in landing position (25 or 30)
- Continuous Ignition switch is ON

Approach idle decreases acceleration time for go-around. Approach idle is maintained until five seconds after touchdown, when minimum idle is selected. Approach idle is available in both normal and alternate EEC modes.

Engine Start and Ignition System

Air from the bleed air duct powers the starter motor, which is connected to the N2 rotor. The starter air source is normally the APU, but air from ground carts or another running engine can be used.

Start Indications

Start indicators display with engine indications when an engine is shutdown. A start limit displays on the EGT indication when the Fuel Control switch is in CUTOFF. The start limit remains displayed until the engine stabilizes at idle. The EGT indication changes color to red if the EGT start limit is reached. A fuel-on indicator displays on the N2 indication when the Fuel Control switch is in CUTOFF. The fuel-on indicator displays the minimum N2 RPM at which the Fuel Control switch should be moved from CUTOFF to RUN.

An in-flight start envelope displays on primary EICAS and the secondary engine indications display when a Fuel Control switch is moved to CUTOFF in flight. The in-flight start envelope displays the airspeed range to ensure an in-flight start at the current flight level. If the current flight level is greater than the maximum start altitude, the maximum start altitude and related airspeed range display. X-BLD displays next to the N2 indication if crossbleed air is necessary for start.

Engine Start

The start is accomplished in accordance with the Engine Start procedure (refer to Volume 1, Chapter NP.20). Pulling the Start switch out opens the start and engine bleed air valves. The Start light illuminates. At maximum motoring, the Fuel Control switch is moved to RUN. The spar and engine fuel valves open and the selected igniter energizes. Two engines can be started at a time during normal ground operations. One igniter is normally selected for ground start while two igniters are selected for in-flight start. Starter cutout occurs at 50% N2 RPM. At starter cutout, the Start switch is released to the in position, the start and bleed air valves close, the Start light extinguishes, and ignition discontinues. The start must be monitored until the engine stabilizes at idle.

Engine Ignition

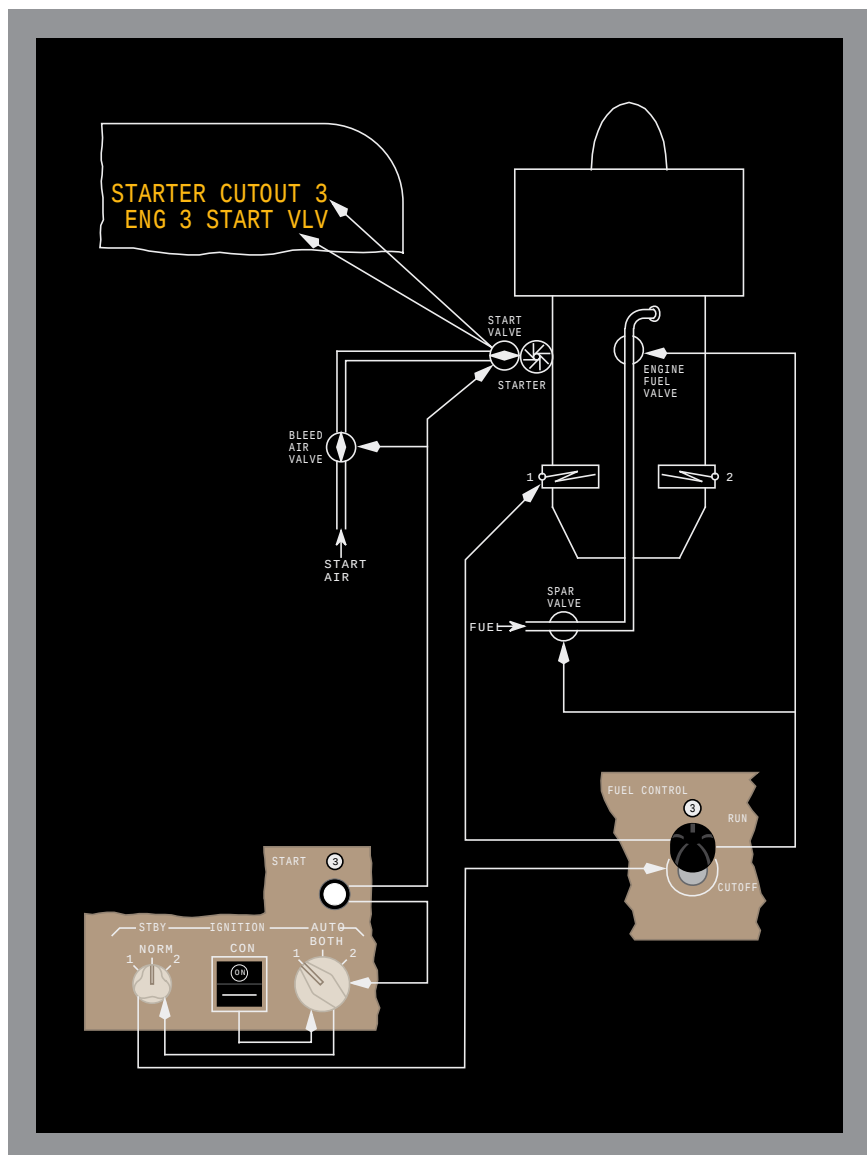
Each engine has two igniters. The igniters operate separately or together as selected by the Auto Ignition selector.

Ignition is armed for each engine when the related Start switch is out or nacelle anti-ice is on. Ignition is armed for all engines when trailing edge flaps are out of the up position or the Continuous Ignition switch is ON. When ignition is selected, the selected igniter on each engine energizes when the related Fuel Control switch is in RUN. The selected igniter deenergizes when the Fuel Control switch is placed in CUTOFF.

See Volume 1, Supplemental Procedures, for guidance on selecting continuous ignition.

The AC power system is the normal power source for ignition. The standby power system provides a backup source. When the Standby Ignition selector is in NORM, the AC power system supplies power to the selected igniters. If the AC power system is not powered, the standby power system supplies power continuously to igniter 1. When the Standby Ignition selector is in 1 or 2, the standby power system supplies power continuously to the related igniter regardless of Auto Ignition selector position.

Engine Start and Ignition System Schematic



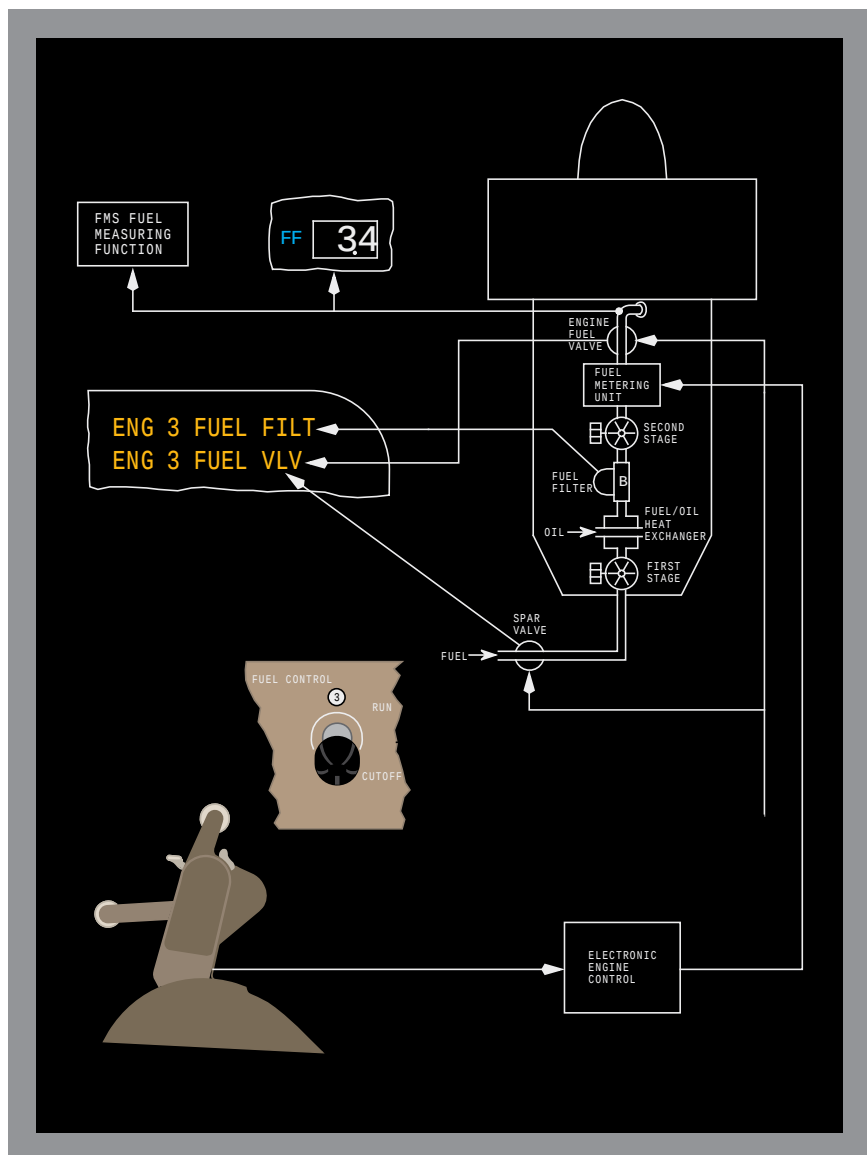
Engine Fuel System

Fuel is supplied under pressure from fuel pumps located in the fuel tanks. Fuel for each engine flows through a spar valve located in the respective main tank. The first stage engine fuel pump adds additional pressure to the fuel. Engine oil heats the fuel as it flows through the fuel/oil heat exchanger. A fuel filter removes contaminants. The second stage engine fuel pump adds final pressure to the fuel. The fuel metering unit adjusts fuel flow to meet thrust requirements. The fuel flows through the engine fuel valve before distribution to the engine.

The engine fuel valve, fuel metering valve, and spar valve allow fuel flow to the engine when all valves are open. The valves open when the Engine Fire switch is in and the Fuel Control switch is in RUN, and the engine pumps are supplying fuel pressure. The pumps supply pressure when the N2 rotor is turning. The engine fuel valve, fuel metering valve, and spar valve close when either the Fuel Control switch is in CUTOFF or the Engine Fire switch is out.

Fuel flow is measured downstream of the engine fuel valve and displays on the secondary engine display. Fuel flow information is also provided to the FMS.

Engine Fuel System Schematic

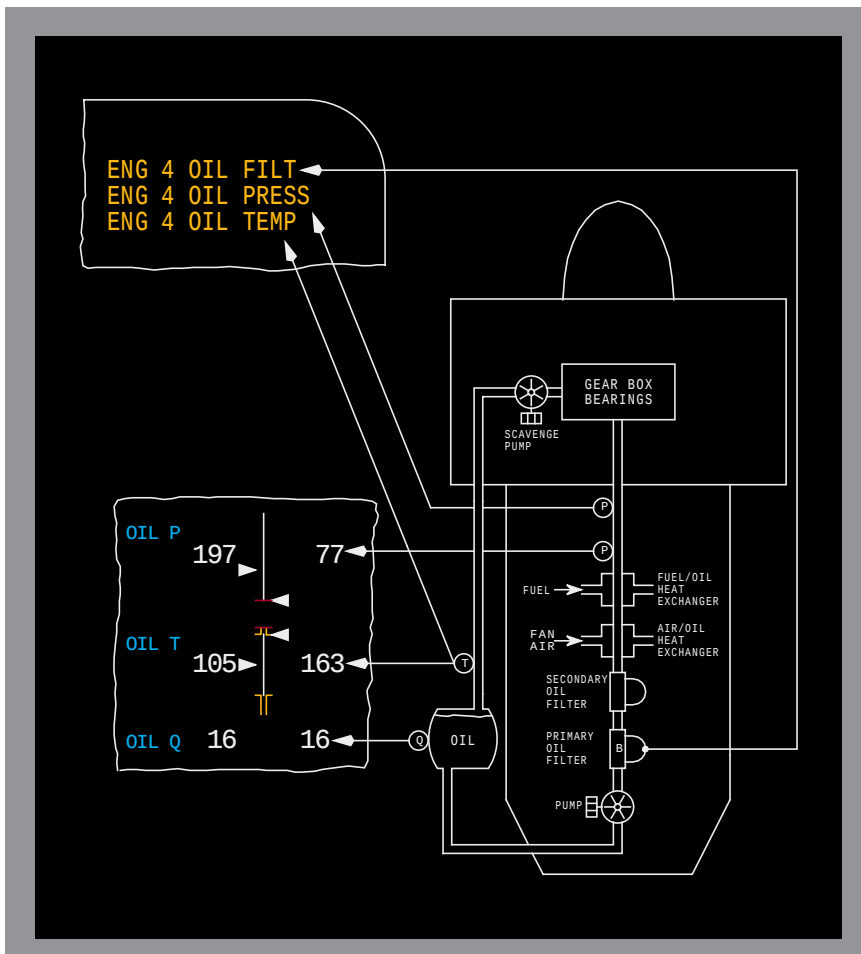


Engine Oil System

The oil system cools and lubricates engine bearings and the accessory gearbox. Oil is pressurized by an oil pump. A dual oil filter removes contaminants. If the primary filter becomes saturated with contaminants, oil bypasses the primary filter. The oil is cooled first by fan air as it flows through the air/oil heat exchanger and then by fuel as it flows through the fuel/oil heat exchanger. The oil cools and lubricates the engine and a scavenge pump returns it to the oil reservoir.

Oil pressure, temperature, and quantity display on the secondary engine display. Oil pressure is measured upstream of the engine. Oil temperature is measured downstream of the engine.

Engine Oil System Schematic



Thrust Reverser System

Each engine has a hydraulically actuated fan air thrust reverser. Each thrust reverser is powered by hydraulic pressure from the related hydraulic system. The reverser does not operate if the hydraulic system loses pressure. Reverse thrust is available only on the ground.

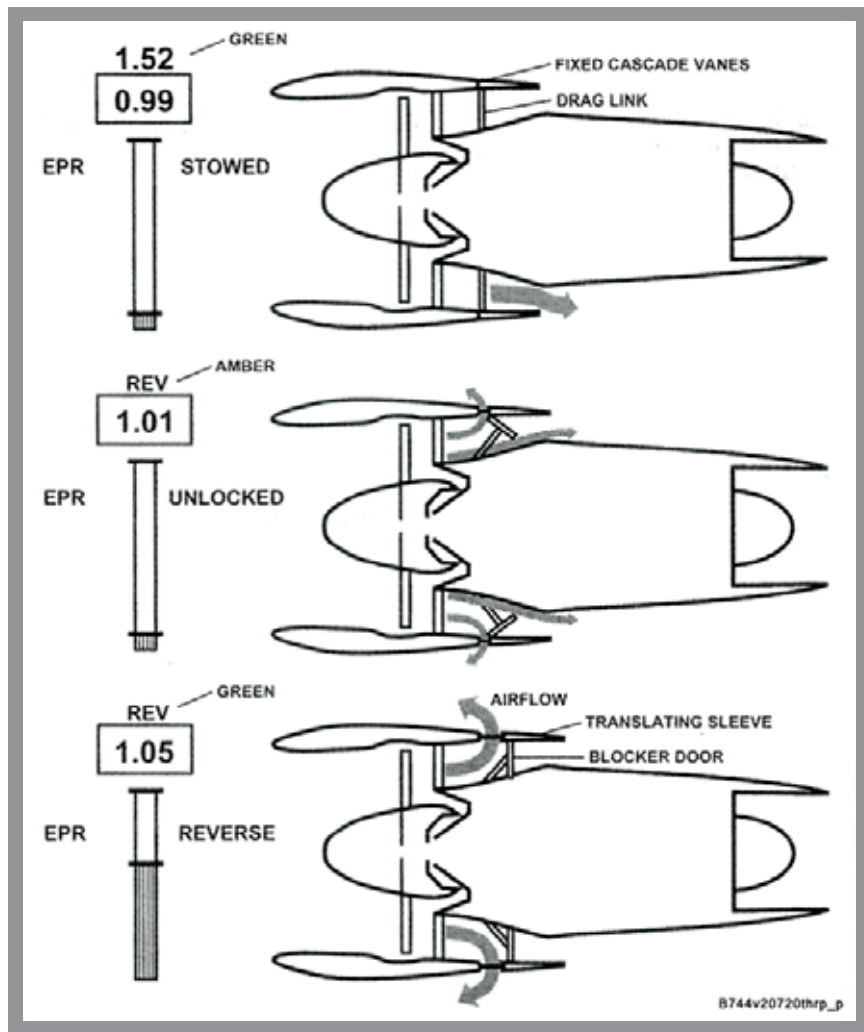
An interlock mechanism in the Thrust lever assembly prevents simultaneous movement of the Forward and Reverse Thrust levers. The Reverse Thrust levers can be raised only when the Forward Thrust levers are in the closed position. When the Reverse levers are down, the reversers are locked in the stowed position.

Raising the Reverse Thrust levers to the idle detent locks the Forward Thrust levers in position. Hydraulic pressure unlocks and extends the reversers aft to the deployed position. A thrust reverser status annunciator displays above the digital indicator of each EPR indication. The annunciator displays in amber when the related reverser is unlocked or moving. The annunciation changes color to green when the reverser is fully deployed. The interlock releases and the Reverse Thrust levers can be moved to full reverse. During reverse the EECs transfer to the alternate mode, and the autothrottle disengages.

Pushing the Reverse Thrust levers to the full down position retracts the reversers to the stowed and locked position. The REV indication changes color back to amber while the reverser is moving. When the reverser is stowed and locked, the REV indication is removed. The Thrust levers cannot be moved forward until the Reverse Thrust levers are fully down.

The thrust reversers are protected against deploying inadvertently. If a reverser unlocks and deploys inadvertently, the reverser system applies hydraulic pressure to stow and lock the reverser.

Engine Thrust Reverser Positions



Airborne Vibration Monitoring System

The airborne vibration monitoring system monitors engine vibration levels. The vibration indications display on the secondary engine display. The vibration source indication also displays. If the vibration monitoring system cannot determine the source (N1 or N2), broadband (BB) displays for the affected engine. Broadband vibration is the average vibration detected.

Certain engine malfunctions can result in airframe vibrations from the windmilling engine. As the airplane transitions from cruise to landing, there can be multiple, narrow regions of altitudes and airspeeds where the vibration level can become severe. In general, airframe vibrations can best be reduced by descending and reducing airspeed. However, if after descending and reducing airspeed, the existing vibration level is unacceptable, and if it is impractical to further reduce airspeed, the vibration level may be reduced to a previous, lower level by a slight increase in airspeed.

Engines, APU

APU System Description

Chapter 7

Section 30

Introduction

The auxiliary power unit (APU) is a self-contained gas turbine engine located in the airplane tail cone.

The APU can be started on the ground and when left running for takeoff can be operated in flight up to 20,000 feet.

The APU drives two generators capable of supplying the entire electrical load of the airplane for normal ground operations. Electrical power is not available in flight. The APU also provides air to the pneumatic system for operation of components which require bleed air. The APU has bleed air capacity to run all air conditioning packs except during engine start. APU bleed air is available in flight for one pack up to 15,000 feet.

Refer to the following chapters for additional information:

- Chapter 2, Air Systems, for a description of APU bleed air operation
- Chapter 6, Electrical, for a description of APU electrical operation
- Chapter 8, Fire Protection, for a description of the APU fire protection system
- Chapter 12, Fuel, for a description of the APU fuel system

APU Operation

APU Start

An APU start requires both the main and APU batteries. With the Battery switch ON, the APU battery supplies power to the starter, air inlet door, APU controller, DC fuel pump, and APU fire detection system. The main battery supplies power for the APU fire extinguisher, APU fuel valve, and standby power for the APU controller. All APU components except the starter are powered by the main battery while the APU starter is engaged during a start sequence.

Rotating the APU selector momentarily to START begins the start sequence. The APU fuel valve and inlet door open simultaneously. Starter engagement occurs when the inlet door is fully open. The start sequence continues with ignition, lightoff, and engine acceleration to rated speed.

APU start cycle restrictions are:

Between starts	Battery wait:
1 and 2	1 minute
2 and 3	5 minutes
3 and 4	1 minute
4 and 5	20 minutes
5 and 6	1 minute
For additional starts, wait 20 minutes then alternate between 1 and 20 minutes for further starts.	

APU Run

The EICAS memo message APU RUNNING is displayed when the APU selector is ON and APU N1 RPM exceeds 95% N1.

APU Shutdown

Rotating the APU selector to OFF begins the shutdown cycle by closing the APU bleed air valve. The APU continues running unloaded for a sixty second cooldown period. When the cooldown period finishes, the APU shuts down.

Shutdown may be monitored on the EICAS status display if AC power is available. The Battery switch should remain ON until APU shutdown is complete.

Note: If the Battery switch is positioned OFF prior to completion of the cooldown period, the APU will shut down immediately.

A complete shutdown sequence with fire detection capability can be assured by waiting at least 2 minutes after the APU selector is rotated to OFF before placing the battery switch OFF. The APU can be shutdown from the flightdeck or from the APU Ground Control panel in the right body gear well.

If a limit is exceeded or a fire detected, the APU shuts down immediately.

Engines, APU EICAS Messages

Chapter 7 Section 40

EICAS Alert Messages

Message	Level	Aural	Message Logic
APU	Advisory		Automatic shutdown of APU with APU selector ON, or APU N1 RPM exceeds 95% with APU selector OFF, or overheat detected in APU bleed air supply line.
APU DOOR	Advisory		APU door not in commanded position.
APU FUEL	Advisory		Low pump pressure detected when pump activated, or APU fuel valve not in commanded position.
>EEC 1, 2, 3, 4 TEST PWR	Advisory		EEC maintenance power switch in TEST.
>ENG 1, 2, 3, 4 CONTROL	Advisory		EEC system fault present. Inhibited in flight.
>ENG CONTROLS	Advisory		Three or four EEC systems operating in a degraded condition and lack complete redundancy. Inhibited in flight.
ENG 1, 2, 3, 4 EEC MODE	Advisory		EEC in alternate control mode.
ENG 1, 2, 3, 4 FAIL	Caution	Beeper	Engine failure or flameout. Inhibited on the ground.
ENG 1, 2, 3, 4 FUEL FILT	Advisory		Impending fuel filter bypass exists on affected engine.
ENG 1, 2, 3, 4 FUEL VLV	Advisory		Engine fuel valve or fuel spar valve position disagrees with commanded position.
ENG IGNITION	Advisory		Ignition system fails to provide ignition when Continuous Ignition switch ON or trailing edge flaps out of up.
>ENG 1, 2, 3, 4 LIM PROT	Caution	Beeper	EEC in alternate control mode and thrust approaching maximum rating.

Message	Level	Aural	Message Logic
ENG 1, 2, 3, 4 LOW IDLE	Advisory		Engine idle not in approach setting when commanded.
ENG 1, 2, 3, 4 OIL FILT	Advisory		Primary engine oil filter contamination approaching bypass condition.
ENG 1, 2, 3, 4 OIL PRESS	Advisory		Oil pressure reaches red line limit.
ENG 1, 2, 3, 4 OIL TEMP	Advisory		Oil temperature reaches amber band.
>ENG 1, 2, 3, 4 REVERSER	Advisory		Fault detected in thrust reverser system.
>ENG 1, 2, 3, 4 RPM LIM	Advisory		Engine thrust limited by N1 or N2 red line limit.
>ENG 1, 2, 3, 4 SHUTDOWN	Caution		Engine Fire switch pulled, or engine Fuel Control switch in CUTOFF. Master Caution lights do not illuminate.
ENG 1, 2, 3, 4 START VLV	Advisory		Start valve position disagrees with commanded position.
>IDLE DISAGREE	Advisory		One or more engine idle settings disagrees with idle commanded.
STARTER CUTOUT 1, 2, 3, 4	Caution	Beeper	Start valve fails to close.

EICAS Memo Messages

Message	Level	Message Logic
APU RUNNING	Memo	APU selector in ON and APU N1 RPM exceeds 95%.
CON IGNITION ON	Memo	Continuous Ignition switch ON. Inhibited if ENG IGNITION message displayed.
STBY IGNITION ON	Memo	Standby Ignition selector is in 1 or 2.

Fire Protection
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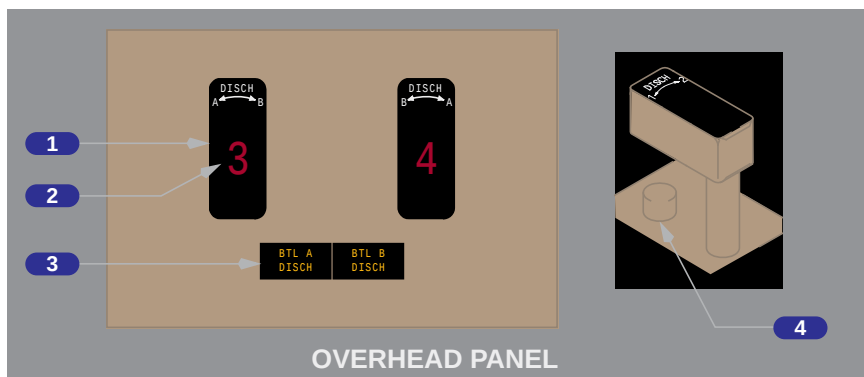
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Fire Protection Controls and Indicators

Chapter 8 Section 10

Engine Fire Protection

Engine Fire Panel



1 Engine Fire Switches

In (normal position, mechanically locked) - unlocks for a fire warning, when the Fuel Control switch is in CUTOFF, or during the FIRE/OVHT switch test.

Out -

- closes the related engine and spar fuel valves
- closes the related engine bleed air valve
- trips off the related engine generator and field
- shuts off hydraulic fluid to the related engine-driven hydraulic pump and depressurizes the pump
- arms respective squibs in engine fire extinguisher bottles
- deactivates the Nitrogen Generating System (NGS)

Rotate to A or B - discharges selected fire extinguisher into the engine nacelle.

2 Engine Fire Warning Lights

Illuminated (red) -

- an engine fire is detected, or
- the Fire/Overheat Test switch is pushed

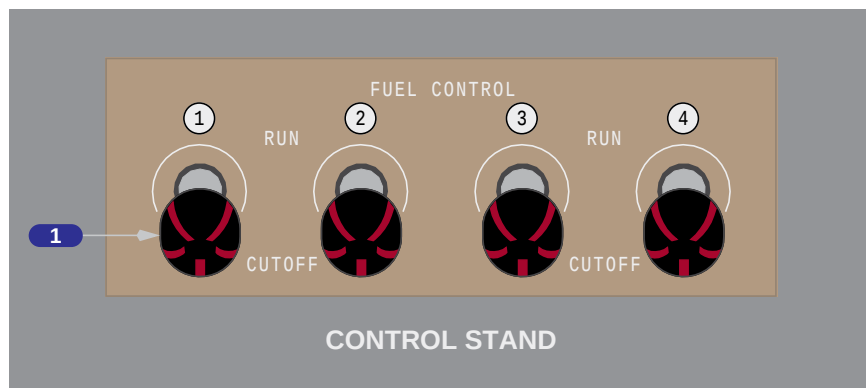
3 Bottle Discharged (BTL DISCH) Lights

Illuminated (amber) - the extinguisher bottle is discharged or has low pressure.

4 Engine and APU Fire Override Switches

Push - unlocks the Fire switch.

Fuel Control Switches



1 FUEL CONTROL Switch Fire Warning Lights

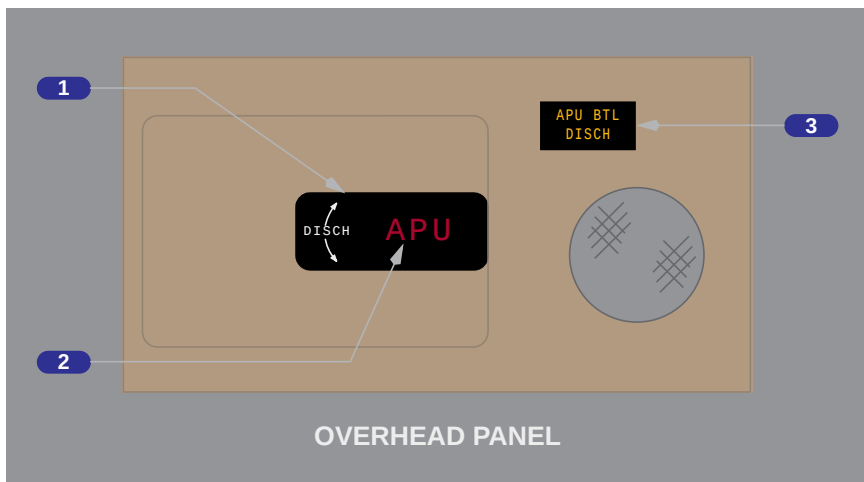
Illuminated (red) -

- a related engine fire is detected, or
- the Fire/Overheat Test switch is pushed

Note: When a Fuel Control switch is positioned to RUN, the respective Engine Fire Switch is locked to the “in” position. When a Fuel Control switch is positioned to CUTOFF, the respective Engine Fire switch is unlocked.

Note: The Nitrogen Generating System (NGS) is inoperative when the Fuel Control switch is placed to CUTOFF.

APU Fire Panel



1 APU Fire Switch

In - normal position, mechanically locked; unlocks for a fire warning.

Out -

- arms the squib in APU fire extinguisher bottle
- closes APU fuel valve
- closes APU bleed air valve
- closes APU air inlet door
- trips APU generator field and generator breaker
- initiates APU shutdown if the automatic shutdown failed, bypassing the 60 second cool-down delay
- silences horn in right body gear wheel well

Rotate - discharges APU fire extinguisher into APU compartment.

2 APU Fire Warning Light

Illuminated (red) -

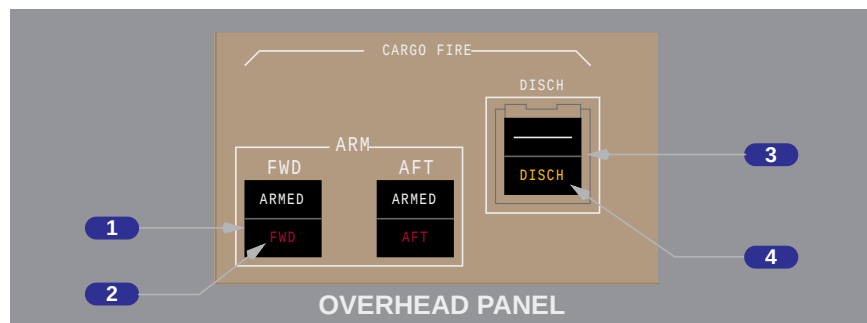
- an APU fire is detected, or
- the Fire/Overheat Test switch is pushed

APU automatically shuts down for a detected fire.

3 APU Bottle Discharged (BTL DISCH) Light

Illuminated (amber) - extinguisher bottle is discharged or has low pressure.

Cargo Fire Panel



1 CARGO FIRE ARM Switches

Push -

FWD - ARMED (white) -

- arms respective squibs in cargo extinguisher bottles
- configures equipment cooling to override mode
- turns off airflow and heat into forward compartment
- turns off pack 3
- turns off all fans
- Nitrogen Generating System (NGS) is inoperative

AFT - ARMED (white)-

- arms respective squibs in cargo extinguisher bottles
- configures equipment cooling to override mode
- turns off airflow and heat into forward compartment
- turns off aft cargo heat
- turns off pack 3
- turns off all fans
- Nitrogen Generating System (NGS) is inoperative

2 CARGO FIRE Warning Light

Illuminated (red) -

- fire in related cargo compartment, or
- the Fire/Overheat Test switch is pushed

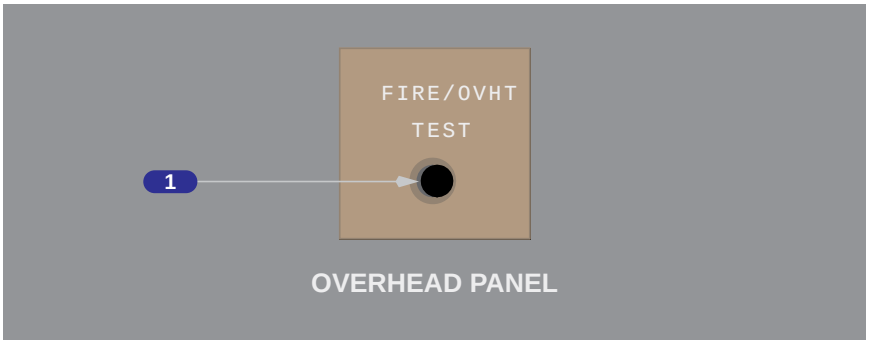
3 CARGO FIRE Discharge (DISCH) Switch

Push - initiates extinguisher discharge sequence to provide effective agent concentration for 193 minutes.

4 CARGO FIRE Discharged (DISCH) Light

Illuminated (amber) - cargo fire extinguishers discharged.

Fire/Overheat Test Switch

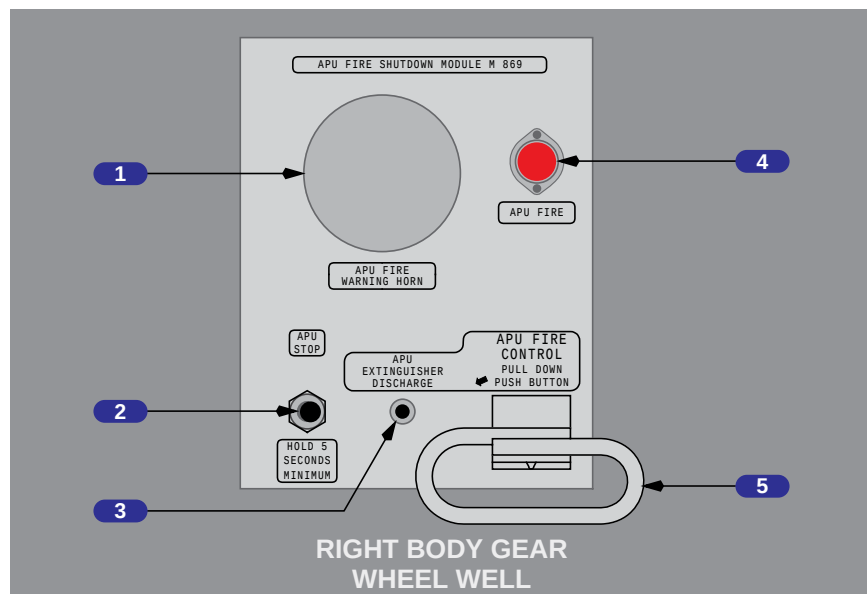


1 FIRE/Overheat (OVHT) TEST Switch

Push and hold -

- sends fire/overheat test signals to the engine, APU, wheel well, cargo, and bleed duct leak detectors
- fire bell rings 1 second ON, 10 seconds OFF
- tests flight deck fire and overheat indications (see Fire and Overheat Detection System Manual Fault Test, Section 20)

APU Ground Control Fire Protection Panel



1 APU FIRE WARNING HORN

Sounds during ground operation for an APU fire or fire test. Silenced when APU Fire Control Switch in wheel well or APU Fire Handle on flight deck is pulled.

2 APU STOP Switch

Push - shuts down APU (hold for 5 seconds minimum).

3 APU EXTINGUISHER DISCHARGE Switch

Push - discharges APU fire extinguisher, when armed, into APU compartment.

4 APU FIRE Light

The APU automatically shuts down for a detected fire.

Illuminated (red) -

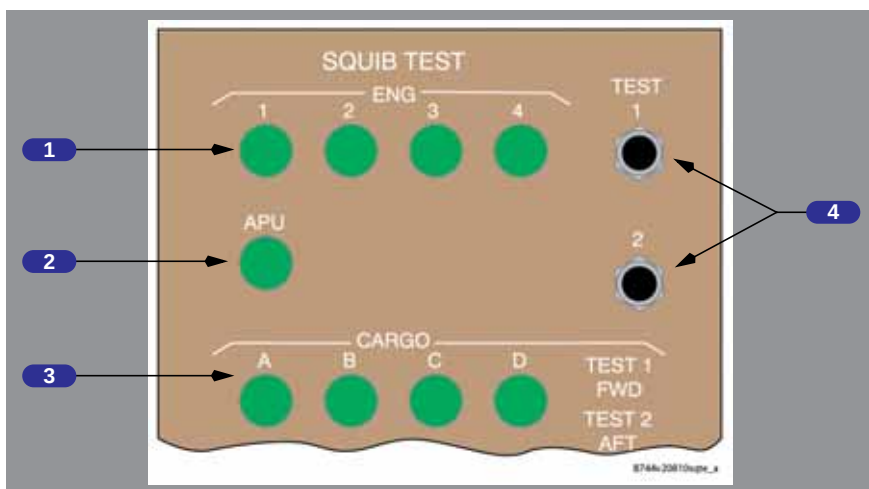
- fire in APU compartment, or
- the Fire/Overheat Test switch is pushed

5 APU FIRE CONTROL Switch

Pull down -

- shuts down APU
- arms APU fire extinguisher

Squib Test Panel



1 Engine Squib Light (green)

Lights illuminate when TEST switch is pushed to indicate squib test is good.

2 APU Squib Light (green)

Lights illuminate when TEST switch is pushed to indicate squib test is good.

3 Cargo Squib Light (green)

Lights illuminate when TEST switch is pushed to indicate squib test is good.

4 Squib Test Switches

Push 1 - tests associated squibs and associated circuits.

Push 2 - tests associated squibs and associated circuits.

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Fire Protection System Description

Chapter 8 Section 20

Fire Warnings

If a fire is detected, the flight deck warning bell rings one second on, then 10 seconds off. If an APU fire occurs on the ground, the APU fire warning horn also sounds on the APU ground control panel in the right body gear wheel well.

The fire bell can be silenced by extinguishing the fire or pushing either Master Warning/Caution Reset switch.

The wheel well horn for APU fire can be silenced by extinguishing the fire or pulling the APU Fire Control switch in the right wheel well, or by pulling the APU Fire switch in the flight deck. Selection of either Master Warning reset switch will not silence the horn in the right body gear well.

In addition to the aural warning, an EICAS FIRE message is displayed as long as the fire condition exists.

The following lights illuminate if a fire is detected and remain illuminated as long as the fire signal exists:

- both Master Warning lights (may be reset while fire signal exists)
- respective Engine, APU, or Cargo Fire Warning lights
- for an engine fire, respective Fuel Control switch Fire light

Introduction

There are fire detection and extinguishing systems for the:

- APU
- cargo compartments
- engines
- lavatories

The crew rest compartments and main gear wheel wells have fire detection systems, but no fire extinguishing systems.

The engines also have overheat detection systems.

Refer to the following chapters for additional information:

- Chapter 2 - Air Systems, for descriptions of equipment smoke evacuation, and bleed duct leak and overheat detection
- Chapter 3 - Anti-Ice, Rain, for a description of engine anti-ice system protection

Overheat Cautions

If an engine overheat condition is detected, the caution beeper sounds, the Master Caution lights illuminate, and an EICAS overheat message displays.

Fire/Overheat Detection

Engine Fire/Overheat Detection

A dual loop fire detector is installed in each engine nacelle. In addition, each engine has a dual loop overheat detector. In normal operation, both loops in a detector must detect a fire or overheat condition to cause an engine fire warning or overheat caution unless configured for single loop operation.

APU Fire/Overheat Detection

A dual loop fire detector is installed in the APU compartment. There is no overheat detection in the APU compartment. Either loop detecting a fire activates an APU fire warning which shuts down the APU.

Cargo Compartment Fire Detection

The forward and aft cargo compartments each have two dual loop smoke detectors. Sample air from throughout each compartment is drawn through the detectors by center bleed duct air. Both loops in a detector must sense smoke to activate the cargo fire warning unless reconfigured for single loop operation.

Wheel Well Fire Detection

Each main gear wheel well has a single loop detector.

Crew Rest Smoke Detection

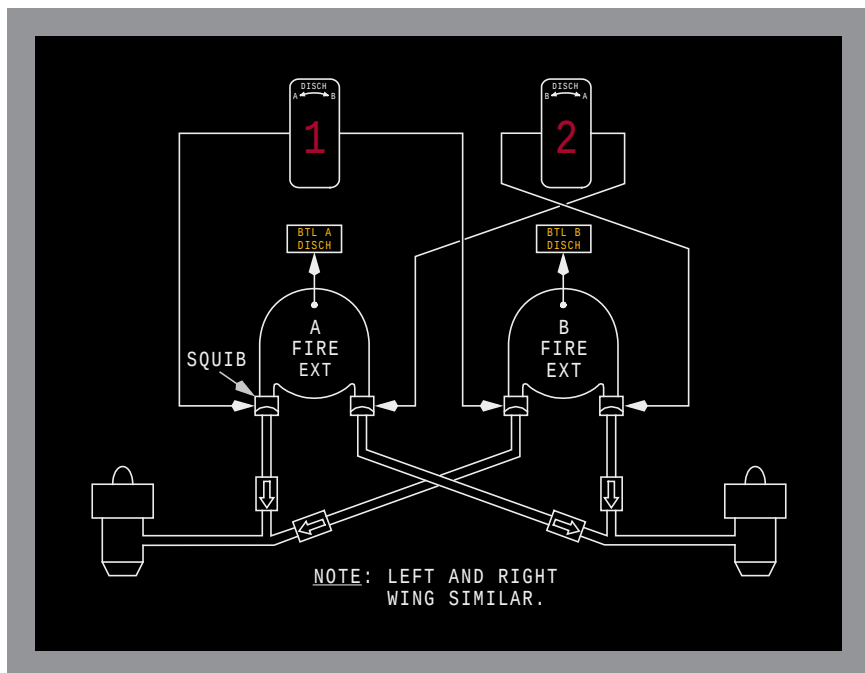
Smoke detectors are installed in crew rest areas. An aural warning sounds in the crew rest compartment when smoke is detected in that compartment. The aircraft recirculation fans shutdown and a >SMOKE DR 5 REST message is displayed when smoke is detected in the F/A crew rest area.

Lavatory Smoke Detection

Smoke detectors are installed in the lavatories. An aural warning sounds in a lavatory when smoke is detected in that lavatory. Each lavatory has a light on the outside that illuminates when smoke is detected. An automatic fire extinguisher is located in the waste compartment in each lavatory.

Fire Extinguishing

Engine Fire Extinguishing



There are two fire extinguisher bottles in each wing for the two engines on that wing. One or both bottles can be discharged in either engine on a wing.

The Engine Fire switches are mechanically locked in. If an engine fire occurs, the respective switch is electrically unlocked and can be pulled out.

Pulling an Engine Fire switch arms a squib in each bottle for discharge to the respective engine. Rotating the Fire switch selects a fire extinguishing bottle and discharges it into the respective engine nacelle. Turning all fire handles in the same direction will discharge one fire bottle into each engine.

The switches can be individually unlocked by pushing the Fire Override switch beneath each Fire switch. The Engine Fire switches are also unlocked when the respective Fuel Control switches are in CUTOFF, or during Fire/Overheat test.

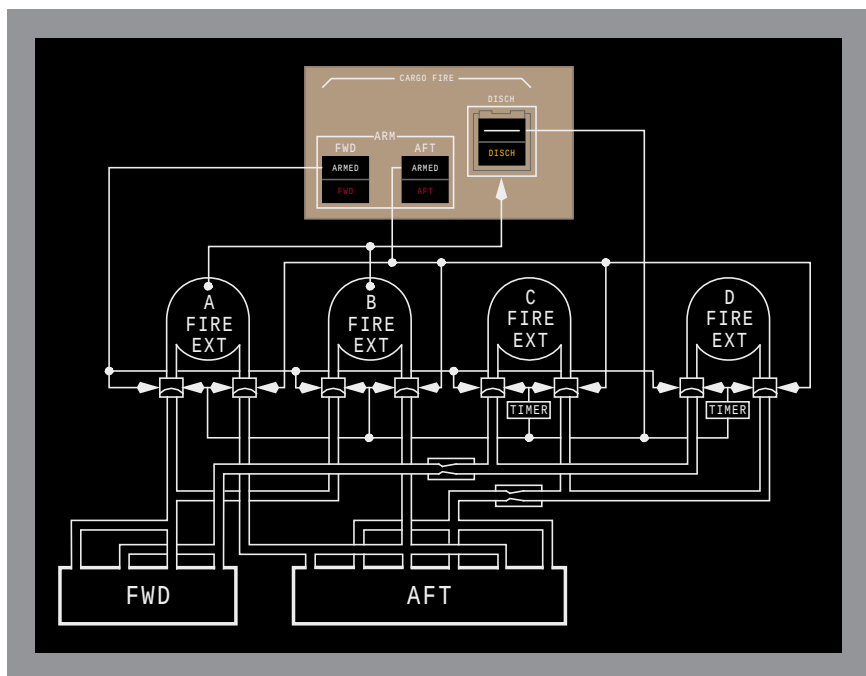
APU Fire Extinguishing

There is one APU fire extinguisher bottle controlled by the APU Fire switch.

The APU Fire switch is mechanically locked in. If an APU fire occurs, the respective switch is electrically unlocked and can be pulled out. Pulling the APU Fire switch arms the fire extinguisher discharge squibs. Rotating the APU Fire switch discharges a fire extinguisher into the APU compartment.

The APU Fire switch can be unlocked by pushing the Fire Override switch beneath the Fire switch.

Cargo Compartment Fire Extinguishing



There are four fire extinguisher bottles for the forward and aft cargo compartments. Pushing the Cargo Fire Discharge switch discharges two bottles (A and B) immediately. If not previously discharged, bottles C and D discharge after a brief delay (about 30 minutes), and maintain a metered flow upon landing. If the discharge switch is pushed while the aircraft is on the ground, bottles A, B, C, and D discharge immediately. However, bottles C and D still maintain a metered flow into the selected compartment. The FIRE CARGO EICAS message may remain illuminated due to the concentration of smoke and agent within the cargo area.

Note: If both forward and aft Cargo Extinguishing switches are armed and the discharge switch is selected, the contents of the bottles will discharge into both cargo compartments, reducing the halon available to both compartments and the overall fire suppression time.

Wheel Well Fire Extinguishing

There is no automatic fire extinguishing for the wheel well area. A fire will generate an EICAS warning message, Master Warning light, and a fire bell. There is no discrete fire light.

Fire and Overheat Detection System Fault Test

The fire overheat detection system has automatic and manual fault testing.

Fire and Overheat Detection System Automatic Fault Test

The engine detector loops are continuously monitored for faults. In addition to continuous testing of engine detection systems, testing of all dual loop fire/overheat detectors occurs when electrical power is initially applied.

Fully operable systems configure for dual loop operation upon completion of any test. Systems with a fault in one loop reconfigure for single loop operation. If the operable loop senses a fire or overheat condition, the respective fire warning or overheat caution activates.

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Additional testing of cargo smoke detectors is initiated when a detection loop senses a fire condition. If the other loop fails or senses a fire condition, a fire signal is activated. If the other loop passes the test and does not sense a fire condition, a fault code is generated for the failed loop, the zone is configured for single loop operation, and automatic testing is conducted every 60 minutes.

Fire and Overheat Detection System Manual Fault Test

The fire and overheat detection systems can be tested manually by pushing and holding the FIRE/Overheat (OVHT) TEST switch.

The indications for a manual fire and overheat detection system test are:

- the fire bell rings (flight deck)
- the APU fire warning horn sounds (on the ground, in the right body gear well)
- the EICAS message TEST IN PROG is displayed
- these lights illuminate:
 - the master WARNING lights
 - the engine fire warning lights
 - the APU fire warning light
 - the FWD and AFT cargo fire warning lights
 - the Fuel Control switch fire warning lights

When the test is complete, the EICAS warning message FIRE TEST PASS or FIRE TEST FAIL replaces the TEST IN PROG message; the switch can be released. Failed system EICAS messages are displayed with the FIRE TEST FAIL message.

All test messages clear when the test switch is released. If the switch is released with the TEST IN PROG message displayed, the test ends without completing.

The wheel well fire detector loop and the bleed duct leak detector loops are tested only during the manually initiated test. The EICAS warning message FIRE WHEEL WELL may momentarily display during the test.

Squib Test

All extinguisher discharge squibs are tested for electrical continuity and the squib control circuit is tested using the Squib Test switches and Squib lights located on the overhead maintenance panel.

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Fire Protection

EICAS Messages

Chapter 8

Section 30

Fire Protection EICAS Messages

The following EICAS messages can be displayed.

Alert Messages

Message	Level	Aural	Message Logic
>BOTTLE LOW APU	Advisory		APU fire extinguisher bottle pressure low.
>BTL LO L, R ENG A, B	Advisory		Left or right wing engine fire extinguisher bottle A or bottle B pressure low.
>CARGO DET AIR	Advisory		Cargo smoke detection airflow insufficient.
>CGO BTL DISCH	Advisory		On the ground, a cargo fire extinguisher bottle pressure low. In flight, bottles A and B discharged.
>DET FIRE APU	Advisory		APU fire detection loops A and B failed.
>DET FIRE/OHT 1, 2, 3, 4	Advisory		Engine fire or overheat detection loops A and B have failed.
FIRE APU	Warning	Fire Bell	Fire detected in the APU.
FIRE CARGO AFT, FWD	Warning	Fire Bell	Smoke detected in lower cargo compartment.
FIRE ENG 1, 2, 3, 4	Warning	Fire Bell	Fire detected in the engine.
FIRE WHEEL WELL	Warning	Fire Bell	Fire detected in a main wheel well.
OVHT ENG 1, 2, 3, 4 NAC	Caution	Beeper	Overheat detected in the engine nacelle.
SMOKE DR 5 REST	Caution	Beeper	Smoke detected in door 5 crew rest area. Recirculating fans automatically shut down and the air conditioning packs switch to high flow.
>SMOKE LAVATORY	Advisory		Smoke detected in a lavatory.

System Test Messages

The following messages are associated only with the manually-initiated fire test.

Message	Level	Aural	Message Logic
>FIRE TEST FAIL	Warning		One or more fire/overheat detection systems have failed to successfully complete the manually initiated fire/overheat test.
>FIRE TEST PASS	Warning		A manually initiated test of the fire/overheat detection system has been completed.
>TEST IN PROG	Warning		A manually initiated fire/overheat detection system test in progress.

Flight Controls
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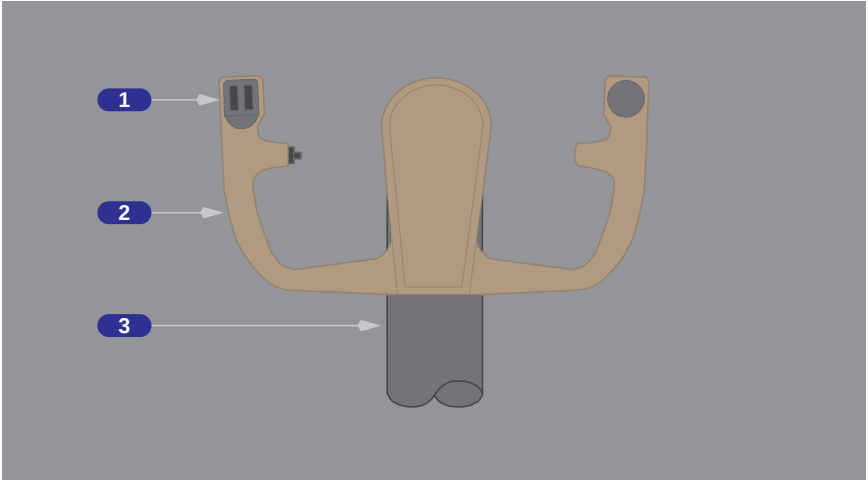
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Pitch and Stabilizer Trim Systems

Control Wheel and Column



1 Stabilizer Trim Switches

Spring-loaded to neutral.

Push (both switches) - trims stabilizer in desired direction.

2 Control Wheel

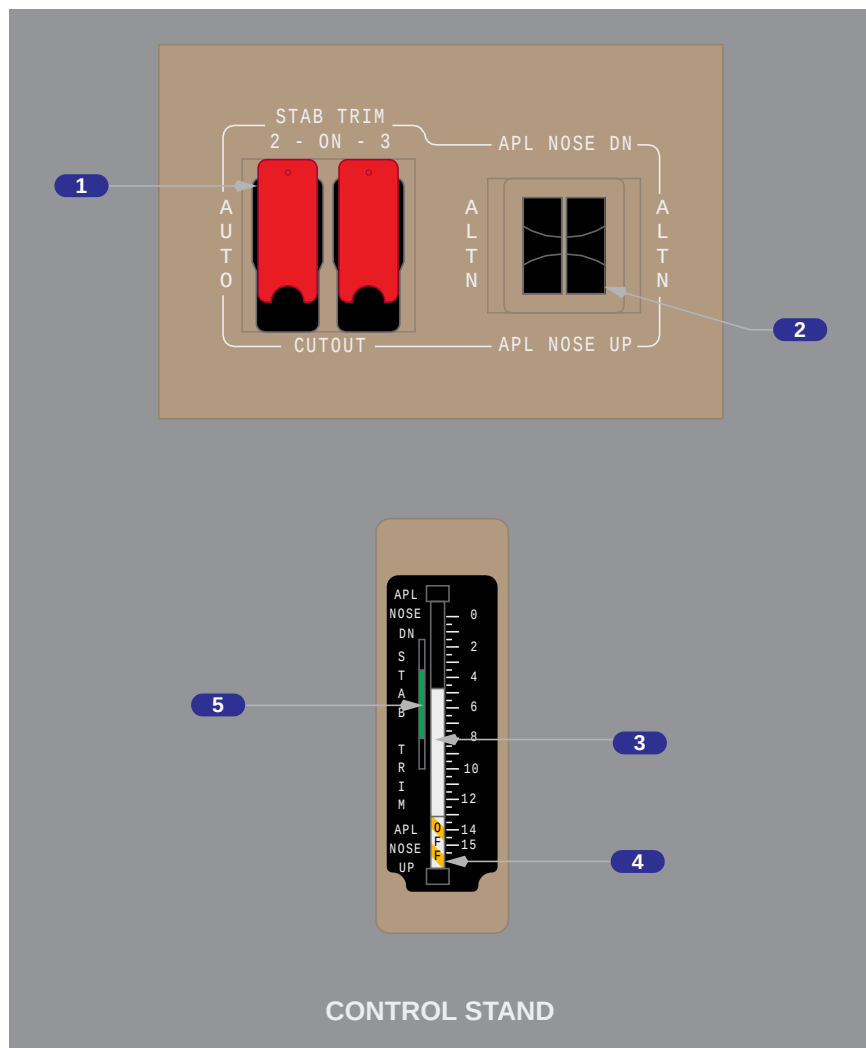
Rotate - deflects ailerons and spoilers in desired direction.

3 Control Column

Push/pull -

- deflects elevators in desired direction
- prevents stabilizer trim in opposite direction

Stabilizer Trim Controls



1 Stabilizer (STAB) Trim Cut Out Switches (toggle, guarded to AUTO)

ON - supplies hydraulic power for stabilizer trim.

AUTO -

- supplies hydraulic power for stabilizer trim
- automatically shuts off related system hydraulic power if unscheduled trim detected

CUTOUT - shuts off related hydraulic power to stabilizer trim.

2 Alternate (ALTN) Stabilizer Trim Switches (spring loaded to neutral)

Push (both switches) - trims stabilizer in desired direction using alternate control channel.

3 Stabilizer Trim Indicator (white band)

- indicates stabilizer position in units of trim

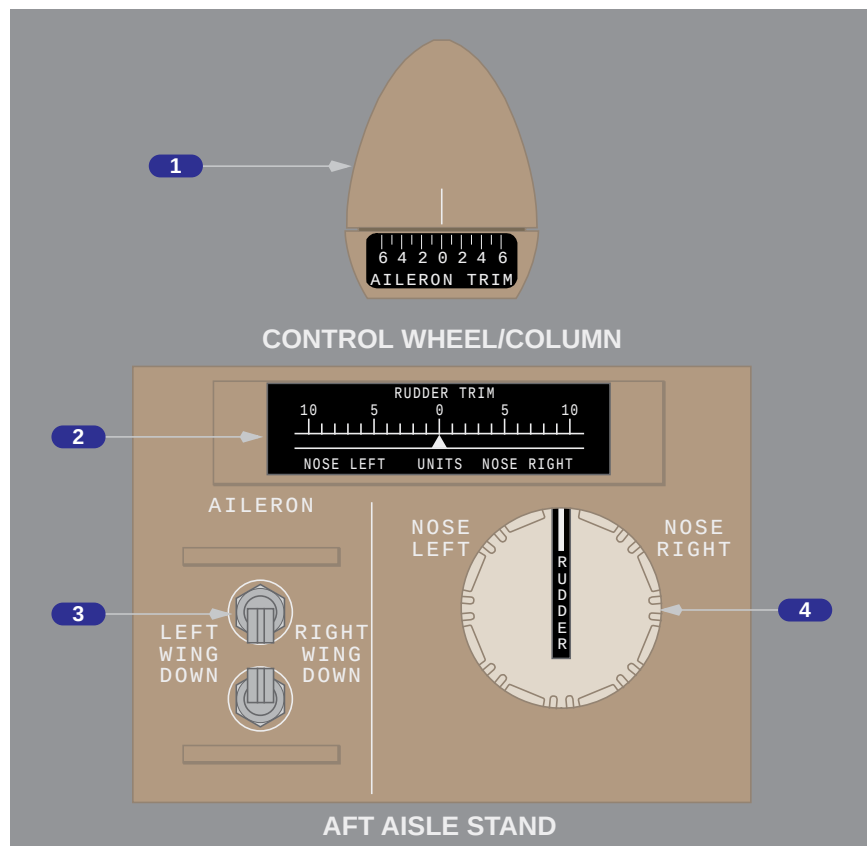
4 Stabilizer Trim Indicator Off Flag

In View - trim indicator inoperative.

5 Stabilizer Trim Range (green band)

- illuminated green band indicates allowable range for takeoff (center green band segment may be backlighted or continuous display with face plate lighting)

Aileron and Rudder Trim Controls



1 AILERON TRIM Indicator

Indicates units of aileron trim.

2 RUDDER TRIM Indicator

Indicates units of rudder trim.

3 AILERON Trim Switches (spring loaded to neutral)

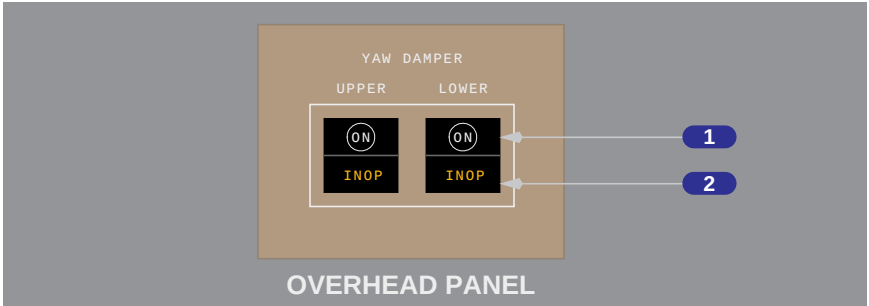
Push (both switches) - trims ailerons in desired direction.

4 RUDDER Trim Selector

Spring-loaded to neutral.

Rotate - trims rudder in desired direction.

Yaw Damper Controls



1 Yaw Damper Switches

ON - yaw damper powered.

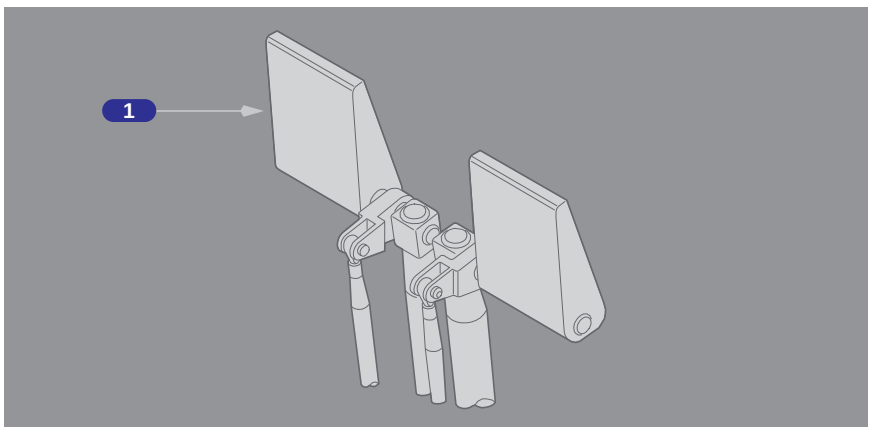
Off (blank) - respective yaw damper is selected off.

2 Yaw Damper Inoperative (INOP) Light

Illuminated (amber) -

- Yaw Damper switch OFF,
- yaw damper inoperative, or
- during IRS alignment both INOP lights extinguish when the first IRU aligns.

Rudder/Brake Pedals



1 Rudder Pedals

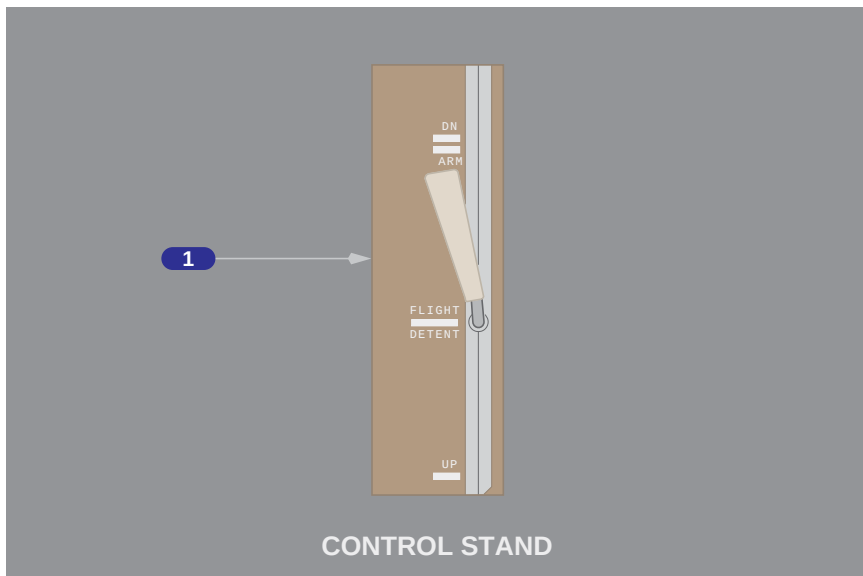
Push - deflects rudders in desired direction.

Refer to Chapter 14, Landing Gear, for brakes and nosewheel steering description.

Speedbrake Lever

On the ground -

- Speedbrake lever moves to UP and all spoiler panels extend when either engine 2 or engine 4 reverse Thrust lever raised to idle detent with engine 1 and engine 3 Thrust levers retarded
- Speedbrake lever moves to DN and all spoiler panels retract if engine 1 or engine 3 Thrust lever advanced



1 Speedbrake Lever

DN (down) (detent) - all spoiler panels retracted

ARM (armed) -

- automatic Speedbrake system armed
- after landing, Speedbrake lever moves to UP and spoiler panels extend if engine 1 and engine 3 Thrust levers retarded

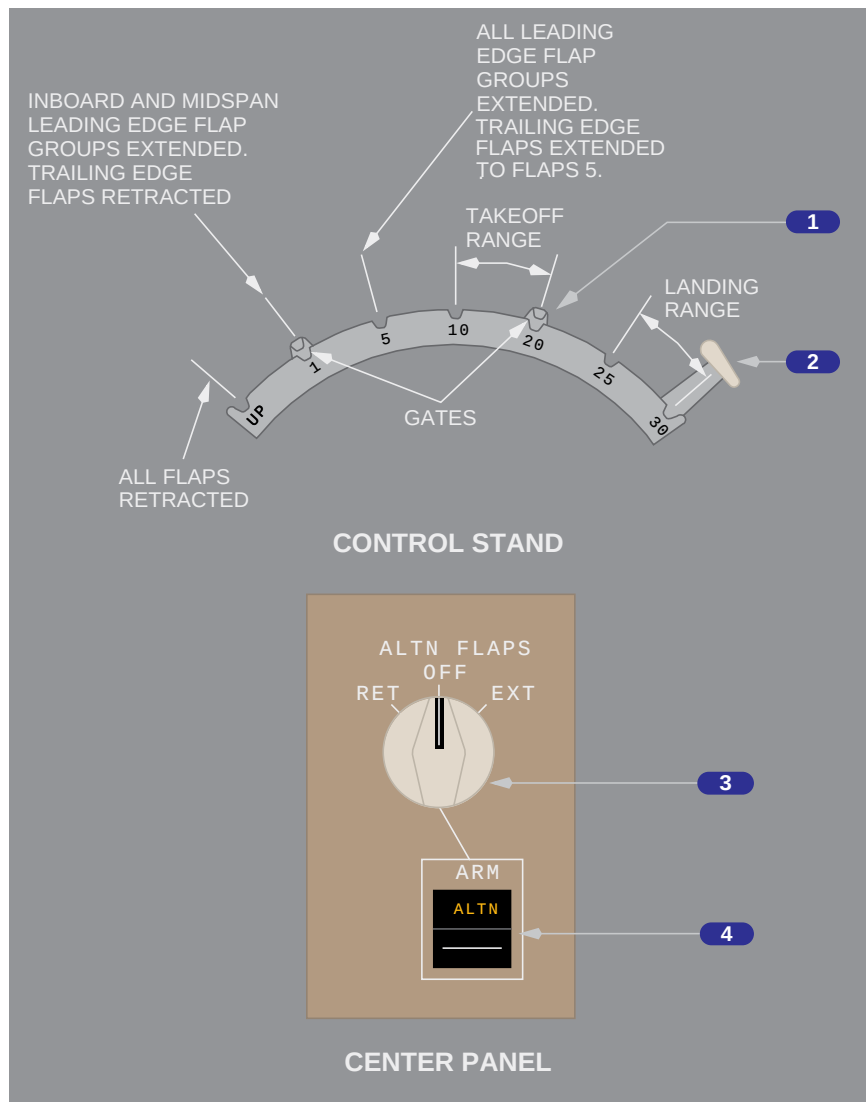
FLIGHT DETENT -

- spoiler panels extend to their maximum in-flight positions
- in flight, aft movement of Speedbrake lever limited to FLIGHT DETENT by an automatic stop

UP - all spoiler panels extend to their maximum on-ground position (intermediate positions can be selected).

Flap System

Flap Controls



1 Flap Gate

1 - prevents inadvertent retraction of remaining leading edge flap groups

20 - signals the maximum flap position for safe takeoff; prevents inadvertent retraction of flaps past go-around position.

2 Flap Lever

Primary mode - positions leading edge flaps pneumatically and trailing edge flaps hydraulically.

Secondary Mode - positions leading and/or trailing edge flaps electrically if flaps fail to drive pneumatically or hydraulically.

3 Alternate (ALTN) Flaps Selector

RET (retract) (detent) - leading and trailing edge flaps electrically retracted.

OFF - alternate flaps deactivated.

EXT (extend) (detent) -

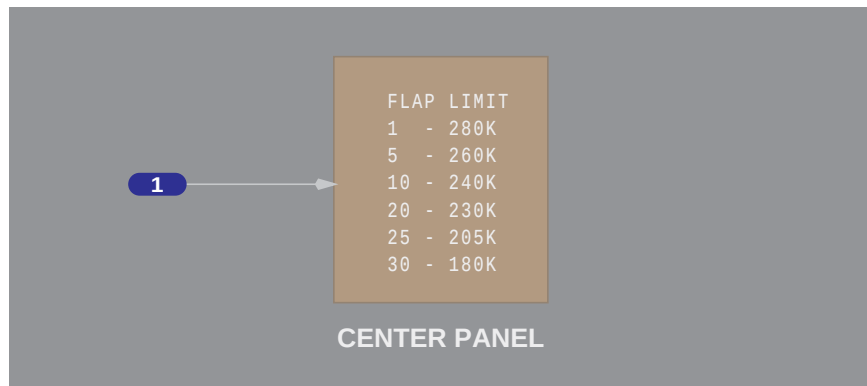
- leading and trailing edge flaps electrically extend
- maximum extension is flaps 25

4 Alternate (ALTN) Flaps Arm Switch

ALTN -

- arms flap alternate control mode
- arms Alternate Flaps selector
- shuts off primary (hydraulics and pneumatics) and secondary mode operation
- asymmetry protection is not available
- flap load relief is not available
- Flap lever is inoperative

Flap Limit Placard



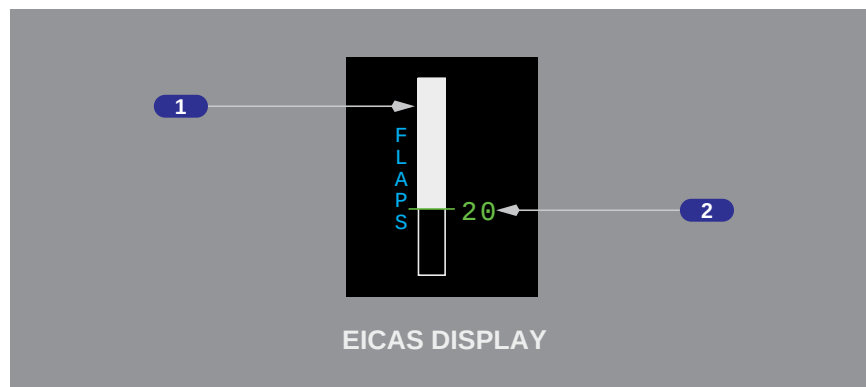
1 Flap Limit Placard

Flaps extended speed limits.

Normal Flap Position Indication

Displays combined leading and trailing edge flap positions when all surfaces are operating normally (AC power available) and control is in the primary mode. The indicator shows continuous motion.

Indication is no longer displayed 10 seconds after flap retraction.



1 Flap Position (white)

UP - all leading and trailing edge flaps retracted.

Between UP and 1 -

- inboard and midspan leading edge flap groups in transit
- actual position of slowest leading edge flap
- all trailing edge flaps retracted

1 -

- inboard and midspan leading edge flap groups extended
- all trailing edge flaps retracted

Between 1 and 30 - actual position of slowest trailing edge flap group.

2 Flap Lever Position (line and number)

Magenta - flaps in transit to position selected by Flap lever.

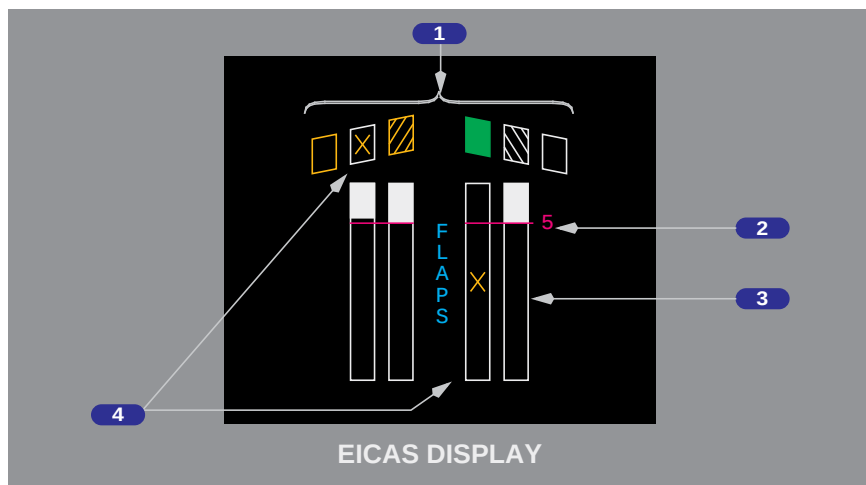
Green - flaps in selected position.

Note: Line and number visible during normal and secondary modes only.

Secondary Mode Expanded Flap Position Indication

If any flap position is non-normal or if flap control is in secondary mode, all flap positions are displayed.

Indicator motion is continuous between flap detents.



1 Leading Edge Flaps Indication

White Box Outline - leading edge flap group retracted.

White Crosshatch - leading edge flap group in transit.

Solid Green Box - leading edge flap group extended.

Amber Box Outline, Crosshatch, or Solid Box - drive unit is inoperative

2 Flap Lever Position (line and number)

Magenta - flaps in transit to position selected by Flap lever.

Green - all leading and trailing edge flaps in position selected by Flap lever.

3 Trailing Edge Flaps Indication

White - position of inboard and outboard trailing edge flaps.

Amber - asymmetry or drive failure has occurred in related group.

4 Inoperative Sensor (amber)

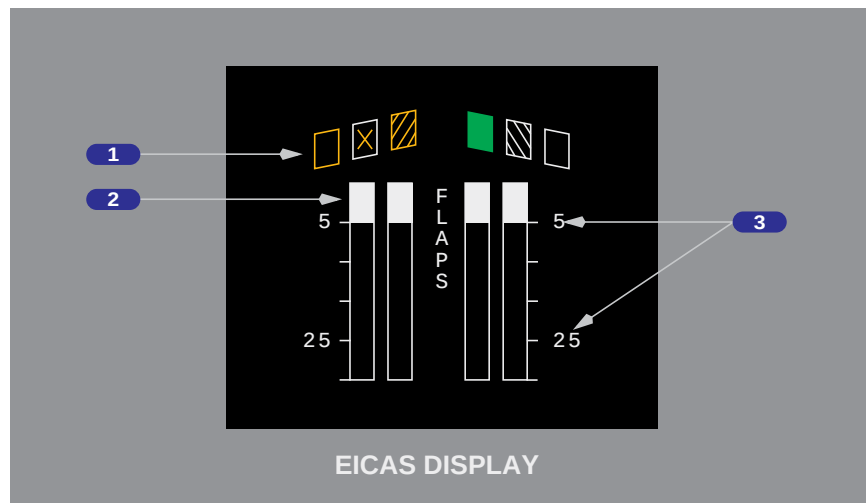
Position sensor for related flap has failed.

Note: While on standby power only, both left trailing edge position indicators will indicate inoperative.

Alternate Mode Expanded Flap Position Indication

If alternate flaps armed, expands to display all flap positions.

Indicator motion is continuous between flap detents.



1 Leading Edge Flaps Indication

White Box Outline - leading edge flap group retracted.

White Crosshatch - leading edge flap group in transit.

Solid Green Box - leading edge flap group extended.

Amber Box Outline, Crosshatch, or Solid Box - drive unit is inoperative.

2 Trailing Edge Flap Indication

Position of inboard and outboard trailing flaps.

3 Flap Position Index Marks

Reference flaps 5 and 25 positions.

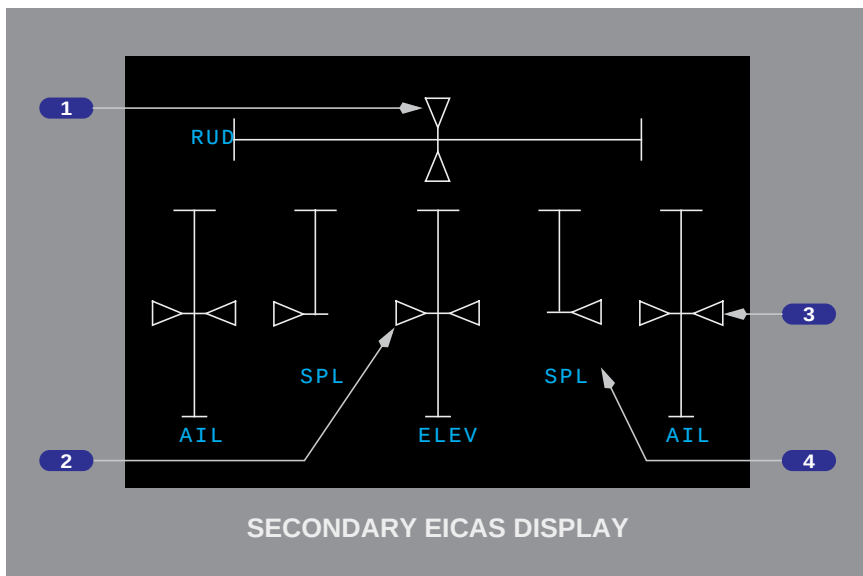
Scale added to manually position trailing edge flaps (flap handle inoperative in alternate mode).

Surface Position Indication

The surface position indication is displayed by pushing the ENG Display switch on the display select panel. Display select panel operation is described in Chapter 10, Flight Instruments, Displays.

Full pointer deflection indicates full control surface displacement.

Surface Position Indication



1 Rudder (RUD) Position

Indicates upper and lower rudder positions.

2 Elevator (ELEV) Position

Indicates left and right outboard elevator positions.

3 Aileron (AIL) Position

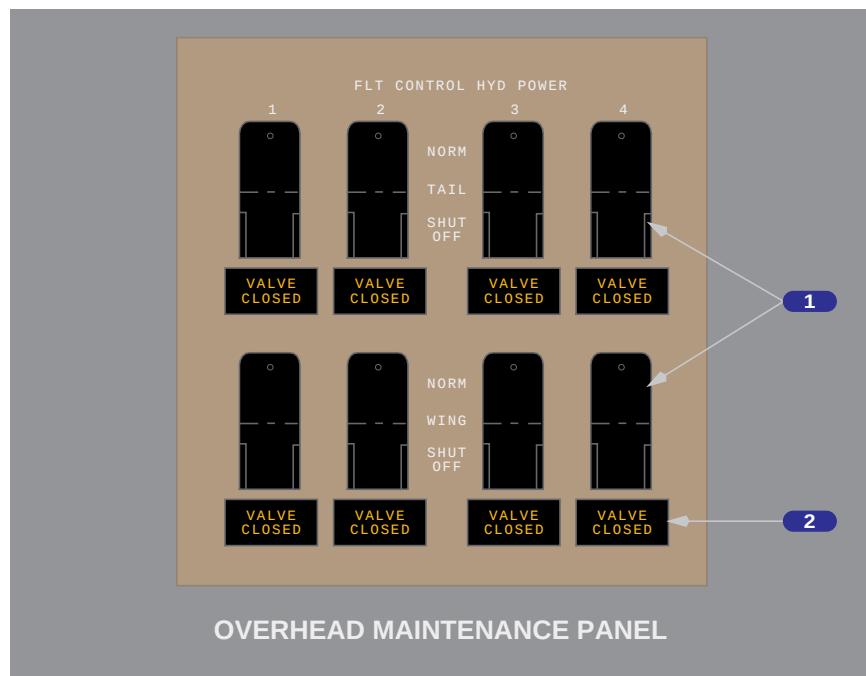
Indicates inboard and outboard aileron positions.

4 Spoiler (SPL) Position

- indicates flight and ground spoiler positions (left wing #4, right wing #12)
- indicates in-flight speedbrake position (left wing only, #4)

Note: Flight control surfaces deflect regardless of flap position.

Flight Control Hydraulic Power Controls



1 Flight (FLT) Control Hydraulic (HYD) power Shutoff Switches

NORM (guard closed) - supplies hydraulic power for flight control surfaces.

SHUT OFF - shuts off hydraulic power to respective flight control surfaces.

2 VALVE CLOSED Light

Illuminated (amber) - hydraulic system flight control valve is closed.

Flight Controls

System Description

Chapter 9

Section 20

Introduction

The primary flight controls are elevators, ailerons, and rudders. The control column, control wheel, and rudder pedals control these flight control surfaces. The primary flight controls are redundantly powered from the four airplane hydraulic systems; there is no manual reversion.

Secondary flight controls include a moveable horizontal stabilizer, spoilers, and leading and trailing edge flaps. Spoilers operate differentially to assist ailerons for roll control and symmetrically as speedbrakes.

Pilot Controls

The pilot controls consist of:

- two control columns
- two control wheels
- two pairs of rudder pedals
- control wheel Stabilizer Trim switches
- Alternate Stabilizer Trim switches
- Speedbrake lever
- Flap lever
- Aileron Trim switches
- Rudder Trim control

Control wheels are connected through jam override and shearout mechanisms. If a jam occurs, the pilots can maintain control by applying force to the other control.

The Speedbrake lever allows manual or automatic symmetric actuation of the spoilers.

Trim switches allow the pilots to adjust flight control surfaces to reduce flight control pressures.

Flight Control Surfaces

Pitch control is provided by:

- four elevator surfaces
- a moveable horizontal stabilizer

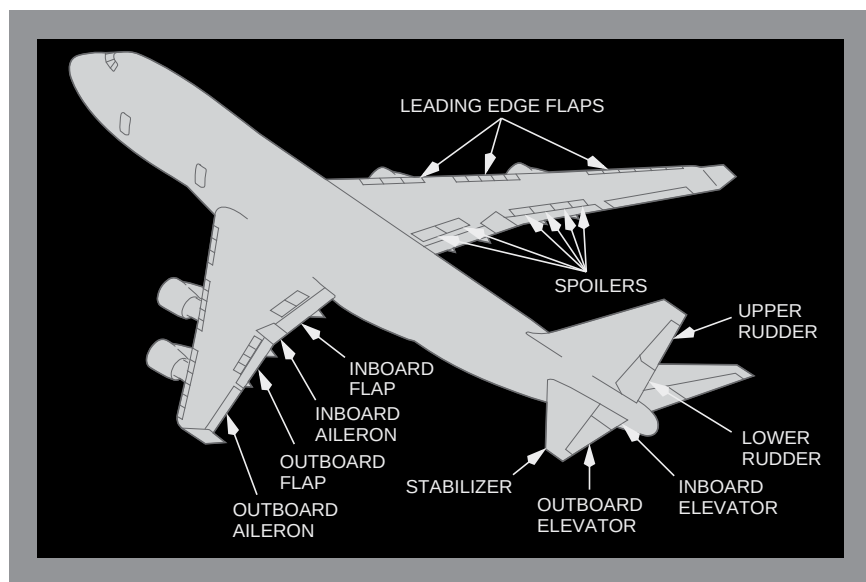
Roll control is provided by:

- four ailerons
- ten spoilers

Yaw control is provided by an upper and lower rudder.

Increased lift and decreased stall speed for takeoff and landing are provided by leading and trailing edge flaps.

Flight Control Surface Locations



Pitch Control

Four elevator surfaces hinged at the rear of the horizontal stabilizer and a moveable horizontal stabilizer provide pitch control.

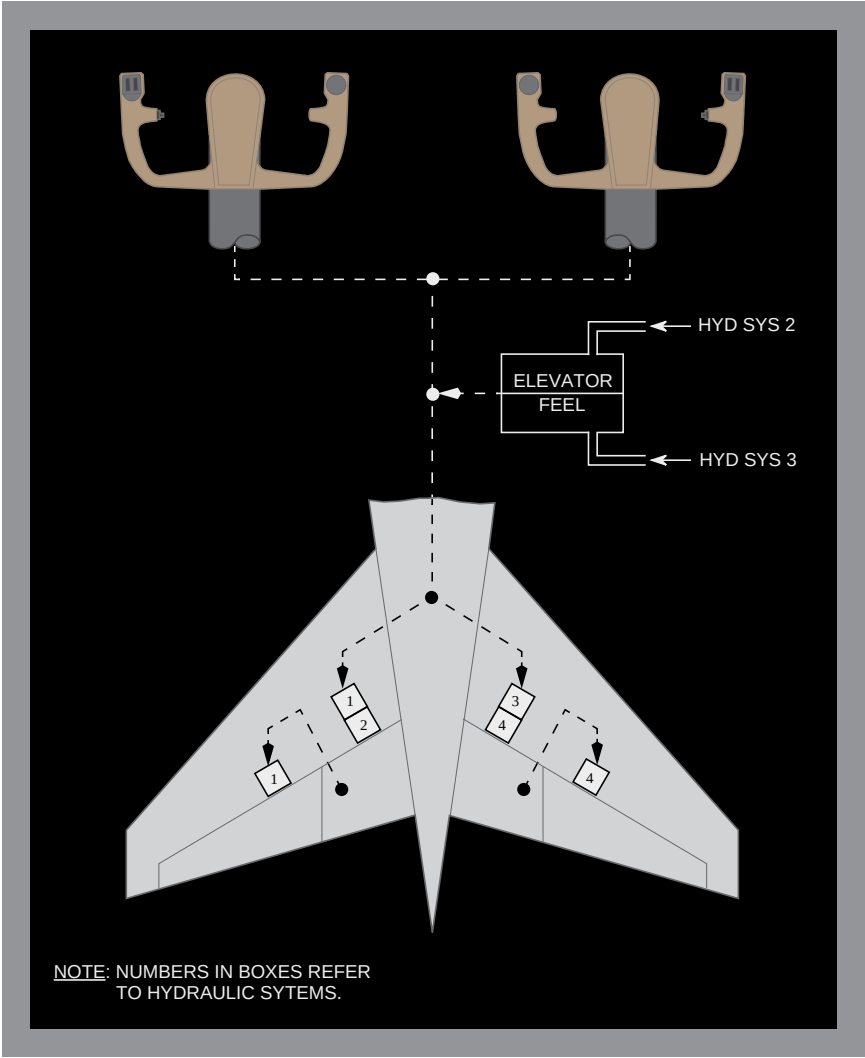
Elevator Control

Control column inputs transfer mechanically to hydraulic actuators on the inboard elevator control surfaces. Inboard elevator position controls input for the related adjacent outboard elevator actuator. Shearouts between the inboard and outboard elevators allow elevator control to be regained if a jam occurs and a significant manual force is applied to the control columns.

Left and right outboard elevator positions display on the EICAS secondary engine display. A full scale indication corresponds to maximum elevator deflection.

An elevator feel mechanism provides artificial feel at control columns. The force increases as airspeed increases. Hydraulic systems 2 and 3 power the feel mechanism. Loss of one of the hydraulic systems does not affect feel forces. If both hydraulic systems fail, mechanical springs provide feel forces. Feel force is no longer a function of airspeed.

Elevator Control Diagram



Note: Elevator feel is dependent on airspeed and stabilizer position.

Stabilizer Trim

The stabilizer trim system provides pitch trim by varying the angle of incidence of the horizontal stabilizer. Normal and alternate electrical channels control two stabilizer trim control modules. Each control module hydraulically powers a trim actuator. Actuator outputs mechanically sum to drive the stabilizer. Trim rate is reduced at high airspeeds.

Trim Control

Stabilizer Trim switches on the pilots' control wheels or Alternate Stabilizer Trim switches on the control stand control stabilizer trim. Pushing both switches in a pair in the same direction power the actuators, which drive the stabilizer in the desired direction. The Alternate Stabilizer Trim switches provide trim commands in the same manner as the Stabilizer Trim switches through a separate control channel. The Alternate Stabilizer Trim switches also provide an increased range of stabilizer travel. If the Alternate Stabilizer Trim switches and control wheel switches are held in opposite directions, no trim is commanded. Holding the captain's and first officer's control wheel switches in opposite directions commands no trim.

Stabilizer Trim Position Indication and Green Band

Stabilizer position, measured in trim units, displays on trim indicators on both sides of the control stand. A Stabilizer Trim indicator OFF flag displays if the trim indicator is inoperative.

The Stabilizer Trim indicators incorporate a multiple green band which indicates the acceptable range of trim settings for takeoff. There are three possible green bands: a mid-band, a nose down band which includes the mid-band plus additional nose down trim, and a nose up band which includes the mid-band plus additional nose up trim.

6301 - 6310

The mid-band segment may be either backlighted or a highly visible green paint stripe illuminated by ambient light and integral panel lighting.

6311 - 6316

The mid-band segment is a highly visible green paint stripe illuminated by ambient light and integral panel lighting.

The FMCs use entered center of gravity, gross weight, and takeoff thrust setting to calculate the correct green band.

A nose gear oleo pressure switch provides a crosscheck to ensure the correct green band has been selected. With either nose up or nose down band selected, the pressure switch position is compared to the selected green band. If not in agreement, the EICAS advisory message >STAB GREENBAND is displayed.

Stabilizer Trim Cut out

Hydraulic systems 2 and 3 power stabilizer trim. Two guarded Stabilizer Trim Cutout switches control stabilizer trim. With the guards closed, the switches are held in AUTO position, allowing automatic cutout of the related hydraulic system if unscheduled stabilizer trim is detected. With a Stabilizer Trim Cutout switch in CUTOUT, hydraulic power to the related trim control module is shut off.

Positioning a Stabilizer Trim Cutout switch from CUTOUT to AUTO, activates the related actuator after a short time delay. Positioning a switch to ON overrides the automatic cutout function and supplies hydraulic power to the related control module. If automatic cutout has occurred, hydraulic power remains shut off until the related cutout switch is placed ON. If one actuator fails to operate, trim commanded by the flight crew reduces to half the normal scheduled rate.

Trimming with Autopilots Engaged

If a single autopilot is engaged, using the control wheel Stabilizer Trim switches causes the autopilot to disengage and the stabilizer to move in the desired direction. If multiple autopilots are engaged, the control wheel Stabilizer Trim switches are inhibited. The Alternate Stabilizer Trim switches override autopilot trim commands with any number of autopilots engaged and do not cause disengagement.

Control Column Cutoff

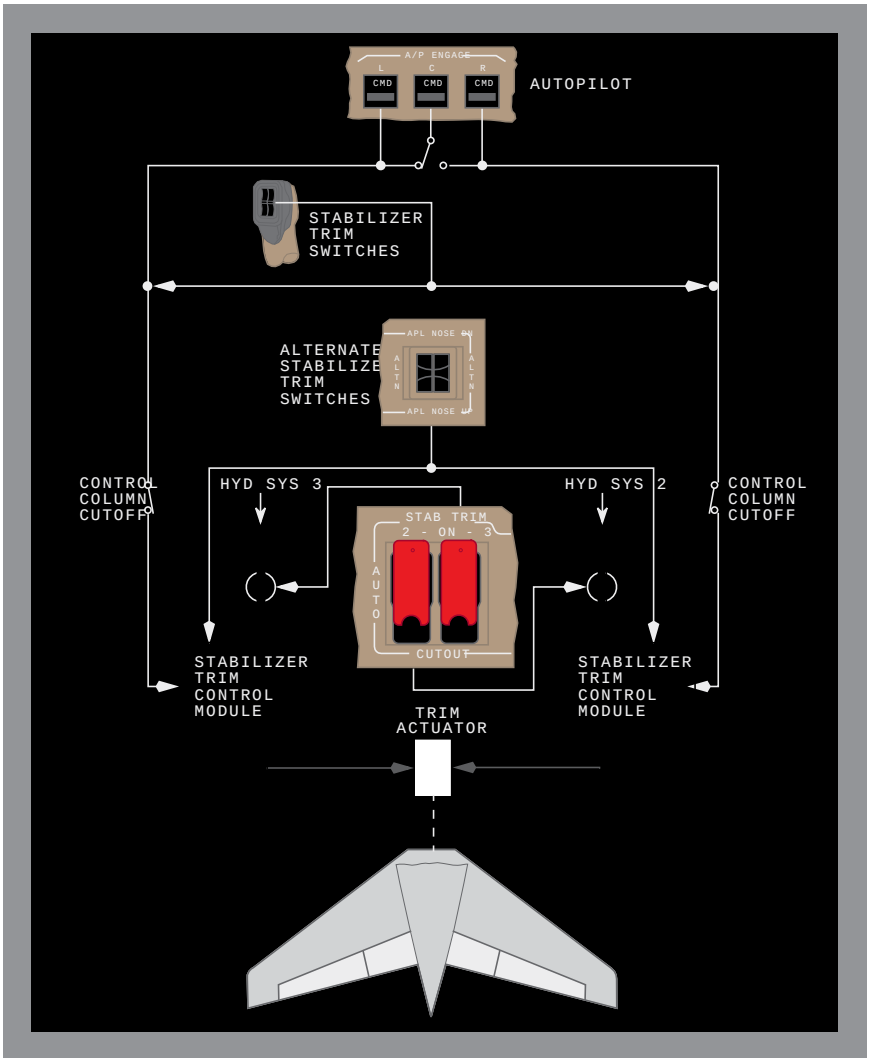
Control column inputs in the direction opposing stabilizer trim will cutoff electric trim commands to the control modules. The control column trim cutoff function does not affect alternate trim inputs.

Speed Stability Trim

Speed stability trim uses stabilizer trim to improve handling characteristics of the airplane in the lower speed range (<220 kts.).

Activating the Stabilizer Trim switches (control wheel or alternate) or engaging an autopilot inhibits speed stability trim.

Stabilizer Control Diagram



Roll Control

Hydraulically powered inboard and outboard ailerons and spoilers provide roll control.

Aileron and Spoiler Roll Control

Rotating either control wheel positions ailerons and spoilers to provide roll control. An aileron lockout system locks the outboard ailerons in the neutral position above 238 knots or when the leading edge flaps are retracted. The aileron lockout system unlocks the outboard ailerons below 238 knots or when flaps 1 (or greater) is selected. This prevents overcontrolling at high airspeeds or leading edge flaps extended, and provides the required roll authority at low airspeeds.

All spoilers, except the inboard spoiler on each wing, function as flight spoilers which operate with the ailerons to provide roll control. Spoiler mixers combine Speedbrake lever and control wheel inputs allowing roll inputs to deflect spoiler panels up or down from their deployed positions when speedbrakes or ground spoilers are in use.

Aileron positions display on the EICAS secondary engine 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.

The control wheels connect through an override mechanism which allows either wheel to move independently if the other wheel jams and significant manual force is applied to the free wheel. Roll control is then available through the ailerons on the wing corresponding to the free wheel. Approximately half of the flight spoilers are also available for roll control under these conditions.

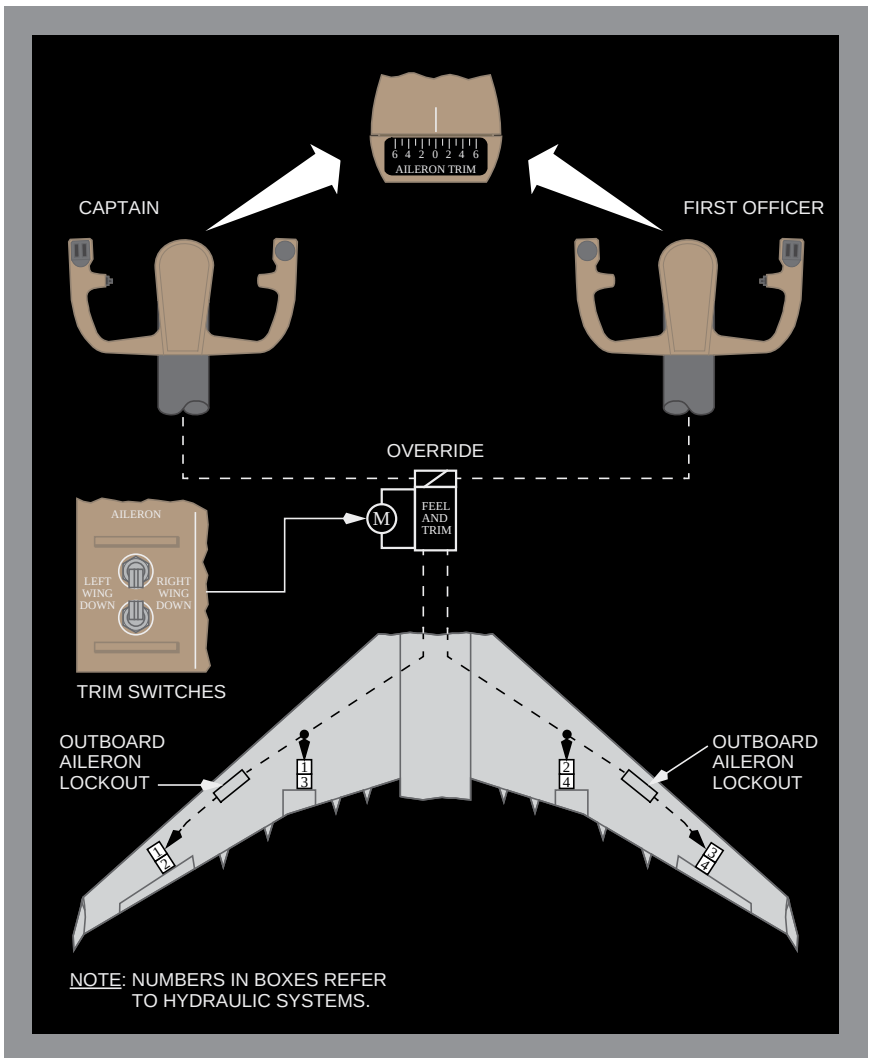
Each side of the mechanical system also incorporates shearouts which may allow the jammed control wheel to be freed when a significant manual force is applied to the jammed wheel.

Aileron Trim

Pushing both Aileron Trim switches in the desired direction causes the feel and trim mechanism to reposition the aileron neutral point. Both control columns have an aileron trim indicator.

If the Aileron Trim switches are activated with an autopilot engaged, the aileron neutral point is repositioned. When the autopilot is disengaged, the wheel and ailerons move to the repositioned aileron neutral point. The airplane responds with roll proportional to the amount of aileron trim input.

Aileron Control Diagram



Yaw Control

The rudder control system provides yaw control.

Rudder Control and Trim

Either pilot's rudder pedals control the hydraulically powered upper and lower rudders. Rudder pedal inputs mechanically transfer to a single feel and trim mechanism, then transfer through separate ratio changers to the upper and lower rudder hydraulic actuators.

Rudder positions display on the EICAS secondary engine display. On the ground, pushing a rudder pedal to the stop causes a full scale deflection of the upper and lower rudder position indicators.

The rudder system shearouts allow rudder control to be regained if a jam occurs and a significant manual force is applied to the rudder pedals.

When the Rudder Trim selector is rotated in the desired direction, the rudder feel and trim mechanism repositions the rudder pedal neutral point. The rudder trim indicator displays units of rudder trim. A black tape displays with pointer out of view if the trim indicator is inoperative.

Rudder Ratio Changers

Two rudder ratio changer systems gradually reduce each rudder surface's response to pedal inputs as airspeed increases. This protects the vertical tail structure from stresses which could result from large rudder surface deflections at high airspeeds.

If a ratio changer system fails, the response of the related rudder surface to pedal inputs remains the same as when the failure occurred, regardless of changes in airspeed. Pilot inputs to the rudder may no longer be limited by the ratio changer and abrupt rudder pedal inputs at high airspeeds could result in excessive rudder deflections. At low airspeeds, full rudder deflection may not be available. The airplane crosswind capability is reduced for both manual and automatic landings.

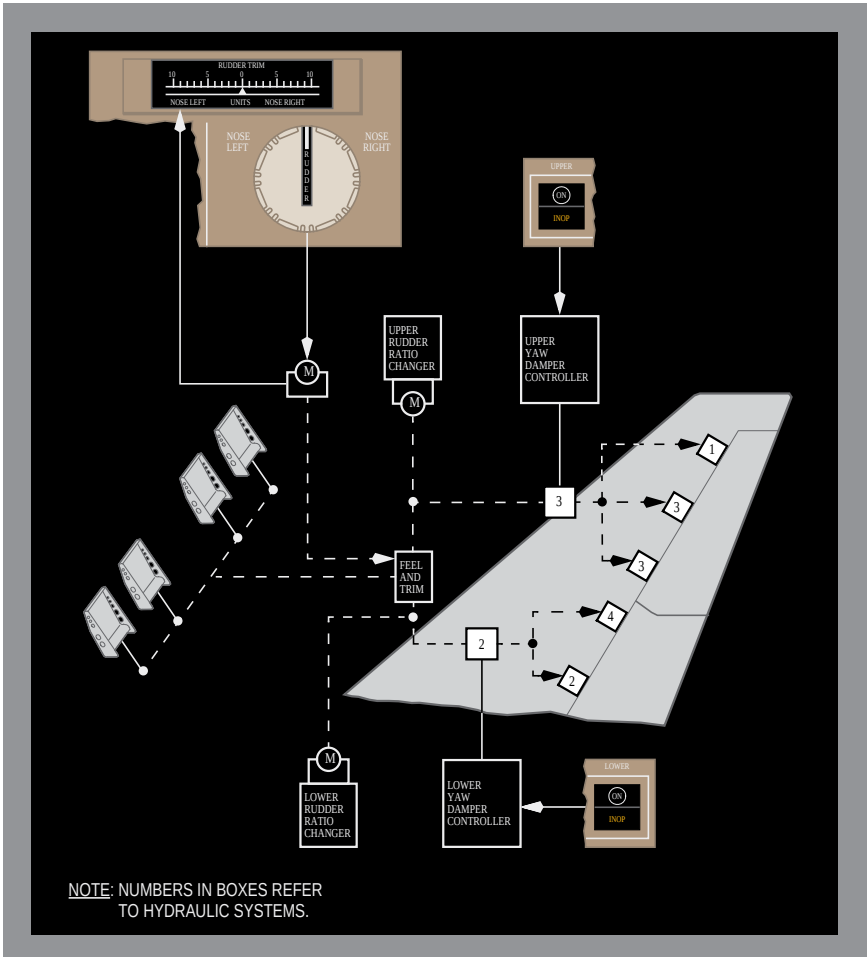
Yaw Dampers

Two independent yaw damper systems operate continuously in flight to improve airplane directional stability and provide turn coordination. There is a separate yaw damper for each rudder. The upper and lower yaw damper actuators are powered by hydraulic systems 3 and 2 respectively. Yaw damper inputs do not result in rudder pedal motion.

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With the Yaw Damper switches ON, the systems are powered. If a yaw damper fault exists, hydraulic power is removed from the system and the related yaw damper INOPERATIVE light illuminates. The remaining yaw damper can provide the required control. The yaw damper INOP lights illuminate during IRS alignment, or if all three IRUs are inoperative. Both INOP lights will extinguish when the first IRU aligns.

Rudder Control Diagram



Note: The upper and lower rudder changers are dependent on airspeed

Spoilers

There are six spoiler panels on each upper wing surface just forward of the trailing edge flaps. All spoilers except the inboard spoiler on each wing function as flight spoilers, which operate with the ailerons to provide roll control. The four inboard panels on each wing function as speedbrakes in flight. On the ground, all six spoiler panels on each wing function as ground spoilers. The speedbrake and ground spoiler functions are controlled with the Speedbrake lever.

The position of one spoiler on each wing is displayed on the EICAS secondary engine display. On the left wing, the position of the fourth spoiler panel in from the wingtip is displayed. This panel functions as a flight spoiler, speedbrake, and ground spoiler. On the right wing, the position of the outboard-most spoiler panel is displayed. This panel functions as a flight spoiler and ground spoiler only. Therefore, speedbrake extension is not indicated on the right wing spoiler position indicator.

Speedbrakes

Speedbrake lever in-flight input is limited to mid-travel FLIGHT DETENT position by an automatic stop. With the Speedbrake lever in FLIGHT DETENT position, the two inboard spoiler panels on each wing extend to mid-travel position and the two middle spoiler panels on each wing extend to full travel position.

Ground Spoilers

On the ground, the Speedbrake lever stop retracts allowing the Speedbrake lever to be moved fully aft to UP position. All six spoiler panels on each wing extend to their full travel positions.

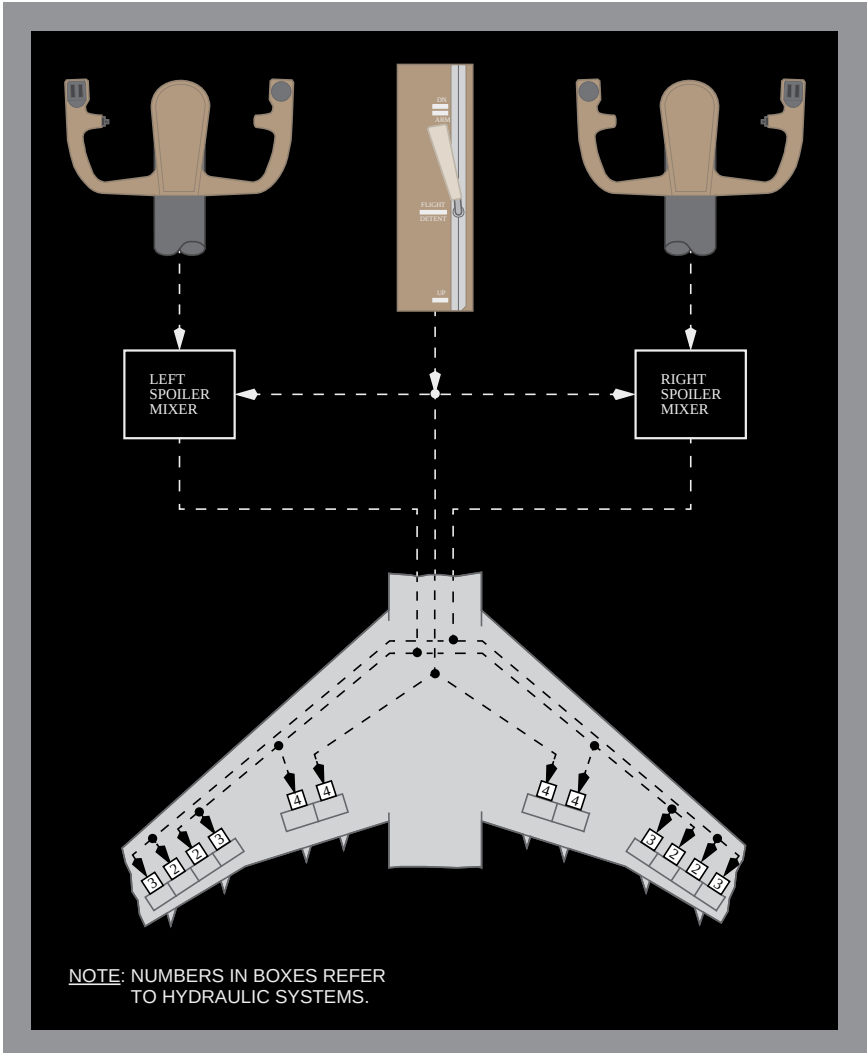
When the Speedbrake lever is in ARM position, Thrust levers 1 and 3 are near the idle position, and the main landing gear touch down, the Speedbrake lever is driven to UP position, extending all spoiler panels.

The Speedbrake lever is driven to the UP position from the DN position when the main gear are on the ground, thrust levers 1 and 3 are near the idle position, and reverse thrust levers 2 or 4 are pulled up to idle detent. This automatic ground spoiler extension is a backup for landing when the Speedbrake lever is not armed during approach.

For go-around protection, if Thrust lever 1 or 3 is advanced from closed position, the Speedbrake lever is driven to DN position. This occurs whether ground spoilers were automatically or manually extended. The Speedbrake lever can be manually returned to DN position.

The EICAS advisory message SPEEDBRAKE AUTO indicates a fault which could result in the loss of the automatic ground spoiler function. If the Speedbrake lever is in ARM position, the message indicates a fault which could result in inadvertent spoiler extension in flight. No inadvertent spoiler extension can occur with the Speedbrake lever in DN position. The spoilers can be operated manually.

Spoiler Control Diagram



Flaps

Increased lift and decreased stall speed for takeoff and landing are provided by leading and trailing edge flaps. There are three groups of leading edge flaps on each wing: outboard flap section, midspan section, and inboard section. The leading edge flaps are normally pneumatically powered from the bleed air duct. The trailing edge flaps consist of an inboard group normally powered by hydraulic system 1 and an outboard group normally powered by hydraulic system 4. Opposite trailing edge flaps are mechanically connected to maintain symmetry.

Flap Control

Flap lever position is transmitted to three identical flap control units (FCUs) which sequence and monitor flap operation. Each FCU is capable of performing any or all of the three basic functions: primary control, secondary control, and indication and annunciation. They also provide trailing edge flap asymmetry protection in the primary and secondary modes, control the flap load relief function in primary mode only, and provide flap position information to EICAS and other systems.

The FCUs operate in two control modes, primary and secondary. In primary mode, the FCUs drive the leading edge flaps pneumatically and the trailing edge flaps hydraulically to the selected position. If any flap group fails to move to the commanded position, the FCUs switch to secondary mode for the related group driving the flap group through electric motors. The change from primary to secondary mode for both leading and trailing edge flaps is by symmetrical flap groups on both wings. If a primary control failure occurs in either the inboard or midspan leading edge flap group, both groups switch to secondary mode. For all other flap groups, only the failed group operates in secondary mode. Secondary mode flap operation is much slower than primary mode operation. If a failure occurs in a leading edge flap group on one wing, the flap groups on both wings change to secondary mode after a time delay of between 20 to 45 seconds.

However, due to the rapid rate of primary mode flap movement, the non-affected side completes movement before changing to secondary mode.

If a trailing edge flap group is driven in secondary mode due to a lack of hydraulic system pressure, the FCUs switch back to primary mode operation once hydraulic pressure is restored. However, if a trailing edge flap group is driven in secondary mode with hydraulic pressure available, the group remains in secondary mode until fully retracted. For leading edge flaps, if any groups are driven in secondary mode, the groups remain in secondary mode until they reach the commanded position.

If a trailing edge asymmetry is detected, primary mode operation is immediately shut down for the asymmetric group and the FCUs do not use secondary mode. The EICAS caution message FLAPS CONTROL displays if all three FCUs fail in their control function. EICAS flap indications from the FCUs may still be valid.

An alternate control mode which bypasses the FCUs can be manually selected. All flaps are extended or retracted by a simplified control system and electric motors. In the alternate mode the hydraulic and pneumatic systems are not utilized. In addition, there is no asymmetry protection. When the Alternate Flaps Arm switch is pushed to ALTN, the Flap lever is inoperative. Flaps are extended and retracted using the Alternate Flaps selector.

Flap Sequencing

When the Flap lever is moved from UP detent to flaps 1 detent, the trailing edge flaps remain retracted and the inboard and midspan leading edge flap groups extend. When the Flap lever is moved from flaps 1 detent to flaps 5 detent, the trailing edge flaps move to flaps 5 position and the outboard leading edge flap groups extend. When the Flap lever is moved to the flaps 10, 20, 25, or 30 detents, the trailing edge flaps move to the selected position. The reverse sequence occurs during flap retraction. Secondary mode sequencing is the same as primary mode.

During alternate control mode extension, all leading and trailing edge flap groups begin extending immediately. Trailing edge flaps extend to a maximum position of flaps 25. During retraction, all leading edge flap groups retract after the inboard trailing edge flaps are completely retracted.

Flap Load Relief

The flap load relief function of the FCUs operates if flap airspeed limits are exceeded with flaps 25 or 30. Automatic retraction protects the flaps from excessive airloads. If the airspeed limit is exceeded with flaps 30 selected, the flaps retract to flaps 25. If airspeed is still excessive at flaps 25, the flaps retract to 20. Similarly, if the airspeed limit is exceeded with flaps 25 selected, the flaps retract to 20.

The Flap lever does not move. The flaps extend to the selected position when airspeed is sufficiently reduced. Maximum flap speeds are placarded on the center panel. Flap load relief is only available in the primary mode.

Flap Indications

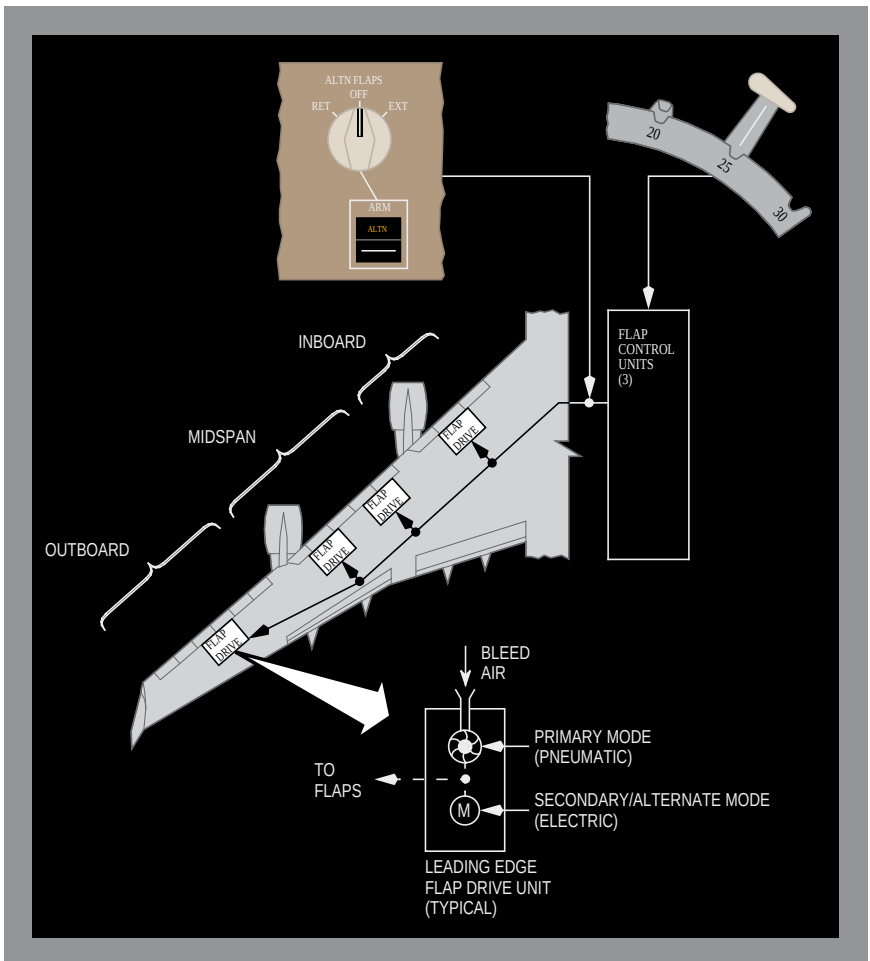
Flap position indications are displayed on the primary EICAS display. A single vertical indicator displays combined leading and trailing edge flap position. The position commanded by the Flap lever is also displayed. Ten seconds after all flaps are up, the entire indication is no longer displayed.

If flap control is in secondary or alternate mode, or if any non-normal flap position is detected, an expanded flap indication is displayed. The position of each flap group is separately indicated. In alternate mode, the position commanded by the Flap lever is replaced by flap position index marks at flaps 5 and flaps 25. The index marks are used by the flight crew as a guide to position the flaps at the desired setting.

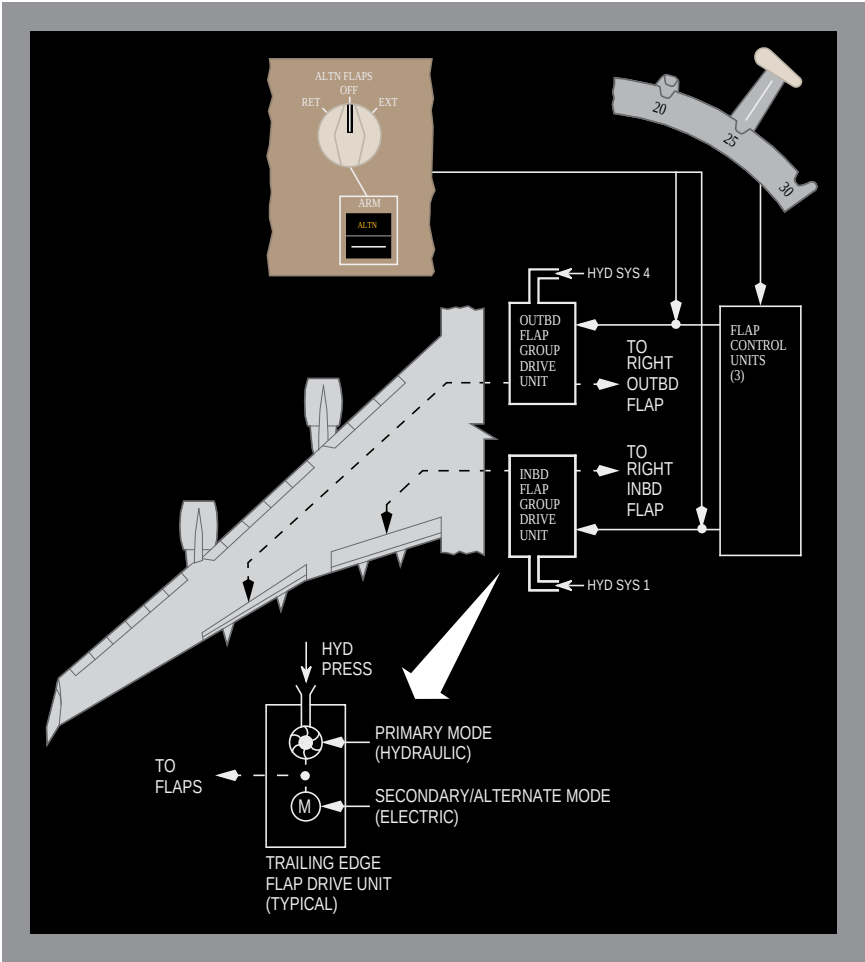
If the standby bus is the only powered AC bus, the left wing trailing edge flap position sensors are not powered. An expanded indication is displayed with an amber X on the left outboard and inboard trailing edge flap indications.

During engine reverse thrust operation, automatic retraction of inboard and midspan leading edge flaps occurs to improve structural life of the panels. The flap handle position does not change. Both primary and secondary flap modes (if pneumatic power available) will reflect leading edge retraction during reverse operations.

Leading Edge Flaps Control Diagram



Trailing Edge Flaps Control Diagram



Flight Controls EICAS Messages

Note: Configuration (CONFIG) warning messages are described in Chapter 15, Warning Systems.

The following EICAS messages can be displayed.

EICAS Alert Messages

Message	Level	Aural	Message Logic
AILERON LOCKOUT	Advisory		Aileron lockout actuator position disagrees with commanded position. One or both outboard ailerons may be unlocked at high airspeeds or locked out at low airspeeds.
>FLAP RELIEF	Advisory		Flap load relief system operating.
FLAPS CONTROL	Caution	Beeper	Flap control units inoperative, or Alternate Flaps Arm switch in ALTN.
FLAPS DRIVE	Caution	Beeper	One or more flap groups have failed to drive in secondary mode, or an asymmetry condition detected.
FLAPS PRIMARY	Caution	Beeper	One or more flap groups operating in secondary control mode.
>FLT CONT VLVS	Advisory		One or more flight control shutoff valves closed.
RUD RATIO DUAL	Advisory		Rudder ratio changers have failed.
RUD RATIO SNGL	Advisory		Rudder ratio changer has failed.
SPEEDBRAKE AUTO	Advisory		Fault detected in automatic ground spoiler system. Fault could result in loss of automatic ground spoiler function, or in flight with Speedbrake lever in ARM position could result in inadvertent spoiler extension.

Message	Level	Aural	Message Logic
>SPEEDBRAKES EXT	Caution	Beeper	Speedbrakes extended at an inappropriate flight condition. Occurs when Speedbrake lever aft of ARMED detent and radio altitude is between 800 feet and 15 feet, or flaps are in a landing position, or two or more Thrust levers are forward of closed position.
>STAB GREENBAND	Advisory		Nose gear pressure sensor disagrees with computed stabilizer green band.
>STAB TRIM 2, 3	Advisory		Stabilizer trim automatic cutout has occurred, or a Stabilizer Trim Cut Out switch in CUTOUT, or trim commanded and respective actuator failed to function.
STAB TRIM UNSCHD	Caution	Beeper	Uncommanded stabilizer motion detected and automatic cutout does not occur, or Alternate Stabilizer Trim switches used with autopilot engaged.
>YAW DAMPER LWR, UPR	Advisory		Yaw damper failure or power failure. May be due to module fault, actuator fault, IRUs off or in align, Yaw Damper switch off, or module power off.

EICAS Memo Messages

Message	Level	Aural	Message Logic
SPEEDBRAKE ARMED	Memo		Speedbrake lever in ARM position.

Flight Instruments, Displays

Chapter 10

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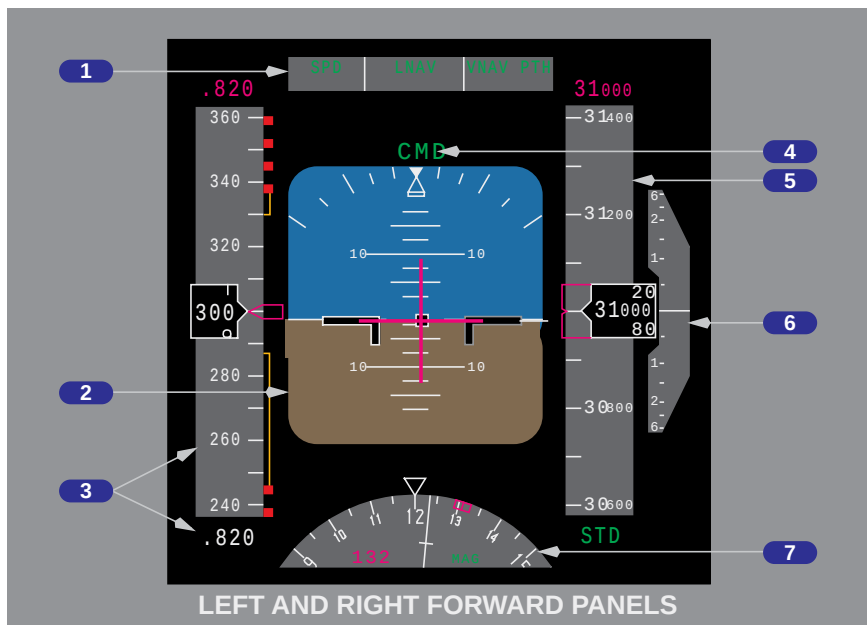
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Primary Flight Display (PFD)



1 Flight Mode Annunciations

Refer to Chapter 4, Automatic Flight.

2 Attitude, Steering, and Miscellaneous Displays

Displays IRU attitude information.

3 Airspeed/Mach Displays

Displays ADC airspeed information and other airspeed related information.

4 Autopilot, Flight Director System Status

Refer to Chapter 4, Automatic Flight.

5 Altitude Displays

Displays ADC altitude and other altitude-related information.

6 Vertical Speed Display

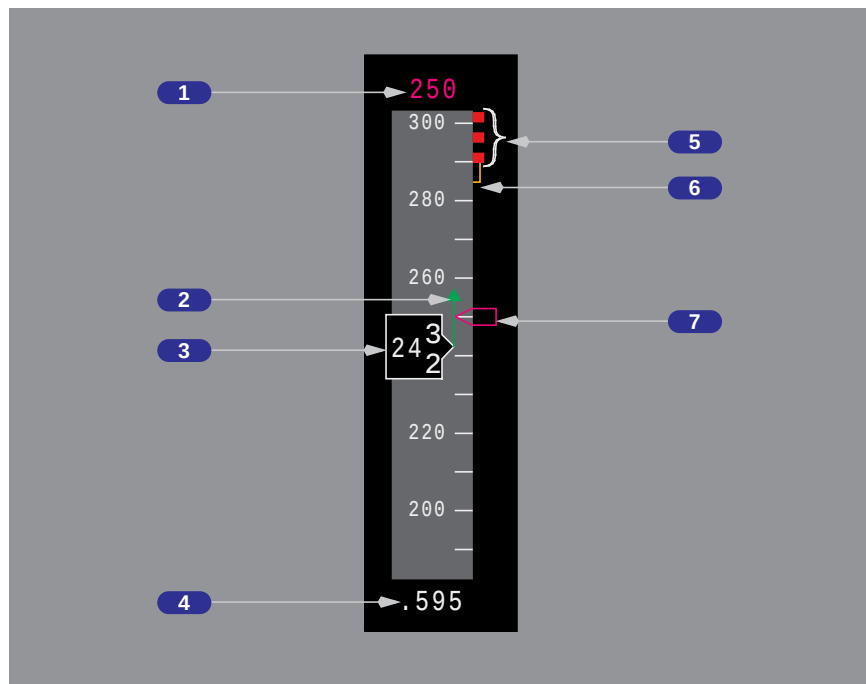
Displays ADC vertical speed as dampened by the IRS.

7 Heading and Track Displays

Displays current IRS heading, track, and other heading information.

Airspeed Displays

Indicates 30 knots with no computed information. Airspeed indication is removed and SPD flag is displayed if associated ADC fails.



1 Command Speed

Displays airspeed/Mach set in the MCP IAS/MACH window (refer to Chapter 4, Automatic Flight).

Displays FMC-computed airspeed/Mach when the IAS/MACH window is blank.

2 Trend Indication

Indicates predicted airspeed in ten seconds based on current acceleration or deceleration.

3 Current Airspeed

Displays ADC airspeed.

Displays 30 knots with no computed information.

Airspeed box changes to amber if current airspeed less than minimum maneuvering speed. In addition, a caution EICAS message >AIRSPEED LOW displays.

4 Current Mach

Displays ADC Mach when Mach .40 or greater. Removed with no computed data. Mach flag displays with invalid data.

5 Maximum Speed [AFM]

Indicates maximum airspeed limited by lowest of the following:

- Vmo/Mmo
- landing gear placard speed, or
- flap placard speed

6 Maximum Maneuvering Speed [AFM]

Bottom of amber bar indicates the maximum maneuvering speed. This airspeed provides 1.3g maneuver capability to high speed buffet. May be displayed when operating at high altitude at relatively high gross weights.

Note: 1.3g maneuver capability occurs at 40 degrees of bank in level flight.

CAUTION: Reduced maneuver capability exists when operating within the amber regions above the maximum maneuvering speed.

7 Command Speed

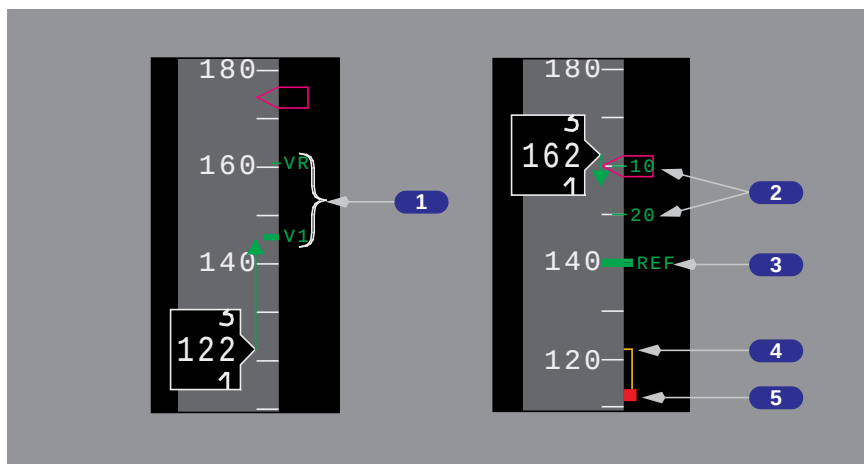
Points to airspeed/Mach set in MCP IAS/MACH window.

Points to FMC-computed airspeed when MCP IAS/MACH window blank.

Pointer is five knots in height.

When the selected speed is off scale, the pointer is parked at the top or bottom of the tape, with half the pointer visible.

Reference Speeds



1 Takeoff Reference Speeds

Displays takeoff reference speeds V1 and VR (displays R when VR within 4 knots of V1) selected on the CDU (refer to Chapter 11, Flight Management, Navigation):

- displayed for takeoff
- NO V SPD displays when:
 - All V speeds are not selected (large font) on the TAKEOFF REF page
 - Runway is modified on DEP/ARR page
 - Runway is changed on the ACT RTE page
 - Changing RTE 1 to ACT RTE 2
 - Modifying gross weight, fuel, or zero fuel weight on the PERF INIT page
 - Entering/modifying the assumed temp (SEL) (1L) on the PERF INIT page
 - Selecting TO (2L), TO 1 (3L), TO 2 (4L) on the THRUST LIM page
 - Changing Flaps (1L) or Wind/Slope (4L) on the TAKEOFF REF page
 - When reverse thrust is selected
- V1 displays at the top of the airspeed indication when selected and if the value is off the scale
- V1 and VR are removed at lift-off

2 Flap Maneuvering Speeds

Displays flap maneuvering speed for flap retraction or extension for current flap setting and next lesser flap setting.

Not displayed above approximately 20,000 feet altitude.

3 Landing Reference Speed

Displays VREF speed selected on the CDU (refer to Chapter 11, Flight Management, Navigation).

VREF speed displays at the bottom of the airspeed indication when the value is off the scale.

4 Minimum Maneuvering Speed

Top of amber bar indicates minimum maneuvering speed. This airspeed provides:

- 1.3g maneuver capability to stick shaker with flaps down
- 1.3g maneuver capability to stick shaker or VREF+80, whichever is less, with flaps up at approximately 20,200 feet
- 1.3g maneuver capability to low speed buffet (or an alternative approved maneuver capability as preset by maintenance) with flaps up at approximately 20,200 feet

Displayed with first flap retraction after takeoff.

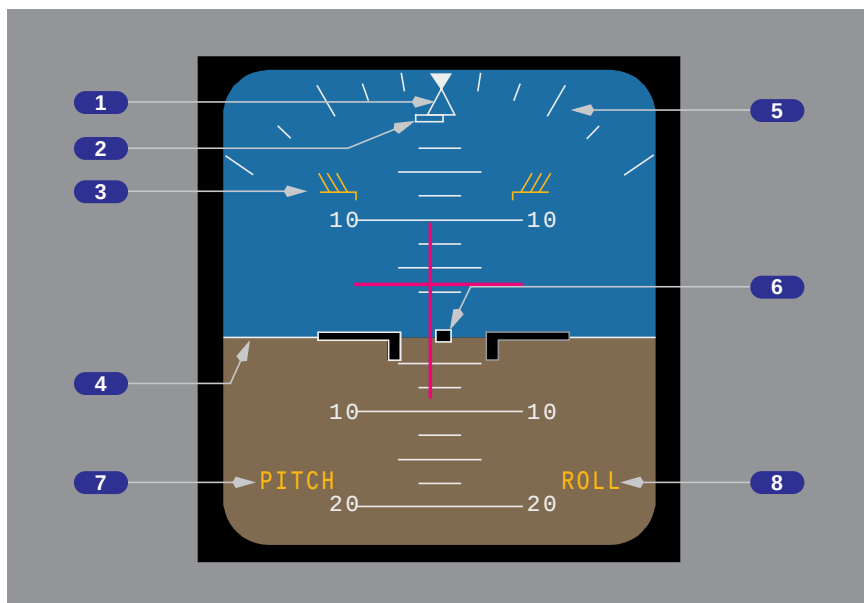
Note: 1.3g maneuver capability occurs at 40 degrees of bank in level flight.

CAUTION: Reduced maneuver capability exists when operating within the amber regions below the minimum maneuvering speed. During non-normal conditions the target speed may be below the minimum maneuvering speed.

5 Minimum Speed

Indicates airspeed where stick shaker or low speed buffet occurs.

Attitude Indications



1 Bank Pointer

Indicates IRS bank in reference to bank scale.

2 Slip/Skid Indication

Displaces beneath bank pointer to indicate slip or skid. Information obtained from IRS.

3 Pitch Limit Indication

Indicates pitch limit (stick shaker activation point for existing flight conditions).
Displayed when flaps are not up.

4 Horizon Line and Pitch Scale

Indicates IRS horizon relative to the airplane symbol.
Pitch scale is in 2.5 degree increments.
The ATT flag is visible when the IRS attitude fails.

5 Bank Scale

Fixed reference for the bank pointer.
Scale marks are at 0, 10, 20, 30, 45, and 60 degrees.

6 Airplane Symbol

Indicates airplane attitude with reference to the IRS horizon.

7 PITCH Disagree Flag

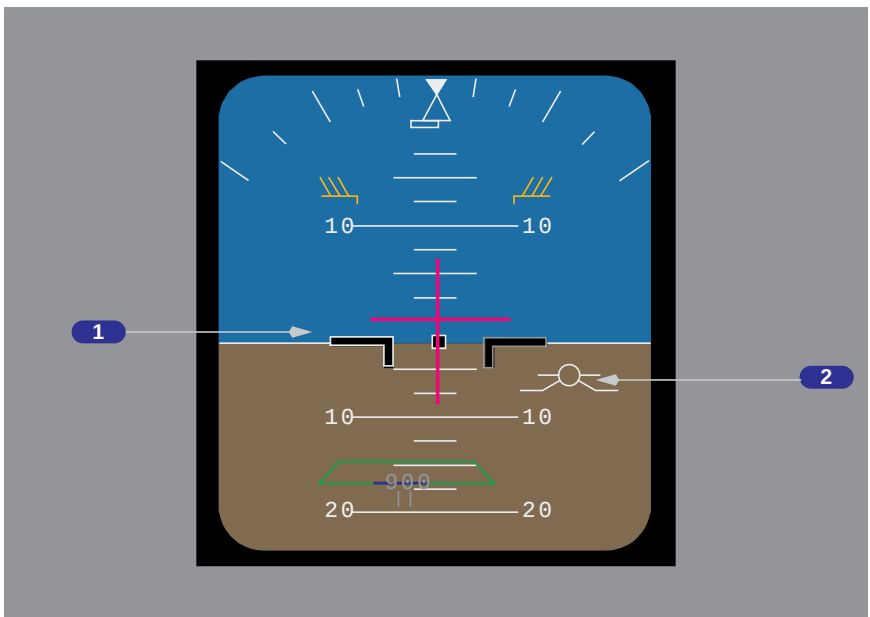
Displays if Captain's and First Officer's PFD pitch attitude disagree.

8 ROLL Disagree Flag

Displays if Captain's and First Officer's roll attitude disagree.

Steering Indications

Note: Refer to Chapter 15, Warning Systems, for TCAS Steering Indications and Time Critical Warnings.



1 Flight Director Command Bars

Indicates flight director pitch and roll steering commands.

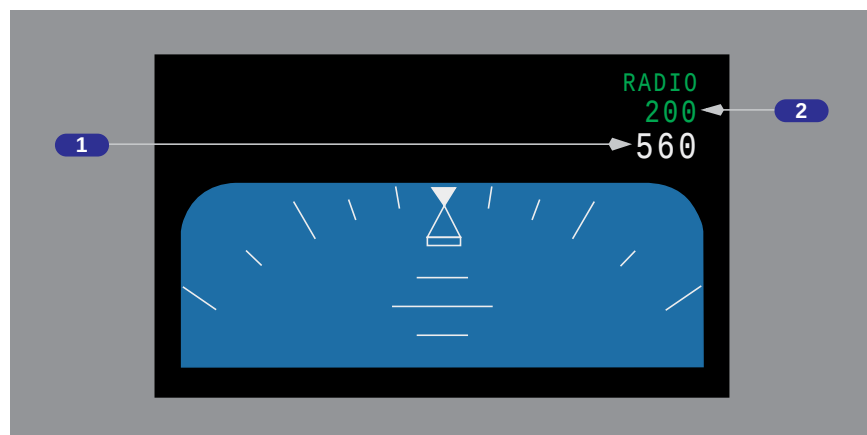
Refer to Chapter 4, Automatic Flight.

2 Flight Path Vector

Not used at Delta Air Lines

- Displays flight path angle and drift angle when selected on EFIS control panel.
- Flight path angle displays relative to the horizon line.
- Drift angle is represented by the perpendicular distance from the centerline of the pitch scale to the FPV symbol.
- “Arms” are parallel to the horizon line and “feet” are parallel to the airplane symbol (CRT).
- At 30 degree bank angle, one of the bent legs is parallel to the horizon line.

Radio Altitude Indications



1 Radio Altitude

Displays airplane radio altitude below 2,500 feet AGL. Selected on the associated EFIS control panel.

2 RADIO Minimums

Displays radio altitude set on EFIS control panel.

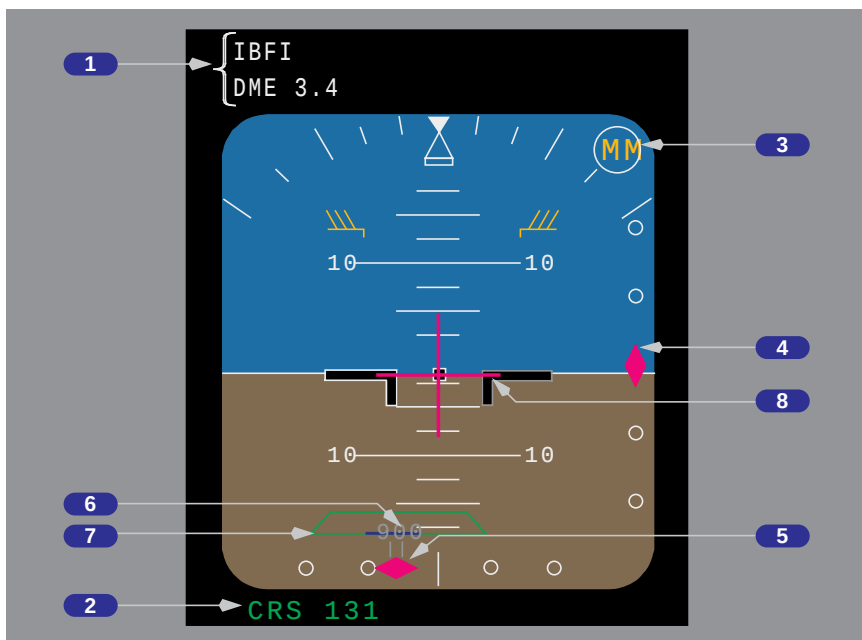
RADIO and the altitude setting change color to amber and flash when radio altitude is at or below the setting.

RADIO and the altitude are not displayed when set below 0 feet.

Flashing amber RADIO and the altitude setting reset:

- upon landing
- on go-around at 75 feet above the setting
- when MINS RST switch is pushed

Instrument Landing System Indications



1 Approach Reference

Displays the selected ILS identifier or frequency and ILS DME distance.

If the tuned ILS frequencies disagree, an amber horizontal line is drawn through the frequency.

Refer to Chapter 11, Flight Management, Navigation.

2 Approach Course

Displays the selected ILS approach course.

If the approach courses in the ILS receivers disagree, an amber horizontal line is drawn through the course.

3 Marker Beacon Annunciation

The marker beacon annunciation appears flashing when over one of the marker beacon transmitters:

- IM - an airway or inner marker beacon (white)
- MM - a middle marker beacon (amber)
- OM - an outer marker beacon (blue)

Annunciation flashes in cadence with the beacon identifier.

Annunciation not available if left VOR has failed.

4 Glideslope Pointer and Scale

Glideslope pointer indicates glideslope position relative to the airplane and:

- is in view when receiving the glideslope signal
- fills in solid when within 2 1/3 dots of the scale center

Scale is in view after the frequency is tuned.

At low radio altitudes, with the autopilot or flight director engaged, scale turns amber and the pointer flashes to indicate excessive glideslope deviation.

5 Localizer Pointer and Scale

Localizer pointer:

- indicates localizer position relative to the airplane
- is in view when the localizer signal is received
- fills in solid when within 2 1/3 dots from the center

Scale is in view after the frequency is tuned.

At low radio altitudes, with the autopilot or flight director engaged, scale turns amber and the pointer flashes to indicate excessive localizer deviation.

At low altitudes, with LNAV engaged and LOC armed, localizer scale turns amber and the pointer flashes if localizer is not captured.

6 Radio Altitude Indicator

Displays radio altitude below 2,500 feet AGL:

- centered over the localizer scale between 2,500 feet and 1,000 feet AGL
- centered over the localizer deviation indicator below 1,000 feet AGL
- centered at the bottom of the attitude indication if localizer scale not displayed
- centered over the localizer scale while flying a backcourse approach (backcourse sensing)

7 Rising Runway

Displays below 1000 feet radio altitude when the localizer pointer is in view.

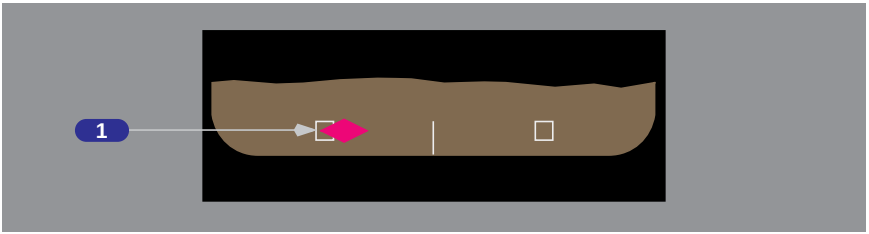
Moves toward the airplane symbol below 200 feet radio altitude.

Removed while flying a backcourse approach (backcourse sensing).

8 Airplane Symbol

Indicates airplane attitude.

Expanded Localizer Indications

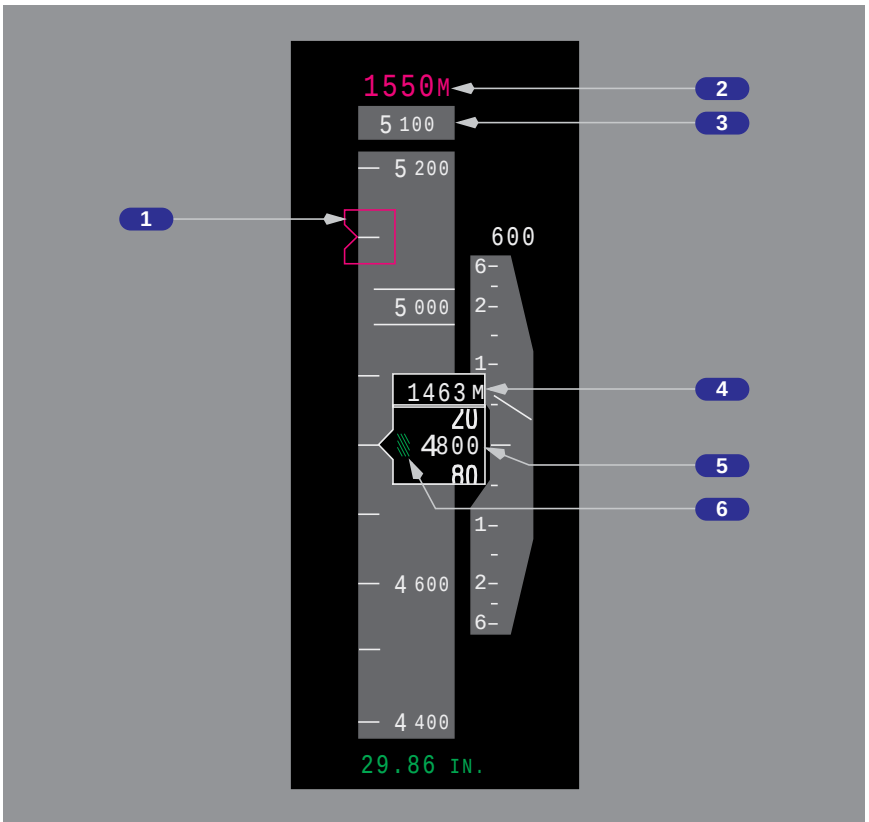


1 Expanded Localizer Deviation Scale

Displays when the airplane is close to the localizer centerline. Provides a more sensitive display.

A rectangle equals 1/2 dot deviation. Displayed during an autopilot or flight director approach.

Altitude Indications



1 Selected Altitude Pointer

Indicates altitude set in the MCP altitude window.

When selected altitude is off scale, pointer displays at the top or bottom of the tape with half the pointer visible.

2 Selected Altitude - Meters

Displays when MTRS selected on EFIS control panel MTRS switch.

Indicates selected altitude in meters (selected in feet in MCP altitude window).

Displays in 10 meter increments.

3 Selected Altitude

Displays altitude set in altitude window on MCP.

Selected altitude box is highlighted in white between 900 feet and 300 feet prior to reaching the selected altitude.

4 Current Altitude - Meters

Displays when MTRS selected on EFIS control panel MTRS switch.

Displays altitude in meters.

5 Current Altitude

Displays barometric altitude from selected ADC.

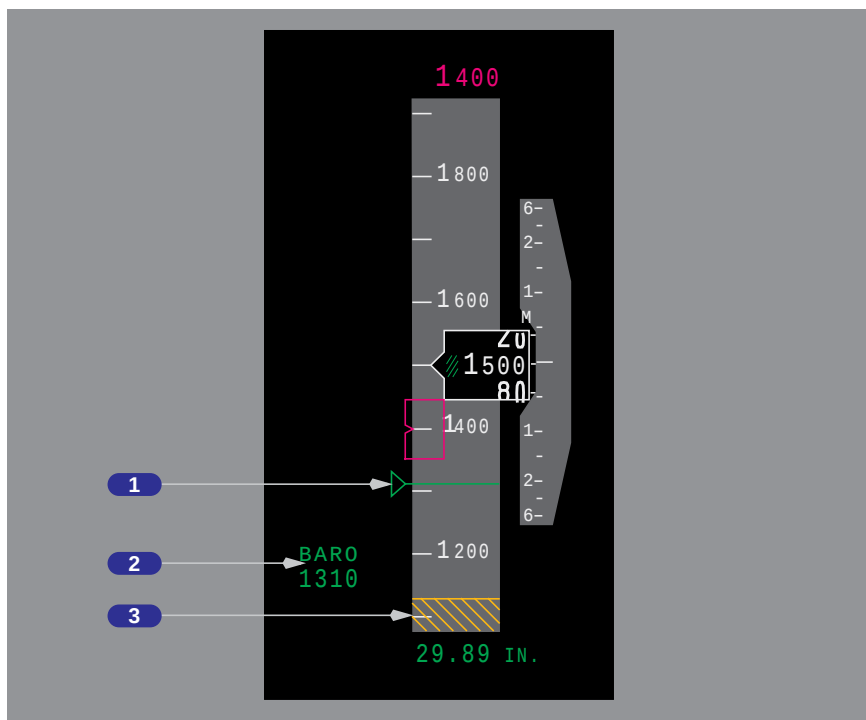
Altitude box is highlighted in white between 900 feet and 300 feet when approaching selected altitude.

Altitude box changes to amber when deviating from selected altitude between 300 feet and 900 feet.

6 Ten Thousand Digit Display

Cross hatch displays when altitude is below 10,000 feet.

Landing Altitude/Minimums Indications



1 BARO Pointer

Indicates barometric altitude set on EFIS control panel. Selected on the associated EFIS control panel.

2 BARO Display

Displays barometric altitude set on EFIS control panel.

Not displayed when BARO set below -100 feet.

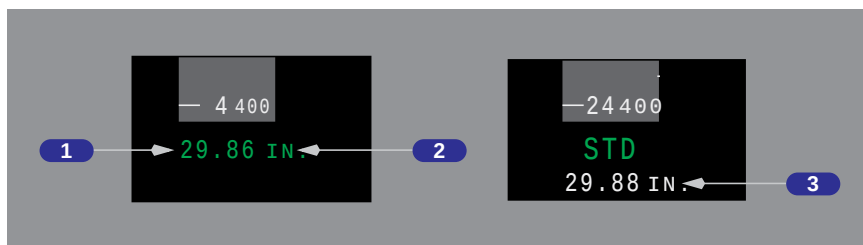
3 Touchdown Zone Indicator (amber)

Upper edge of crosshatched area indicates FMC landing altitude for destination runway or airport.

Indicates the landing altitude for the departure runway or airport until 400 NM or one-half the distance to the destination whichever occurs first. See Chapter 11, Flight Management, Navigation, Section 43, arrivals page information.

During cockpit setup (before runway is entered), and when FMC information is unavailable, an amber “NO TDZ” flag appears to the right and below the altitude tape.

Barometric Indications



1 Barometric Setting

Displays barometric setting set on EFIS control panel barometric control.

STD displays when STD selected on EFIS control panel barometric standard switch.

Display is boxed and changes to amber if a barometric setting is set, MCP altitude above transition altitude, and airplane climbs 300 feet above transition altitude, or if STD is selected, MCP altitude below transition flight level, and airplane descends 300 feet below transition flight level.

2 Barometric Reference

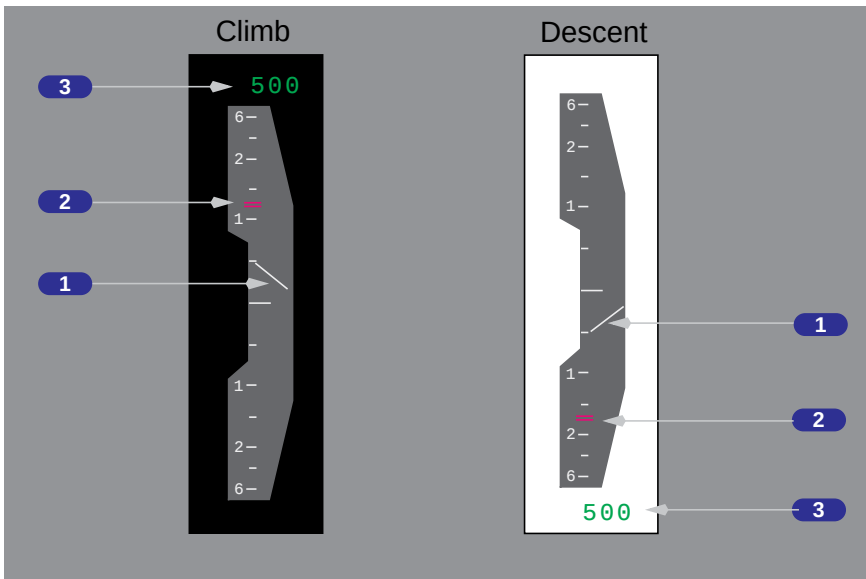
Displays barometric units selected on EFIS control panel barometric reference selector:

- IN - inches of mercury
- HPA - Hectopascals

3 Preset Barometric Setting

When STD is displayed, a preset barometric setting can be set using the barometric selector on EFIS control panel. Active pressure setting is green; preset (inactive) pressure setting is white.

Vertical Speed Indications



1 Vertical Speed Pointer

Indicates ADC vertical speed as dampened by the IRS. Not displayed and vertical flag is displayed if respective IRS fails.

2 Selected Vertical Speed Pointer

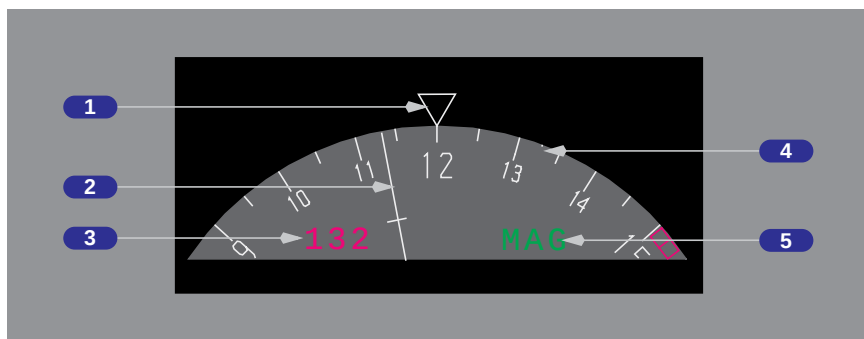
Indicates vertical speed set in MCP vertical speed window with V/S pitch mode active.

3 Vertical Speed

Displays IRS vertical speed when greater than 400 feet per minute.

Display is above the vertical speed display when climbing and below when descending.

Heading/Track Displays



1 Heading Pointer

Indicates IRS heading.

2 Track Indicator

Indicates airplane track from selected FMC or selected IRU if FMC data invalid.

3 Selected Heading (MCP selection)

Displays heading set in heading window. If selected heading exceeds display range, the bug parks on the side of the compass rose in the direction of the shorter turn to the heading.

4 Selected Heading Indicator

Indicates heading set in heading window.

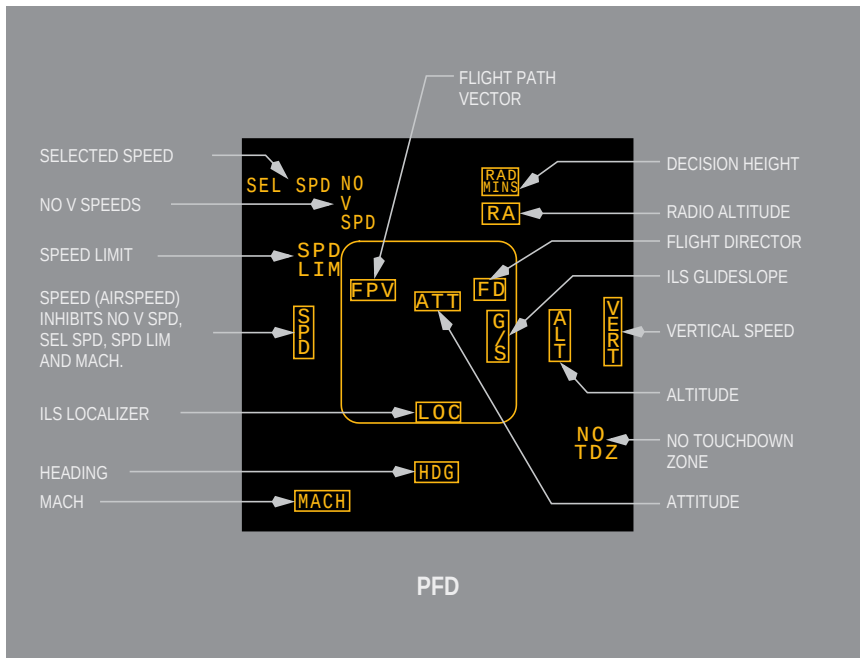
5 Heading Reference

Displays selected heading reference:

- MAG - magnetic north
- TRU - true north, boxed for emphasis

PFD Failure Flags

Note: PFD failure flags replace the appropriate display to indicate source system failure, or lack of computed information.

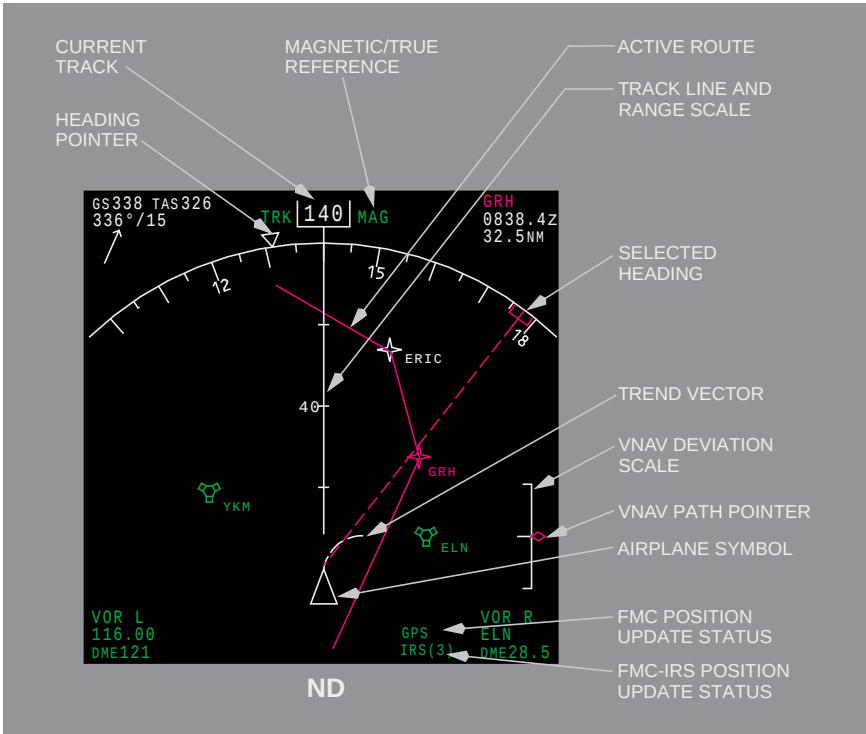


Navigation Display (ND)

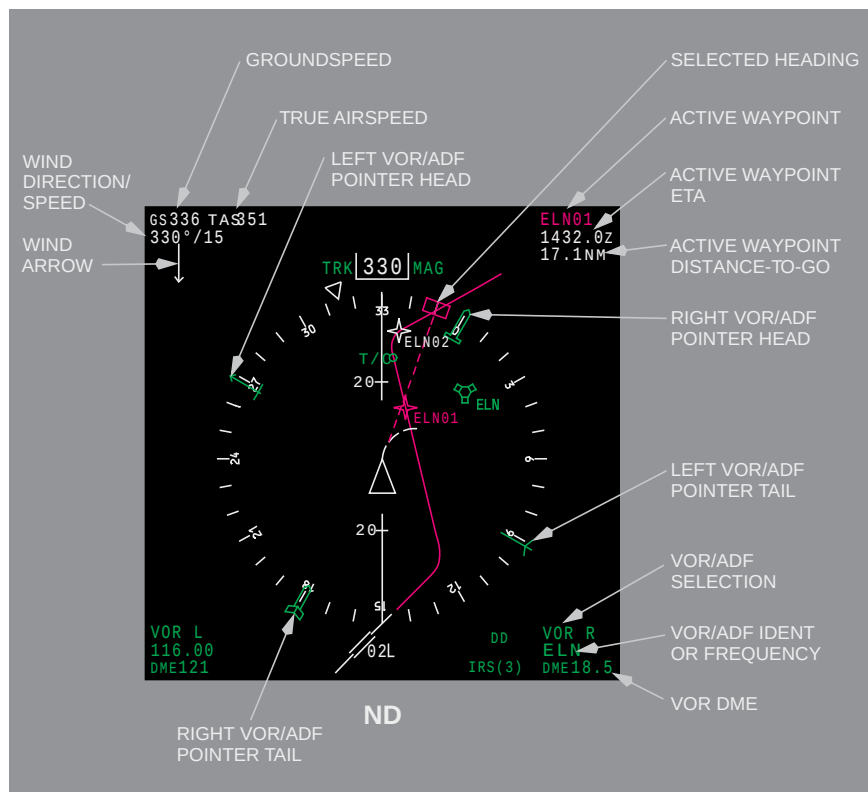
Note: Refer to Navigation Display section of this chapter for a detailed explanation of ND symbology shown on the following pages.

Map Mode

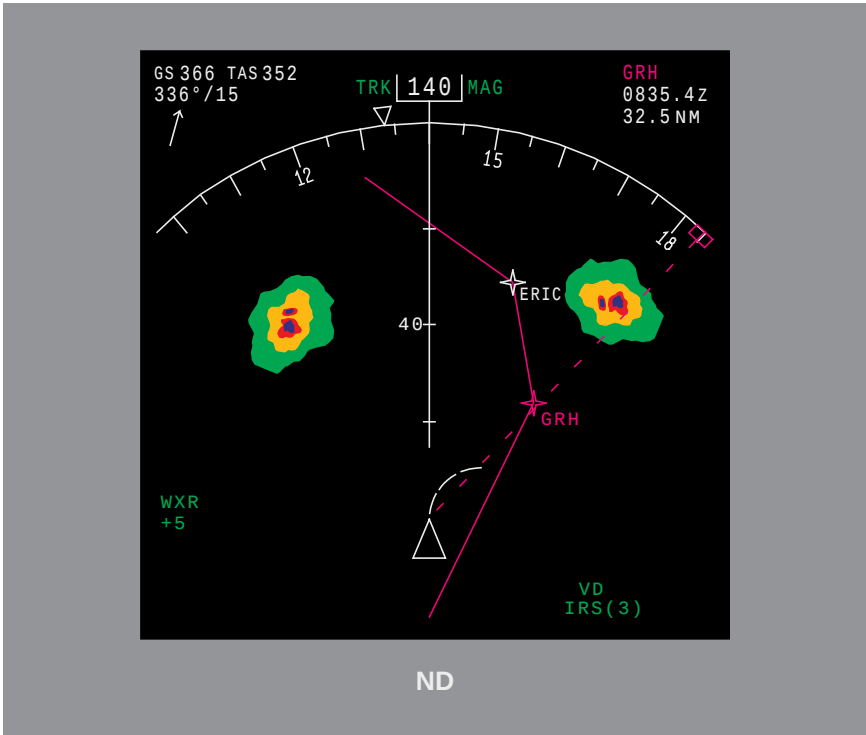
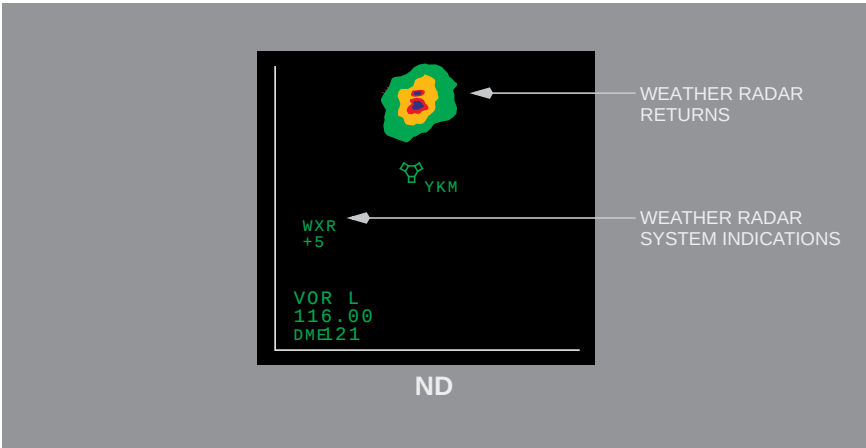
Expanded Map Mode



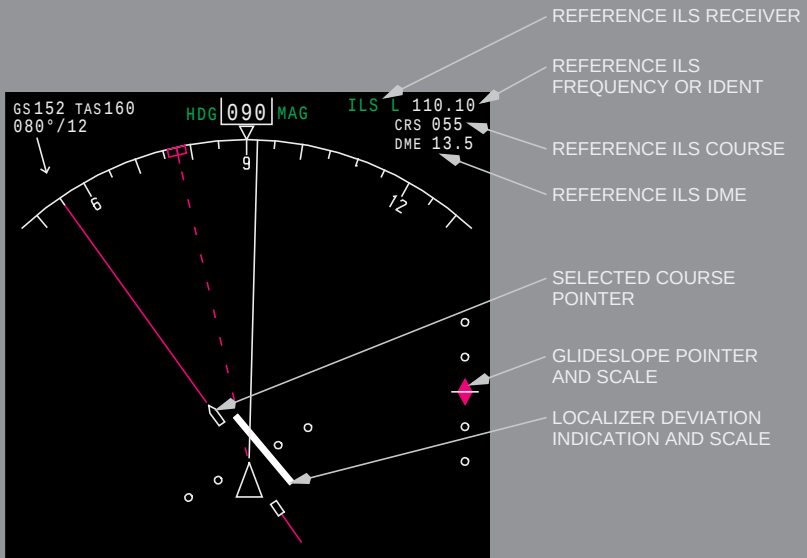
Centered Map Mode



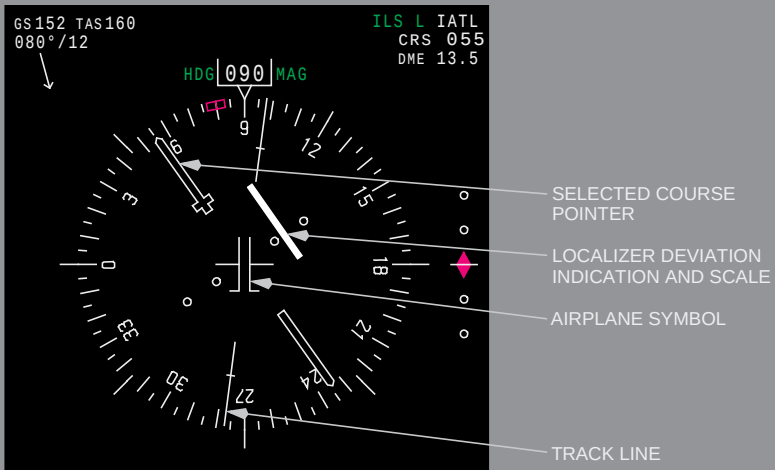
Weather Radar System Display Indications



Approach Mode

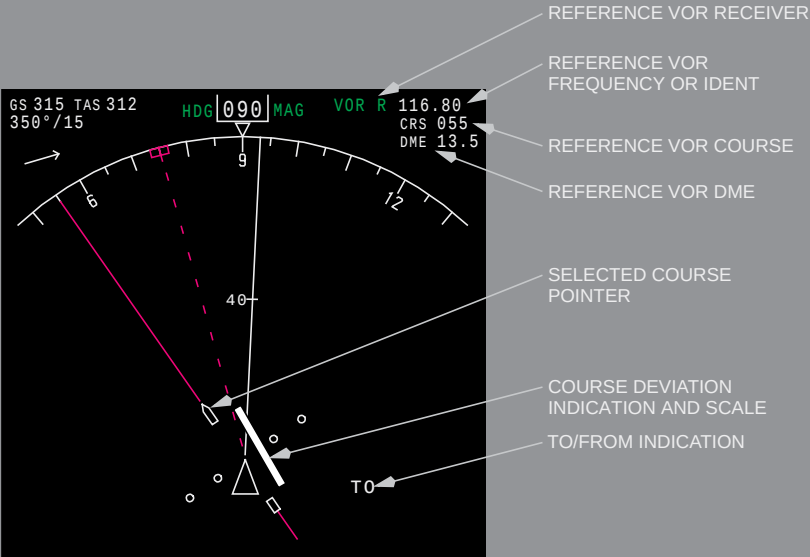


**ND
EXPANDED APPROACH MODE**

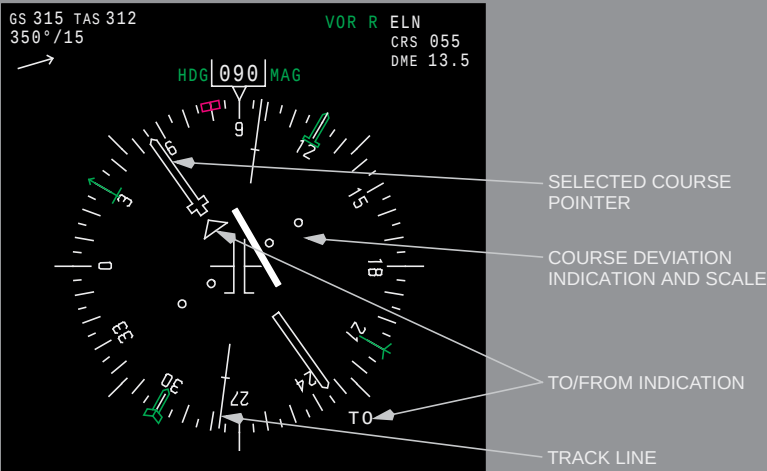


CENTERED APPROACH MODE

VOR Mode

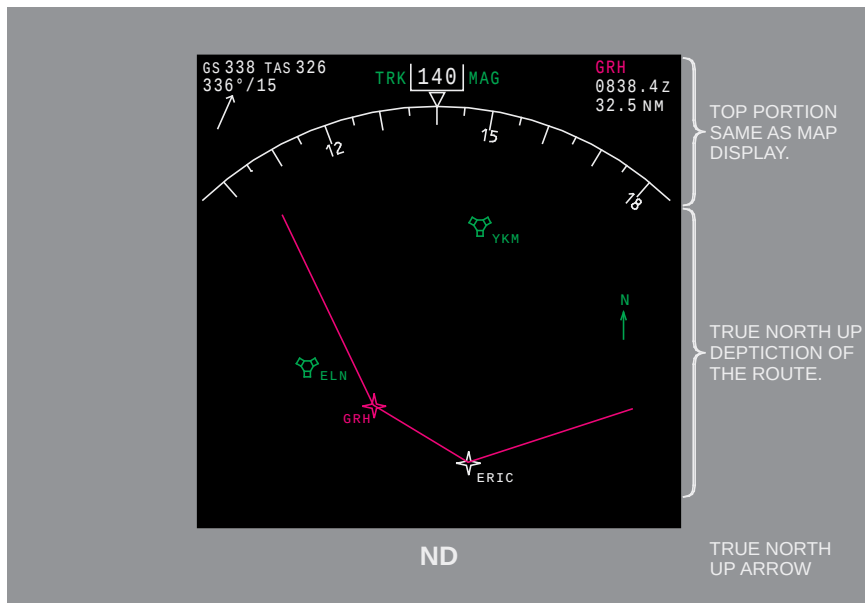


ND
EXPANDED VOR MODE



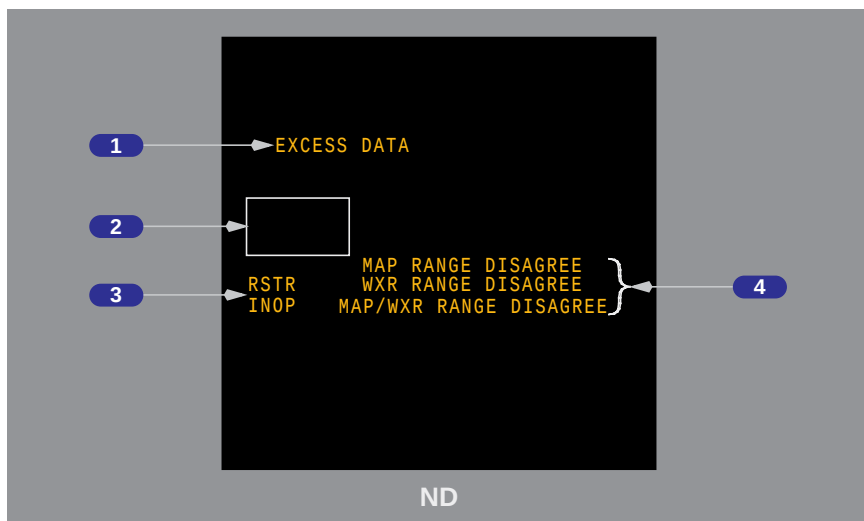
CENTERED VOR MODE

Plan Mode



ND Failure Indications and Flags

Failure Messages



1 Excess Data

Amount of map information sent to the primary display system is too great to display. Deselecting EFIS WXR, STA, WPT, ARPT, DATA, or POS switches may clear the condition.

2 Weather Radar Failure

Displays weather radar failure messages (refer to section 40, this chapter).

3 Raster Inoperative (RSTR INOP)

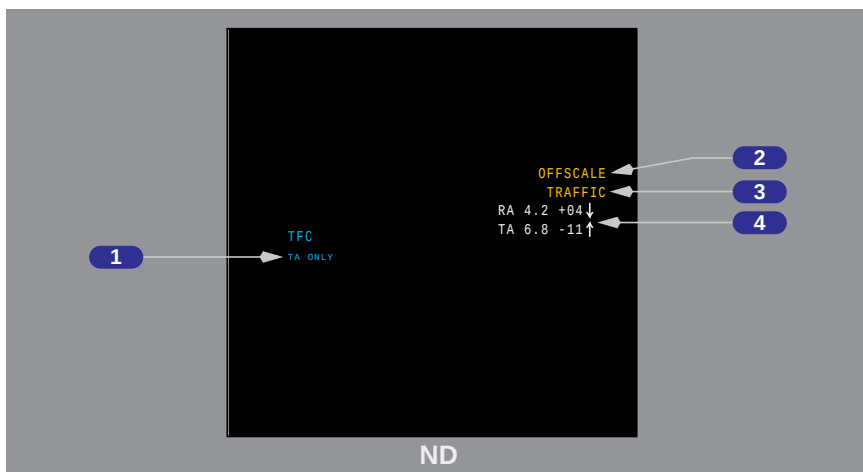
Displays overheat condition.

4 MAP/WXR Range Disagree

Selected range and range of display information disagree.

Map information is removed.

TCAS Messages



1 TCAS Mode Display

TCAS modes displayed -

TFC (blue) - traffic selected for display on ND from EFIS control panel in MAP, MAP CTR, VOR, and APP ND modes.

TCAS TEST (blue) - TCAS in test mode and displayed in all ND modes.

TCAS FAIL (amber) - TCAS failed and displayed in MAP, MAP CTR, VOR, and APP ND modes with TFC selected.

TA ONLY (blue) - TCAS TA ONLY mode selected; displayed in all ND modes.

TCAS OFF (amber) - TCAS selected off and displayed in MAP, MAP CTR, VOR, and APP ND modes with TFC selected.

2 Offscale

TA (amber) or RA (red) traffic beyond ND display range.

Displayed in MAP, MAP CTR, VOR, and APP ND modes with TFC selected.

3 Traffic

Displayed during a TA (amber) or RA (red) condition.

Displayed in all ND modes.

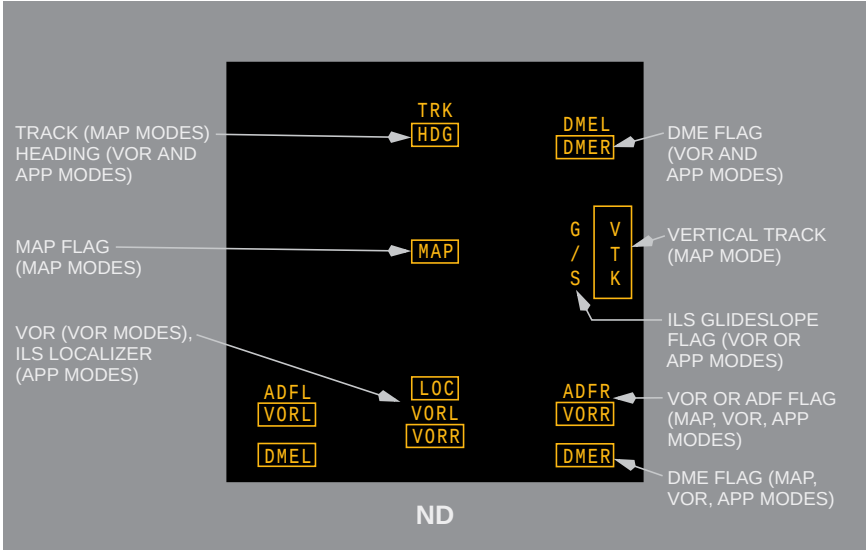
4 No Bearing Traffic Messages

Displayed when no bearing information is available for traffic (see ND symbology chart for display).

Displayed in MAP, MAP CTR, VOR, and APP ND modes with TFC selected.

Failure Flags

Dashes replace numbers if there is no computed information. Failure flags replace symbols, or failure messages are displayed, as appropriate. Flag location varies, depending on ND mode selected. Expanded compass rose locations are shown in the following displays.

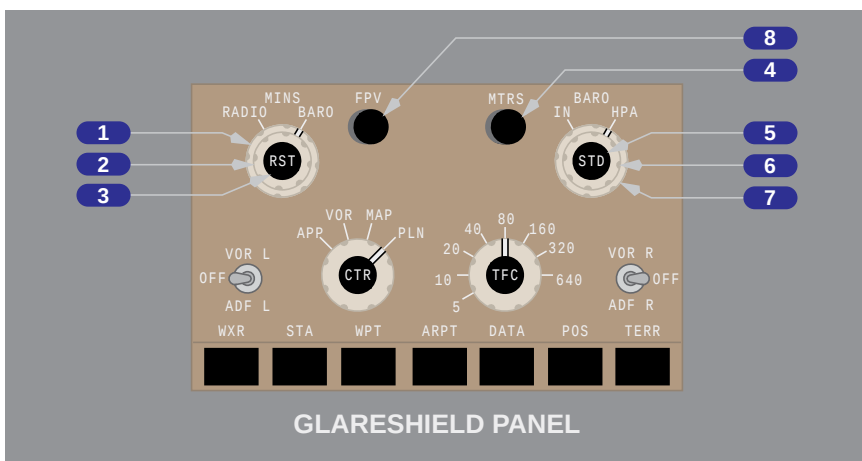


EFIS Control Panels

The left EFIS control panel controls the left PFD and ND. The right EFIS control panel controls the right PFD and ND.

If an EFIS control panel fails, displays are controlled through the related CDU.

Control Panel PFD Controls



1 Minimums (MINS) Selector (outer)

RADIO - selects radio altitude for display on the PFD.

BARO - selects barometric altitude for display on the PFD.

2 RADIO Altitude/Barometric (BARO) Altitude Control (middle)

Rotate -

- when RADIO selected, sets a radio altitude reference in RADIO display in one foot increments
- when BARO selected, sets a barometric altitude reference in BARO display, in one foot increments. BARO pointer indicates the same altitude on the altitude display

3 Minimums Reset (MINS RST) Switch (inner)

Push - resets PFD flashing amber RADIO.

4 Meters (MTRS) Switch

Push - displays PFD altitude meters indications.

5 Barometric Standard (BARO STD) Switch (inner)

Push -

- selects standard barometric setting (29.92 inches Hg/1013 HPA) for PFD barometric reference
- when STD displayed, selects preselected barometric setting
- if no preselected barometric setting displayed, displays the last value before STD was selected

6 Barometric (BARO) Selector (middle)

Rotate -

- adjusts PFD barometric reference
- preselects PFD barometric reference

7 Barometric (BARO) Reference Selector (outer)

IN - selects inches of mercury as PFD barometric reference.

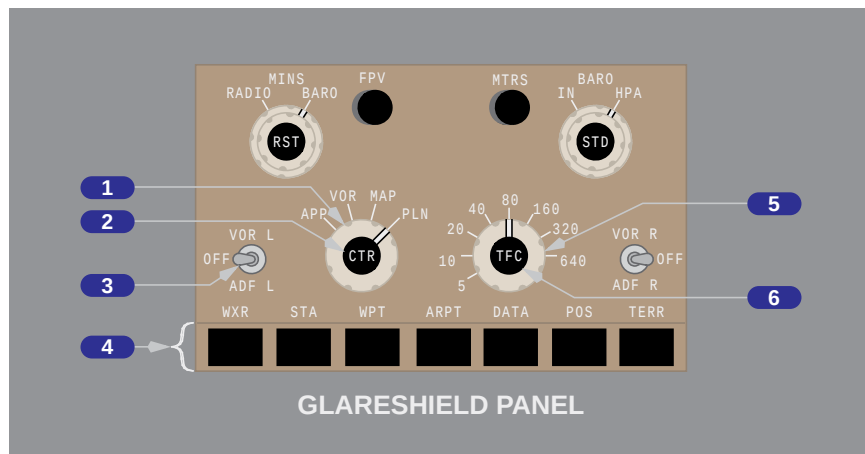
HPA - selects Hectopascals as PFD barometric reference.

8 Flight Path Vector (FPV) Switch

Not used at Delta Air Lines

Push - displays PFD flight path vector.

Control Panel ND Controls



1 ND Mode Selector (outer)

Selects desired ND display.

APP -

- displays localizer and glideslope information in heading-up format
- displays reference ILS receiver, ILS frequency or identification, course, and DME
- look-ahead terrain, weather radar, and TCAS are not displayed in APP CTR mode

VOR -

- displays VOR navigation information in heading-up format
- displays reference VOR receiver, VOR frequency or identification, course, DME, and TO/FROM indication
- look-ahead terrain, weather radar, and TCAS are not displayed in VOR CTR mode

MAP -

- displays track up, full compass rose, FMC-generated route and map information, airplane position, heading, and track
- displays active waypoint data
- displays vertical path deviation at T/D

PLN -

- displays a non-moving, true north-up, route depiction
- airplane symbol represents actual airplane position
- allows route step-through using CDU legs page
- look-ahead terrain, weather radar, and TCAS are not displayed in PLN mode

2 ND Center (CTR) Switch (inner)

Push -

- displays full compass rose (centered) for APP, VOR, and MAP modes
- subsequent pushes alternate between expanded and centered displays

3 VOR/ADF Switches

Display VOR or ADF information on the respective ND.

VOR - displays VOR pointer, VOR frequency or identification and associated DME information in all modes except PLAN.

OFF - removes VOR and ADF displays.

ADF - displays ADF pointer and frequency or identification in all modes except PLAN.

4 WXR, STA, WPT, ARPT, DATA, POS, TERR Switches

The switches:

- select detailed ND information displays
- displays can be selected simultaneously
- EXCESS DATA message displays on ND if amount of data selected is more than can be displayed
- second push removes information

WXR (weather radar) -

- powers radar transceiver selected on weather radar control panel
- displays in MAP, MAP CTR, VOR, and APP modes
- displays weather radar information (refer to Chapter 11, Flight Management, Navigation)
- with WXR FAIL displayed on ND, cancels WXR FAIL message
6311 - 6316
- not available with 5 NM range selected

STA (station) - MAP modes:

- displays high and low altitude navigation aids when ND Range selector is in 5, 10, 20, or 40 NM range
- displays high altitude navigation aids when ND Range selector is in 80, 160, 320, or 640 NM range

WPT (waypoint) - MAP modes, displays waypoints when ND Range selector is in the 5, 10, 20, or 40 NM range.

ARPT (airport) - MAP modes, displays airports on all ranges.

DATA - in PLAN, MAP modes, displays FMC estimated time of arrival, altitude at each waypoint, and altitude constraints at each waypoint.

POS (position) - MAP modes:

- displays VOR raw data radials extended from the nose of the airplane to the VOR stations displayed on the CDU NAV RAD page. When co-located DME data received, tick mark displayed at DME distance; radial extends to edge of display if no valid DME data received
- displays IRU and GPS positions

TERR (terrain) - GPWS look-ahead terrain mode is described in Chapter 15, Warning Systems.

5 ND Range Selector (outer)

Selects desired ND nautical mile range scale.

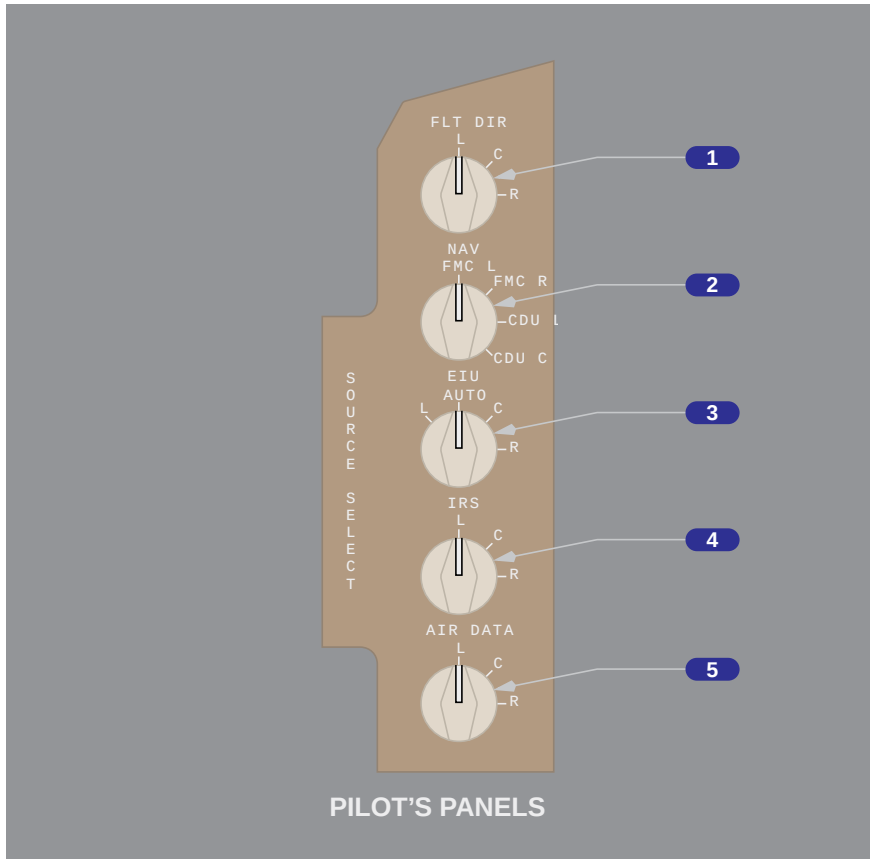
6 ND Traffic (TFC) Switch (inner)

Push - in VOR, APP, MAP, and MAP CTR modes:

- enables TCAS traffic display (Refer to Chapter 15, Warning Systems)
- with TCAS FAIL displayed on ND, cancels TCAS FAIL message.

Instrument Source Select Panels

The left panel is shown.



1 Flight Director (FLT DIR) Source Selector

L - left FCC selected

C - center FCC selected

R - right FCC selected

2 Navigation (NAV) Source Selector

FMC L - left FMC provides information to PFD and ND.

FMC R - right FMC provides information to PFD and ND.

CDU L (Captain's panel) - left CDU provides information to ND during alternate navigation.

CDU C - center CDU provides information to ND during alternate navigation.

CDU R (F/O's panel) - right CDU provides information to ND during alternate navigation.

3 EFIS/EICAS Interface Unit (EIU) Source Selector

L - left EIU provides information to PFD and ND.

AUTO - selects operable EIU. Captain's selects left, then center, then right; F/O's selects right, then center, then left.

C - center EIU provides information to PFD and ND.

R - right EIU provides information to PFD and ND.

Determines which localizer and glideslope receivers provide information to the respective PFD and ND.

4 IRS Source Selector

L - left IRU provides attitude and vertical speed information to PFD.

C - center IRU provides attitude and vertical speed information to PFD.

R - right IRU provides attitude and vertical speed information to PFD.

Source for heading, wind direction and speed, slip/skid, track angle, drift angle, and ground speed displayed on PFD and ND depends on the status of the FMCs, IRUs, and position of the Navigation and IRS source selectors.

IRU selected by Captain provides autobrake reference. IRU selected by F/O provides RMI reference.

5 AIR DATA Source Selector

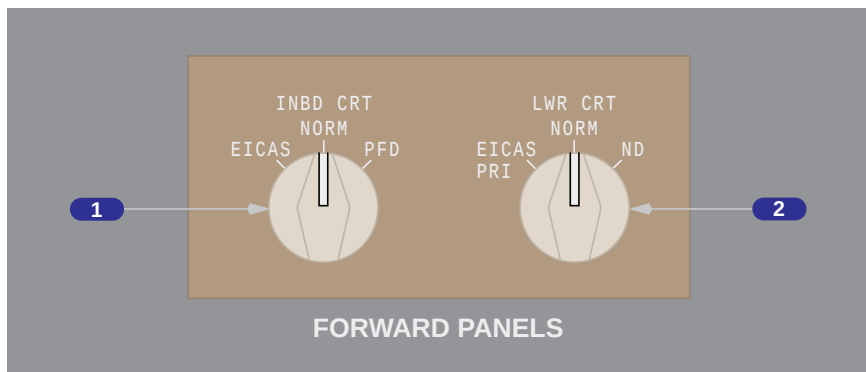
L - left ADC provides information to the PFD and ND.

C - center ADC provides information to the PFD and ND.

R - right ADC provides information to the PFD and ND.

Heading Reference, Inboard and Lower Displays

Inboard and Lower Display Controls



1 Inboard (INBD) Display Selector

EICAS - displays secondary or primary EICAS display on inboard unit.

NORM - displays ND on inboard display unit. Displays PFD if outboard display unit fails.

PFD - displays PFD on inboard display unit.

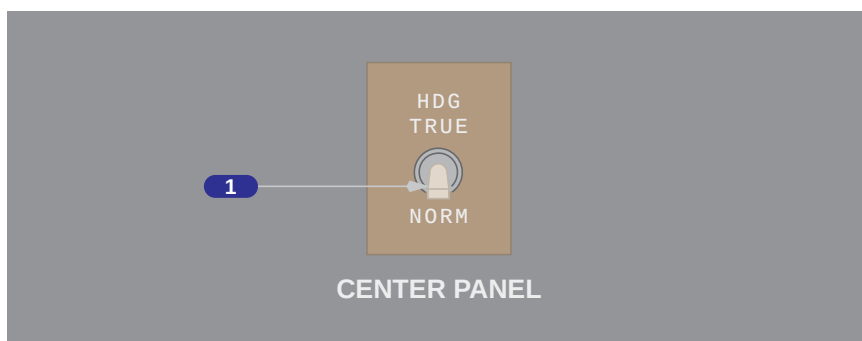
2 Lower (LWR) Display Selector

EICAS PRI - displays primary EICAS on lower display unit.

NORM - displays on lower display unit as selected on EICAS display select panel. Displays primary EICAS if upper display unit fails.

ND - displays ND on lower display unit.

Heading Reference Switch



1 Heading (HDG) Reference Switch

Selects heading reference for PFDs, NDs, AFDS, FMCs and RMI.

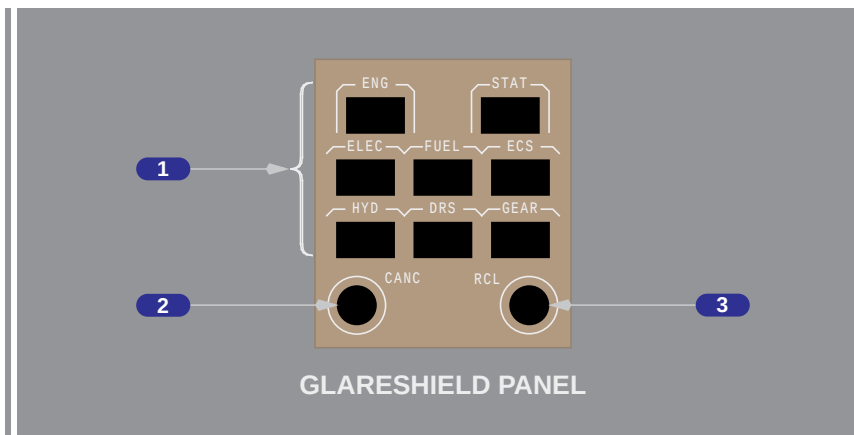
TRUE - references true north.

NORM -

- references magnetic north
- references true north when north of 82°N latitude (or north of 70°N between 80°W and 130°W) or south of 82°S latitude (or south of 60°S between 120°E and 160°E) for PFDs, NDs, and FMCs. Provides no reference for RMI and AFDS roll modes other than LNAV in these areas; HDG SEL, HDG HOLD, and localizer modes are inoperative.

When AFDS roll mode is HDG SEL, switching the Heading Reference switch from NORM to TRUE or TRUE to NORM activates HDG HOLD mode.

Display Select Panel



1 Display Switches

Pushing a switch displays the related synoptic/display on the lower display unit. Pushing the same switch a second time blanks the display. Pushing STAT pages through more than one page of status messages. Synoptics present a simplified view of system status as an aid for crew situational awareness.

If the display select panel fails, displays are controlled through the CDU.

ENG - secondary engine display (Ch 7).

STAT - status display, (Ch. 15).

ELEC - electrical system synoptic (Ch. 6).

FUEL - fuel quantity indications and fuel system synoptic (Ch. 12).

ECS - air systems synoptic (Ch. 2).

HYD - hydraulic system synoptic (Ch. 13).

DRS - doors synoptic (Ch. 1).

GEAR - landing gear and brake systems synoptic (Ch. 14).

2 Cancel (CANC) Switch

Refer to Warning Systems, Chapter 15.

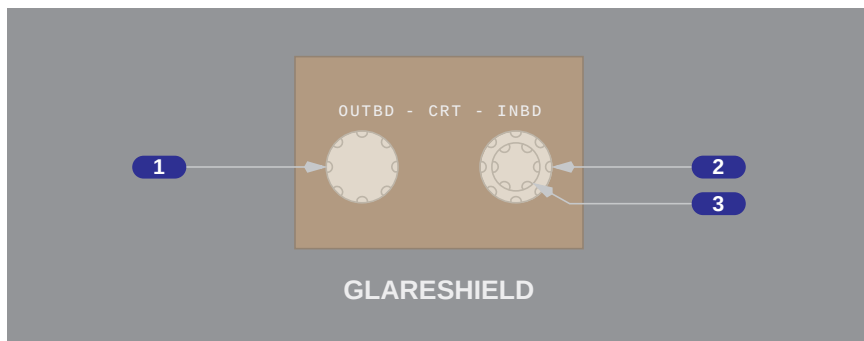
3 Recall (RCL) Switch

Refer to Warning Systems, Chapter 15.

Display Brightness Controls

The left panel is shown.

Outboard/Inboard Display Brightness Controls



1 Outboard (OUTBD) Display Brightness Control

Rotate - adjusts brightness of outboard display.

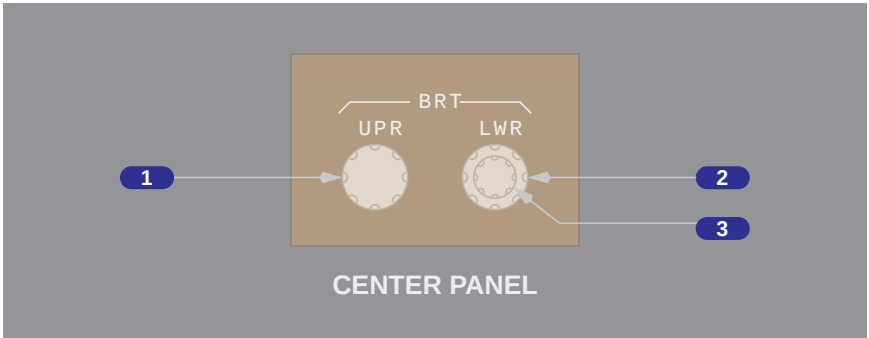
2 Inboard (INBD) Display Brightness Control (outer)

Rotate - adjusts brightness of inboard display.

3 Inboard (INBD) Display Brightness Control (inner)

Rotate - adjusts weather radar or terrain display brightness on inboard display.

Upper/Lower Display Brightness Controls



1 Upper (UPR) Display Brightness Control

Rotate - adjusts brightness of upper display.

2 Lower (LWR) Display Brightness Control (outer)

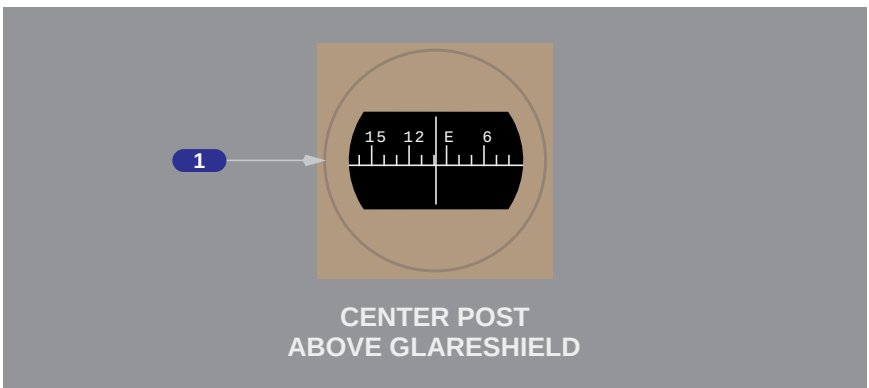
Rotate - adjusts brightness of lower display.

3 Lower (LWR) Display Brightness Control (inner)

Rotate - adjusts weather radar or terrain display brightness on lower display.

Standby Flight Instruments

Standby Magnetic Compass

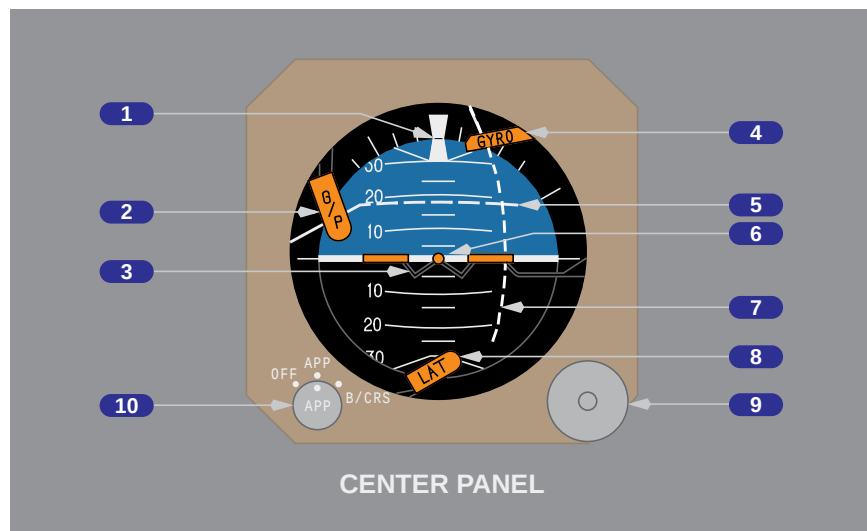


1 Standby Magnetic Compass

Displays magnetic heading.

Standby Attitude Indicator

Standby attitude indicator provides an independent source of airplane attitude.



1 Bank Indicator and Scale

Indicates airplane bank.

Scale marks at 0, 10, 20, 30, 45, 60 degrees.

2 Glide Path (G/P) Flag

Displays when glide slope information unreliable.

3 Airplane Symbol

Indicates airplane position.

4 Attitude (GYRO) Flag

Displays when attitude information unreliable.

5 Glide Slope Indicator

Indicates glide slope position relative to the airplane.

6 Horizon Line and Pitch Scale

Indicates position of horizon relative to the airplane.

Scale marks in five degree increments.

7 Localizer Indicator

Indicates localizer position relative to the airplane.

8 Localizer (LAT) Flag

Displays when localizer information unreliable.

9 Caging Control

Pull - levels horizon with airplane symbol.

10 Approach Selector

OFF - glide slope and localizer indicators and flags retracted from view.

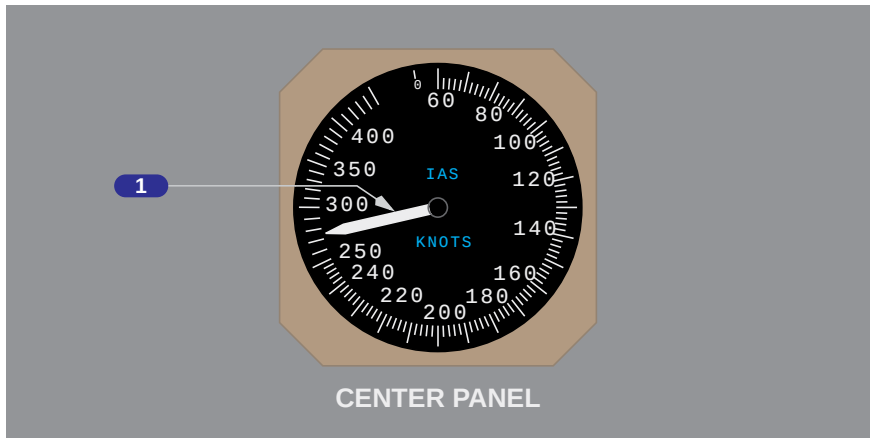
APP (Approach) - glide slope and localizer information displayed. Left ILS receiver used.

B/CRS (Back Course) - **Not Used At Delta Air Lines**

- reverses sensing for localizer information

Standby Airspeed Indicator

Standby airspeed indicator displays airspeed from auxiliary pitot 1 and alternate static source.

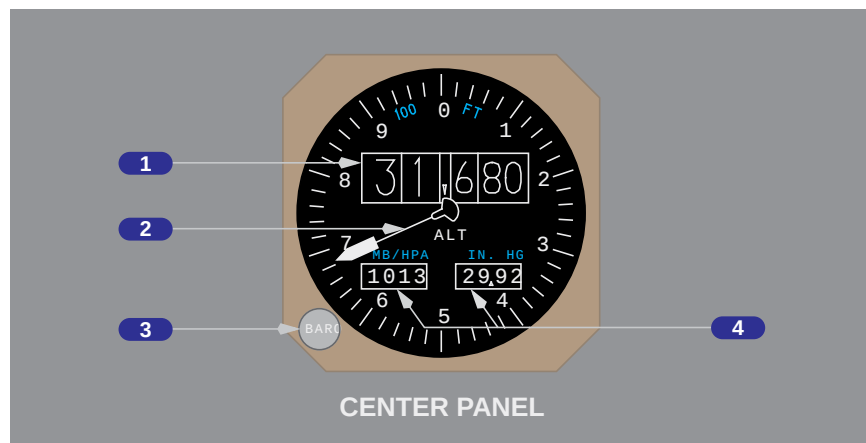


1 Airspeed Pointer

Indicates uncorrected airspeed.

Standby Altimeter

Standby altimeter displays barometric altitude from alternate static source.



1 Altitude Display

Displays uncorrected barometric altitude.

2 Altitude Pointer

Indicates uncorrected barometric altitude.

One full rotation of pointer is 1,000 feet.

3 Barometric Setting Control

Rotate - sets altimeter barometric setting.

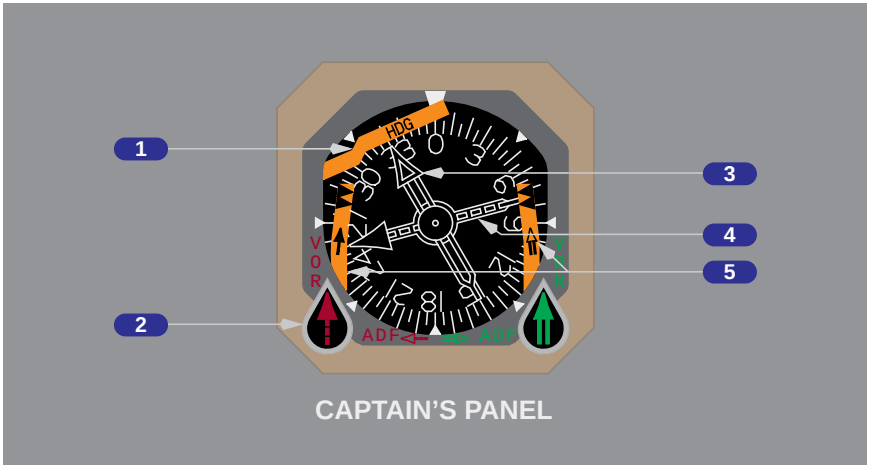
4 Barometric Setting Display

Displays selected barometric reference in Hectopascals (MB/HPA) and inches (IN. HG).

Radio Magnetic Indicator

Radio magnetic indicator displays heading and VOR and ADF bearing to the selected station.

Heading information is provided by the right or center IRU as selected by the F/O IRS source selector.



1 Heading (HDG) Flag

Displays when heading invalid.

2 VOR/ADF Selectors

VOR - VOR information provided to related pointer.

ADF - ADF information provided to related pointer.

3 Wide Pointer

Indicates right VOR or ADF bearing to selected station.

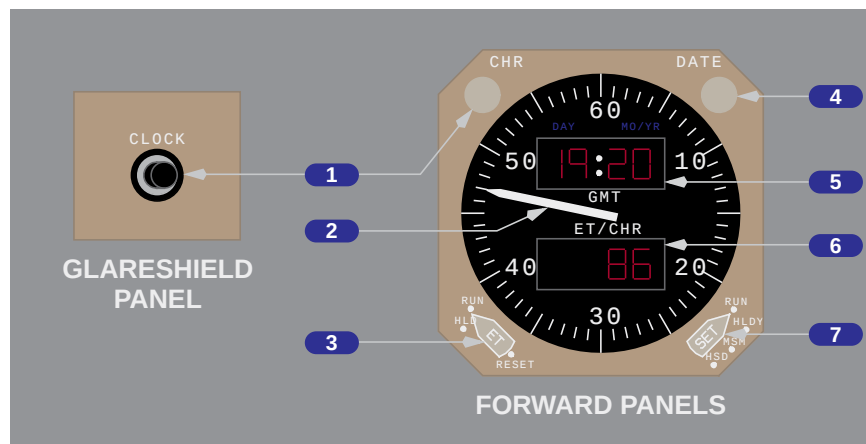
4 Narrow Pointer

Indicates left VOR or ADF bearing to selected station.

5 Pointer Flags

Display when selected information invalid.

Clock



1 Chronograph (CHR or CLOCK) Switch

Push - subsequent pushing starts, stops, resets the chronograph.

2 Chronograph Pointer

Indicates chronograph seconds.

3 Elapsed Time (ET) Selector

Controls elapsed time function.

RESET - returns elapsed time display to zero (spring loaded to HLD).

HLD (Hold) - stops elapsed time display.

RUN - starts elapsed time display.

4 DATE Switch

Push -

- displays date (alternates day and month, then year) on GMT display
- subsequent push returns display to time (hours, minutes) on GMT display.

5 GMT Display

Displays time (hours, minutes).

Displays date when date switch pushed.

6 Elapsed Time (ET)/Chronograph (CHR) Display

Displays elapsed time (hours, minutes) or chronograph minutes.

Chronograph display replaces elapsed time display.

Elapsed time continues to run in the background and will be displayed after chronograph is reset.

7 Clock Set Selector

Sets time and date.

Hours Slew, Day (HS D) -

- advances hours when time selected on time/date selector
- advances days when date selected on time/date selector

Minutes Slew, Month (MS M) -

- advances minutes when time selected on time/date selector
- advances months when date selected on time/date selector

Hold, Year (HLD Y) -

- stops time indicator and sets seconds to zero when time selected on time/date selector
- advances years when date selected on time/date selector

RUN - starts time indicator.

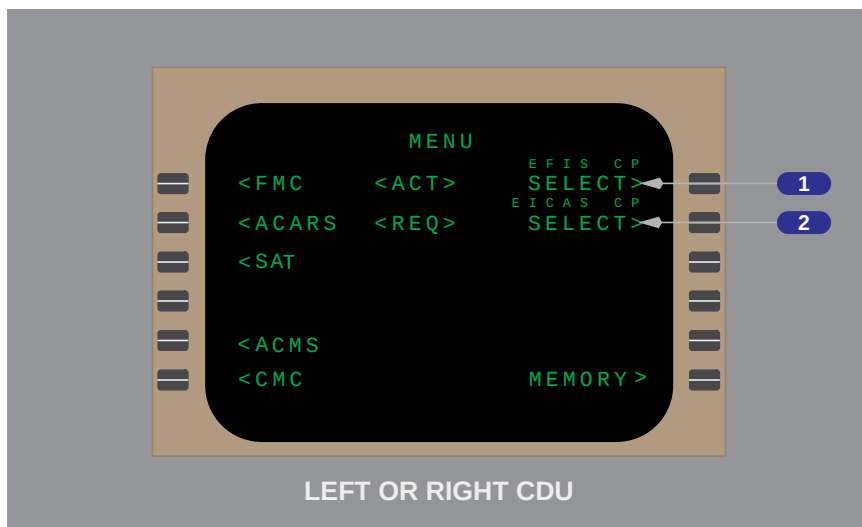
EFIS Control Panel and Display Select Panel (DSP) - CDU Alternate Control

The CDU provides an alternate way to control the functions of the EFIS control panel and the display select panel except for TCAS and GPWS if the panel fails (CDU-150 and -152).

The CDU provides an alternate way to control the functions of the EFIS control panel and the display select panel (CDU-161).

Note: The control callouts on the following pages correspond to the control names on the EFIS control panels and the display select panel. Explanations of the CDU functions are the same as on the related control panels except where described.

CDU EFIS/DSP Control Selection (CDU-152)



1 Alternate EFIS Control

Push -

- displays alternate EFIS control page
- available if EFIS control panel fails

2 Alternate EICAS Control

Push -

- displays alternate EICAS control page
- available if EICAS control panel fails

CDU EFIS/DSP Control Selection (CDU-161)



1 Alternate EFIS Control

Push - (with SELECT displayed) displays alternate EFIS CONTROL page.

SELECT is displayed when the control panel (CTL PNL) prompt is selected ON or there is a failure of the associated control panel. The line title EFIS CP remains when the SELECT prompt is removed.

2 Alternate EICAS Control

Push - (with SELECT displayed) displays alternate EICAS CONTROL page.

SELECT is displayed when the control panel (CTL PNL) prompt is selected ON or there is a failure of the control panel. The line title EICAS CP remains when the SELECT prompt is removed.

3 Control Panel Switch

Push - alternately selects the EFIS and EICAS CP SELECT prompts ON and OFF. ON is displayed if the associated control panel fails. The selected mode (ON or OFF) is displayed in large font. The SELECT prompts are blank when OFF is displayed in large font.

EFIS Control Page (CDU-152)



1 Barometric (BARO SET) Reference

Valid entry is reference barometric setting.

Entry of S or STD displays 29.92 IN or 1013 HPA on BARO SET line and displays STD on the PFD.

2 Decision Height (DH SET)

Valid entry is decision height.

3 Decision Height Reset (DH RESET)

Push - resets PFD flashing amber DH.

4 Minimum Descent Altitude

Valid entry is minimum descent altitude.

5 ND Range Increase (RANGE INCR)

Push - increases ND nautical mile range scale.

6 ND Range Decrease (RANGE DECR)

Push - decreases ND nautical mile range scale.

7 ND Mode

Push - selects desired ND display.

8 ND Center (CTR)

Push - alternately displays centered and expanded APP, VOR, and MAP modes.

9 EFIS OPTIONS

Push - displays EFIS OPTIONS page.

EFIS Control Page (CDU-161)



1 Barometric (BARO SET) Reference

Valid entry is reference barometric setting.

- entries of 22.00 to 32.00 or 2200 to 3200 display as inches of Hg
- entries of 745 to 1084 display as hecto pascals
- entry of "I" to change the displayed value to inches Hg
- entry of "H" to change the displayed value to hPa
- entry of "S" or "STD" displays 29.92 IN or 1013 HPA (depending on units being displayed on BARO SET line) and displays STD on the PFD.

2 Radio (RAD) or Barometric (BARO) select (SEL)

- Push - alternately selects radio altimeter (RAD) or barometric altimeter (BARO) as the minimums reference on the PFD. Selected mode displays in large font.

3 Minimums (MINS) SET

- Entered minimums display on respective PFD.
- BARO selected in 2L, valid entries are -1001 to 15000 feet.
- RAD selected in 2L, valid entries are -20 to 999 feet.

4 Minimums (MINS) RESET

Push - resets the minimums alert on the PFD.

5 Range Increase (RANGE INCR)

Push - increases ND nautical mile range scale.

6 Range Decrease (RANGE DECR)

Push - decreases ND nautical mile range scale.

7 Mode

Push - selects desired ND display.

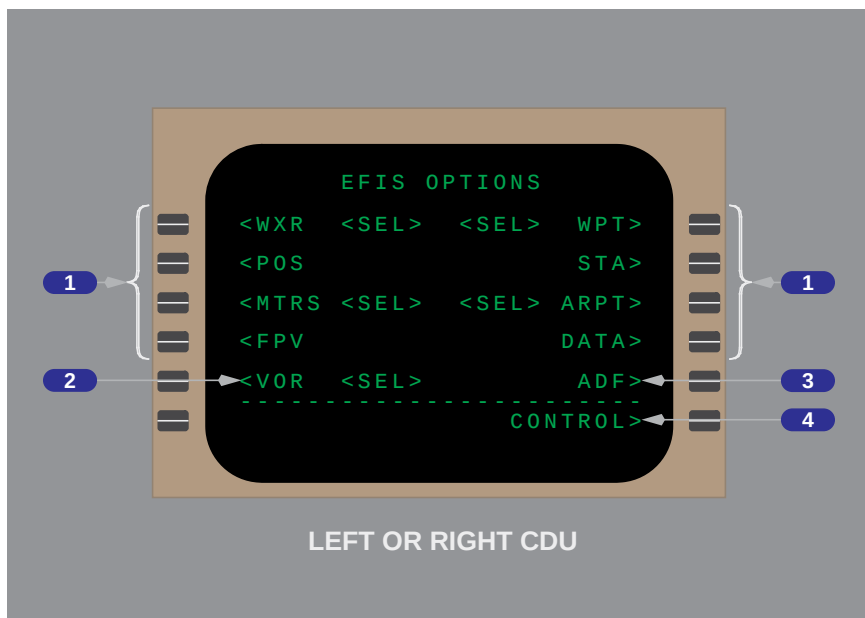
8 Center (CTR)

Push - alternately displays centered and expanded APP, VOR, and MAP modes.

9 OPTIONS

Push - displays EFIS OPTIONS page.

EFIS Options Page (CDU-152)



1 WXR, POS, MTRS, FPV, WPT, STA, ARPT, DATA

Push - select related PFD/ND options.

2 VOR

Push - selects left and right VORs for display on ND and deletes ADFs when previously selected.

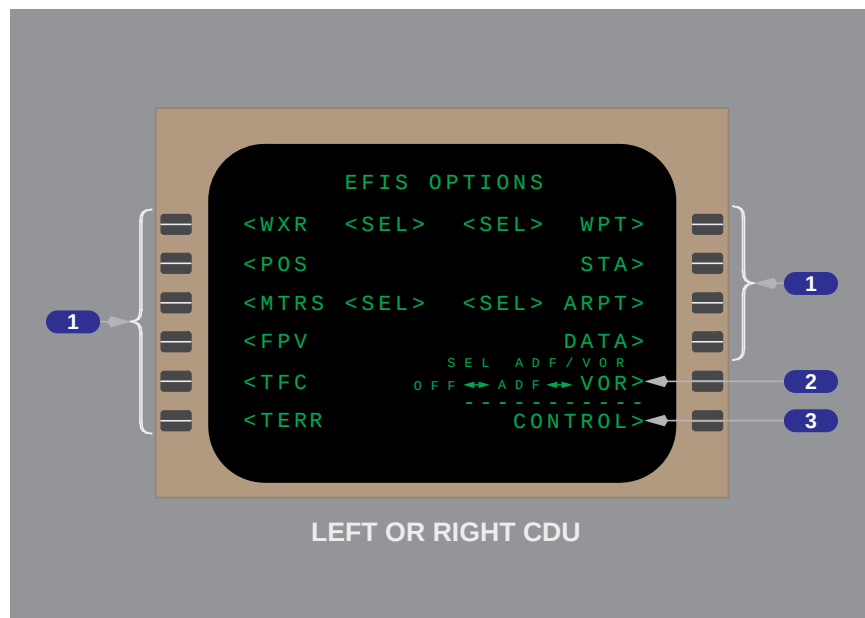
3 ADF

Push - selects left and right ADFs for display on ND and deletes VORs when previously selected.

4 EFIS CONTROL

Push - selects EFIS CONTROL CDU page.

EFIS Options Page (CDU-161)



1 WXR, POS, MTRS, FPV, TFC, TERR, WPT, STA, ARPT, DATA

Push - selects related PFD/ND options.

2 ADF/VOR

Push - sequentially selects ADF, VOR, or OFF for the pointer display on the ND.

ADF - displays the ADF pointers and frequency on the ND in all modes except PLAN.

VOR - displays the VOR pointer, frequency, and associated DME on the ND in all modes except PLAN.

OFF - removes ADF and VOR data from the ND.

3 CONTROL

Push - selects EFIS CONTROL CDU page.

EICAS Modes Page



1 Synoptic/Display

Push - displays respective synoptics/displays.

2 Cancel (CANC)

Refer to Warning Systems, Chapter 15.

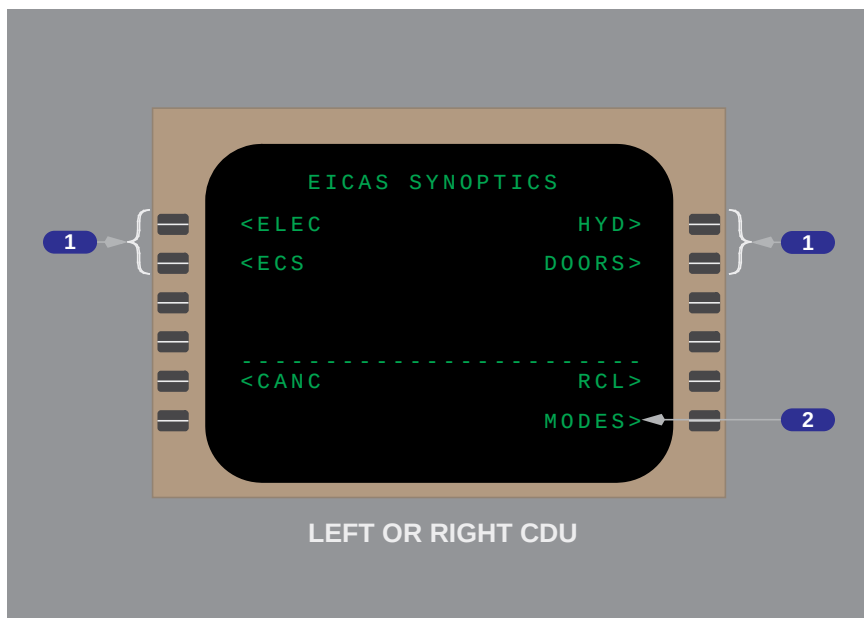
3 Recall (RCL)

Refer to Warning Systems, Chapter 15.

4 EICAS SYNOPTICS

Push - selects EICAS SYNOPTICS page.

EICAS Synoptics Page



1 Synoptic/Display

Push - displays respective synoptics/display.

2 MODES

Push - selects EICAS MODES page.

Flight Instruments, Displays System Description

Chapter 10 Section 20

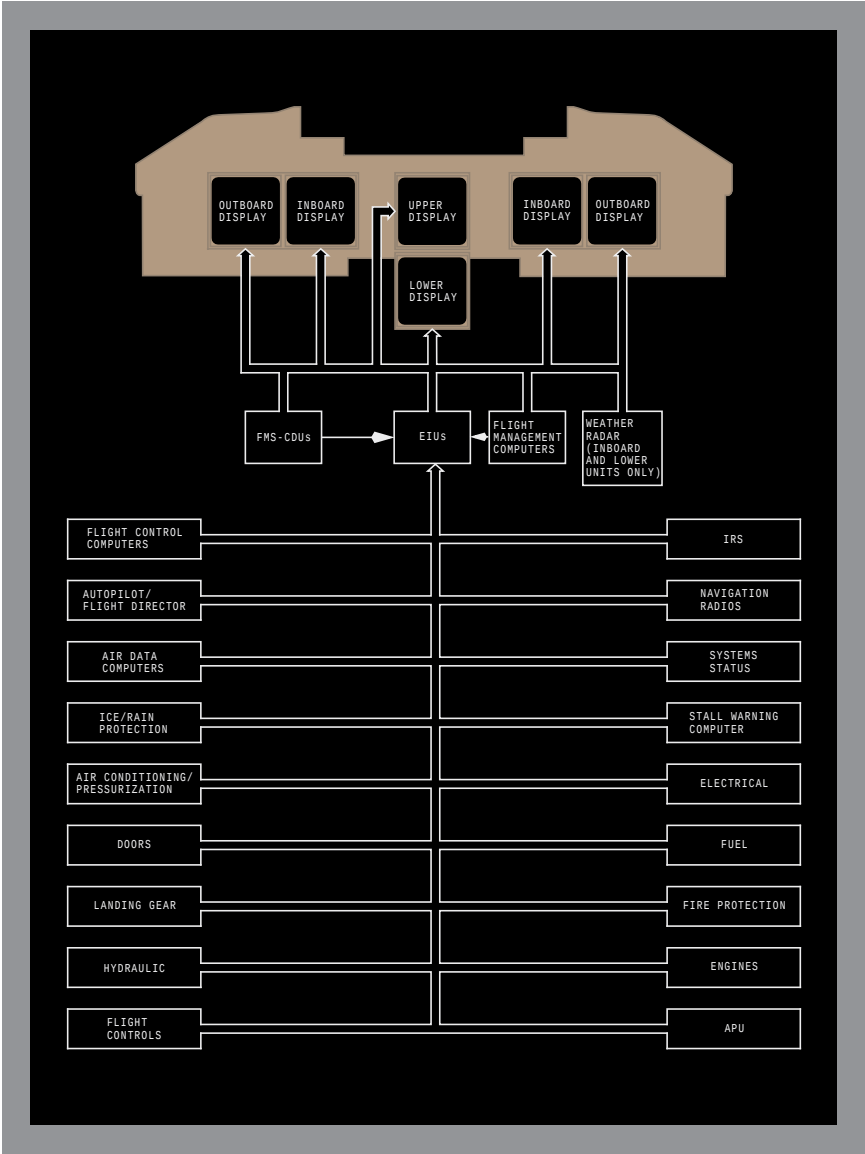
Introduction

The integrated display system consists of three identical EFIS/EICAS interface units (EIUs) which receive airplane systems information. The EIUs supply information to the flight crew on six display units. The units display three primary groups of information:

- primary flight display (PFD)
- navigation display (ND)
- engine indication and crew alerting system (EICAS)

The Electronic Flight Instrument System (EFIS) consists of the PFD and ND. Detailed information on the PFD and ND is found in Sections 30 and 40 of this chapter.

Integrated Display System



Display Selection and Control

During normal operations:

- inboard and lower display selectors are set to NORM
- PFDs display on two outboard display units
- NDs display on two inboard display units
- EICAS displays on upper and lower display units

Instrument Display Source Selection

The information sources for PFDs and NDs are selected with the source selectors. The desired flight director, navigation source, EIU, IRU, and ADC can be selected.

Display Brightness Control

The brightness of each display can be adjusted. The outboard and inboard display brightness controls are on the glareshield. The upper and lower display brightness controls are on the center panel. The inner brightness control for the inboard and lower display units control the weather radar returns.

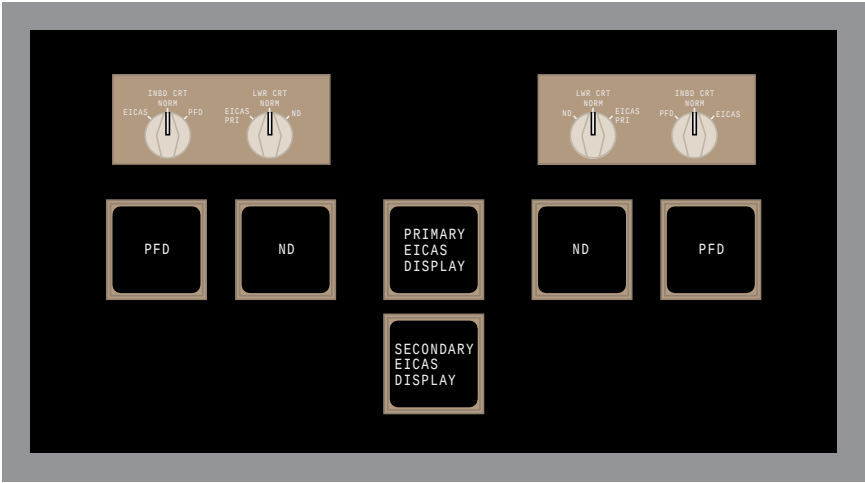
If a display color fails, the display changes color but all indications remain distinguishable and no information is lost.

Light sensors above the glareshield and near each display and CDU measure ambient light level and adjust display brightness to maintain the desired illumination.

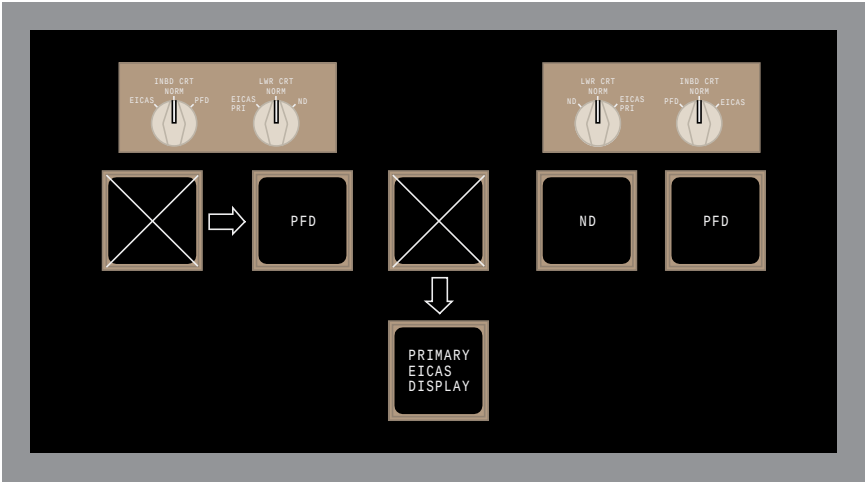
Display Selection and Control Examples

The following examples depict display selections.

Normal Display Configuration

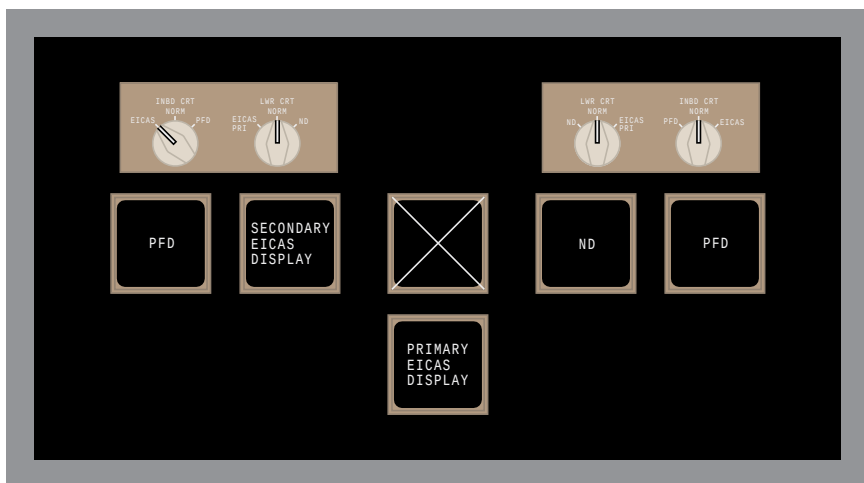


Display Failure Automatic Switching

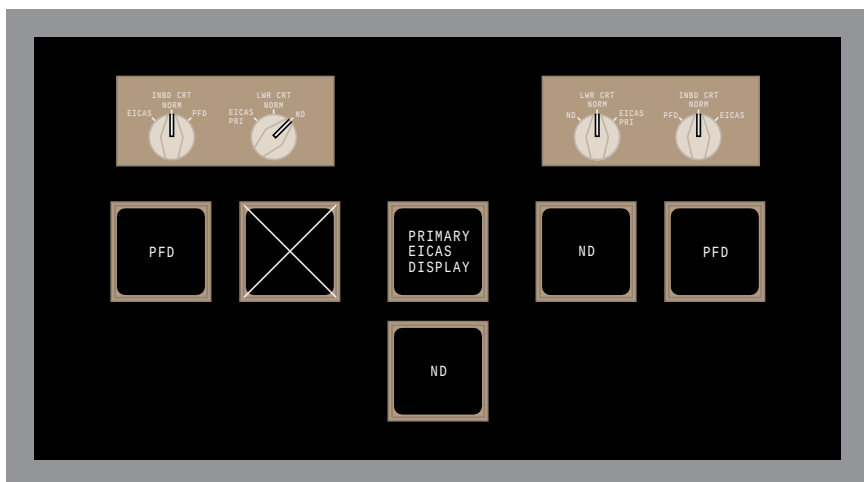


- Failure of PFD with automatic switching, or
- Failure of Primary EICAS with automatic switching

Inboard Display Switching



Lower Display Switching



Standby Flight Instruments

The standby flight instruments include:

- standby magnetic compass
- standby altimeter
- standby attitude indicator
- radio magnetic indicator
- standby airspeed indicator

Standby Magnetic Compass

A standard liquid-damped magnetic standby compass is located on the center post above the glareshield. A card located near the compass provides heading correction factors.

Standby Attitude Indicator

The standby attitude indicator on the center instrument panel incorporates an (APP) display, a bank indicator, and a pitch scale display. The main battery powers the standby attitude indicator. The left ILS receiver provides approach information.

Standby Airspeed Indicator

The standby airspeed indicator on the center instrument panel receives pitot pressure from auxiliary pitot source 1 and static pressure from the alternate static source.

Standby Altimeter

The standby altimeter on the center instrument panel receives static pressure from the alternate static source. The pointer completes one revolution every 1,000 feet.

Radio Magnetic Indicator

The radio magnetic indicator displays selected VOR and ADF bearings. The right IRU provides heading information when the F/O's IRS source selector is in RIGHT. The center IRU provides heading information when center or left is selected.

- When the Heading Reference switch is in NORM, a heading flag is in view north of 82°N latitude (or north of 70°N between 80°W and 130°W) or south of 82°S latitude (or south of 60°S between 120°E and 160°E). When the switch is in TRUE, true heading displays and selecting a VOR displays the VOR failure flag.

Clocks

The Captain's clock provides time and date to the FMCs if GPS is not available. If the Captain's clock fails, the F/O's clock provides this information. In addition to time, the clocks provide alternating day and month-year, elapsed time, and chronograph functions. Chronograph switches on the glareshield control the clock chronograph function.

Time and date no longer display if APU battery bus power is removed. However, all internal clock functions continue to operate and the correct time and date display when power is restored. All display and internal clock functions fail if the main hot battery bus power is removed. The clock must be reset when battery power is restored.

Flight Recorder (DFDR)

The Digital Flight Data Recorder (DFDR) provides a permanent record of operational and systems information including time, heading, altitude, airspeed, acceleration, attitude, engine thrust, and flight control surface position.

The recorder is a solid state device and complies with Federal Aviation Administration and European Aviation Safety Agency requirements for data sampling rates and number/type of parameters sampled.

Operational and systems information are automatically recorded whenever the flight recorder is powered.

The DFDR has the following features:

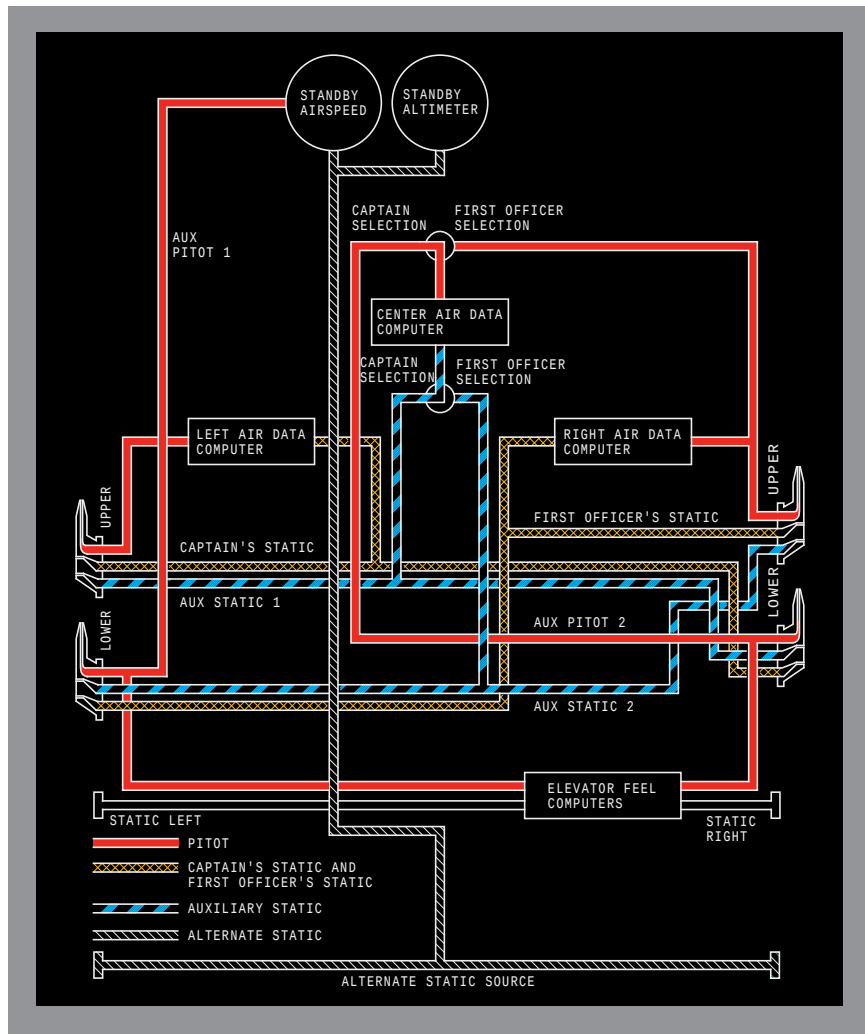
- Continuously records the most recent flight data, saving the most current data for the last 25 hours of operation.
- The DFDR is housed in a sealed container located in the aft equipment center (near the FA Crew Rest area).
- Corrosion, fire, and impact resistant, survives deep sea pressure to 20,000 feet.
- Locator beacon operable for 30 days.
- Receptacle for downloading and copying data for analysis.

Display System Information Sources

Pitot Static System

The pitot static system provides pitot pressure and static pressure to the air data computers, standby airspeed indicator, standby altimeter, and elevator feel computer.

Pitot Static Diagram



Air Data Computer (ADC) System

The ADC system supplies air data information to various airplane systems. Air data information enables the EIUs to display altitude, airspeed, Mach, and air temperature.

There are two primary ADCs and one standby ADC. Each ADC receives inputs from AOA sensors, TAT probes, pitot static system, and barometric settings from the EFIS control panels sent through the related CDUs. The left and right primary ADCs provide flight information to the Captain's and F/O's flight instruments. The center ADC is a backup for the left and right ADCs and is selected with the Air Data Source selectors. AOA sensor inputs to ADCs are required for displaying airspeed, Mach, and altitude information. When selecting the center ADC, vertical speed indications may lag actual conditions.

Angle-of-Attack (AOA)

There are two angle-of-attack vanes, one located on each side of the forward fuselage. The vanes measure airplane angle-of-attack relative to the air mass.

Total Air Temperature (TAT)

Left and right dual total air temperature probes sense outside air temperature (OAT) and heat of compression. TAT displays on primary EICAS. TAT indication on the ground approximates OAT. The TAT probe must be aspirated by bleed air to provide accurate information.

Static Air Temperature (SAT)

SAT displays on Progress page 2.

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Flight Instruments, Displays

Primary Flight Displays (PFDs)

Chapter 10

Section 30

Introduction

PFDs present a dynamic color display of parameters necessary for flight path control. PFDs provide the following information:

- flight mode annunciation
- airspeed
- altitude
- vertical speed
- attitude
- steering information
- radio altitude
- instrument landing system display
- approach minimums
- heading/track indications
- time critical warnings

Failure flags display for airplane system failures. Displayed information is removed or replaced by dashes if no valid information is available to the display system (because of out-of-range or malfunctioning navigation aids). Displays are removed when a source fails or when no system source information is available.

Flight mode annunciations are described in Chapter 4, Automatic Flight.

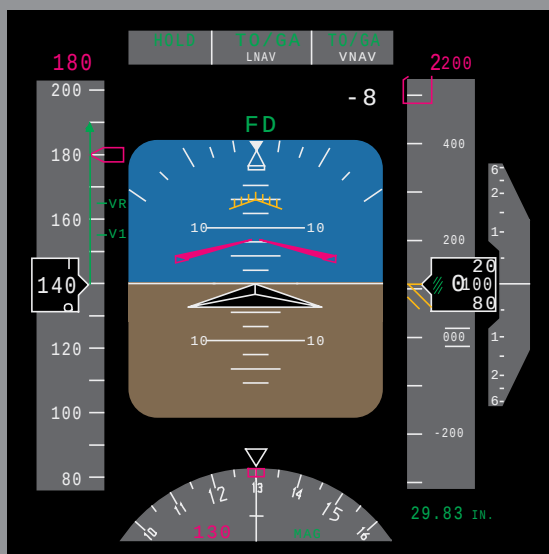
TCAS resolution advisories are described in Chapter 15, Warning Systems.

Alerts on the PFD display in capital letters between the attitude display and the compass rose. Refer to Chapter 15, Warning Systems.

Typical PFD Displays

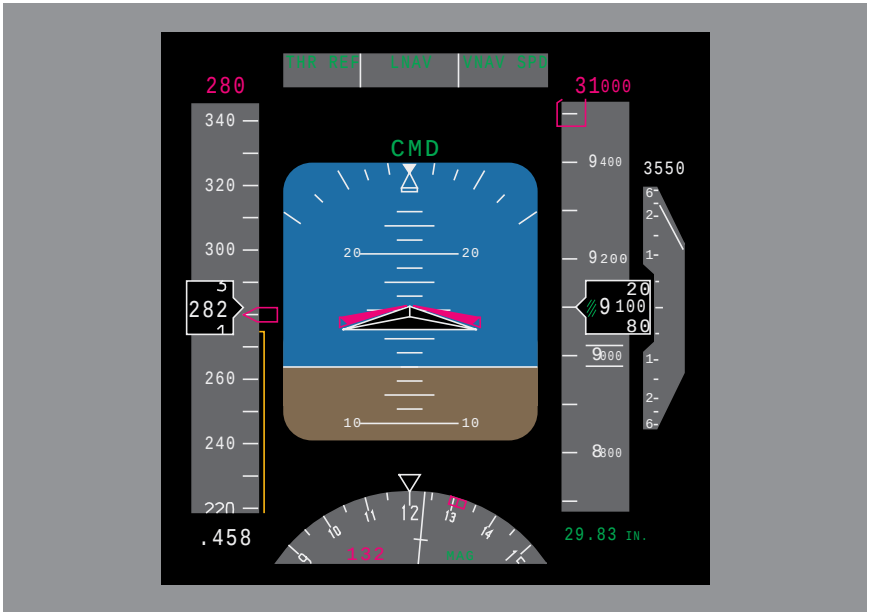
Typical PFD configurations for six phases of flight follow. The autopilot, LNAV, and VNAV are active for climb, cruise, descent, approach, and landing. The AFDS approach mode is used for approach and landing.

Single Cue (Pre Flight Director Modification)

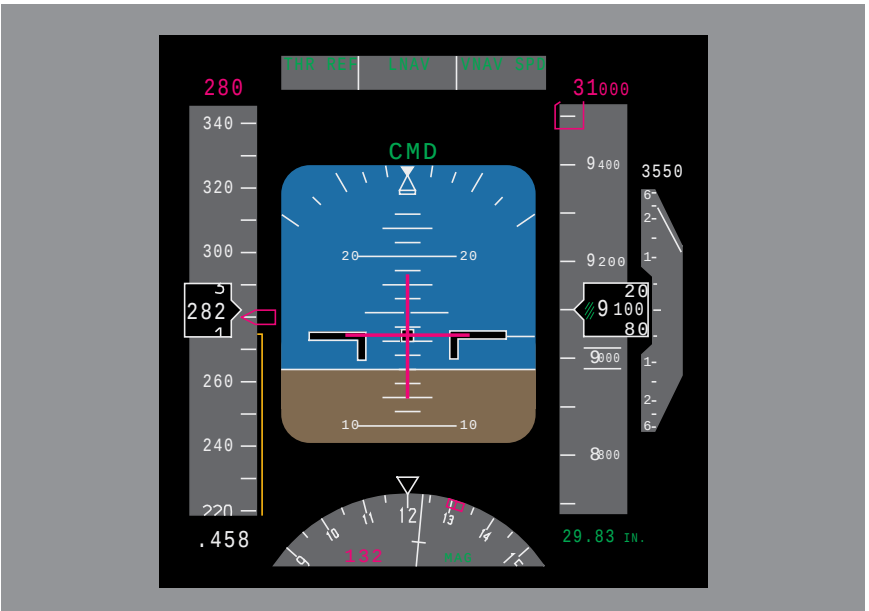


PFD Climb Display

Single Cue (Pre Flight Director Modification)

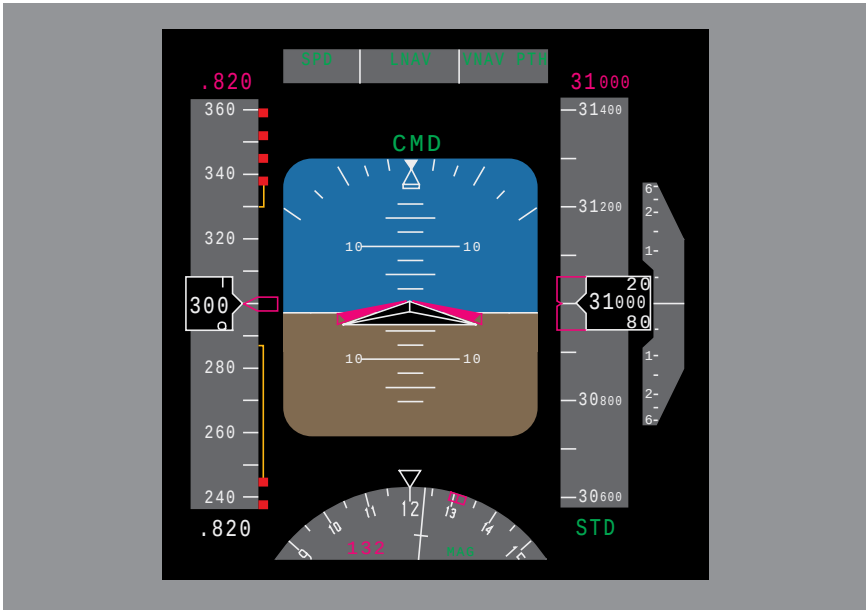


Dual Cue (Post Flight Director Modification)

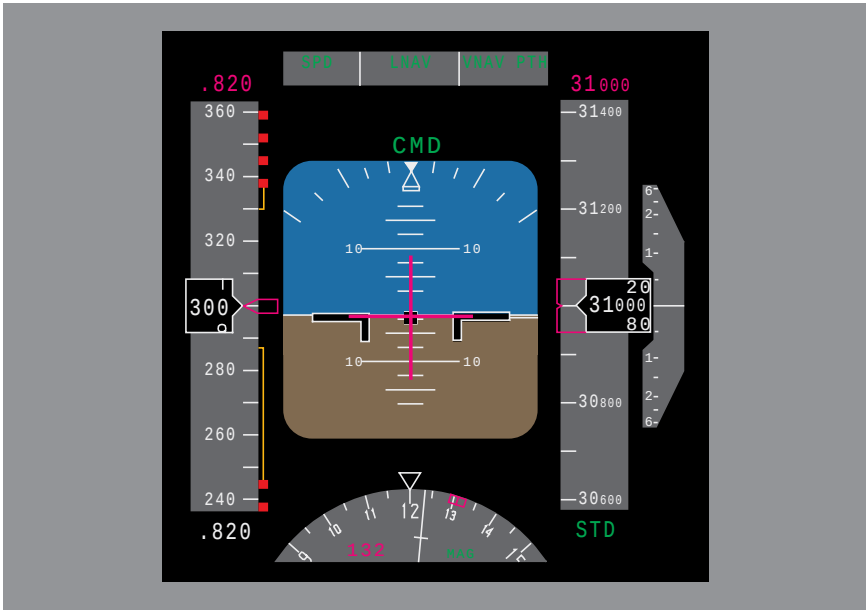


PFD Cruise Display

Single Cue (Pre Flight Director Modification)

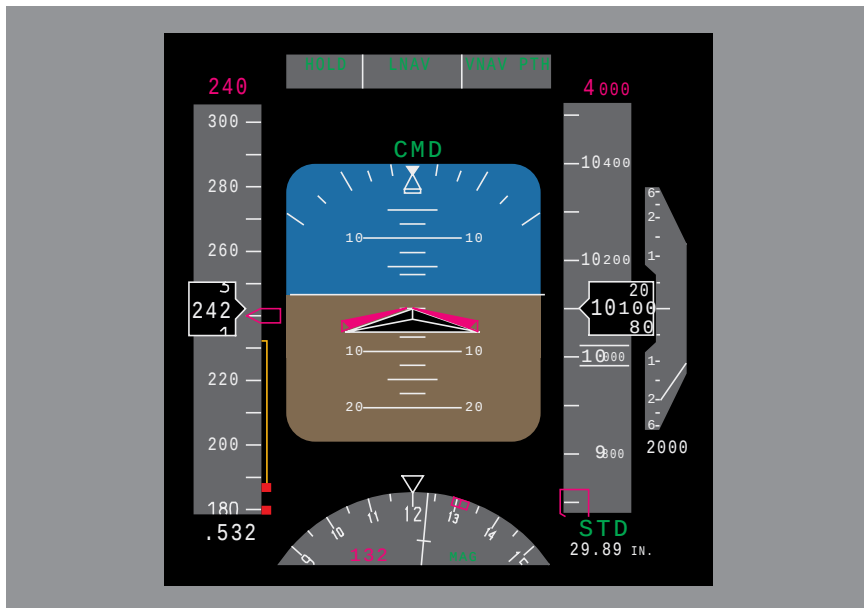


Dual Cue (Post Flight Director Modification)

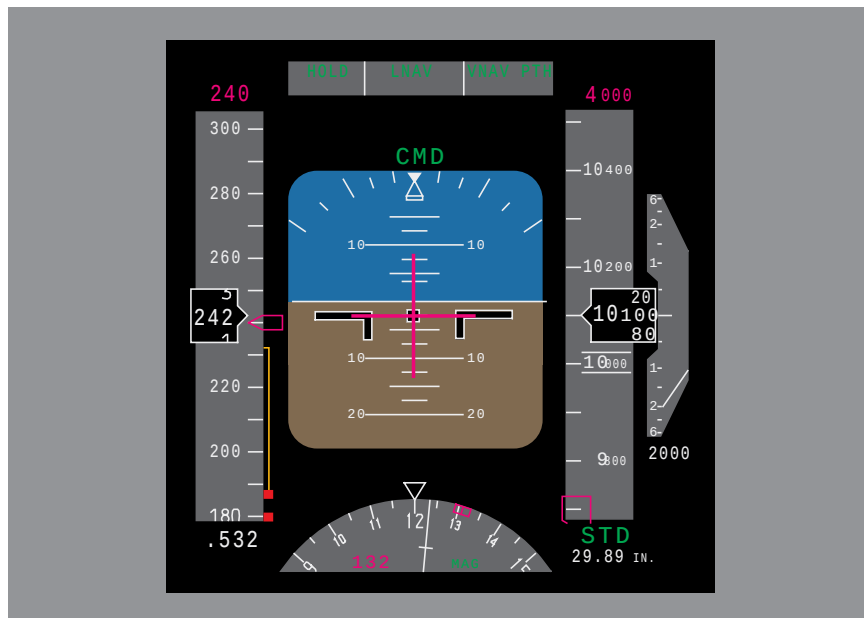


PFD Descent Display

Single Cue (Pre Flight Director Modification)

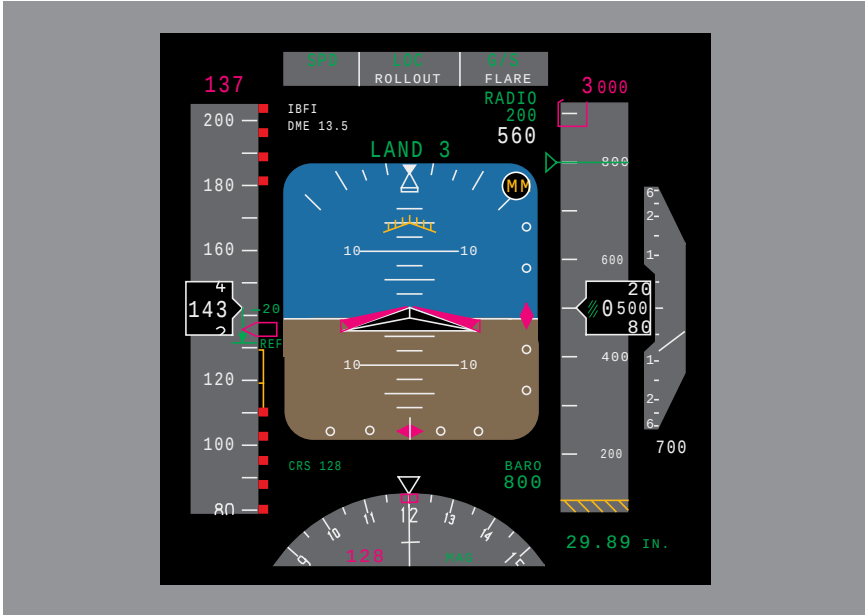


Dual Cue (Post Flight Director Modification)

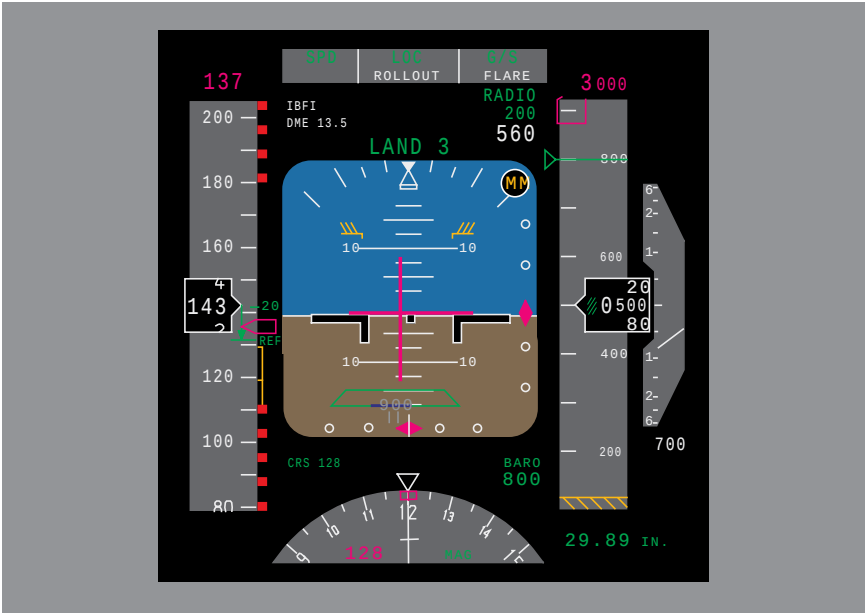


PFD Approach Display

Single Cue (Pre Flight Director Modification)

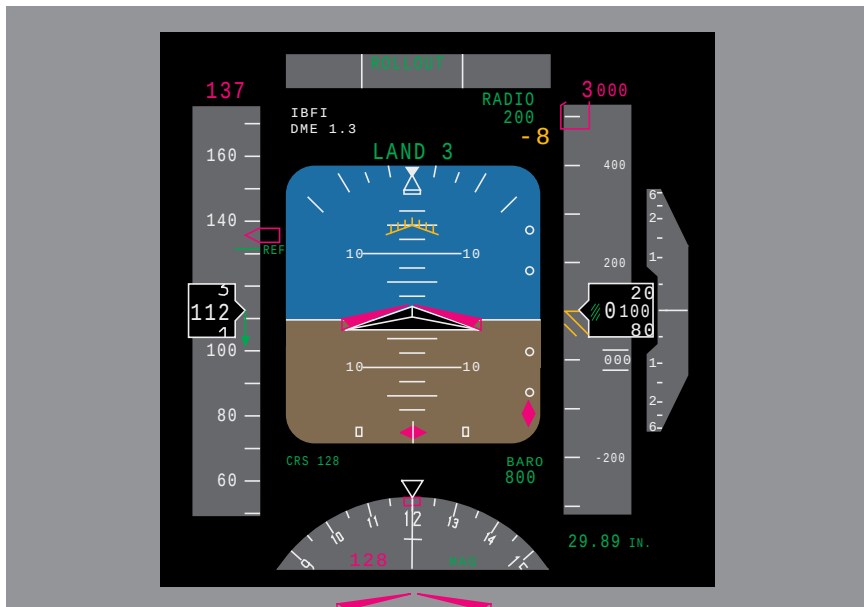


Dual Cue (Post Flight Director Modification)

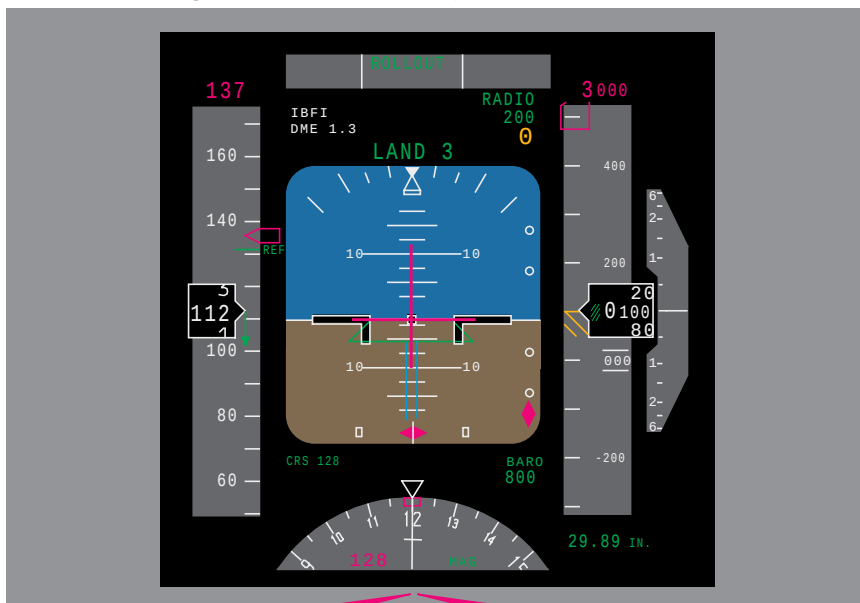


PFD Landing Display

Single Cue (Pre Flight Director Modification)



Dual Cue (Post Flight Director Modification)



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Flight Instruments, Displays

Navigation Displays

Chapter 10

Section 40

Introduction

The NDs provide a mode-selectable color flight progress display. The modes are:

- MAP
- APP (approach)
- VOR
- PLN (plan)

MAP, VOR, and APP modes can be switched between an expanded mode with a partial compass rose and a centered mode with a full compass rose.

Map Mode

MAP mode is recommended for most phases of flight.

Presented track up, this mode shows airplane position relative to the route of flight against a moving map background.

Displayed information can include:

- track
- heading
- route
- position trend vector
- range to selected altitude
- map range scale
- ground speed
- true airspeed
- wind direction and speed
- next waypoint distance
- waypoint estimated time of arrival
- selected navigation data points
- TCAS Traffic Display

Navigation Data Points

Additional navigation facility (STA), waypoint (WPT), airport (ARPT), route progress (DATA), and position (POS) data may be displayed on the ND in both the expanded and center map modes.

VOR and Approach Modes

VOR and APP modes display heading up. VOR and APP modes display track, heading, and wind speed and direction with VOR navigation or ILS approach information.

Plan Mode

PLN mode displays true north up. The active route may be viewed using the STEP prompt on LEGS pages. Position DATA is available for display in plan mode

ND Information

Heading

Heading is supplied by the selected IRU. The ND compass rose can be referenced to magnetic north or true north. The Heading Reference switch is used to manually select magnetic or true reference. The compass display references true north when the airplane is north of 82° N latitude (or north of 70°N between 80° W and 130° W) or south of 82° S latitude (or south of 60°S between 120° E and 160°E).

If the ND is referenced to true north and the airplane descends 2,000 feet at more than 800 feet per minute, the heading reference box changes color to amber and flashes for 10 seconds. The box returns to white when the airplane climbs 2,000 feet at more than 500 feet per minute.

Track

Track is supplied by the FMC during normal operation and by the IRU in alternate navigation.

Traffic

Traffic information from the TCAS can be displayed on the ND. TCAS is described in Chapter 15, Warning Systems.

Weather Radar

Weather radar information displays on the ND. The weather radar system is described in Chapter 11, Flight Management, Navigation.

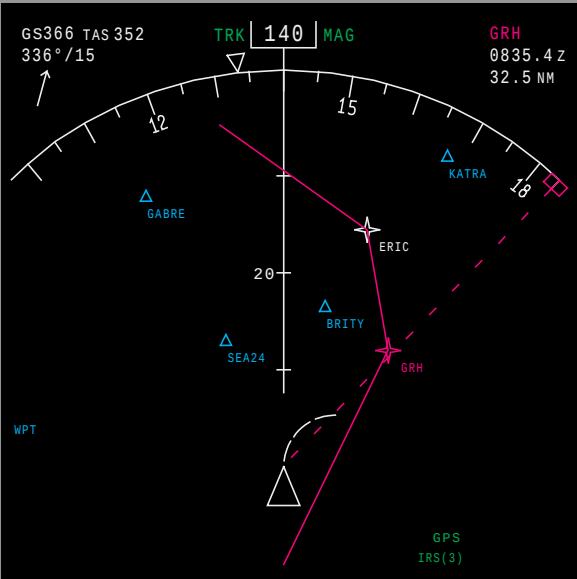
Failure Flags and Messages

Failure flags display for system failures or invalid information. Indications are removed or replaced by dashes when source system information is not available.

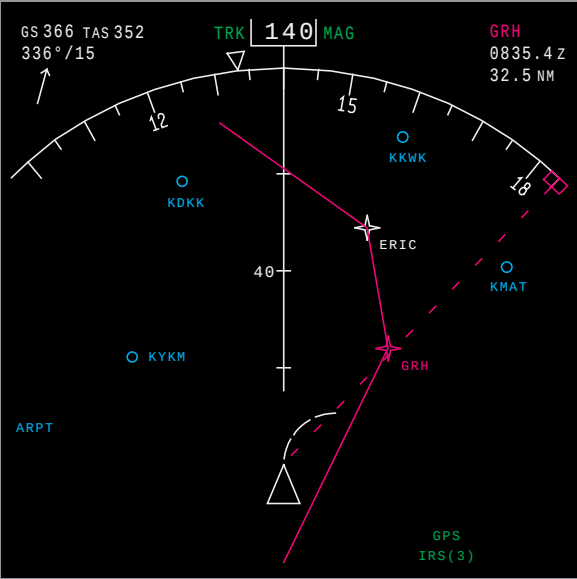
The message EXCESS DATA displays on the ND if the amount of information sent to the ND exceeds the display capability. The message can be removed by deselecting one or more of the EFIS control panel map switches (STA, WPT, ARPT, DATA).

Typical ND map displays are shown on the following pages. Examples of other ND displays (centered map, approach, VOR, and plan modes) are shown in Section 10 of this chapter.

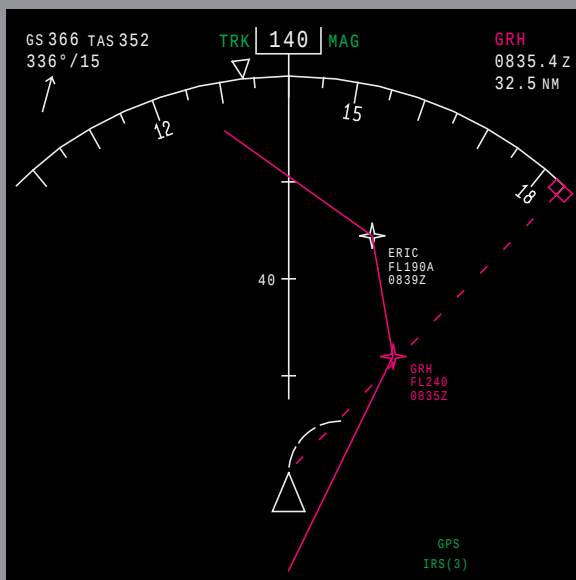




WPT (WAYPOINT) SELECTED



ARPT (AIRPORT) SELECTED



DATA SELECTED



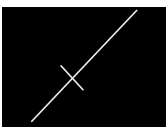
POS (POSITION) SELECTED

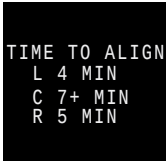
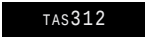
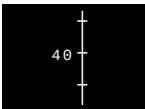
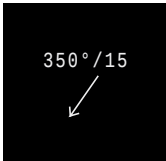
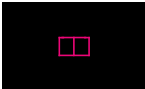
ND Symbology

The following symbols display on each ND, depending on EFIS control panel switch selections. Colors indicate the following:

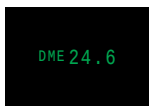
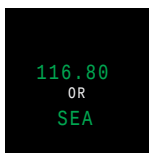
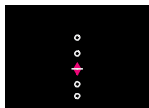
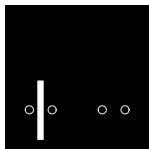
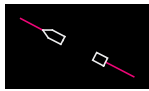
- W (white) - present or modified status, range scales, armed flight mode annunciations
- G (green) - dynamic conditions, active flight mode annunciations
- M (magenta) - active waypoint and route, command information, pointers, symbols, fly-to condition
- B (blue) - inactive or background information, ADF symbols
- A (amber) - cautions, faults, flags
- R (red) - warnings

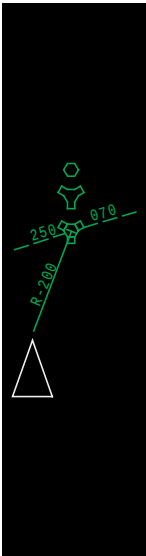
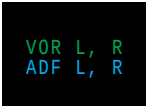
Heading, Track, and Speed

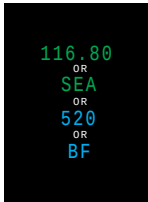
Symbol	Name	ND Mode	Remarks
	Current heading pointer (W)	MAP, MAP CTR, PLAN	Points to current heading on the compass rose.
	Expanded compass (W)	MAP, APP, VOR, PLAN	Displays 90 degrees of compass rose.
	Groundspeed (W)	All	Displays ground speed in large font below 30 knots; small font at 30 knots and above.
	Heading/track reference (G) box (W) in TRU, box (A) if TRU displayed in descent	All except PLAN	Indicates heading/track is referenced to magnetic north or true north. Switching from TRU to MAG displays a box around MAG for 10 seconds.
	Track orientation (G), current heading (W), heading reference (G), and heading pointer (W)	MAP, MAP CTR, PLAN	Displays TRK as display orientation, current heading, MAG or TRU as heading reference, and points to the heading on the compass rose.
	Heading orientation (G), current heading (W), heading reference (G), and heading pointer (W)	VOR, VOR CTR, APP, APP CTR	Displays HDG as display orientation, current heading, MAG or TRU as heading reference, and points to the heading on the compass rose.
	Track indicator (W)	VOR, VOR CTR, APP, APP CTR	Indicates airplane track when selected mode has heading orientation.

Symbol	Name	ND Mode	Remarks
	IRU time to align (W)	All	Indicates time remaining for IRU alignment. Replaces wind direction/speed and wind arrow, on the ground, during alignment.
	True airspeed (W)	All	Displays true airspeed above 100 knots.
	Track line and range scale (W)	MAP, MAP CTR, VOR, APP	Line indicates track. Number indicates range. Displays in VOR or APP mode when WXR, TERR, or TFC on.
	Wind direction/ speed and wind arrow (W)	All	Indicates wind bearing, speed, and direction, with respect to display orientation and heading/track reference. Arrow not displayed in PLAN map mode (LCD).
	Selected heading (M)	All except PLAN	Displays MCP-selected heading. A dashed line (M) may extend from the marker to the airplane symbol. In MAP mode with LNAV, LOC, or ROLLOUT engaged, dashed line is removed 10 seconds after the selected heading is moved.

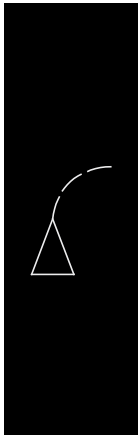
Radio Navigation

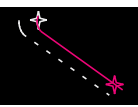
Symbol	Name	ND Mode	Remarks
	DME distance (G)	MAP, MAP CTR, VOR, VOR CTR, APP, APP CTR	Displays DME distance to the referenced navaid.
	ILS/VOR (G) Reference receiver frequency or identifier display	VOR, VOR CTR, APP, APP CTR	Displays frequency before the identifier is decoded. The decoded identifier replaces the frequency. Medium size characters for VOR, small size characters for DME only.
	Reference receiver (G)	VOR, VOR CTR, APP, APP CTR	Displays selected receiver as display reference.
	Glide slope pointer (M) and scale (W)	APP, APP CTR	Displays glideslope position and deviation. Deviation indicator fills (M) when less than 2 1/2 dots from center.
	ILS localizer or VOR course deviation indication (M) and scale (W)	VOR, VOR CTR, APP, APP CTR	Displays LOC or VOR course deviation. Deviation indicator points in direction of VOR or ILS selected course.
	Selected course pointer (W) and line (M)	VOR, VOR CTR, APP, APP CTR	Indicates CDU-selected course.
	To/from indication (W)	VOR CTR	Located near airplane symbol. Displays VOR TO/FROM indication.
	To/from indication (W)	VOR, VOR CTR	Displays VOR to/from indication.

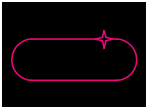
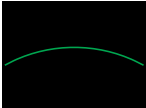
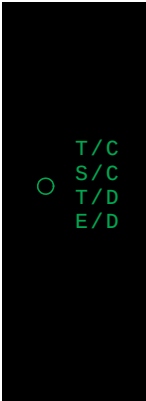
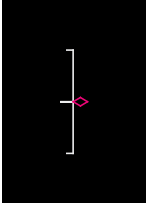
Symbol	Name	ND Mode	Remarks
	VOR (B, G), DME/TACAN (B, G), VORTAC (B, G)	MAP, MAP CTR	Displays appropriate navaids (B) when EFIS control panel STA switch selected on. Tuned VHF navaids display in green, regardless of switch selection. When a navaid is manually tuned, the selected course and reciprocal display.
	VOR/DME raw data radial and distance (G)		Extends the station radial from the airplane to the CDU-tuned VOR when EFIS control panel POS switch selected on. If co-located DME data received, tick mark displays at DME distance from airplane; extends to edge of display if no valid DME data displayed.
	Left VOR (G) or ADF (B) pointer head and tail	MAP, MAP CTR, VOR, VOR CTR, PLAN	Indicates bearing to (head) or from (tail) the tuned station, if selected on related EFIS control panel.
	Right VOR (G) or ADF (B) pointer head and tail	.	.
	VOR (G) or ADF (B) selection	MAP, MAP CTR, VOR, VOR CTR, APP, APP CTR	Located lower left or right corner. Represents positions of VOR/ADF switches.

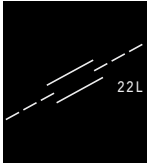
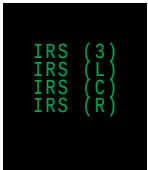
Symbol	Name	ND Mode	Remarks
	VOR frequency or identifier (G), ADF frequency or identifier (B)	MAP, MAP CTR, VOR, VOR CTR, APP, APP CTR	Displays frequency before identifier is decoded. Decoded identifier replaces the frequency. For VORs, small size characters indicate only DME information is being received.
	DME distance (G)	VOR, VOR CTR, APP, APP CTR	Displays DME distance to the reference navaid.
	Reference ILS or VOR course (W)	VOR, VOR CTR, APP, APP CTR	Displays VOR course or FMC runway course.

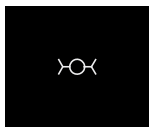
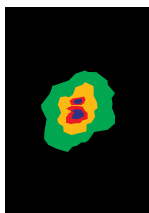
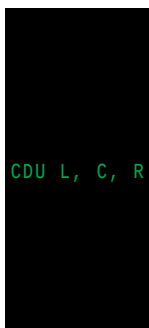
Map

Symbol	Name	ND Mode	Remarks
	Airplane symbol (W)	MAP, MAP CTR, VOR, APP	Current airplane position is at the apex of the triangle.
	Airplane symbol (W)	VOR CTR, APP CTR	Current airplane position is at the center of the symbol.
	Position trend vector (W) (dashed line)	MAP, MAP CTR	Predicts position at the end of 30, 60, and 90 second intervals. Each segment represents 30 seconds. Based on bank angle and ground speed. Selected range determines the number of segments displayed. For range: • greater than 20 NM, 3 segments • = 20 NM, 2 segments • = 10 NM, 1 segment

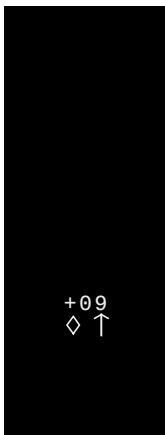
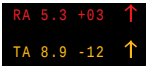
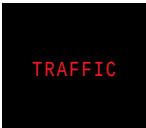
Symbol	Name	ND Mode	Remarks
	Active waypoint identifier (M)	MAP, MAP CTR, PLAN	Displays active flight plan waypoint, the next waypoint on the route of flight.
	Active waypoint distance (W)	MAP, MAP CTR, PLAN	Distance to active waypoint.
	Active waypoint ETA (W)	MAP, MAP CTR, PLAN	Displays FMS-calculated ETA at the active waypoint.
	Waypoint: active (M), inactive (W)	MAP, MAP CTR, PLAN	Active - represents the waypoint the airplane is currently navigating to. Inactive - represents the waypoints on the active route.
	Off route waypoint (B)	MAP, MAP CTR	Displays waypoints not on selected route displayed in ND ranges of 10, 20, or 40 when WPT switch selected on.
	Flight plan route: active (M), modified (W), inactive (B)	MAP, MAP CTR, PLAN	Displays active route with a continuous line (M) between waypoints. Active route modifications display with short dashes (W) between waypoints. Inactive routes display with long dashes (B) between waypoints.
	Offset path and identifier: active route (M), modified route (W)	MAP, MAP CTR, PLAN	Presents a dashed line parallel to and offset from the active or modified route.
	Route data: active waypoint (M), inactive waypoint (W)	MAP, MAP CTR	Displays entered or procedural altitude and ETAs for applicable route waypoints when DATA switch selected on.

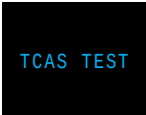
Symbol	Name	ND Mode	Remarks
	Holding pattern: active route (M), modified route (W), inactive route (B)	MAP, MAP CTR, PLAN	Displays a holding pattern when in flight plan. Pattern increases to correct size when entering holding.
	Altitude range arc (G)	MAP, MAP CTR	Displays position where MCP altitude will be reached based on vertical speed and groundspeed.
	Altitude profile point and identifier (G)	MAP, MAP CTR	Displays position of FMC-calculated T/C (top-of-climb), S/C (step climb), T/D (top- of-descent), and E/D (end of descent) points. Predicted altitude/ETA points entered on the FIX page display the altitude/ETA along with the profile point. Deceleration points have no identifier.
	VNAV path pointer (M) and deviation scale (W)	MAP, MAP CTR	Displays vertical deviation from selected VNAV PATH during descent only. Scale indicates ± 400 feet deviation. Digital display displays when the pointer indicates more than ± 400 feet.
	Procedure turn: active route (M), modified route (W), inactive route (B)	MAP, MAP CTR, PLAN	Displays procedure turn when in the flight plan. It increases in size upon entering the procedure turn.
	Airport and runway (W)	MAP, MAP CTR, PLAN	Display when selected as the origin or destination and ND range is 80, 160, 320, or 640 NM.

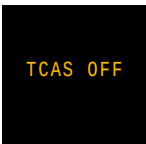
Symbol	Name	ND Mode	Remarks
	Airport (B)	MAP, MAP CTR	Displays when ARPT switch selected on. Origin and destination airports always display, regardless of map switch selection.
	Airport and runway (W)	MAP, MAP CTR, PLAN	Display when selected as the origin or destination and ND range is 10, 20, or 40 NM. Dashed runway centerlines extend 14.2 NM.
	Energy management circles (B, W)	MAP, MAP CTR	Displays clean (B) and drag (W) energy management circles as defined on CDU OFFPATH DES page.
	Selected reference point and bearing distance information (G)	MAP, MAP CTR, PLAN	Displays reference point selected on CDU FIX page. Bearing and/or distance from the fix are displayed with dashes (G).
	FMC-IRS position update status (G)	MAP, MAP CTR	Displays FMC-IRS status based on IRUs. Transition from IRS (3) to any other annunciation highlighted by a green box for 10 seconds.
	FMC-radio position update status (G)	MAP, MAP CTR	Displays FMC-radio update mode. DD, DME DME; VD, VOR DME; LOC, localizer; LOC DD, localizer and DME DME; LOC VD, localizer and VOR DME.
	FMC-GPS position update status (G)	MAP, MAP CTR	Displays FMC-GPS update mode. LOC GPS, localizer and GPS; GPS, GPS only.

Symbol	Name	ND Mode	Remarks
	GPS position (W)	MAP, MAP CTR	Displays GPS position relative to FMC position when POS switch selected on.
	IRU positions (W)	MAP, MAP CTR	Displays IRU positions relative to FMC position when POS switch selected on.
	Weather radar returns (R, A, G, M)	MAP, MAP CTR, VOR, APP	Displayed when WXR switch selected on. Most intense areas display in red, lesser intensity in amber, and lowest intensity green. Turbulence displays in magenta.
	Selected map options (B)	MAP, MAP CTR	Indicates STA, WPT, ARPT, and WXR switches selected on.
	Map source annunciation (G)	MAP, MAP CTR	Displays ND source if: • CDU is selected on related Navigation Source Select switch • both FMCs fail, or • a manually selected FMC fails
	North up arrow (G)	PLAN	Indicates map background is oriented and referenced to true north.

TCAS

Symbol	Name	ND Mode	Remarks
	TCAS resolution advisory (RA), relative altitude (R)	MAP, MAP CTR, APP, VOR	Refer to Chapter 15, Warning Systems.
	TCAS traffic advisory (TA), relative altitude (A)		Proximate traffic is traffic within 1,200 feet vertical and 6 miles lateral of present position.
	TCAS proximate traffic, relative altitude (W)		Other traffic is greater than 1,200 feet vertical or 6 miles lateral from present position.
	TCAS other traffic, relative altitude (W)		Arrow indicates traffic climbing or descending at a rate greater than or equal to 500 fpm. At rates less than 500 fpm, arrow is not displayed. Number and associated signs indicate altitude of traffic in hundreds of feet relative to the airplane. Number is below the traffic symbol when the traffic is below, and above the traffic symbol when the traffic is above the airplane. Absence of the number implies altitude unknown.
	TCAS no bearing message (RA-R, TA-A)	MAP, MAP CTR, APP, VOR	Message provides traffic type, range in NM, altitude and vertical direction.
	TCAS traffic alert message (RA-R, TA-A)	All	Displays when TCAS RA or TA is active.

Symbol	Name	ND Mode	Remarks
	TCAS off scale message (RA-R, TA-A)	MAP, MAP CTR, APP, VOR	Displays whenever RA or TA traffic is outside the traffic area covered by the ND range.
	TCAS mode (B)	MAP, MAP CTR, APP, VOR	Indicates ND TCAS display is active; TFC switch selected on.
	TCAS mode (B)	All	Indicates TCAS is operating in test mode.
	TCAS mode (A)	MAP, MAP CTR, APP, VOR	Indicates TCAS failure, when traffic is selected.

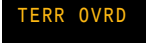
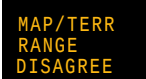
Symbol	Name	ND Mode	Remarks
	TCAS mode (B)	All	Indicates TCAS computer is not computing RAs.
	TCAS mode (A)	MAP, MAP CTR, APP, VOR	Displays when TCAS/ATC mode switch is not in TA ONLY or TA/RA, when traffic is selected. Not displayed if TCAS is failed.

Radar

Symbol	Name	ND Mode	Remarks
	Weather radar (WXR) test mode (A) (B)	MAP, MAP CTR, APP, VOR	Weather radar system selected on EFIS control panel (refer to Chapter 11, Flight Management, Navigation).
	WXR precipitation only mode (B)		
	WXR and turbulence mode (B)		
	Mode used with down-tilt, when ground mapping (B)		
	WXR antenna tilt (B)		
	WXR system failure (A)		
	WXR antenna failure (A)		
	Automatic gain control failure (A)		
	WXR control panel failure (A)		
	Auxiliary weather display failure (A)		
	WXR receiver transmitter failure (A)		
	IRS stabilization signal failure (A)		
	Antenna at pitch or roll stabilization limit		

Look-Ahead Terrain

Symbol	Name	ND Mode	Remarks
	Terrain display (R, A, G, M)	MAP, MAP CTR, APP, VOR	Terrain data displayed from the GPWS terrain data base. Terrain 2,000 feet below to 500 feet (250 feet with gear down) below the airplane's current altitude (G), terrain 500 feet (250 feet with gear down) below to 2,000 feet above the airplane's current altitude (A), terrain more than 2,000 feet above airplane's current altitude (R), no terrain data available (M).
	Terrain mode annunciation (B)	MAP, MAP CTR, APP, VOR	Terrain display enabled (manual or automatic display).
	Terrain test mode annunciation (B)	All	GPWS operating in self-test mode.
	Terrain annunciation (R, A)	All	Look-ahead terrain caution alert (A), look-ahead terrain warning alert (R).

Symbol	Name	ND Mode	Remarks
	Terrain status annunciations (A)	MAP, MAP CTR, APP, VOR	Look-ahead terrain alerting and display have failed.
		MAP, MAP CTR, APP, VOR	Look-ahead terrain alerting and display unavailable due to position uncertainty.
		MAP, MAP CTR, APP, VOR	Ground Proximity Terrain Override Switch in OVRD position, GPWS look-ahead terrain alerts and terrain display inhibited.
	Terrain range status annunciations (A)	MAP, MAP CTR, APP, VOR	Terrain output range disagrees with selected EFIS control panel range.
		MAP, MAP CTR	Terrain output range and map display output range disagree with selected EFIS control panel range.

Flight Instruments, Displays

EICAS Messages

Chapter 10

Section 50

Flight Instruments, Displays EICAS Messages

Note: OVERSPEED warning and ALTITUDE ALERT caution messages are covered in Chapter 15, Warning Systems.

The following EICAS messages can display.

Flight Instruments Source EICAS Alert Messages

Message	Level	Aural	Message Logic
>SNGL SOURCE RA	Advisory		Both pilots' displays referenced to the same radio altimeter receiver.
>SOURCE SEL ADC	Advisory		Both pilots' displays referenced to the same ADC.
>SOURCE SEL EIU	Advisory		Both pilots' displays referenced to the same EIU.
>SOURCE SEL F/D	Advisory		Both pilots' displays referenced to the same FCC.
>SOURCE SEL IRS	Advisory		Both pilots' displays referenced to the same IRU.
>SOURCE SEL NAV	Advisory		Both pilots' displays referenced to the same FMC.

Flight Instruments Disagree EICAS Alert Messages

Message	Level	Aural	Message Logic
ALT DISAGREE	Caution	Beeper	Captain and First Officer uncorrected altitude indications disagree by more than 200 feet. Inhibited until disagreement lasts for more than five seconds.

Message	Level	Aural	Message Logic
>ATTITUDE	Caution	Beeper	Captain and First Officer selected IRS attitude output disagree by 3 degrees or more.

Message	Level	Aural	Message Logic
>BARO DISAGREE	Advisory		Captain and First Officer barometric reference settings disagree for more than one minute.

Message	Level	Aural	Message Logic
IAS DISAGREE	Caution	Beeper	Captain and First Officer airspeed indicators disagree by five knots or more. Inhibited until disagreement lasts for more than five seconds.

Flight Instruments Components EICAS Alert Messages

Message	Level	Aural	Message Logic
>AOA RIGHT	Advisory		Right AOA sensor has failed. AOA system redundancy lost.

Message	Level	Aural	Message Logic
>EFIS CONTROL L, R	Advisory		(CDU-150, -152) EFIS control panel inoperative. (CDU-161) EFIS control panel inoperative or CDU control of the EFIS control panel active.

Message	Level	Aural	Message Logic
>EFIS/EICAS C/P	Advisory		(CDU-150, -152) Both EFIS control panels and EICAS display select panel inoperative. (CDU-161) Both EFIS control panels and EICAS display select panel inoperative or CDU control of both EFIS control panels and EICAS display panel active.

Message	Level	Aural	Message Logic
>EIU LEFT	Advisory		Left EIU failed. Inhibited in flight.

Flight Management, Navigation

Chapter 11

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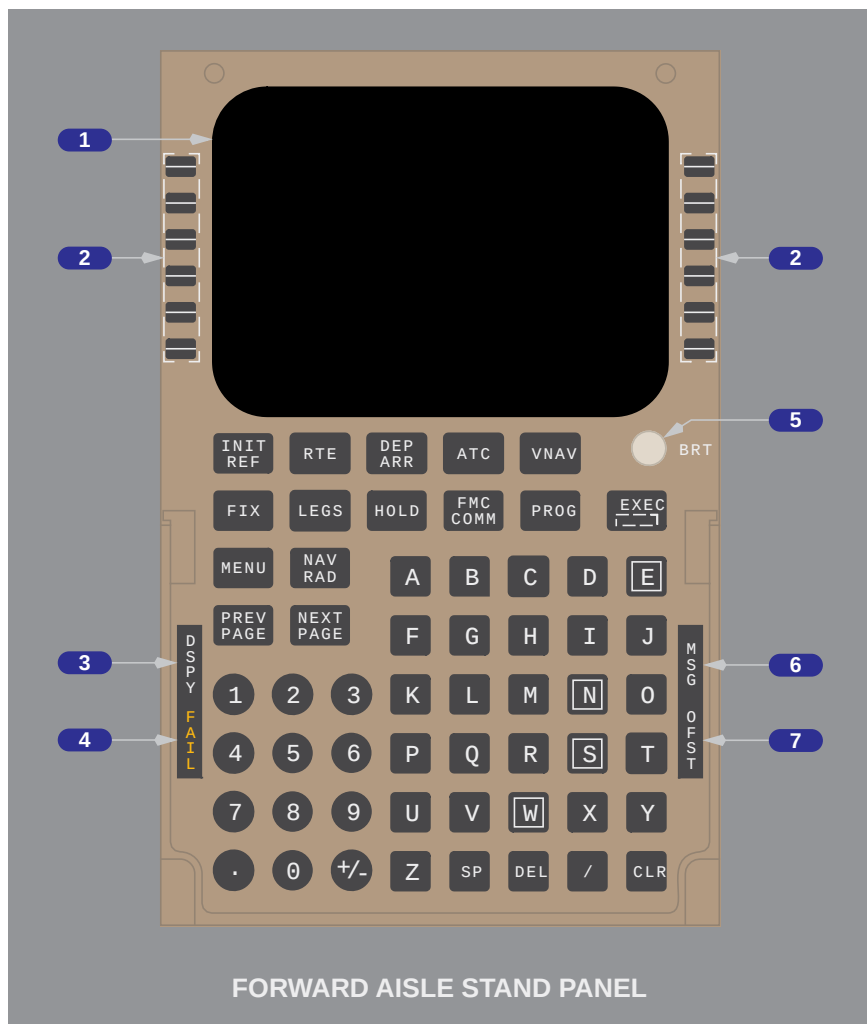
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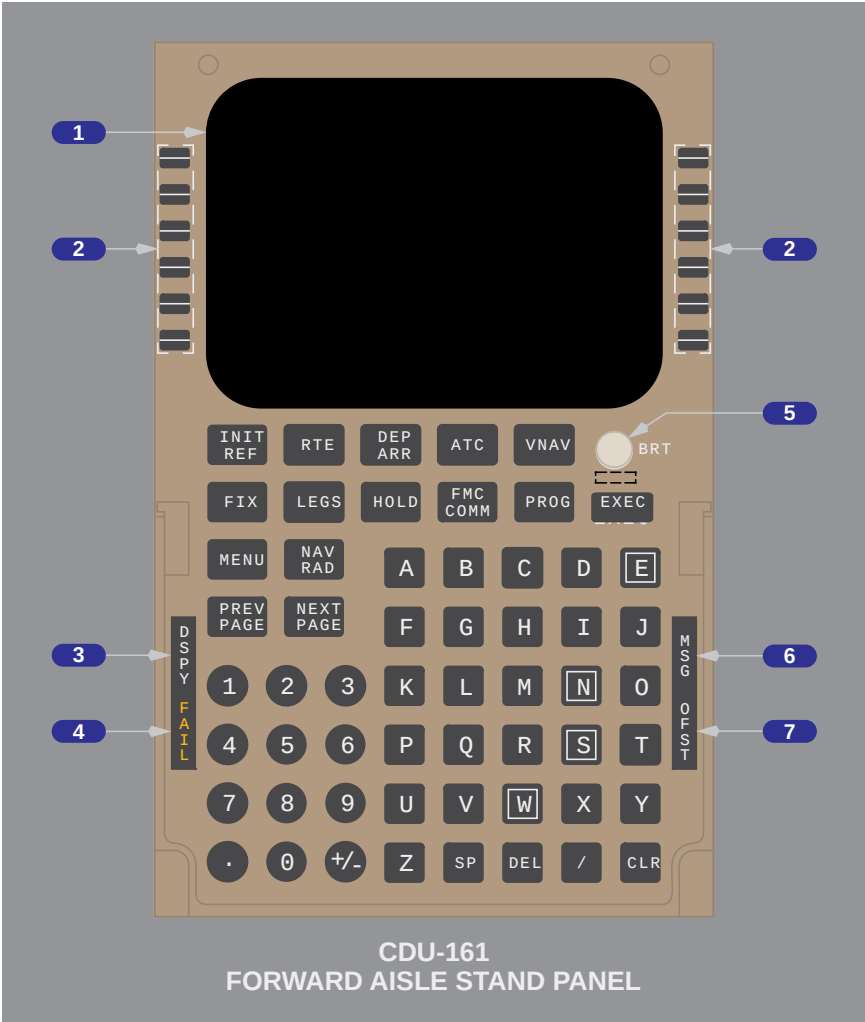
Flight Management System

The control display units shown in the Operations Manual have been labeled CDU-152 or CDU-161 where necessary to distinguish between Part Numbers S242T102-152 and S242T102-161. A Delta B747-400 aircraft may contain all similar or different CDUs. All panels have been shown in the following pages.

Control Display Unit (CDU - 152)



Control Display Unit (CDU - 161)



1 Control Display Unit (CDU) Display

Displays FMS data pages.

2 Line Select Keys

Push -

- moves data from scratchpad to selected line
- moves data from selected line to scratchpad
- selects page, procedure, or performance mode as applicable
- deletes data from selected line when DELETE is displayed in scratchpad

Conventions -

- scratch pad must be blank for line select transfer
- data cannot be transferred to a blank line
- a blank scratch pad cannot be transferred to a line
- not all data can be modified
- message displays if inappropriate entries attempted

3 Display (DSPY) Light

Illuminated (white) - indicates current display is not related to the active leg or current performance mode.

4 FAIL Light

Illuminated (amber) - indicates fault detected in FMC.

5 Brightness (BRT) Control

Rotate - controls display brightness.

Light sensors located near each CDU measure ambient light level and adjust CDU brightness to maintain desired illumination.

6 Message (MSG) Light

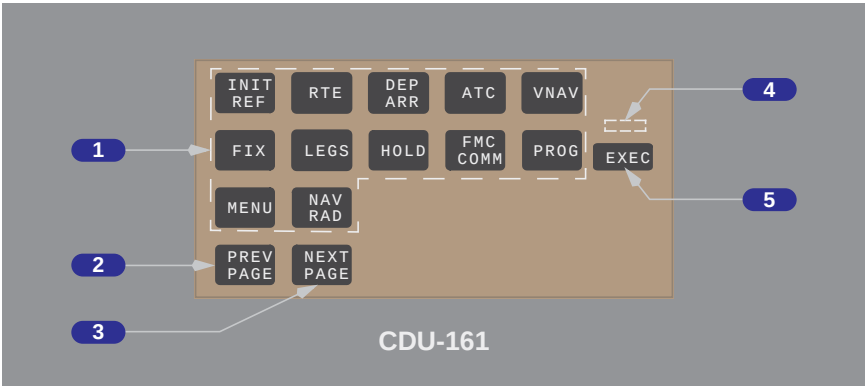
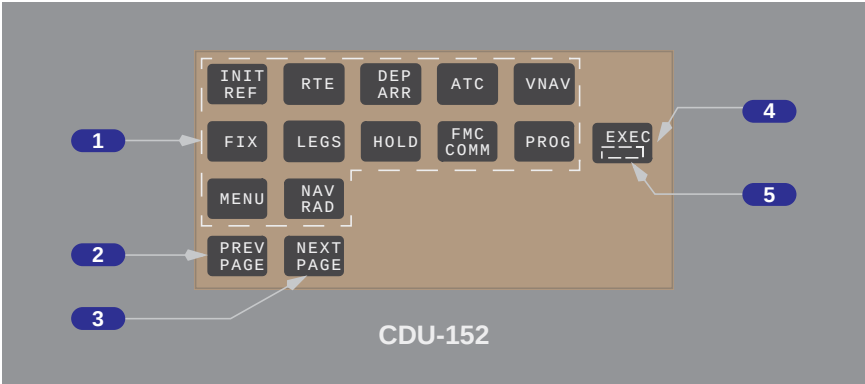
Illuminated (white) -

- scratchpad displays message
- pushing clear key extinguishes light and clears message

7 Offset (OFST) Light

Illuminated (white) - LNAV gives guidance for lateral route offset.

Function and Execute Keys



1 CDU Function Keys

Push -

- INIT REF - displays page for data initialization or for reference data
- RTE - displays page to input or change origin, destination, or route
- DEP ARR - displays page to input or change departure and arrival procedures
- ATC - displays ATC/ADS STATUS page
- VNAV - displays page to view or change vertical navigation path data
- FIX - displays page to create reference points on ND map
- LEGS -
 - displays page to evaluate or modify lateral and vertical route data
 - displays page to correlate route waypoints on ND
- HOLD - displays page to create holding patterns and holding pattern data, or to exit holding pattern
- FMC COMM - displays pages that access datalink, provides datalink status
- PROG - displays page to view dynamic flight and navigation data, including waypoint and destination ETAs, fuel remaining, and arrival estimates
- MENU - displays page to choose subsystems controlled by CDU
- NAV RAD - displays page to view or control navigation radio tuning

2 Previous (PREV) PAGE Key

Push - displays previous page in multiple page displays.

3 NEXT PAGE Key

Push - displays next page in multiple page displays.

4 Execute Light

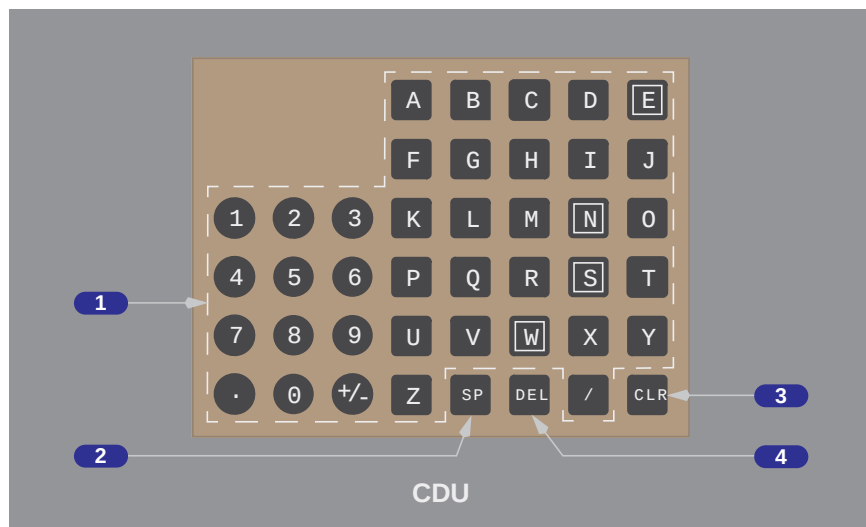
Illuminated (white) - active data modified but not executed.

5 Execute (EXEC) Key

Push -

- makes data modification(s) active
- extinguishes execute light

Alpha/Numeric and Miscellaneous Keys



1 Alpha/Numeric Keys

Push -

- enters selected character in scratchpad
- Slash (/) key - enters “/” in scratchpad
- Plus Minus (+/-) key - first push enters “-” in scratchpad. Subsequent pushes alternate between “+” and “-”

2 Space (SP) Key

Push - enters a space in scratchpad when using ACARS or SATCOM.

3 Clear (CLR) Key

Push -

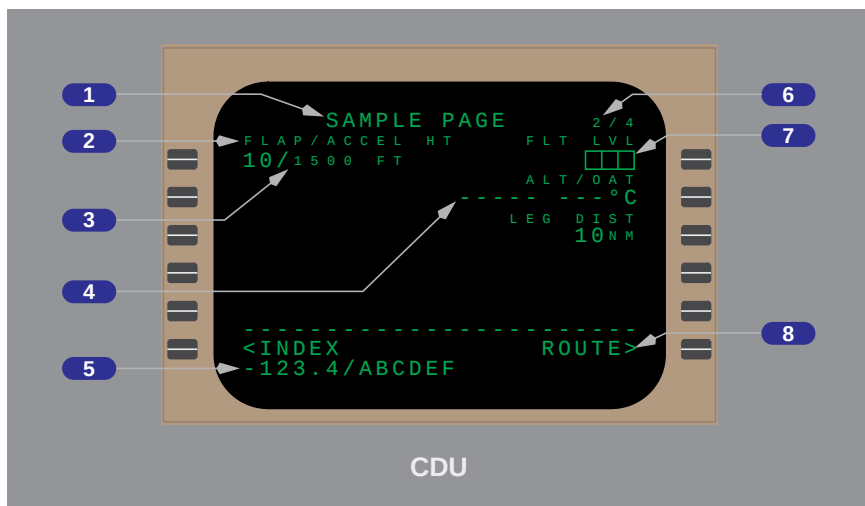
- clears last scratchpad character
- clears scratchpad message

Push and hold - clears all scratchpad data.

4 Delete (DEL) Key

Push - enters “DELETE” in scratchpad.

CDU Page Components



1 Page Title

Subject or name of data displays on page.

ACT (active) or MOD (modified) indicates whether page contains active or modified data.

2 Line Title

Title of data on line below.

3 Line

Displays -

- prompts
- data associated with line title

Large font indicates crew entered or verified data. Small font indicates FMC computed data.

4 Dashes

Data input is optional.

5 Scratchpad

Displays messages, alphanumeric entries, or line selected data.

6 Page Number

Left number is page number. Right number is total number of related pages. Page number is blank when only one page exists.

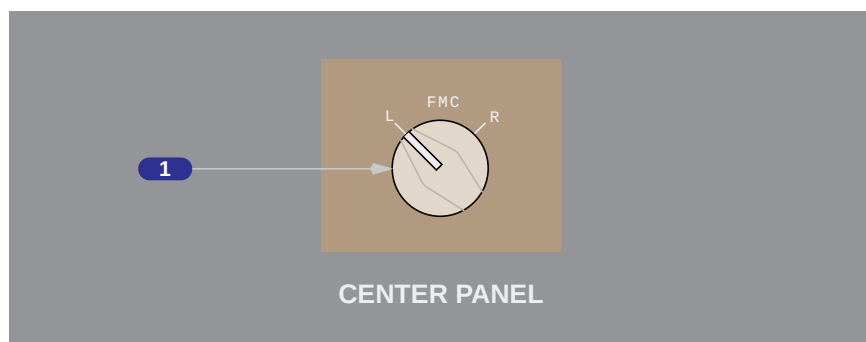
7 Boxes

Data input is mandatory.

8 Prompts

Display pages and control displays. Caret “<” or “>” is before or after prompt.

FMC Selector



1 FMC Master Selector

L - selects left FMC to provide guidance commands

R - selects right FMC to provide guidance commands.

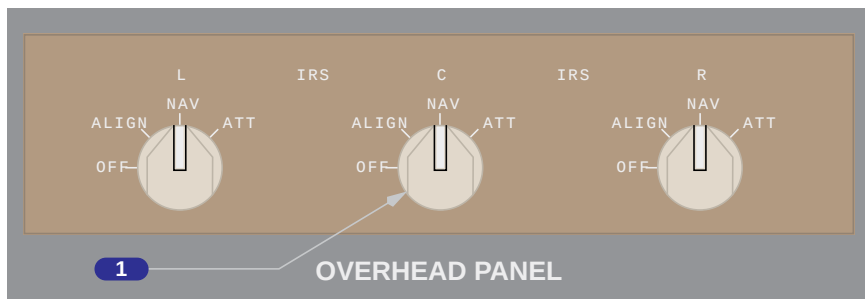
Each FMC (when selected) provides the following:

- Autoflight operations including LNAV and VNAV
- Autothrottle operation
- Automatic NAVRAD tuning (e.g., SFO vs. 115.800)

Note: Switching between FMCs with the autothrottle active causes the autothrottle to disconnect.

Inertial Reference System (IRS)

Inertial Reference Unit (IRU) Selectors



1 IRU Mode Selectors

IRU mode selector must be pulled out to move from NAV position.

OFF - alignment lost.

ALIGN (alignment)- when parked and momentarily selected:

- initiates alignment
- removes sensor errors when selected from navigation mode

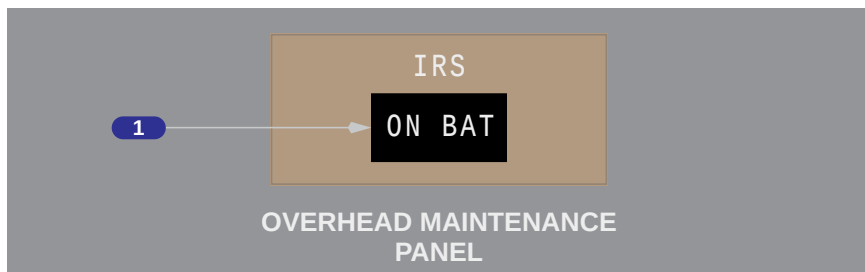
NAV (navigation) -

- system enters navigation mode after completing alignment
- provides IRS information to airplane systems for normal operations

ATT (attitude) -

- system enters attitude mode
- position and velocity information lost until system realigned on ground
- requires magnetic heading input from CDU

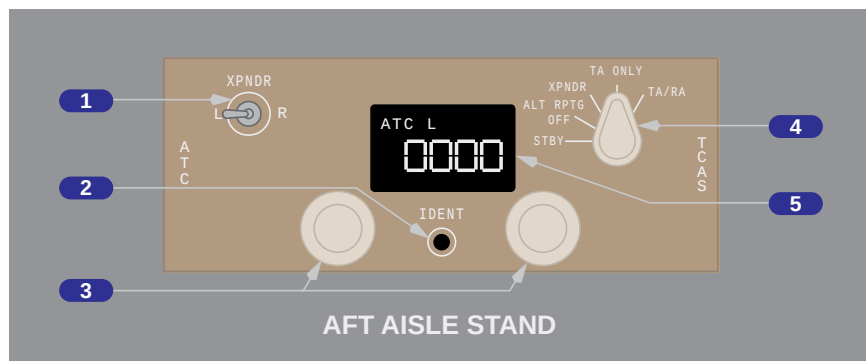
IRS On Battery Light



1 IRS ON Battery (BAT) Light

Illuminated (white) - IRS operating on backup electrical power (APU hot battery bus).

Transponder Panel



1 Transponder (XPNDR) Switch

L - selects left transponder.

R - selects right transponder.

2 Identification (IDENT) Switch

Push - transmits ident signal.

3 Transponder Code Selectors

Rotate - sets transponder code.

4 Transponder Mode Selector

STBY (standby) - transponder disabled.

ALT RPTG OFF (altitude reporting) -

- transponder enabled
- altitude reporting disabled

XPNDR (transponder) -

- transponder enabled
- in flight, altitude reporting enabled

TA ONLY (traffic advisory) and TA/RA (traffic advisory/resolution advisory) -

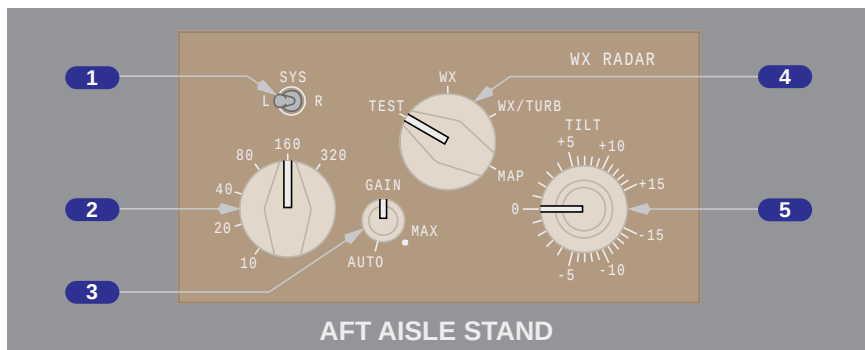
Refer to Chapter 15, Warning Systems.

5 Transponder Code Display

ATC L, ATC R - transponder selected.

Displays transponder code.

Weather Radar Panel



1 System (SYS) Switch

Selects receiver/transmitter (R/T) for operation.

L - radar antenna stabilized by left and center IRUs.

R - radar antenna stabilized by right and center IRUs.

2 Range Selector

Selects desired nautical mile range for auxiliary weather radar display.

3 GAIN Control

Rotate - sets receiver sensitivity.

AUTO (automatic) - maintains optimum receiver sensitivity.

4 Mode Selector

Controls display on NDs and on auxiliary display.

TEST -

- tests weather radar system operation without transmitting
- displays test pattern and any fault message on ND with WXR selected (except in PLAN, CTR VOR, and CTR APP modes)

WX (weather) - displays weather returns at selected gain level.

WX/TURB (weather/turbulence) - displays weather returns and turbulence.

Turbulence display available with display ranges of 40 nm or less.

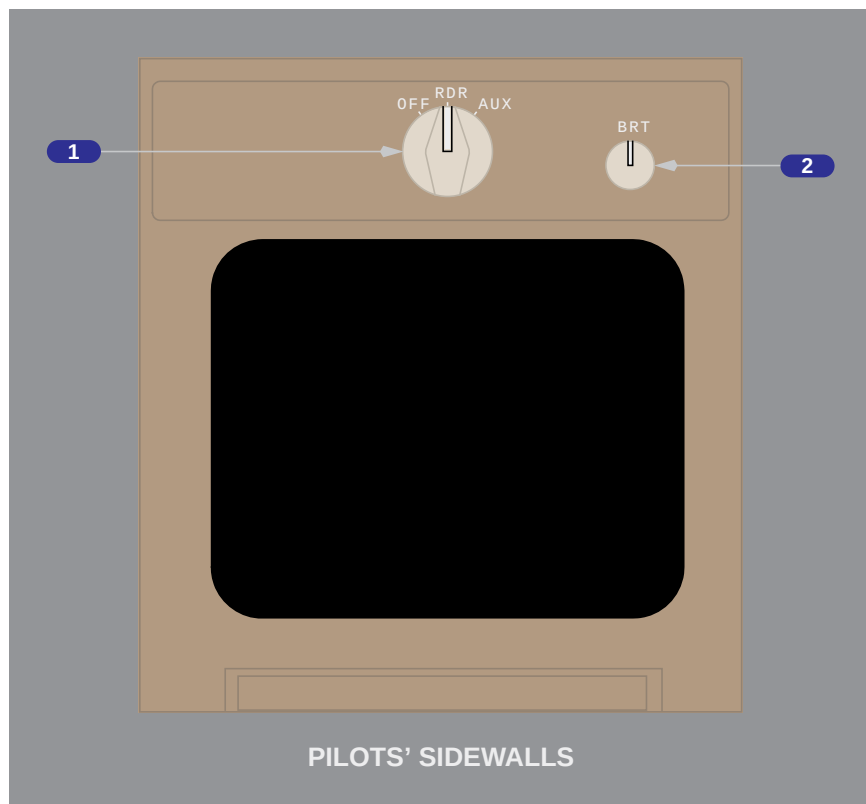
Note: Turbulence detection requires presence of detectable precipitation. Clear air turbulence cannot be detected by radar.

MAP - displays ground returns at selected gain level.

5 TILT Control

Controls antenna tilt angle with reference to horizon.

Auxiliary Weather Radar Display



1 Auxiliary Weather RADAR Display Switch

OFF - removes power from display.

RDR (radar) - activates weather radar and displays radar returns.

AUX (auxiliary) - activates other displays.

2 Brightness Control

Controls brightness of display.

Flight Management, Navigation

Navigation Systems Description

Chapter 11

Section 20

Introduction

Navigation systems include global positioning system (GPS), inertial reference system (IRS), VOR, DME, ILS, ADF, ATC transponder, weather radar, and the flight management system (FMS). The FMS is described in the Flight Management System Description section of this chapter.

Navigation Systems Flight Instrument Displays

Refer to Chapter 10, Flight Instruments, Displays for flight instrument display system operations and typical instrument displays.

Global Positioning System (GPS)

Left and right GPS receivers are independent and supply very accurate position data to the FMC. GPS tuning is automatic.

The GPS also provides data to the GPWS.

GPS Displays

POS REF 3/3 page displays the left and right GPS position. The ND annunciates GPS when the FMC uses GPS position updates.

Pushing the POS (position) switch on the EFIS control panel displays left and right GPS positions on the ND. The GPS symbols are identical and display as a single symbol when the GPS receivers calculate the same position.

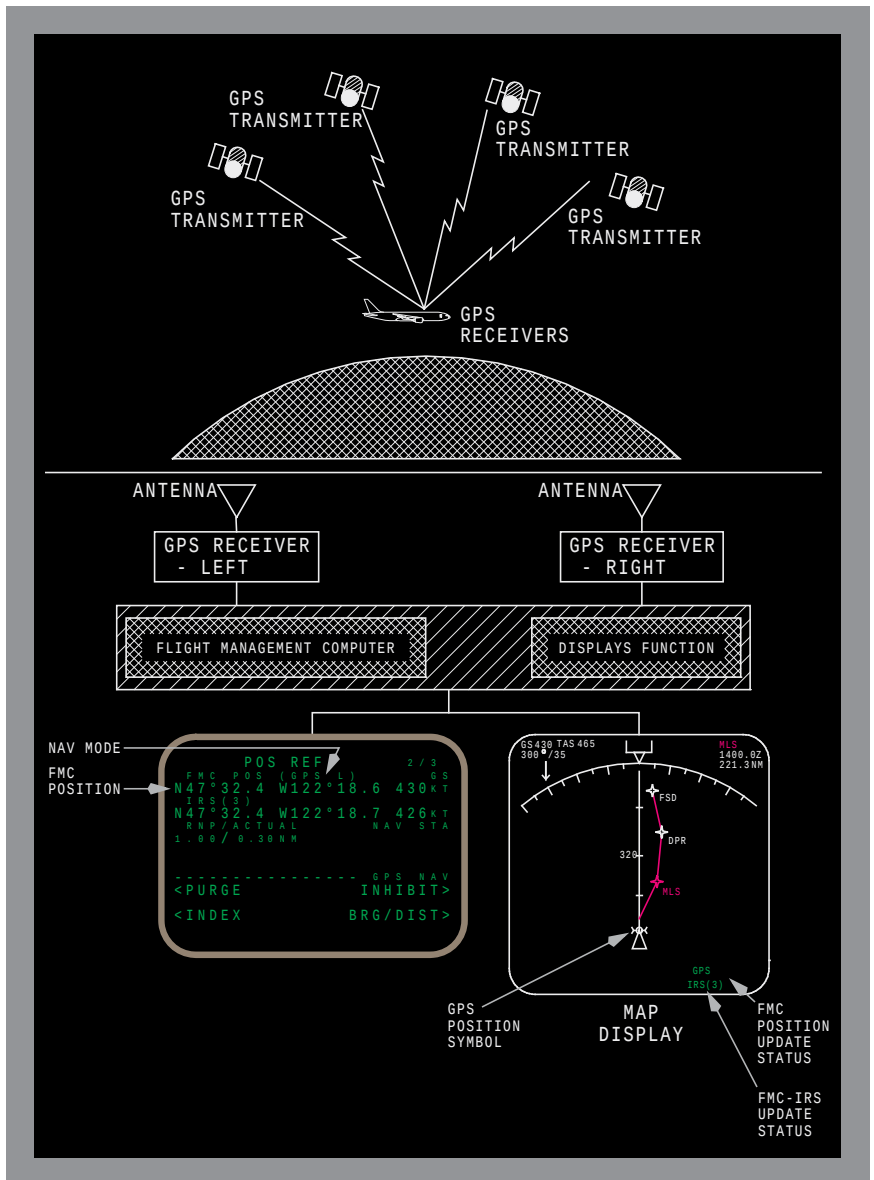
GPS Data

The FMC uses GPS position data to estimate errors in the inertial reference system (IRS) position and velocity. The flight crew can manually inhibit GPS updating. This is accomplished on the CDU POS REF 2/3 page.

GPS position updates should be used during all approaches in which the FMC database and approach procedures are referenced to the WGS-84 reference datum. GPS updates should be inhibited for other approach operations not based on WGS-84 unless other appropriate procedures are used.

GPS position updates should be used for all operations unless a specific state requires the use of other update provisions within their airspace (eg, to accommodate a non-WGS reference datum or other reason).

GPS System Schematic



Inertial Reference System

The inertial reference system (IRS) calculates airplane position, acceleration, track, vertical speed, ground speed, true and magnetic heading, wind speed and direction, and attitude data for the displays, flight management system, flight controls, engine controls, and other systems. The IRS consists of three inertial reference units (IRUs) and the IRS mode selector panel.

IRS Alignment

Full Alignment

Rotating the IRS mode selector from OFF to NAV begins IRS alignment. Alignment requires approximately ten minutes. Present position (latitude and longitude) must be entered on the CDU position initialization page to complete alignment. Alignment can be accomplished only when the airplane is parked. Alignment stops if an IRU detects motion during alignment. Alignment continues and completes in approximately ten minutes after motion stops. The IRS is aligned when all IRUs enter the navigation mode. Latitude and longitude entries then blank on the SET IRS POS line on the CDU position initialization page. In addition, heading information appears on the PFD and ND. Alignment is lost if the selector is moved out of the NAV position.

A full alignment, accomplished by rotating the IRS mode selector to OFF and back to NAV, must be accomplished when the time from the last full alignment to the next expected arrival time exceeds 18 hours.

Fast Realignment

Following operation in the navigation mode and with the airplane parked, performing a fast alignment removes accumulated track, ground speed, and attitude errors, relevels the system, and updates present position. This is accomplished by positioning selectors to ALIGN, entering present position, and repositioning selectors to NAV. Fast alignment completes in approximately 30 seconds.

Fast alignment can be accomplished without entering present position. However, greater navigational accuracy is attained by entering present position.

IRS Attitude

If alignment is lost in flight, the navigation mode is inoperative for the remainder of the flight. Attitude information can be obtained by moving the selector to ATT. The IRU enters align mode for 30 seconds. This aligns the system. For best accuracy, the airplane must be in straight and level flight. Some attitude errors may occur during acceleration. After acceleration, errors are slowly removed.

The attitude mode can also provide heading information. A magnetic heading input is required to initialize the IRU while in attitude mode. This heading is available for backup if all three IRUs fail. Heading information displayed on the PFD and ND is from an IRU operating in the navigation mode. This information is independent of the IRS source selector position if an operating FMC is selected by the navigation source selector.

IRS Power

The IRS can operate on AC or DC power. The center IRU operates on DC power for five minutes, then shuts down. If an IRU loses both AC and DC power, alignment is lost.

Radio Navigation Systems

Automatic Direction Finding (ADF)

ADF Tuning

Two ADF receivers can be manually tuned from the left or right CDU on the NAV RADIO page.

ADF Displays

Left and right ADF bearings display on the ND when the VOR/ADF switch is in the ADF position. ADF data is cyan.

If both FMCs fail, left and right ADF radios can be tuned on the respective left and right ALTN NAV RADIO page.

Distance Measuring Equipment (DME)

The FMC usually tunes the two, five channel DME transceivers. Channels 3 and 4 can be tuned manually.

DME Tuning

Entering the VOR portion of a VOR/DME pair on the NAV RADIO page manually tunes the DME. Manual DME tuning does not inhibit FMC DME tuning.

The FMC tunes DME channels 1-4 for radio position updates. DME/DME position updates are usually more accurate than VOR/DME updates. The FMC cannot tune DMEs inhibited on the REF NAV DATA page. Channel 5 is reserved for tuning the selected ILS frequency.

If both FMCs fail, left and right DME transceivers can be tuned by entering the VOR portion of a VOR/DME pair on the related left and right CDU ALTN NAV page. Each DME channel 1 is tuned to the VOR shown on the CDU unless the related EFIS control panel ND mode selector is set to APP. In APP mode, DME channel 1 is tuned to the ILS.

DME Displays

DME distance displays at the top of the ND with the VOR mode selected. DME distance displays on the PFD when ILS receivers are tuned to a collocated DME and localizer facility. DME distances also display at the bottom of the ND when either or both VOR L or VOR R switches are selected.

POS REF page 2 displays the identifiers of the DME stations used for FMC position updates.

Instrument Landing System (ILS)

The FMC usually tunes the three ILS receivers. The receivers can be tuned manually on the NAV RADIO page.

ILS Tuning

Receivers tune and frequency/course display after selecting an ILS, LOC, back course, VOR, runway, or a VFR approach to an ILS/LOC equipped runway and the airplane is within 150 nm of the destination airport, 50 nm of T/D, or in FMC descent.

For non-ILS database approaches to an ILS/LOC-equipped runway, the ILS autotunes and pointers and deviation scales display for positional awareness.

On initial takeoff, ILS autotuning is inhibited for 10 minutes to prevent clutter on the PFD. Selection and execution of a new approach in the active flight plan causes the ILS to autotune the new approach frequency, even if this is accomplished during the 10 minute takeoff inhibit period. ILS autotune inhibit does not apply to subsequent takeoffs on the same flight (for example, touch-and-go or stop-and-go landings).

All three ILS receivers can be manually tuned from the NAV RADIO page unless ILS approach tuning inhibit is active.

ILS approach tuning inhibit is active when:

- the autopilot is engaged and either the localizer or glideslope is captured
- the flight director is engaged, and either the localizer or the glideslope is captured, and the airplane is below 500 feet radio altitude, or
- on the ground, the localizer is alive, airplane heading is within 45 degrees of the localizer front course, and ground speed is greater than 40 knots

ILS tuning is enabled by disengaging the autopilot and turning OFF both flight director switches.

If both FMCs fail, ILS receivers can be tuned on the CDU ALTN NAV RADIO page. The left ILS receiver is tuned with the left CDU, the center receiver is tuned with the center CDU, and the right receiver is tuned with the right CDU.

ILS Displays

The tuned ILS frequency displays on the PFD; and, on the ND in the approach mode. When receiving the identification signal, the decoded identifier displays.

Localizer and glideslope deviation display on the PFD. Localizer and glideslope deviation, and selected course display on the ND when the related ND is in the approach mode.

VOR

The FMC usually tunes the two VOR receivers. The receivers can be tuned manually on the NAV RADIO page using the station frequency or identifier.

VOR Tuning

The FMC tunes a VOR and a collocated DME for position updating when more accurate sources are not available. Specific VOR/DME pairs can be inhibited on the REF NAV DATA page. If the crew enters two VOR identifiers/frequencies on the NAV RADIO page, the FMC cannot tune any other VOR/DME station for updating.

If both FMCs fail, left and right VOR receivers can be tuned on the respective ALTN NAV RADIO page.

VOR Displays

Left and right VOR bearings display on the ND when the VOR/ADF switch is in VOR position. VOR data is green. With the VOR mode selected, the VOR frequency and selected course display at the top of the ND and course deviation displays.

The NAV RADIO page displays FMC-tuned or manually-tuned VOR data. POS REF page 2 displays identifiers of the VOR stations used for FMC position updating.

Navaid Identifier Decoding

The Morse code identifier of a tuned VOR, ILS, or ADF can be converted to alpha characters. The decoded identifier displays on the PFD and ND. Monitoring this identifier ensures correct navigation radio reception. The identifier name is not compared with the FMC data base.

Due to the large variation in ground station identifier quality, the decode feature may incorrectly convert the intended identifier name. Examples: the Hong Kong localizer “KL” may show as “KAI”, or the Boeing Field ILS may show as “QBFI” or “TTTT” instead of “IBFI.”

It is essential to verify the identity of the tuned navigation station from the audio Morse code if the tuned frequency remains displayed or an incorrect identifier displays.

Transponder

The transponder panel controls two ATC transponders and the traffic alert and collision avoidance system (TCAS). Mode S operates continuously when the transponder mode selector is out of standby; and when on the ground, it provides airport position.

In flight, traffic displays if the transponder mode selector is in TA ONLY or TA/RA.

In flight, the selected transponder activates beacon and altitude reporting when the transponder mode selector is in XPNDR, TA ONLY, or TA/RA.

Refer to Chapter 15, Warning Systems, for a description of TCAS.

Weather Radar

The weather radar system consists of two receiver-transmitter units, an antenna, auxiliary displays, and a control panel.

Radar returns display on the navigation display (ND) in all modes except:

- plan
- VOR center
- approach center

The EFIS control panel weather radar (WXR) map switch controls power to the transmitter/receiver and controls the weather radar display on the ND. The radar display range adjusts to the ND range selected on the EFIS control panel. Weather radar operating modes and fault conditions display on the ND.

If the EFIS control panel fails, the CDU can control the EFIS control panel functions, including the WXR.

Turbulence can be sensed by the weather radar only when there is sufficient precipitation. Clear air turbulence can not be sensed by radar.

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Flight Management, Navigation

Flight Management System Description

Chapter 11

Section 30

Introduction

The flight management system (FMS) aids the flight crew with navigation, in-flight performance optimization, fuel monitoring, and flight deck displays using Flight Management Computers (FMCs). Automatic flight functions manage the airplane lateral flight path (LNAV) and vertical flight path (VNAV). The displays include a map for airplane orientation and command markers on the airspeed, altitude, and thrust indicators to help fly efficient profiles.

The flight crew enters the applicable route and flight data into the CDUs. The FMS then uses the navigation database, airplane position, and supporting system data to calculate commands for manual and automatic flight path control.

The FMS tunes the navigation radios and sets courses. The FMS navigation database supplies the necessary data to fly routes, SIDs, STARs, holding patterns, approaches, and procedure turns. Cruise altitudes and crossing altitude restrictions are used to calculate VNAV commands. Lateral offsets from the programmed route can be calculated and commanded.

Flight Management Computer

Under normal conditions, the left FMC is designated the primary for CDU operations. The left FMC determines which key pushes should be executed and in what order. It then transmits the key-push messages to the right FMC. Each FMC processes the key-push message and updates its own CDU.

The FMC uses flight crew-entered flight plan data, airplane systems data, and data from the FMC navigation database to calculate airplane present position and pitch, roll, and thrust commands necessary to fly an optimum flight profile. The FMC sends these commands to the autothrottle, autopilot, and flight director. The FMC also sends landing altitude data to the cabin altitude controller. Map and route data are sent to the NDs. The EFIS control panels select the necessary data for the ND. The mode control panel selects the autothrottle, autopilot, and flight director operating modes. Refer to the following chapters for operation of these other systems:

- Chapter 4, Automatic Flight
- Chapter 10, Flight Instruments, Displays

Non-GPS Equipped Aircraft

The FMC is certified for area navigation when used with navigation radio updating. The FMC and CDU are used for enroute and terminal area navigation, RNAV approaches, and to supplement primary navigation means when conducting other types of nonprecision approaches.

GPS Equipped Aircraft

The FMC is certified for area navigation when used with navigation radio and/or GPS updating. The FMC and CDU are used for enroute and terminal area navigation, RNAV approaches, and to supplement primary navigation during all types of instrument approaches.

Two IRUs in conjunction with one FMC and two FMS-CDUs meet the requirements as the sole means of navigation for flights up to 18 hours duration.

Control Display Units (CDUs)

The flight crew controls the FMC using three CDUs. The CDUs give alternate display and navigation capability if both FMCs fail (refer to the Alternate Navigation section of this chapter). Refer to Chapter 10, Flight Instruments, Displays for a description of alternate display control.

Flight Management, Navigation

Flight Management System Operation

Chapter 11

Section 31

Introduction

When first powered, the FMS is in preflight phase. When completing a phase, the FMS changes to the next phase in this order:

- preflight
- takeoff
- climb
- cruise
- descent
- approach
- flight complete

Preflight

During preflight, the flight crew enters flight plan and load sheet data into the CDU. The flight plan defines the route of flight from the origin to the destination and initializes LNAV. Flight plan and load sheet data provide performance data to initialize VNAV.

FANS/CPDLC Equipped Aircraft

Some company and ATC information can be entered into the CDU by datalink.

Required preflight data consists of:

- initial position
- route of flight
- performance data
- takeoff data

Optional preflight data includes:

- navigation database selection
- route 2
- alternate airport
- standard instrument departure (SID)
- standard terminal arrival route (STAR)
- thrust limits
- wind

Preflight starts with the IDENT page. If the IDENT page is not displayed, it can be selected with the IDENT prompt on the INIT/REF INDEX page. Visual prompts help the flight crew select CDU preflight pages. Preflight pages can be manually selected in any order.

After the data on each preflight page is entered and checked, pushing the lower right line select key selects the next preflight page. After selecting ACTIVATE on the ROUTE page, the execute (EXEC) light illuminates. Pushing the EXEC key activates the route.

The departure/arrival (DEP/ARR) page can be used to select a SID. Selection of the SID may cause a route discontinuity. Resolution of the discontinuity and execution of the modification should be accomplished on the LEGS page.

When all required preflight entries are complete, the PRE-FLT line title on the TAKEOFF REF page is replaced by dashes and the THRUST LIM prompt displays at the next page select line location.

Takeoff

Takeoff phase starts with selection of TO/GA and terminates with thrust reduction for climb. LNAV and VNAV can be armed before takeoff to activate at the applicable altitude (refer to Chapter 4, Automatic Flight).

Climb

Climb phase starts at thrust reduction for climb and terminates at the top of climb (T/C) point. The T/C point is where the airplane reaches the cruise altitude entered on the PERF INIT page.

Cruise

Cruise phase starts at the T/C point and terminates at top of descent (T/D) point. Cruise can include step climbs and en route descents.

Descent

Descent phase starts at the T/D point or when the VNAV descent page becomes active and terminates at the start of approach phase.

Approach

Approach phase starts when the first waypoint of the procedure sequences or when the runway is the active waypoint and the distance to go is less than 25 nm.

Flight Complete

Thirty seconds after engine shutdown, flight complete phase clears the active flight plan and load data. Some preflight data fields initialize to default values in preparation for the next flight.

Operational Notes

When operating in LNAV and VNAV modes, observe system operation for unwanted pitch, roll, or thrust commands. If unwanted operation is observed, select heading select and flight level change modes.

The system must be carefully observed for errors following:

- activation of a new data base
- power interruption
- IRU failure

The FMC will not sequence the active waypoint when: more than 21 nm off the active route and not on an offset route. Return to the active route can be accomplished using the DIRECT TO or INTERCEPT COURSE TO procedures.

When a waypoint is made on the LEGS page with a duplicate identification, the SELECT DESIRED WPT page displays and the correct navaid can be selected and entered into the active route.

Some SIDs or STARS contain a heading vectors leg. VECTORS waypoints display on the ND as a magenta line without an end point leading away from the airplane symbol. If LNAV is active, the DIRECT TO or INTERCEPT COURSE TO procedures can be used to start waypoint sequencing beyond the vectors leg.

When entering airways on a route page, the start and end waypoints must be in the data base. Otherwise, the route segment must be entered as a DIRECT leg.

If the engines remain operating between flights, entering a new cruise altitude before the next flight recalculates the proper vertical profile.

If a climb to cruise altitude is necessary after completing a descent, a new cruise altitude entry must be made. Cruise altitude can be entered on the CLB page.

DIRECT TO courses are segments of a great circle route. When entering a DIRECT TO waypoint on the Legs page, the course above the waypoint before execution is the arrival course at the waypoint. However, after execution, the course is the current course to fly to the waypoint. These courses may not be the same.

Terminology

The following paragraphs describe FMC and CDU terminology.

Active - flight plan data used to calculate LNAV or VNAV guidance commands.

Activate - changing a route from inactive to active for navigation by:

- selecting ACTIVATE prompt
- pushing execute (EXEC) key

Altitude constraint - a crossing restriction at a waypoint.

Delete - using DELETE key removes FMC data and reverts to default values, dash or box prompts, or a blank entry.

Econ - a speed schedule calculated to minimize operating cost. Economy speed is based on the cost index. A low cost index causes a lower cruise speed. Maximum range cruise or the minimum fuel speed schedule may be obtained by entering a cost index of zero. This speed schedule ignores the cost of time. A minimum time speed schedule may be obtained by entering a cost index of 9999. This speed schedule calls for maximum flight envelope speeds. A low cost index may be used when fuel costs are high compared to operating costs.

Enter - putting data in the CDU scratchpad and line selecting the data to the applicable location. New characters can be typed or existing data can be line selected to the scratchpad for entry.

Erase - removing entered data, which has resulted in a modification, by selecting the ERASE prompt.

Execute - pushing the illuminated EXEC key to make modified data active.

Inactive - data not being used to calculate LNAV or VNAV commands.

Initialize - entering data required to make the system operational.

Message - FMC information displayed in the scratchpad.

Modify - changing active data. When a modification is made to the active route or performance mode, MOD displays in the page title, ERASE displays next to line select key 6 left, and the execute key illuminates.

Prompt - CDU symbols that aid the flight crew in accomplishing a task. Prompts can be boxes, dashes, or a caret (< or >) line to remind the flight crew to enter or validate data.

Resynchronization - one FMC loading data into the other when a significant difference between the two FMCs is detected.

Select - pushing a key to obtain necessary data or action, or to copy selected data to the scratchpad.

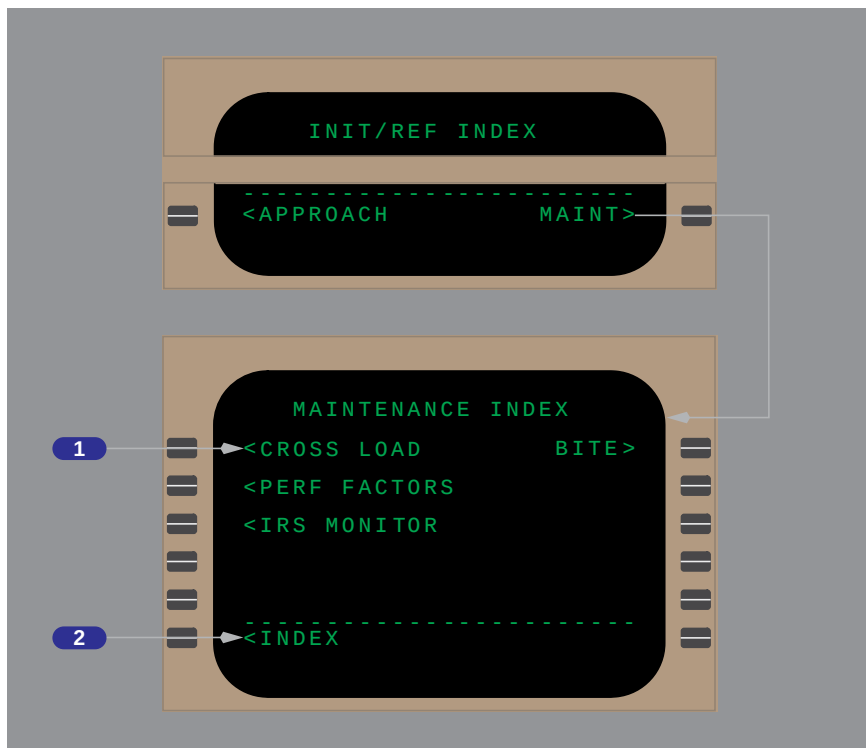
Speed restriction - an airspeed limit.

Speed transition - an airspeed limit associated with a specified altitude entered by the FMC.

Waypoint - a point on the route or in the navigation data base. It can be a fixed point such as a latitude and longitude, VOR or ADF station, or an airway intersection. A conditional waypoint is not associated with a land reference; it is based on a time or altitude requirement. An example of a conditional waypoint is “when reaching 4,000 feet”.

Maintenance Index

MAINTENANCE INDEX page prompts are only used on the ground.



1 Maintenance Prompts

All prompts on this page are maintenance functions.

2 INDEX

Push - displays the INIT/REF INDEX page.

Navigation Position

The FMC determines present position from these navigation systems: GPS, navigation radios, and IRS. When receiving reliable GPS data, the primary mode of navigation is from a GPS updated FMC position. If GPS data is not available, cannot be validated, or is inhibited, the FMC position is updated using navigation radios. When navigation radios are not available or reliable, the FMC position comes from the IRS. In the case of IRS-only navigation, at least one IRU is required. The FMC requires position data from the IRS. All other position sources are validated against the IRS position.

FMC Position Update

The FMC position may be manually updated to the mixed IRS position. This update is accomplished using the PURGE prompt on the POS REF page 2.

On the ground, the FMC calculates present position based on IRS and/or GPS data.

When GPS is not active, pushing a TO/GA switch updates the FMC position to the runway threshold or to the position shift position when entered. When making an intersection takeoff, the intersection displacement distance from the runway threshold must be entered on the TAKEOFF REF page.

In flight, the FMC position is the IRS position updated by GPS or navigation radio source data to compensate for inertial reference errors. Updating priority is based on the availability of valid data from these sources.

During an ILS/LOC approach, localizer signals (LOC, LOC DD, LOC VD, or LOC GPS) update the FMC.

The navigation radios update the FMC position using two DME stations (DD) or one VOR and its collocated DME(VD).

FMC selected stations display on the POS REF page 2. Position error can be detected by selecting the EFIS POS switch and observing calculated VOR (Chapter 10, VOR navigation display symbology) positions relative to VOR/DME RAW DATA radial and distance information.

The FMC automatically tunes VOR, DME, and ILS radios and displays them on the ND and CDU NAV RADIO page. Selection is related to the active route and any procedure (SID, STAR, etc.) in the active route. Manually selecting VOR frequencies precludes the FMC from autotuning other VOR/DME frequencies for position updating; however, the FMC continues to tune DME-DME pairs for position updating.

IRS position updating occurs in the following priority order:

- LOC and GPS
- LOC and DME-DME
- LOC and collocated VOR/DME
- LOC
- GPS
- DME-DME
- collocated VOR/DME

The selected station identifiers of the radio navigation aids display on the POS REF page 2.

Primary FMC Position Update Source	POS REF page 2/3	ND Annunciation
LOC, GPS valid*	LOC-GPS	LOC GPS
LOC, DME DME valid; GPS invalid*	LOC-RADIO	LOC DD
LOC, VOR DME valid; GPS invalid*	LOC-RADIO	LOC VD
LOC valid; GPS, DME, VOR invalid*	LOC	LOC
GPS valid, LOC invalid	GPS L, GPS R	GPS
DME valid; GPS invalid	RADIO	DD
VOR DME valid; GPS invalid	RADIO	VD
GPS, VOR, DME invalid	INERTIAL	IRS(X)
* The FMC changes to LOC updating when: • the tuned localizer is associated with the destination runway • the airplane is less than 6,000 feet above the localizer navaid elevation • the airplane is less than 20 nm from the localizer navaid for a front course approach or less than 12 nm for a back course approach • the airplane is within a 25° sector of the inbound localizer course • the difference between airplane track and the localizer course is less than a 45° intercept angle		

FMC Polar Operations

Polar operation begins when the FMC calculated airplane position passes north of 84°N or south of 84°S. FMCs revert to split IRS operation, the CDU message SPLIT IRS OPERATION displays, and each FMC connects to a different IRU. Radio update corrections are lost and FMCs incrementally remove the difference between FMC and IRU positions.

Split IRS operation may result in differences between Captain's and F/O's NDs if GPS updating is not available.

When GPS is available, GPS updating continues until the FMC position passes north of 88.5°N or south of 88.5°S. At this point, GPS update corrections are inhibited and the FMC position becomes a single IRU position. The EICAS alert message UNABLE RNP is inhibited. When the FMC position passes south of 88.0°N or north of 88.0°S, GPS updating resumes.

When both FMC positions pass south of 83.5°N or north of 83.5°S latitude, FMCs return to normal operation using the triple mixed IRU position.

High Latitude Operations

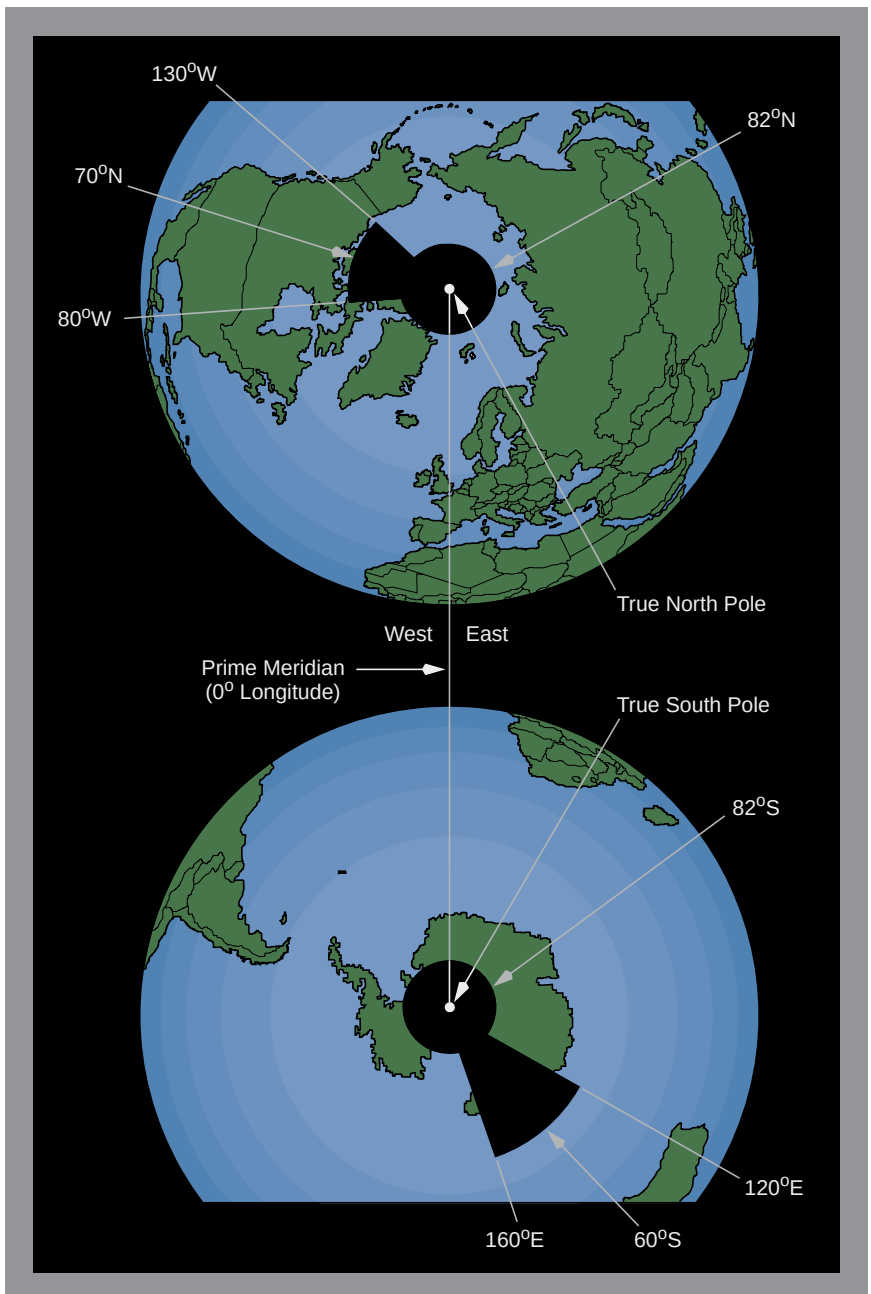
The heading reference for PFDs, NDs, and RMI changes to true north at 82°N (or north of 70°N between 80°W and 130°W) or at 82°S (or south of 60°S between 120°E and 160°E).

At latitudes between 82°N (or south of 70°N between 80°W and 130°W) and 82°S (or north of 60°S between 120°E and 160°E), the FMC and IRU reference is determined by Heading Reference switch position. Outside this region, the FMC and IRUs reference true north regardless of Heading Reference switch position.

Automatic switching to a true north reference annunciates by a flashing white box around the word TRU on the ND. A TRUE heading reference can be selected with the Heading Reference switch inside or outside high latitudes. The ND displays a green box around the word MAG to annunciate the change back to magnetic reference. If the heading reference is TRU in the descent phase, the ND displays an amber box around the word TRU.

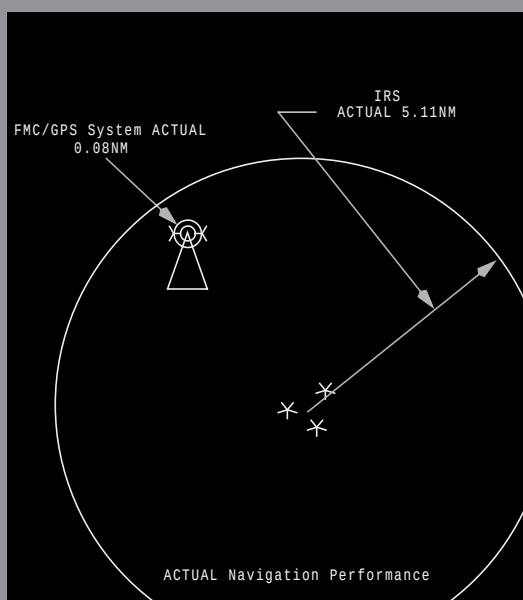
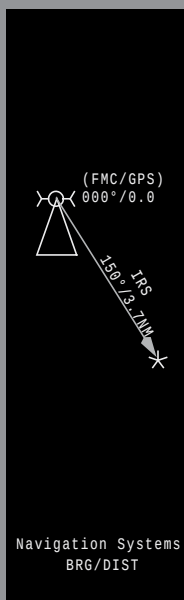
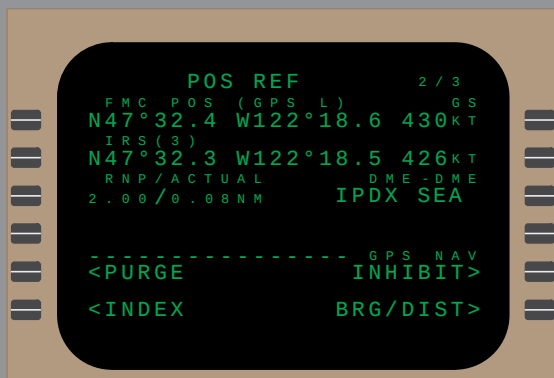
Note: For autopilot operation in high latitudes using a roll mode other than LNAV, the TRUE position on the Heading Reference switch should be selected.

Areas of High Latitude Operations (with expanded MAGVAR)



Navigation Performance

The FMC uses data from navigation systems to accurately calculate the position of the airplane. The current FMC position is on line 1 of the POS REF page 2. The primary source of update is in parentheses above the FMC position. The inertial reference system position is on line 2. The FMC position displays on the ND at the tip of the triangle. The IRS position displays relative to the FMC position. The ACTUAL navigation performance circles shown below do not display on the ND.



Actual Navigation Performance

Actual navigation performance (ANP) is the FMC current computed position accuracy. It is titled ACTUAL and displays on the POS REF page 2 for the navigation system displayed in title line 1. ACTUAL navigation performance is a circular prediction centered at the FMC position. Airplane position is estimated to be within this ACTUAL navigation performance circle 95% of the time.

Required Navigation Performance

Required Navigation Performance (RNP) is the navigation accuracy required for operation within a defined airspace. It is expressed in nautical miles. RNP values have been published for areas of operation around the world. Operations in these areas require on-board navigation systems to alert the flight crew if ANP exceeds RNP. The FMC supplies a default RNP value for takeoff, en route, oceanic/remote, terminal, and approach phases of flight. The flight crew may enter an RNP value, when required. RNP is on POS REF page 2.

Lateral Navigation (LNAV)

LNAV normally provides great circle courses between waypoints making up the active route. When an FMC database procedure is entered in the active route, the FMC commands a heading, a track, or a DME arc to comply with the procedure.

Waypoints

Waypoint identifiers display on the CDU and navigation display.

The CDU message NOT IN DATABASE displays if a manually entered waypoint identifier is not in the database. Waypoints can be entered as latitude/longitude, place/bearing/distance, or place bearing/place bearing.

FMC-generated waypoints contain a maximum of five characters assigned according to the following rules.

Navaid Waypoints

VHF - waypoints located at VHF nav aids (VOR/DME/LOC) are identified by one, two, three, or four character facility identifier. Example: Los Angeles VORTAC - LAX.

NDB - waypoints located at NDBs are identified by use of the station identifier. Example: FORT NELSON, CAN - YE.

Fix Waypoints

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

Long Waypoints

Waypoints with more than five characters are abbreviated using the following rules sequentially until five characters remain:

- for double letters, one letter is deleted. Example: KIMMEL becomes KIMEL.
- keep the first letter, first vowel, and last letter. Delete other vowels starting from right to left. Example: BAILEY becomes BAILY
- the next rule abbreviates names even further. Apply the previous rule, then delete consonants from right to left. Example: BRIDGEPORT becomes BRIDGPRT then BRIDT
- fixes with multiword names use the first letter of the first word and abbreviate the last word, using the above rules sequentially until a total of five characters remain. Example: ROUGH ROAD becomes RROAD

Unnamed Waypoints

When an unnamed turn point, intersection, or fix is collocated with a named waypoint or navaid on a different route structure (such as low altitude routes or an approach), the name or identifier of the collocated waypoint is used. Example: Unnamed turn point on J2 between Lake Charles (LCH) and New Orleans (MSY) VORTACs is coincidental with the Lafayette (LFT) low altitude VORTAC. LFT is used as the identifier for the turn point.

Identifier codes for unnamed turn points not coincidental with named waypoints are constructed from the identifier of a navaid serving the point and the distance from the navaid to the point. If the distance is 99 nautical miles or less, the navaid identifier is placed first, followed by the distance. If the distance is 100 nautical miles or more, the last two digits are used and placed ahead of the navaid identifier. Examples (NAVAID - DISTANCE - IDENT):

- INW - 18 - INW18
- CSN - 106 - 06CSN

Waypoints located at unnamed flight information region (FIR), upper flight information region (UIR), and controlled airspace reporting points are identified by the three-letter airspace type identification followed by a two-digit sequence number. Example: FRA01.

Unnamed oceanic control area reporting points in the northern hemisphere use the letters N and E, while points in the southern hemisphere use the letters S and W. Latitude always precedes longitude. For longitude, only the last two digits of the three digit value are used.

Placement of the designator in the five character set indicates whether the first longitude digit is 0 or 1. The letter is the last character if the longitude is less than 100° and is the third character if the longitude is 100° or greater.

N is used for north latitude, west longitude. E is used for north latitude, east longitude. S is used for south latitude, east longitude. W is used for south latitude, west longitude. Examples:

- N50° W040° becomes 5040N
- N75° W170° becomes 75N70
- N50° E020° becomes 5020E
- N06° E110° becomes 06E10
- S52° W075° becomes 5275W
- S07° W120° becomes 07W20
- S50° E020° becomes 5020S
- S06° E110° becomes 06S10

Procedure Arc Fix Waypoints

Unnamed terminal area fixes along a DME arc procedure are identified with the first character D. Characters 2 through 4 indicate the radial on which the fix lies. The last character indicates the arc radius. The radius is expressed by a letter of the alphabet where A = 1 mile, B = 2 miles, C = 3 miles and so forth. Example: EPH252°/24 = D252X.

An unnamed waypoint along a DME arc with a radius greater than 26 miles is identified by the station identifier and the DME radius. Example: CPR338°/29 = CPR29.

When there are multiple unnamed waypoints along a DME arc with a radius greater than 26 miles, the station identifier is reduced to two characters, followed by the radius, and then a sequence character. Examples:

- CPR134°/29 = CP29A
- CPR190° /29 = CP29B

Procedure Fix Waypoints

Marker beacons are identified by the marker type identifier followed by the runway number. Examples: Outer Marker 13R = OM13R.

Runway-related fixes - waypoints located at unnamed runway-related fixes are identified by adding a two-letter prefix to the runway number:

- RX - runway extension fix
- FA - VFR final approach fix
- CF - final approach course fix
- FF - final approach fix
- IF - initial approach fix
- OM - outer marker
- MM - middle marker
- IM - inner marker
- BM - back course marker
- MD - minimum descent altitude
- A - (+ an alpha) step down fix
- RW - runway threshold
- MA - missed approach point other than RW
- TD - touchdown point inboard of RW

Examples: OM25L, MM09, IM23, RW04, RW18L.

For airports with more than one approach to the same runway, the two letter prefix may change to allow different identifiers for the same waypoint. The first letter identifies the type of fix and the second letter identifies the type approach:

-
• C () - final approach course fix	• ()L - localizer only
• F () - final approach fix	• ()B - backcourse ILS
• P () - missed approach point	• ()D - VOR/DME
• I () - initial approach fix	• ()V - VOR only
• D () - minimum descent altitude	• ()S - VOR with DME points
• T () - touch down point	• ()N - NDB
• R () - runway centerline intercept.	• ()Q - NDB with DME points
• ()I - ILS	• ()M - MLS
	• ()T - Tacan
	• ()R - RNAV

Examples: CI32R, PV15, FN24L.

Unnamed turn points that are part of a procedure are identified as a latitude and longitude waypoint. These include waypoints (except conditional waypoints) defined by flying a course or track from a waypoint (except conditional waypoints) to a radial or DME distance. These waypoints are automatically entered in a route by selection of a procedure using these waypoints, from the departures or arrivals page.

Airport reference points are identified by the ICAO identifier.

DME step down fixes are identified by the distance and a “D.” Examples: 138D, 106D, 56D, 3D

Duplicate Waypoints

Application of the abbreviation rules may create identical identifiers for different waypoints. When a duplicate waypoint identifier is entered, the page changes to the SELECT DESIRED WPT page. The page lists the latitude and longitude of waypoints with the same identifier and the type of facility or waypoint. Selecting the latitude/longitude of the correct waypoint enters the correct waypoint on the original page.

When a waypoint which has a duplicate identifier in the active route is entered in the scratchpad and line selected, the SELECT DESIRED WPT page does not display. A direct-to the downtrack waypoint displays on the ND. Entering the local waypoint (the duplicate) using latitude/longitude, place/bearing/distance, or place bearing/place bearing enables the modification.

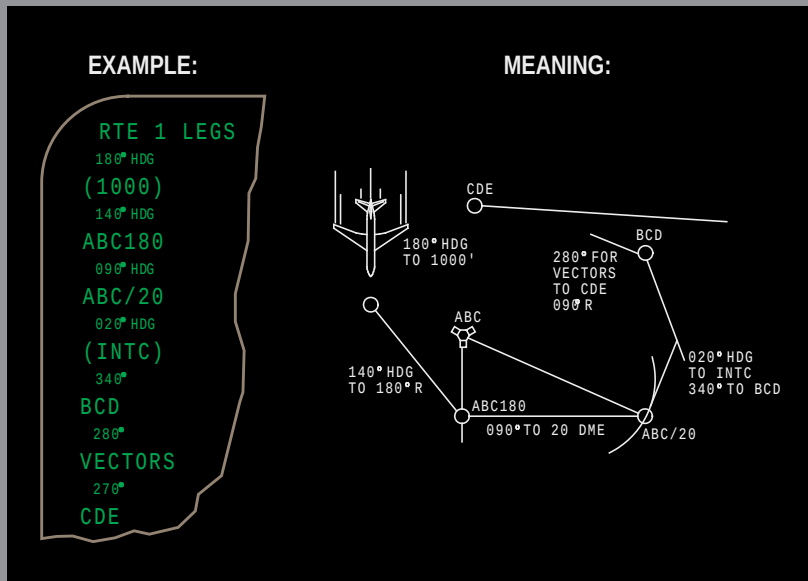
Conditional Waypoints

Conditional waypoints may display in the route when selecting a DEPARTURES or ARRIVALS page procedure. Usually, conditional waypoints cannot be manually entered on a route or legs page. These waypoints indicate when an event occurs and are not at a geographically-fixed position. The types of conditions are:

- climb/descent through an altitude
- flying a heading to a radial or DME distance
- intercepting a course
- heading vectors to a course or fix

Altitude and course intercept conditional waypoints display on the CDU inside (parenthesis) marks. The diagram below shows conditional waypoints.

(1000) is a conditional waypoint. LNAV guidance is to hold a 180° heading until above 1,000 feet; then, turn to a heading of 140°.



NOTE: ALL WAYPOINTS EXCEPT BCD AND CDE ARE
EXAMPLES OF CONDITIONAL WAYPOINTS.

Manually Entered Latitude/Longitude Waypoints

Pilot defined waypoints entered as a latitude and longitude display in a seven-character format. Latitude and longitude waypoints are entered with no space or slash between the latitude and longitude entries. Leading zeroes must be entered. All digits and decimal points (to 1/10 minute) must be entered unless the latitude or longitude are full degrees. Examples:

- N47° W008° is entered as N47W008 and displayed as N47W008
- N47° 15.4' W008° 3.4' is entered as N4715.4W00803.4 and displayed as N47W008

Manually Entered Place/Bearing/Distance or Place Bearing/Place Bearing Waypoints

Waypoints entered as a place/bearing/distance or place bearing/place bearing are identified by the first three characters of the entry followed by a two-digit sequence number. Examples:

- SEA330/10 becomes SEA01
- SEA240/OLM320 becomes SEA02

The two digit sequence numbers reserved for RTE1 are 01 through 49. The two digit sequence numbers reserved for RTE2 are 51 through 99.

Manually Entered Airway Crossing Waypoints

Airway crossing fixes are entered as a five character waypoint name or by entering consecutive airways on the ROUTE page. In the latter case, the display is an X followed by the second airway name. Example: entering J70 on the VIA line of the ROUTE page causes box prompts to display opposite on the same line.

Leaving the box prompts empty and entering J52 on the next VIA line, directly below J70, causes the FMC to calculate the intersection of the two airways and replace the boxes with the waypoint identifier XJ52.

If the number of waypoints in the existing route plus the new waypoints added to reach the new intersection (XJ52) exceeds 120, the FMC rejects the second entry. Repeated attempts to enter the second airway result in an FMC resynchronization. Delaying modification of the route until the number of waypoints to reach the new intersection does not exceed 120 prevents resynchronization.

Manually Entered Latitude or Longitude Reporting Point Waypoints

Latitude or longitude reporting waypoints are entered as the latitude or longitude followed by a dash, then the increment chosen for the following waypoints.

Example:

- W060-10 adds waypoints starting at W060 in ten degree increments from that point to the destination
- the entry must be made on a LEGS page on any line before the first reporting point
- usually, this entry is made on the active waypoint line and proper sequencing is performed by the FMC

Manually Entered Along-Track Waypoints

Along-track waypoints are created on the active route and do not cause route discontinuities where they are created.

Along-track waypoints are created using the waypoint name (the place), followed by a slash and minus sign, for points before the waypoint, or no sign for points after the waypoint, followed by the mileage offset for the newly defined waypoint. The created waypoint is then inserted over the original waypoint. The distance offset must be less than the distance between the originating waypoint and next (positive value) or preceding (negative value) waypoint. Latitude and longitude waypoints cannot be used to create along-track waypoints. Examples:

- VAMPS/25 is 25 miles after VAMPS on the present route, and displays as VAM01
- ELN/-30 is 30 miles before ELN on the present route, and displays as ELN01

ND Map Displays

The route displays on the ND in map, map center, and plan modes. The display color and format represent the following status:

- an inactive route displays as a cyan dashed line
- an activated, but not yet executed route, displays as an alternating cyan/white dashed line
- the active route displays in magenta
- modifications to an active route display as dashed white lines
- modified waypoints display in white
- executed route offsets display as a dashed magenta line

The ND displays the FMC position at the apex of the airplane symbol. All ND map data displays relative to this apex.

When adequate radio (or GPS) updating is not available, the ND map may display a shift error. This error results in the displayed position of the airplane, route, waypoints, and navigation aids being shifted from their actual position. An undetected, across track map shift may result in the airplane flying a ground track offset from the desired track. An undetected, along track map shift may result in the flight crew initiating altitude changes earlier or later than desired. In either case, an undetected map shift may compromise terrain or traffic separation.

Map shift errors can be detected by comparing the position of the airplane on the ND map with data from the ILS, VOR, DME, and ADF systems.

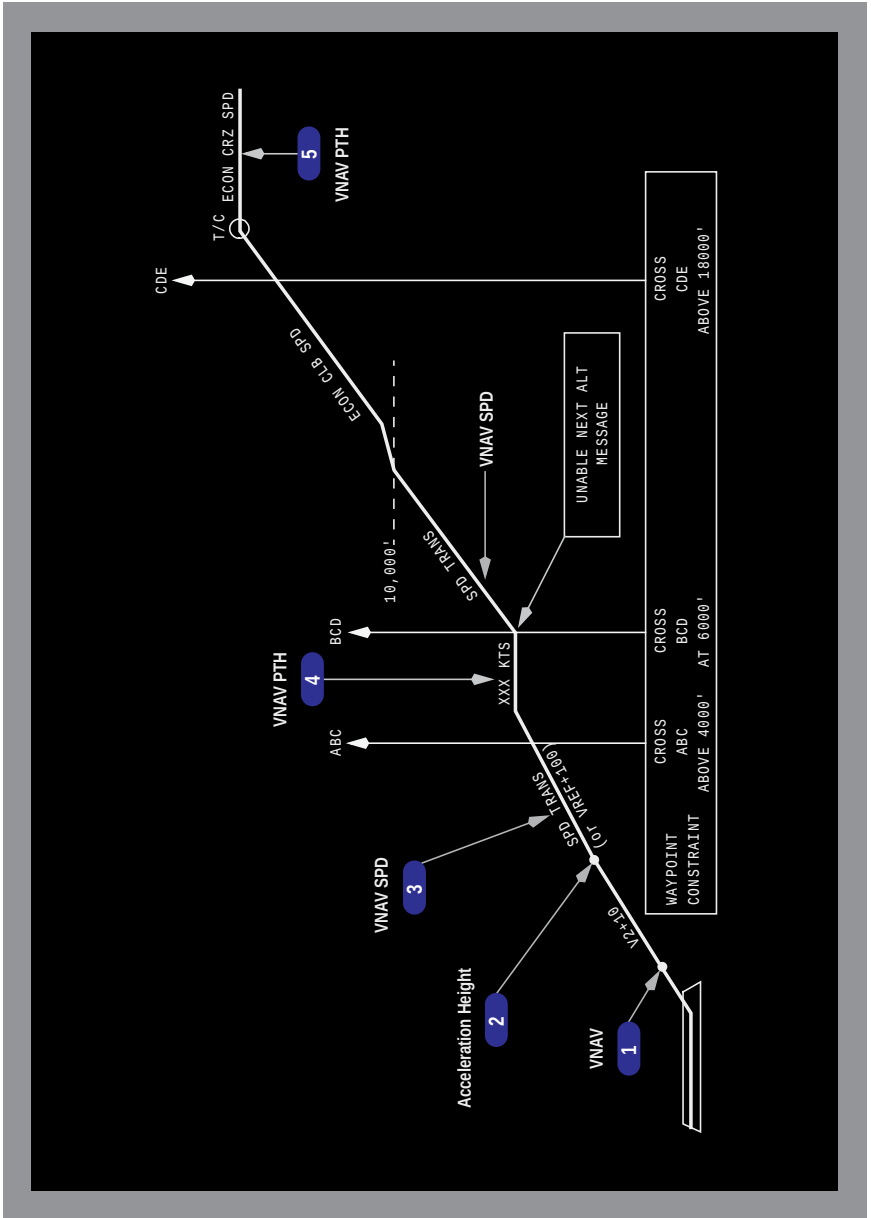
Vertical Navigation (VNAV)

VNAV provides vertical profile guidance through the climb, cruise, and descent phases of flight.

Speed/Altitude Constraints

VNAV controls the path and speed to comply with waypoint crossing constraints. Waypoint crossing constraints are entered on the LEGS page waypoint line by pushing the applicable key on the right side of the CDU. Barometric altitude constraints must be below the cruise altitude to be valid. Values entered as part of a procedure and manually entered constraints display in large font. FMC predicted values do not act as constraints, and display in small font.

Takeoff and Climb



1 Takeoff

When armed for takeoff, VNAV activates at 400 feet and pitch guidance continues to maintain the target airspeed.

During takeoff, the FMC updates the target airspeed to the current airspeed until VNAV activates. The target airspeed is between $V_2 + 10$ and $V_2 + 25$.

2 Acceleration Height

At acceleration height or flap retraction, VNAV commands an airspeed increase to a speed 5 knots below the flap placard speed for the existing flap setting. When flaps are retracted or at an AFDS capture altitude, VNAV commands the greater of $V_{30REF} + 100$ knots or the speed transition associated with the origin airport, limited by configuration.

The FMC changes the reference thrust limit to the armed climb thrust at the thrust reduction point.

3 VNAV Climb

VNAV climb profile uses VNAV SPD or VNAV PTH as the default climb speed or pilot selected climb speed to remain within all airspeed and altitude constraints of an active route Standard Instrument Departure. Autothrottle uses the armed climb thrust limit.

If the climb speed profile cannot achieve an altitude constraint, the UNABLE NEXT ALT scratchpad message displays.

4 Climb Constraints

VNAV enters the VNAV PTH mode to remain within departure or waypoint constraints. Speed maintained during this time can be:

- procedure based speed restriction
- waypoint speed restriction
- default VNAV climb speed
- manually entered climb speed

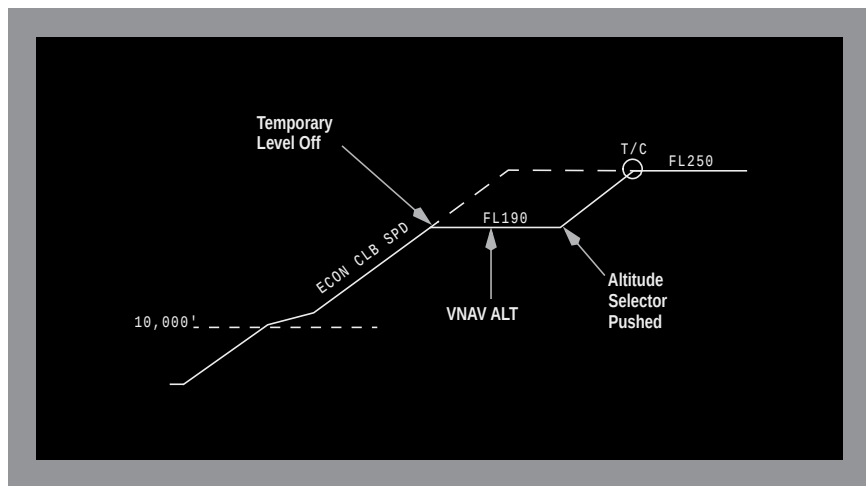
If the FMC predicts the airplane will not reach an altitude constraint, the FMS-CDU message UNABLE NEXT ALTITUDE displays. Speed intervention can be used by pushing the IAS/MACH selector and manually setting a lower airspeed to provide a steeper climb; or, climb derates can be deleted on the Thrust Limit page.

5 Top Of Climb (T/C)

The point where climb phase meets the cruise altitude is called the top of climb. Approaching this point, the FMC changes from climb phase to cruise phase. The T/C displays any time the FMC calculates a change from climb phase to cruise phase, such as step climb.

The T/C point displays on the map as a green circle with the label T/C.

MCP Altitude Intervention



Whenever the airplane levels at an MCP altitude not in the FMC, VNAV ALT annunciates. For example, FMC cruise altitude is FL250 and the clearance altitude, FL190, is set in the MCP. Pitch maintains altitude and thrust maintains FMC target speed. In the example, the speed after the temporary level off would be ECON CLB SPEED.

Setting the clearance altitude in the MCP altitude window and pushing the altitude selector continues the climb. VNAV SPD activates. Pitch maintains FMC speed and thrust increases to the armed reference thrust limit. In the example, the airplane climbs to FMC CRZ ALT and levels at FL250 in cruise.

Cruise

During cruise, the FMC commands economy cruise speed until reaching the top-of-descent (T/D) point. Other cruise speed options are:

- long range (LRC)
- engine out (ENG OUT), or
- flight crew entered speed
- required time of arrival (RTA)

The FMC commands maximum range cruise speed with the cost index set to zero. Cost index modifications are allowed until within ten miles of the top of descent.

Cruise Climb

Setting an altitude above the current cruise altitude in the MCP altitude window and pushing the altitude selector causes the cruise altitude to be set to the MCP altitude and the airplane to climb to the new cruise altitude. The CRZ page displays ACT ECON CRZ CLB.

Step Climb

Fuel and ETA calculations assume the airplane climbs at each calculated step climb point as airplane weight decreases. FMC calculated step climb increments are based on the step size shown on the CRZ page. Entering a step size of zero causes the FMC to assume a constant altitude cruise.

Flight crew entry of a STEP TO altitude on the CRZ page or “S” on a waypoint on the LEGS page overrides FMC step climb calculations. Entry of a step altitude on the LEGS page overrides a STEP TO entry made on the CRZ page.

Calculated step altitudes display on the LEGS page. The distance and ETA to the next step point (calculated or flight crew entered) display on the CRZ and PROGRESS pages. They also display on the ND map display with a green circle and “S/C”.

The FMC calculates step climb locations and altitudes as a function of lateral flight plan, current cruise speed mode and altitude, entered forecast winds and temperatures, step size, cruise cg, and gross weight.

The primary factor affecting step climb calculation is the entry of accurate forecast cruise winds and temperatures on the WINDS page. Unless enroute winds are entered, all step climb locations and altitudes are calculated assuming zero wind. IRS winds are not used in the calculation of step climb data.

For ECON cruise, step climbs are optimized to provide minimum trip cost according to the entered Cost Index. For other selected speeds, calculated step climbs minimize trip fuel.

Calculated step locations display on the ND (S/C); the next step displays on the ECON CRZ page. Flight plan calculations of time and fuel at destination are based on executing step climbs as calculated. Legs page waypoint altitudes reflect the optimum step climb profile.

Inflight entry of a STEP TO altitude in 1R causes the FMC to use the entered enroute winds and temperatures to calculate the optimum location for a climb to the step altitude; the ETA and DTG for the step display in 2R. Following entry of an altitude in 1R, the FMC uses only that altitude to calculate data for 2R. When the FMC calculates an immediate step climb to the entered altitude is optimal, 2R displays NOW. If the FMC determines remaining at the current altitude for the duration of the flight is more optimal than flying at the entered altitude, 2R displays NONE.

Planned step climb points (S/C) may be entered on the Legs page at selected waypoints. In this case, both altitude and step location are constrained. With planned step climb points entered, flight plan calculations assume a constant cruise altitude until reaching the planned step waypoint. Optimized step climb calculations resume after passing the last planned step climb waypoint.

When the last planned step is a step descent, step climbs are no longer calculated.

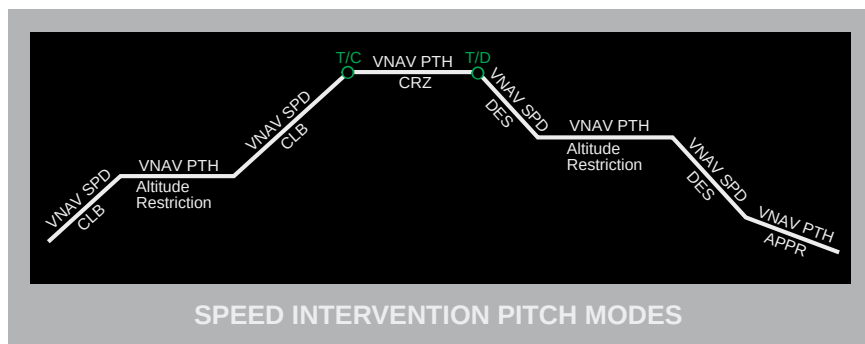
Optimum (OPT) altitude calculation does not use forecast or IRS winds and temperatures. Recommended (RECMD) altitude calculation is based on step size, current CRZ ALT, and entered forecast enroute winds and temperatures.

All altitude calculations are limited by maximum (MAX) altitude.

Cruise Descent

Setting an altitude below the current cruise altitude in the MCP altitude window and pushing the altitude selector (more than 50 nm from a T/D) causes the cruise altitude to be set to the MCP altitude and the airplane to descend to the new cruise altitude. The CRZ page displays ACT ECON CRZ DES. If the altitude set in the altitude window is below the speed transition (SPD TRANS) or restriction (SPD RESTR) altitude displayed on the DES page, those altitudes and speeds are deleted. Transition or speed restrictions must be maintained by flight crew action.

MCP Speed Intervention



With VNAV active, pushing the IAS/MACH selector enables speed intervention. Speed intervention allows the flight crew to change airplane speed with the IAS/MACH selector.

The above illustration shows the VNAV pitch flight mode annunciation for each phase of flight when using speed intervention.

During a VNAV, non-ILS approach while using speed intervention, the pitch mode is VNAV PTH. The vertical path is maintained regardless of IAS/MACH selector changes.

If a “direct to” is executed to a waypoint in the approach, VNAV transitions to the approach phase when the airplane passes the “direct to” waypoint. If a waypoint located after the first waypoint of an FMC database approach is added and executed, VNAV does not transition to approach phase when passing the first waypoint of the approach.

Descent

The FMC calculates a descent path based on airspeed and altitude constraints and the end of descent (E/D) point. Dashes display on the LEGS page for speed and altitude descent waypoints. When an arrival or approach procedure is selected on the ARRIVALS page and incorporated into the flight plan, the FMC creates an E/D. The E/D is located 50 feet above the runway threshold (RW waypoint) for all approaches except VOR approaches. The E/D for VOR approaches is the missed approach point; which may be the VOR, runway waypoint (RWXXX), or a named waypoint. During cruise, an E/D is also created when an altitude constraint is entered on the LEGS page on a downstream waypoint.

The top of descent (T/D) is the point where the cruise phase changes to the descent phase. It displays on the ND as a green circle with the label T/D. The descent path starts at the T/D and includes waypoint altitude constraints. The path to the first constraint is based on:

-
• idle thrust • speedbrakes retracted • FMC cruise wind	• wind entries on the DESCENT FORECAST page • predicted use of anti-ice • applicable target speed

The descent may be planned at economy Mach/CAS (based on Cost Index) or a manually entered Mach/CAS. VNAV will not command an economy target speed greater than 349 knots (VMO/MMO minus 16 knots) or a pilot entered speed greater than 354 knots (VMO/MMO minus 11 knots).

The FMC creates the descent path with a deceleration at the speed transition altitude (typically 250 knots below 10,000 feet). VNAV plans a speed target 10 knots below the transition speed to allow for unknown tailwinds.

Descent path segments after the first altitude constraint waypoint are constructed as straight line point-to-point segments. If the VNAV path segment is too shallow to be flown satisfactorily at IDLE thrust, the FMC commands speed on thrust levers (SPD). Elevators control the shallow descent path.

If flight plan modifications or unknown winds occur when above the first speed constraint, VNAV varies speed to maintain the path up to the following limits:

- with greater than 15 knots below the target speed, the autothrottle changes from IDLE/HOLD to SPD to provide thrust to accelerate to the target speed. If the autothrottle is not active, the scratchpad message THRUST REQUIRED displays. The airspeed may decrease to minimum maneuvering speed. Subsequently, VNAV commands the airplane to fly below the path to stop the deceleration. If VNAV can no longer maintain the airplane within 150 feet of the path without further deceleration, speed reversion occurs, the pitch mode annunciation changes from VNAV PTH to VNAV SPD, VNAV resets the target speed to 5 knots above the greater of best holding speed or minimum maneuvering speed, and the scratchpad message THRUST REQUIRED displays again
- with greater than 349 knots (VMO/MMO minus 16 knots), the scratchpad message DRAG REQUIRED displays. The airplane may accelerate up to 354 knots (VMO/MMO minus 11 knots) to maintain the path. If further correction is required, VNAV may allow the airplane to rise up to 150 feet above the path. If VNAV can no longer maintain the airplane within 150 feet of the path without further acceleration, speed reversion occurs, the pitch mode annunciation changes from VNAV PTH to VNAV SPD, VNAV resets the target speed to 349 knots (VMO/MMO minus 16 knots), and the scratchpad message DRAG REQUIRED displays again

If flight plan modifications or unknown winds occur when below the first speed constraint, VNAV varies speed to maintain the path up to the following limits:

- with greater than 10 knots below the target speed, the autothrottle changes from IDLE/HOLD to SPD to provide thrust to accelerate to the target speed. If the autothrottle is not active, the scratchpad message THRUST REQUIRED displays. The airspeed may decrease to minimum maneuvering speed. Subsequently, VNAV commands the airplane to fly below the path to stop the deceleration. If VNAV can no longer maintain the airplane within 150 feet of the path without further deceleration, speed reversion occurs, the pitch mode annunciation changes from VNAV PTH to VNAV SPD, VNAV commands a speed 10 knots less than the transition speed for the destination airport (not less than minimum maneuvering speed), and the scratchpad message THRUST REQUIRED displays again
- with greater than 10 knots above target speed, the scratchpad message DRAG REQUIRED displays. The airplane may accelerate up to 15 knots above target speed to maintain the path. The maximum speed excursion allowed is 5 knots above the transition speed after the airplane is below transition altitude for the destination airport or 5 knots below the flaps placard speed if flaps are extended. If further correction is required, VNAV may allow the airplane to rise up to 150 feet above the path to stop the acceleration. If VNAV can no longer maintain the airplane within 150 feet of the path without further acceleration, speed reversion occurs, the pitch mode annunciation changes from VNAV PTH to VNAV SPD, VNAV commands a speed 10 knots less than the transition speed for the destination airport, and the scratchpad message DRAG REQUIRED displays again

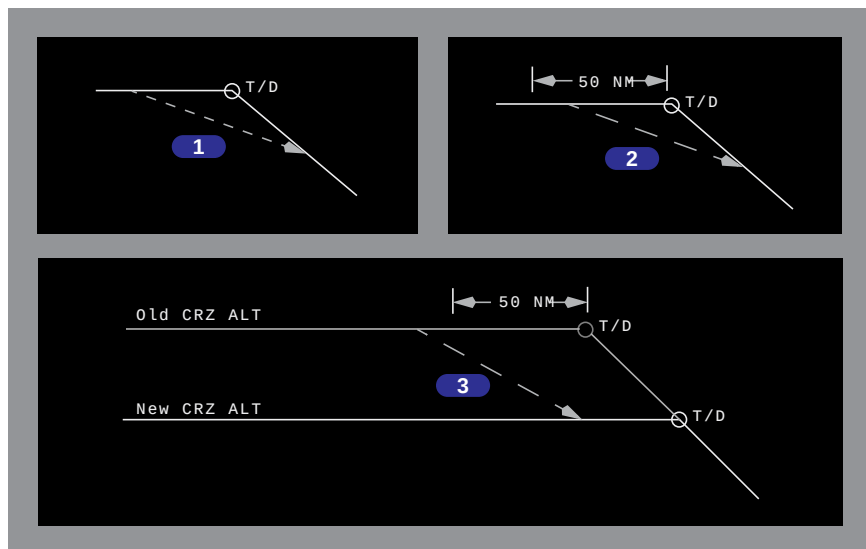
Reversion to VNAV SPD and departure below the path for a condition of speed decrease is inhibited when VNAV is in the “on approach” mode.

The DRAG REQUIRED and THRUST REQUIRED messages are inhibited when VNAV pitch control is speed-on-elevator.

Early Descent

When a descent is started before the T/D, VNAV commands a descent at a reduced descent rate until the idle descent path is intercepted.

Start an early descent by selecting the DES NOW prompt on the DES page or by pushing the MCP altitude selector. In an early descent, the autothrottle mode annunciation is initially THR, followed by HOLD, allowing the pilot to adjust the rate of descent. The pitch mode is VNAV SPD.



1 DES NOW

Use the DES NOW prompt on the VNAV DES page. VNAV starts an early descent and captures the idle descent path.

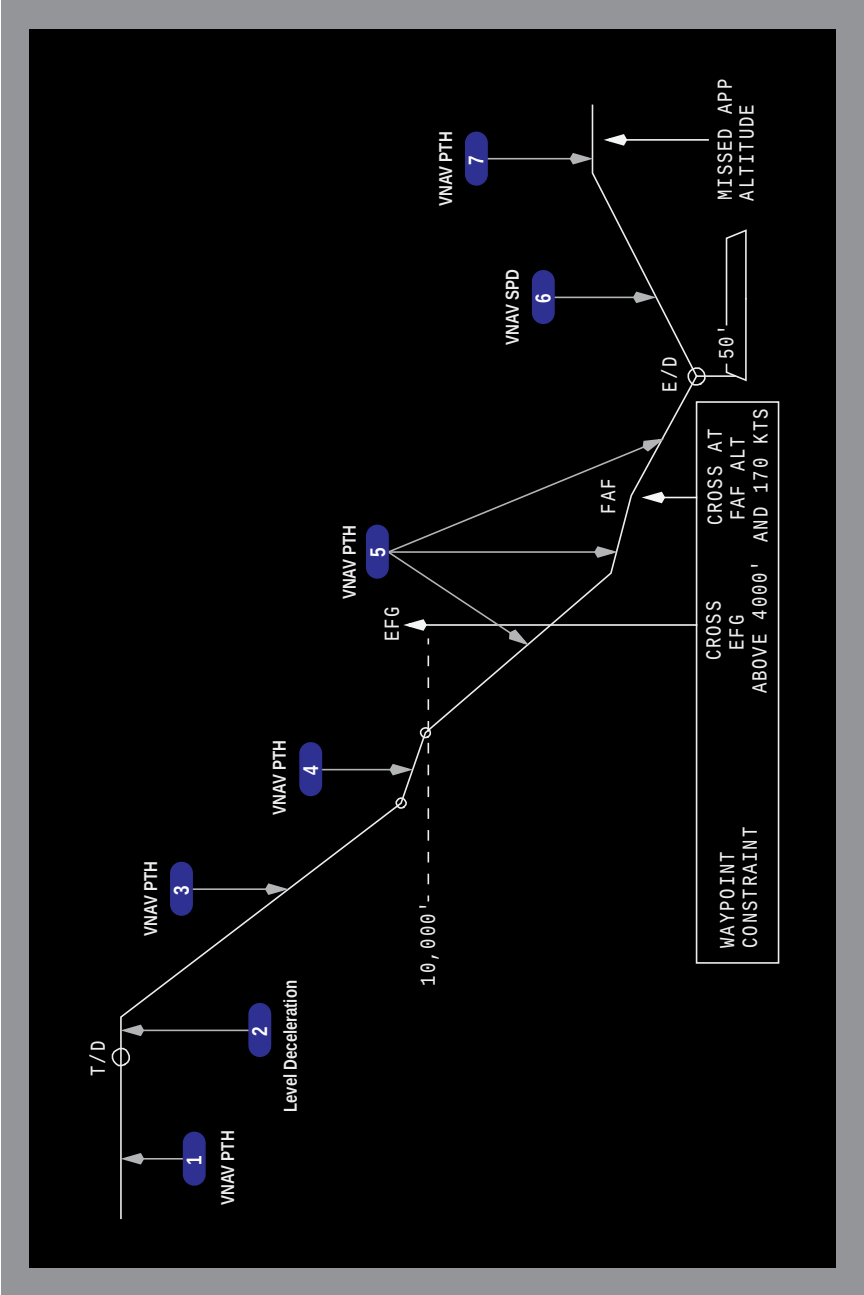
2 Within 50 NM of Top of Descent Point

Use the MCP altitude selector to start an early descent. Within 50 NM of the top of descent point, VNAV starts an early descent and captures the idle descent path.

3 More than 50 NM from Top of Descent Point

Use the MCP altitude selector to start a cruise descent. If the distance from the top of descent is more than 50 NM, VNAV begins a cruise descent to the new cruise altitude. VNAV may not capture the idle descent path since the target airspeed is economy cruise and the descent path is based on idle thrust and economy descent airspeed. In the example, VNAV levels at the new cruise altitude.

Cruise and Descent Profile (Instrument Approach using VNAV)



1 Cruise

Before top of descent, FMC is in cruise and commands VNAV PATH and ECON cruise speed.

2 Level deceleration phase

At top of descent, FMC transitions to descent and commands the airspeed to ECON descent speed and maintains altitude in VNAV PATH.

3 Descent

Nearing descent speed, VNAV commands a descent in VNAV PATH at ECON descent speed.

4 Descent deceleration phase

Before the speed restriction altitude, FMC commands the target descent airspeed. The pitch mode remains VNAV PTH and the descent rate approximates 500 feet per minute.

5 Descent and Approach

When at target speed, VNAV commands a descent and starts approach in VNAV PATH at commanded speed.

6 Missed Approach

When selected during missed approach, VNAV activates in VNAV SPD.

7 Missed Approach Level Off

At missed approach altitude, VNAV SPD changes to VNAV PATH.

Approach

The FMC transitions to “on approach” under the following conditions:

- a VFR approach is created and,
 - the airplane has sequenced the FAXXX, or
 - the airplane is enroute to a direct-to or intercept-to the RWYYY waypoint and the airplane is within 25 nm of the runway threshold
- a published instrument approach has been selected and incorporated in the active flight plan and the airplane has sequenced the first waypoint on the published approach

The FMC transitions out of “on approach” under the following conditions:

- selecting TOGA
- the airplane lands
- the airplane flies beyond the last waypoint in the approach (missed approach waypoint or runway) and the VNAV page title changes from “ACT xxxxxx DES” to “ACT END OF DES”

When the FMC is “on approach,” the following features are available:

- the IAS/MACH window can be opened and the command speed can be set while VNAV remains in VNAV PTH descent; VNAV commands the set speed
- the MCP altitude can be set above the airplane altitude for the missed approach. When the MCP altitude setting is at least 300 feet above the current airplane altitude, VNAV continues to command a descent
- VNAV remains in VNAV PTH and follows the descent path unless the airplane accelerates to within 5 knots of the current flap placard and the airplane rises more than 150 feet above the path. In this case, VNAV PTH changes to VNAV SPD
- When a glide path angle is specified for one or more legs on the approach, it displays on the LEGS page and VNAV provides VNAV PTH guidance at the displayed angle. When sequencing a waypoint prior to a descent leg specified by a glide path angle, VNAV commands level flight until the airplane intercepts the descent path

Note: Display of a specified glide path angle is not limited to approaches. A glide path angle may be defined for a leg in a STAR and displays on the LEGS page for the procedure.

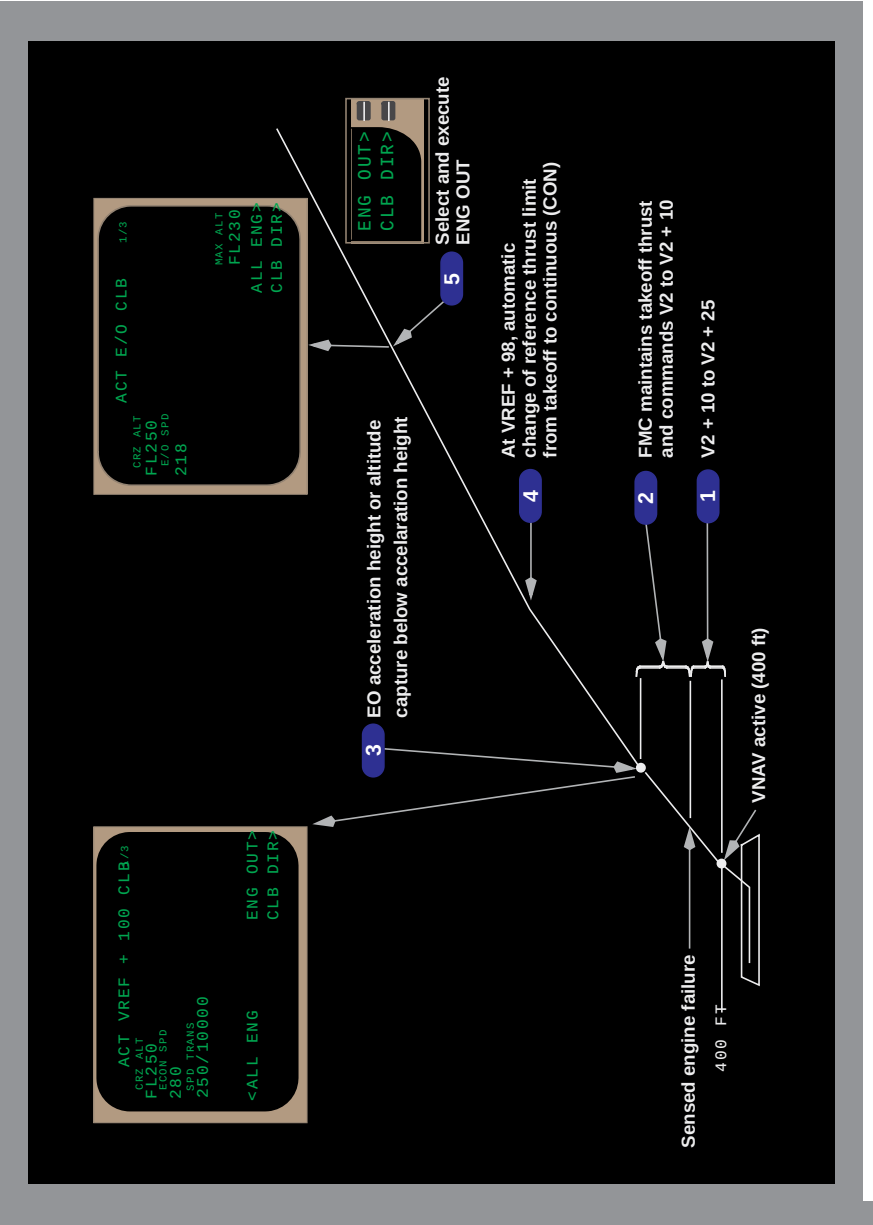
Selection of another approach can be accomplished on the ARRIVALS page. An along-course intercept to an approach waypoint in the new approach can be selected on the “INTC CRS TO” line on the LEGS page or by selecting the “XXXXX INTC>” prompt on the ARRIVALS page.

Missed Approach

A missed approach is accomplished by selection of either TOGA switch. The following features are available:

- VNAV (and LNAV) can only be activated when the airplane climbs above 400 feet radio altitude
- all descent altitude constraints below the current airplane altitude are deleted; the waypoints are retained in the active flight plan
- the highest altitude in the missed approach procedure becomes the new cruise altitude
- the FMC transitions from active descent to active climb
- AFDS guidance to fly the published missed approach procedure to the new cruise altitude is active when VNAV (and LNAV) are selected
- when cruise phase is active, the speed target is the most restrictive of speed transition, best hold speed, or ECON cruise (above speed transition altitude)

Takeoff and Climb (Engine Out)



1 Takeoff

Condition: before a sensed engine failure and above VNAV activation altitude.

Result: VNAV SPD commands a climb at $V2+10$ to $V2+25$ knots. Autothrottle mode is THR REF and the reference thrust limit is takeoff.

2 Sensed Engine Failure

Condition: after VNAV active, engine failure sensed, airplane below engine out acceleration height, and below the thrust reduction point entered on the TAKEOFF REF page.

Result: VNAV remains in VNAV SPD and commands a speed of $V2$ to $V2 + 10$ knots. Autothrottle remains in THR REF at the selected reference thrust limit for takeoff.

3 Acceleration Height

Condition: at acceleration height or altitude capture below acceleration height.

Result: VNAV commands an acceleration to $VREF + 100$ knots, limited by airplane configuration (flap placard). The VNAV climb page shows the ACT $VREF + 100$ CLB page.

4 Thrust Reduction

Condition: airplane has accelerated to $VREF + 98$ knots

Result: thrust is automatically reduced from selected takeoff to continuous (CON) thrust. If the engine failure occurs above the thrust reduction point, the current climb thrust is maintained.

5 VNAV Climb (Engine Out)

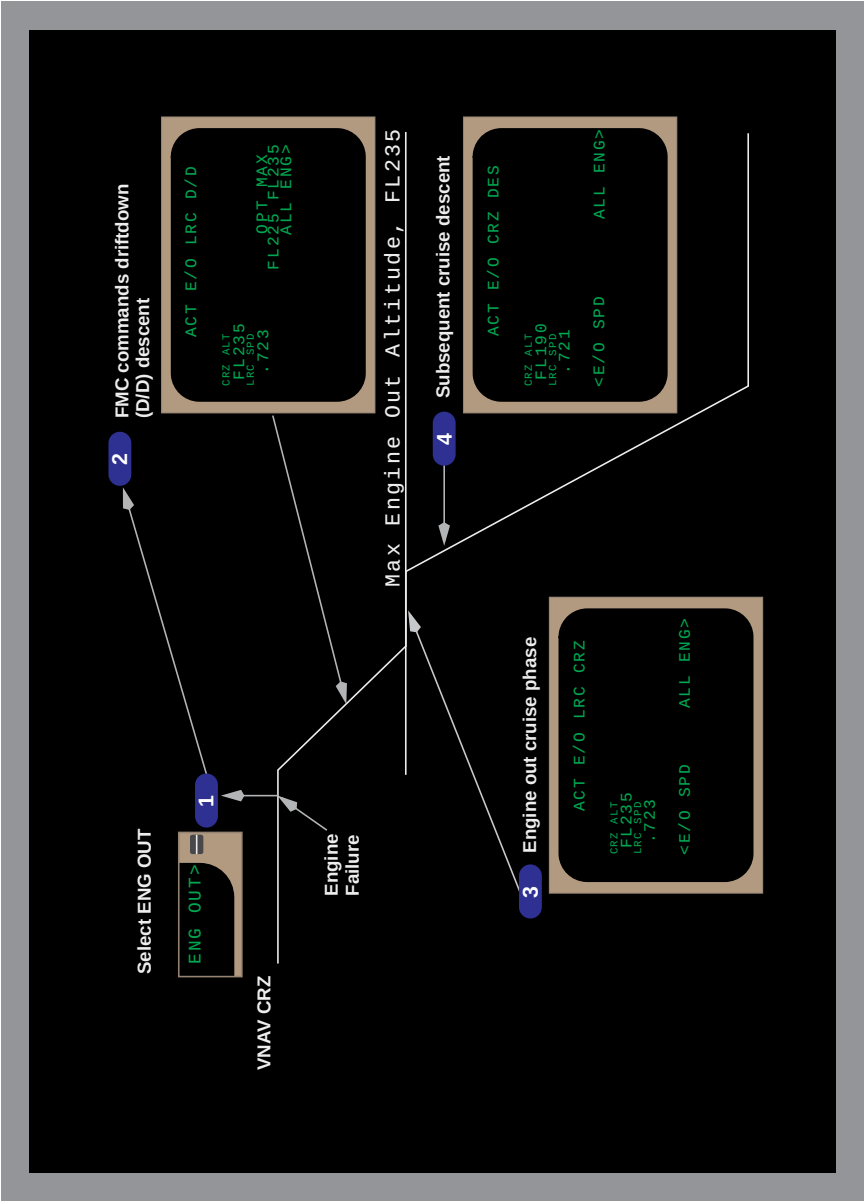
Condition: Selecting the ENG OUT> prompt on the VNAV CLB page displays applicable engine out performance data. Execution activates engine out performance data and terminates the VNAV engine out takeoff phase.

Result: the FMC engine out climb function is active, the pitch mode is VNAV SPD, the command speed is E/O SPD, and the reference thrust limit is CON. The use of VNAV for descent and approach is enabled.

VNAV Climb (Engine Out above EO Max Alt)

When the airplane is above the engine out maximum altitude, selection of the ENG OUT> prompt creates a modification and displays applicable engine out driftdown (D/D) performance data. Setting the altitude window lower and executing the modification activates engine out driftdown.

Cruise (Engine Out Above EO Max Alt)



1 Engine Out Modification

Condition: Select the ENG OUT> prompt on the VNAV CRZ page.

Result: The FMC creates a modification and displays applicable engine out driftdown (D/D) performance data.

2 Drift Down Execution

Condition 1: Set the MCP altitude at or below E/O MAX altitude and execute the FMC modification. This Condition assumes clearance is approved to descend slowly to a non-standard altitude; for example, FL235.

Result: The autothrottle advances operating engines to CON thrust. VNAV commands the driftdown and E/O LRC SPD. The E/O MAX altitude becomes the cruise altitude displayed in 1L. VNAV captures the E/O MAX altitude and commands engine out LRC cruise. The descent rate is controlled to a minimum of 300 feet per minute (fpm). Time and distance for the D/D to E/O MAX altitude display at 2R.

Two other ways to activate EO D/D (to the clearance altitude) are discussed below.

Condition 2: Execute the ENG OUT modification. Then, set the clearance altitude (lower than E/O MAX) in the MCP and push the MCP altitude selector.

Result: Initially, the airplane remains at the MCP altitude, the pitch mode changes to VNAV ALT, the reference thrust limit is CON, and FMC speed is E/O LRC SPD. After setting the MCP altitude window and pushing the altitude selector, the airplane descends in a VNAV driftdown to the clearance altitude in 1L. Initial descent rate may be greater than Condition 1, depending how much airspeed is lost before pushing the altitude selector. If the airspeed has decreased below E/O LRC SPD, the descent rate increases to regain the airspeed.

Condition 3: Set the clearance altitude (lower than E/O MAX) in the MCP, push the altitude selector; then, after the descent is established, execute the FMC modification (ENG OUT).

Result: After pushing the altitude selector, the airplane descends in a normal VNAV cruise descent at four-engine economy cruise speed. The thrust limit is CLB/CRZ and the autothrottle maintains cruise airspeed. Executing the FMC modification while still above E/O MAX altitude sets the driftdown descent airspeed to E/O LRC SPD. The reference thrust limit becomes CON. The airplane initially descends at economy cruise airspeed and approximately 1,250 fpm. After executing the ENG OUT modification, the commanded airspeed is E/O LRC SPD. The rate of descent decreases to a minimum of 300 fpm.

3 Engine Out Cruise

Engine out cruise operates like normal cruise with engine out cruise speeds. Thrust limit remains in CON. VNAV PTH displays as the pitch mode.

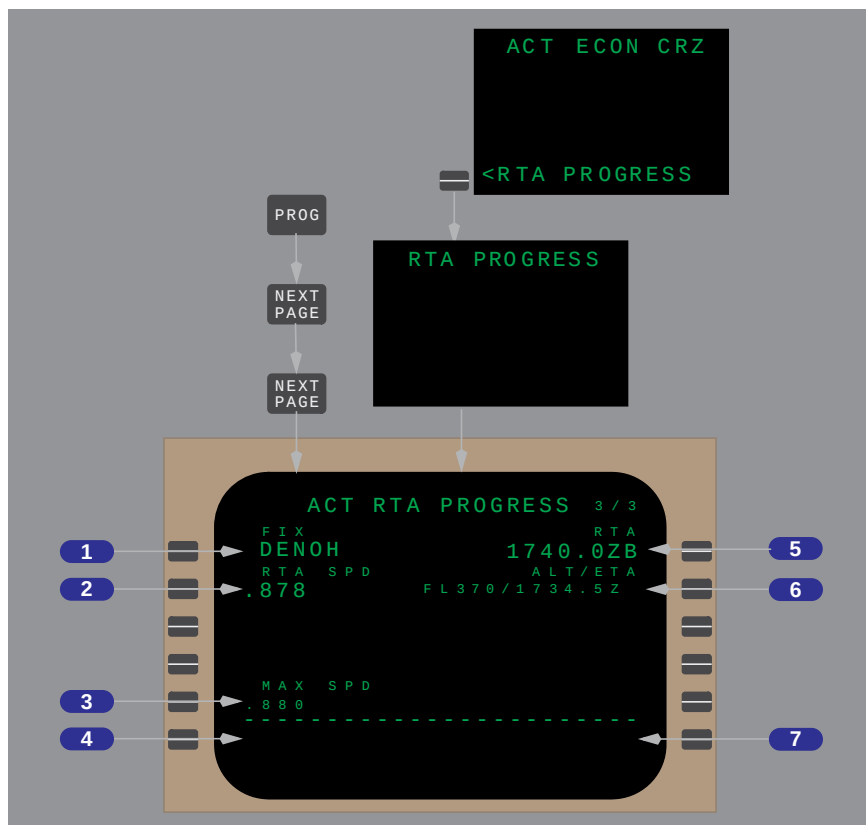
4 Subsequent Cruise Descent

Condition: FMC in engine out mode, setting a lower MCP altitude, and pushing the altitude selector.

Result: VNAV cruise descent at approximately 1,250 feet per minute at E/O LRC airspeed. The thrust limit remains CON and the autothrottle adjusts to maintain the E/O LRC airspeed. The altitude set on the MCP becomes the CRZ ALT on the EO CRZ page.

RTA Progress Page 3/3

Progress page three is used to enter data for required time of arrival (RTA). RTA can be entered or changed during preflight or in flight. Creating an RTA changes PROGRESS and CRZ page titles to include RTA. RTA operates only in cruise.



1 FIX

Displays boxes when an active or modified route exists.

Entry by flight crew or data link.

Valid entry is a waypoint in the active or pending active route prior to the missed approach. Waypoints defined by coordinates must be down selected to the scratchpad, then selected to the FIX line.

Entry displays boxes in 1R and the ALT/ETA line title at 2R.

When RTA active, deletion of FIX terminates RTA mode and resumes ECON. Display returns to boxes.

When RTA not active, deletion of FIX erases a pending RTA MOD. Display returns to boxes.

Displays blank if engine out has been selected.

2 Required Time Of Arrival Speed (RTA SPD)

Displays FMC computed cruise speed to accomplish RTA.

Deletion of entered value display default Mach .880 in small font.

3 Maximum Speed (MAX SPD)

Valid entry is Mach .100 to .99; displays in large font.

Deletion of entered value displays default Mach .80 in small font.

4 ERASE

Displays ERASE when modification pending.

Push - displays previous unmodified page, or if no previous active values, deletes RTA in 1R.

5 Required Time Of Arrival (RTA)

Boxes display after entry of FIX in 1L.

Valid entry is time from 0000.0 to 2359.9. Decimal entry of .0 is optional.

Suffix to RTA indicates:

- no suffix - arrive at entered time
- A - arrive at or after entered time
- B- arrive at or before entered time

Deletion terminates RTA and returns ECON as cruise mode.

6 Altitude/ETA (ALT/ETA)

Displays predicted altitude and ETA at RTA fix after entry of FIX in 1L.
Blank until performance data is entered.

7 PRIOR RTA

Displays when prior RTA fix and time exists.

Push -

- displays previous RTA fix and time
- initiates RTA flight plan modification

Execution activates RTA function.

Data Entry Rules

Altitude Entry

Altitudes can be entered into the FMC as three digit (XXX), four digit (XXXX), five digit (XXXXX), or flight level (FLXXX) numbers. The FMC displays altitude or flight level entries in the proper form based on the transition altitude. Some data lines further restrict the valid entry forms.

Three digit entries represent altitude or flight levels in increments of 100 feet. Leading zeros are required.

Examples of three digit (XXX, FLXXX) entries with transition altitude = 10,000 feet:

- 800 feet is entered as 008 or FL008; displays as 800
- 1,500 feet is entered as 015 or FL015; displays as 1500
- 11,500 feet is entered as 115 or FL115; displays as FL115
- 25,000 feet is entered as 250 or FL250; displays as FL250

Four digit entries represent feet, rounded to the nearest ten feet. Leading zeros are required. This form is used when the altitude does not exceed 9,994 feet.

Examples of four digit (XXXX) entries with transition altitude = 18,000 feet:

- 50 feet is entered as 0050; displays as 50
- 835 feet is entered as 0835; displays as 840
- 1,500 feet is entered as 1500; displays as 1500
- 8,500 feet is entered as 8500; displays as 8500
- 9,994 feet is entered as 9994; displays as 9990

Five digit entries represent feet, rounded to the nearest ten feet. This form is used when the altitude exceeds 9,994 feet.

Examples of five (XXXXX) digit entries with transition altitude = 4,000 feet:

- 50 feet is entered as 00050; displays as 50
- 835 feet is entered as 00835; displays as 840
- 1,500 feet is entered as 01500; displays as 1500
- 8,500 feet is entered as 08500; displays as FL085
- 9,995 feet is entered as 09995; displays as FL100
- 11,500 feet is entered as 11500; displays as FL115
- 25,000 feet is entered as 25000; displays as FL250

Negative altitude entries are allowed to -1000 feet.

Airspeed Entry

Airspeeds can be entered into the FMC as calibrated airspeed, CAS, or Mach number, M. Calibrated airspeeds are entered as three digits (XXX) in knots. Mach numbers are entered as one, two, or three digits following a decimal point.

Data Pairs

Many CDU pages display data in pairs separated by a slash “/.” Examples of these pairs include wind direction/speed and waypoint airspeed/altitude constraints. When entering both values in a pair, the slash is inserted between the values. When it is possible to enter only one value of the pair, the slash may not be required. When entering only the outboard value of a pair, the trailing or leading slash may be entered, but is not required before transferring to the data line. When entering the inboard value of a pair, the trailing or leading slash must be entered before transferring to the data line. Omission of the required slash normally results in an INVALID ENTRY message.

FMC Databases

The FMC contains four databases:

- navigation
- operational program configuration (OPC)
- aero engine database (AEDB)
- MAGVAR tables

The navigation database includes most data found on navigation charts. This data can be displayed on the CDU or ND. The database contains:

- location of VHF navigation aids
- airports
- runways
- other airline selected data, such as SIDs, STARs, approaches, and company routes
- transition altitudes

The operational program configuration (OPC) database contains configurable features controlled by the airplane manufacturer.

The performance database provides performance data for calculation and optimization of the vertical path, flight plan predictions, and flight optimization. Examples of database parameters are:

- airplane drag and engine characteristics
- maximum and optimum altitudes
- maximum and minimum speeds

The FMC contains two sets of navigation data, each valid for 28 days. Each set corresponds to the navigation chart revision cycle. The FMC uses the active data for navigation calculations. The contents of the navigation database are periodically updated and transferred to the FMC before the expiration date of the active data.

Thrust Management

The thrust management function operates the autothrottle in response to flight crew mode control panel inputs or to FMC commands. Reference thrust limits can be selected on the THRUST LIM page. FMC autothrottle commands are made while VNAV is engaged. Thrust management:

- calculates reference thrust limits and thrust settings, or follows FMC thrust settings
- commands thrust levers
- senses and transmits autothrottle failures
- commands thrust equalization through the engine electronic controls

Thrust limits are expressed as EPR limits. Thrust equalization references EPR.

Thrust management calculates a reference thrust for the following thrust settings:

• TO - takeoff	• CLB - climb
• TO 1 - takeoff one	• CLB 1 - climb one
• TO 2 - takeoff two (not used at Delta)	• CLB 2 - climb two
• D-TO - assumed temperature takeoff	• CRZ - cruise
• D-TO 1 - derate one assumed temperature takeoff	• CON - continuous
• D-TO 2 - derate two assumed temperature takeoff (not used at Delta)	• GA - go-around

With VNAV active, the reference thrust limit changes for the phase of flight. Thrust settings can be selected on the THRUST LIM page. The reference thrust limit displays at the top of the EICAS display.

With VNAV active, an engine failure, and flaps fully retracted, the reference thrust limit changes to CON at V30REF + 98. The planned thrust reduction point is inhibited.

The flight crew can specify the thrust reduction height where the change from takeoff to climb thrust takes place by making an entry on the CDU TAKEOFF REF page. This can be an altitude from 400 feet to 9,999 feet or an entry of 5 for flaps 5.

Reduced Thrust Takeoff

Reduced thrust takeoffs lower EGT and extend engine life.

Derate/Variable Takeoff Rating

TO 1 can be selected on the THRUST LIM page. TO 2 is not used at Delta Air Lines.

With both TO 1 and TO 2, the thrust setting parameter is considered a limitation for takeoff; therefore, thrust levers should not be advanced further except in an emergency. A further thrust increase following an engine failure could result in a loss of directional control. Use the takeoff speeds calculated by the FMC for the selected derate or variable takeoff rating condition.

Assumed Temperature Thrust Reduction Takeoff

Entering an assumed temperature higher than the actual temperature reduces takeoff thrust.

The maximum thrust reduction authorized is 25 percent below any certified rating.

The assumed temperature thrust setting is not considered a limitation. The assumed temperature reduction can be removed. If conditions are encountered where more thrust is necessary, the crew can manually apply full thrust.

Derated Thrust Climb

Use of an assumed temperature reduced thrust takeoff or takeoff derate affects automatic selection of climb derate. For a thrust reduction less than 5 percent, maximum climb thrust is selected by the FMC. For takeoff thrust reductions or derates from 5 percent to less than 15 percent, CLB 1 is selected. CLB 2 is selected for all takeoff thrust reductions or derates equal to or greater than 15 percent. On the ground, the pilots may override the automatic climb derate selection after the takeoff selection is complete.

During climb, CLB 1 and CLB 2 derates are gradually removed. In cruise, the thrust reference defaults to CLB or CRZ as set by maintenance.

Two fixed climb thrust derates can be selected on the THRUST LIM page. CLB 1 uses a 10% derate of CLB thrust to 10,000 feet, then increases thrust linearly with altitude to CLB thrust at 15,000 feet. CLB 2 uses a 20% derate of CLB thrust to 10,000 feet, then increases thrust linearly with altitude to CLB thrust at 15,000 feet.

Fuel Monitoring

The FMC receives fuel data from the fuel quantity indicating system (FQIS) or from manual entries. Fuel quantity values display on the PERF INIT page as calculated (CALC), MANUAL, or SENSED. They also display on the PROGRESS page as totalizer and calculated.

The FMC usually uses the calculated value for performance computations. Before engine start, the calculated value is automatically set to agree with the FQIS value. When the FMC receives a positive fuel flow signal at engine start, the calculated value disconnects from the FQIS and decreases at the fuel flow rate.

During fuel jettison, the calculated value is set equal to the FQIS value. When fuel jettison is completed, the calculated value disconnects from the FQIS and decreases at the fuel flow rate. This fuel quantity value displays as CALC on the PERF INIT page and as CALCULATED on the PROGRESS page.

If the flight crew inputs a fuel quantity, the line title changes to MANUAL. The manual value replaces the FQIS value and is updated by the FMC using fuel flow rate, the same as for the calculated value.

If fuel flow data becomes invalid after engine start, the calculated value is considered invalid and the FMC uses FQIS quantity for performance computations. In this case, fuel quantity displays as SENSED on the PERF INIT page and as TOTALIZER on the PROGRESS page.

Fuel flow signals are also used to calculate fuel used by the engines. FUEL USED displays on the PROGRESS page. FUEL USED values are retained through flight completion and are subsequently cleared at engine start or following a long-term power interrupt on the ground. If the fuel flow signal is invalid for greater than two minutes after engine start or is invalid while on the ground, the display blanks.

The scratchpad message FUEL DISAGREE-PROG 2 displays if the FMC calculates a large difference between the total sensed fuel quantity and calculated value. The flight crew should select PROGRESS page 2, and select the fuel value for the FMC to use for the remainder of flight.

The FMC continually estimates the fuel at the destination airport if the active route is flown. FMC calculated fuel predictions are based on landing gear and flaps up during climb, cruise, and descent. Any prolonged flight with landing gear and/or flaps extended increases fuel required. The increased fuel consumption will not be correctly displayed on the FMC fuel predictions pages. The CDU message INSUFFICIENT FUEL displays if the estimate is less than the fuel reserve value entered on the PERF INIT page.

Loss of FMC Electrical Power

The FMC must have continuous electrical power to operate. When the electrical power is interrupted and returns, the FMC restarts.

After restart, performance data displayed on the PERF INIT page must be reentered. The route previously in use may be available. If so, it must be activated. If the route is not available, the route must be reentered.

Before activating LNAV, the FMC must be given guidance to the route. Selecting the appropriate waypoint and performing a direct to or course intercept to the waypoint enables LNAV activation.

FMC Failure

Single FMC Failure

After loss of a single FMC, a resynchronization may occur. The active route may become inactive, the performance data may be lost, and LNAV and VNAV modes may fail. To regain FMC operation, activate and execute the flight plan, enter the necessary performance data, and select LNAV and VNAV.

Note: If the MENU page and the scratchpad message TIMEOUT - RESELECT display, the FMC is no longer connected to the CDU. Use the <FMC prompt on the MENU page to connect the CDU to the FMC.

On the ground, the scratchpad message SINGLE FMC OPERATION displays after loss of either FMC.

In flight, the scratchpad message SINGLE FMC OPERATION displays on only one CDU after loss of the FMC not selected on the FMC selector. The scratchpad message TIMEOUT - RESELECT displays on the CDU with the inoperative FMC.

In flight, the scratchpad message TIMEOUT - RESELECT displays on both CDUs after loss of the selected FMC. The FAIL light illuminates in all three CDUs. The navigation display with the NAV source selector selected to the failed FMC is lost. There is a time delay before the FMC message FMC LEFT, RIGHT displays. When the FMC selector is rotated to the operative FMC, the FMC is available through the CDU. Once an FMC page is accessed, the scratchpad message SINGLE FMC OPERATION displays on the CDU with the operative FMC.

Dual FMC Failure

If both FMCs fail, LNAV and VNAV fail. The CDUs supply route data to their related ND. Alternate navigation using CDUs is discussed in Section 50 of this chapter. Autothrottle operation is not available.

Note: If the MENU page displays and the <FMC prompt is not displayed in line 1, pushing the LEGS function key displays the ALTN NAV LEGS page, the PROG key displays the ALTN NAV PROGRESS page, and the NAV RAD key displays the ALTN NAV RADIO page.

Introduction

Completion of the FMC preflight requires data entry in all minimum required data locations. Entry of all required and optional preflight data optimizes FMC accuracy.

FANS/CPDLC Equipped Aircraft

Datalink can load preflight data from airline ground stations. Using datalink reduces the number of required flight crew actions. Manual flight crew entries replace existing data.

FMS-CDU Operation

Work in a slow, deliberate manner while operating the CDU. Avoid pushing more than one key at a time. Avoid entering information in both CDUs at the same time. Do not push keys when the system is resynchronizing. Resynchronizations complete in approximately 15 seconds. During this time, the respective CDU displays a failed condition, while the other CDU displays the message RESYNCHING OTHER FMC.

Uncareted, small font, or default values are not required to be line-selected to be valid. For example, acceleration heights and the thrust reduction point on the Takeoff Ref page are valid in small font.

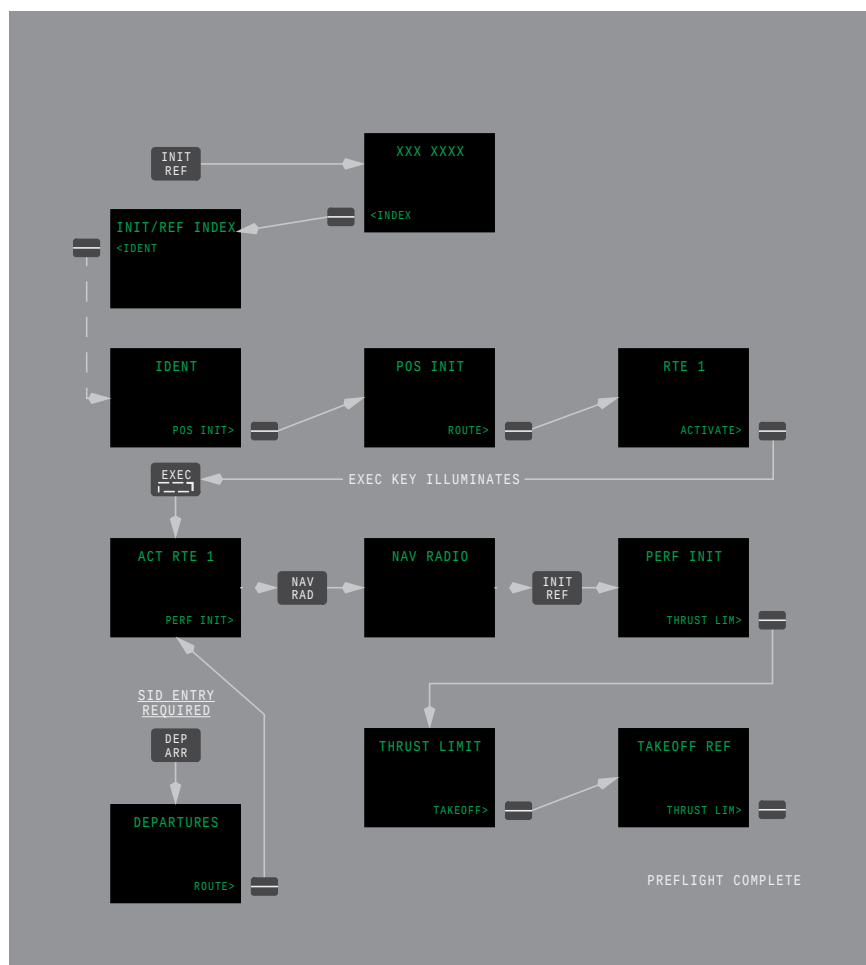
Preflight Page Sequence

The usual FMC power-up page is the identification page. Preflight flow continues in this sequence:

- identification (IDENT) page
- position initialization (POS INIT) page
- route (RTE) page
- DEPARTURES page (no prompt)
- navigation radios (NAV RAD) page (no prompt)
- performance initialization (PERF INIT) page
- thrust limit (THRUST LIM) page
- takeoff reference (TAKEOFF REF) page

Some of these pages are also used in flight.

Minimum Preflight Sequence



During preflight, a prompt in the lower right directs the flight crew through the minimum requirements for preflight completion. Selecting the prompt key displays the next page in the flow. If a required entry is missed, a prompt on TAKEOFF page leads the flight crew to the preflight page missing data.

FMC position is required for FMC preflight and flight instrument operation.

A route must be entered and activated. The minimum route data is origin and destination airports, and a route leg.

Performance data requires entry of airplane weights, fuel reserves, cost index, and cruise altitude.

Takeoff data requires a flap setting and center of gravity.

Supplementary Pages

Supplementary pages are sometimes required. These pages have no prompts and interrupt the usual sequence. Discussion of each page includes a method to display the page.

When the route includes SIDs and STARs, they can be entered using the DEPARTURES or ARRIVALS pages.

Route discontinuities are removed and the route is modified on the ROUTE and RTE LEGS pages. Speed/altitude restrictions are entered and removed on the RTE LEGS page. RTE LEGS page is described in the FMC Takeoff and Climb section of this chapter.

Waypoint, navigation, airport, and runway data is referenced on REF NAV DATA page. REF NAV DATA page is described in the FMC Cruise section of this chapter.

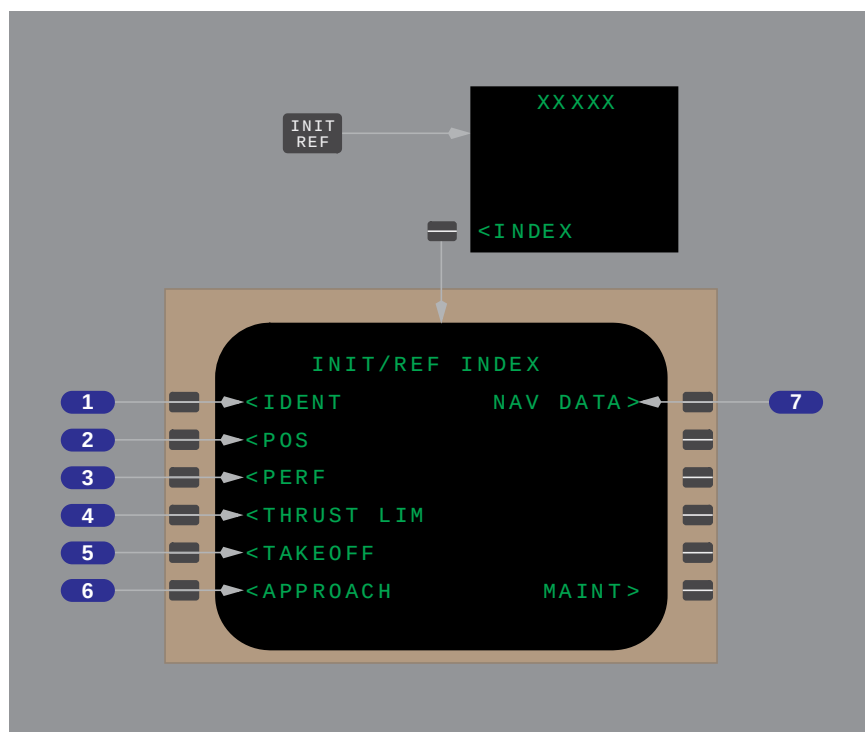
VNAV performance is improved if forecast winds and temperatures are entered during the preflight. Wind and temperature data for specific waypoints is entered on the WIND page. WIND page is described in the FMC Cruise section of this chapter.

Preflight Pages - Part 1A

Preflight pages are presented in the sequence used during a typical preflight.

Initialization/Reference Index Page

Initialization/reference index page allows manual selection of FMC pages. It gives access to pages used during preflight and not usually used in flight.



1 Identification (IDENT)

IDENT page is used to verify basic airplane data and currency of the navigation database.

2 Position (POS)

POS INIT page is used for IRU initialization.

3 Performance (PERF)

PERF INIT page is used for initialization of data required for VNAV operations and performance predictions.

4 Thrust Limit (THRUST LIM)

THRUST LIM page is used to select thrust limits and derates.

5 TAKEOFF

TAKEOFF REF page is used to enter takeoff reference data and V speeds.

6 APPROACH

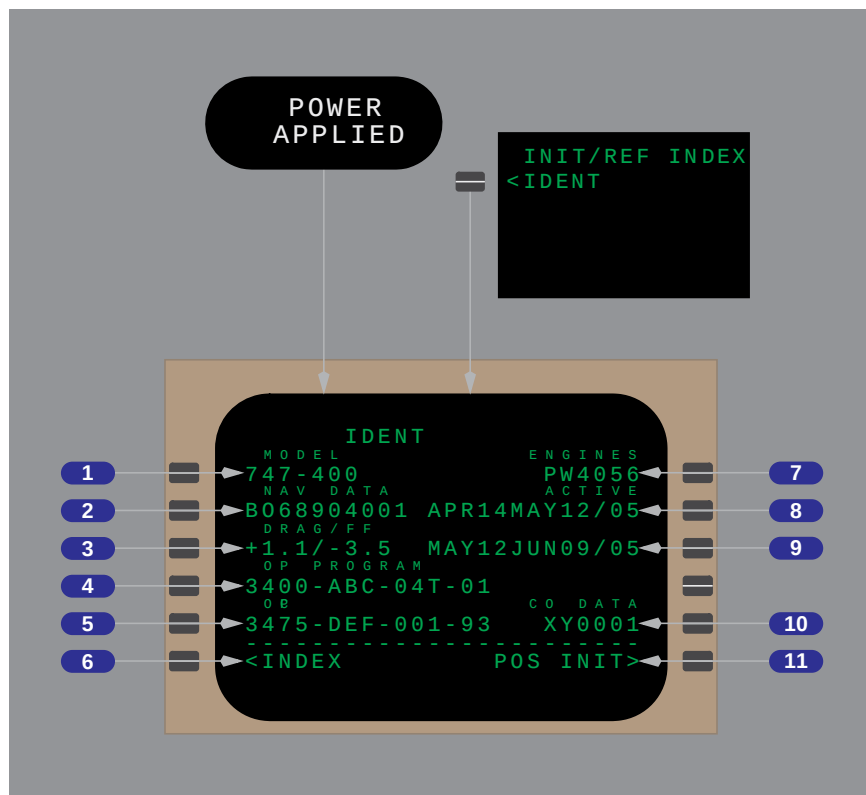
APPROACH REF page is used for entry of the approach VREF speed.

7 Navigation Data (NAV DATA)

REF NAV DATA page is used for data on waypoints, nav aids, airports, and runways. The REF NAV DATA page is accessible only from this page.

Identification Page

Most data on this page is for flight crew verification. The active navigation database can be selected.



1 MODEL

Displays airplane model from FMC performance database.

2 Navigation Data (NAV DATA)

Displays navigation database identifier.

3 DRAG/Fuel Flow (FF)

Displays airplane drag and fuel flow correction factors.

4 Operating (OP) PROGRAM

Displays systems operating program identifier (FMC software load).

5 Operational Program Configuration (OPC) Number

Displays the operational program configuration (OPC) part number.

6 INDEX

Push - displays INIT/REF INDEX page.

7 ENGINES

Displays engine model from the FMC performance database.

8 ACTIVE

Displays the effectivity date range for the active navigation database.

The active navigation database may be out of date. It can be changed to the inactive navigation database. Pushing the date range prompt of the inactive navigation database copies that date into the scratchpad. Pushing the date range prompt of the active navigation database transfers the scratchpad date to the ACTIVE database line. The previous active date moves to the inactive date line.

The line title ACTIVE is above the active navigation database date. No line title is above the inactive navigation database date. The navigation database date can only be changed on the ground. Changing the navigation database removes all previously entered route data.

When an active database expires in flight, the expired database is used until the active date is changed after landing.

9 Inactive Date Range

Displays the effectivity date range for the inactive navigation database. The inactive database becomes effective at 0901Z on the respective day.

10 Company (CO) DATA

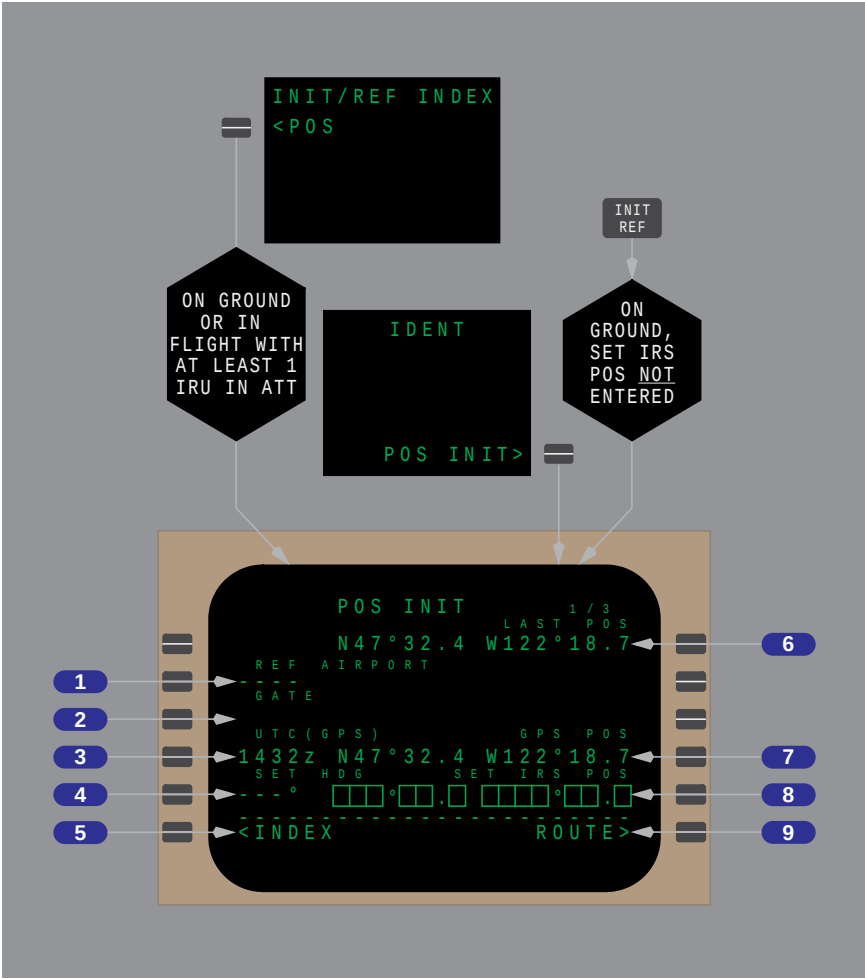
Displays airline policy file identifier.

11 Position Initialization (POS INIT)

Push - displays POS INIT page.

Position Initialization Page 1/3

Position initialization page allows entry of airplane present position for IRU alignment. The same page is used to enter the heading for IRUs in attitude mode.



1 Reference (REF) AIRPORT

Entry of the reference airport displays airport latitude/longitude.

Valid entries are ICAO four letter airport identifiers.

Entry blanks at lift-off.

2 GATE

Gate entry allows further refinement of the latitude/longitude position.

Valid entry is a gate number at the reference airport.

Displays latitude and longitude of the reference airport gate.

Changes to dashes when a new reference airport entered.

Entry blanks at lift-off.

3 UTC

UTC (GPS) - displays time from a GPS sensor.

UTC (MAN) -

- displays time from Captain's clock when operative; otherwise, displays time from F/O's clock
- time set by resetting appropriate pilot's clock

4 SET Heading (HDG)

Dashes display if an IRU is in attitude mode.

Entering heading updates IRS magnetic heading signal for all IRUs in attitude mode.

Valid entry is 0 to 360 (0 or 360 is shown as 360°). Dashes display two seconds after entry to allow another entry.

5 INDEX

Push - displays INIT/REF INDEX page.

6 LAST Position (POS)

Displays the last FMC calculated position.

7 GPS Position (POS)

Displays GPS position. During preflight, GPS POS may not display due to satellite availability, performance, or unfavorable geometry.

8 SET IRS Position (POS)

IRS position entry is required to initialize the IRUs.

Enter airplane position latitude and longitude. Select the most accurate latitude/longitude from LAST POS, REF AIRPORT, GATE, GPS POS, or make a manual entry.

If an entry is not made before the IRUs finish initial alignment, the scratchpad message ENTER IRS POSITION displays. If an entry has been made and the message displays, check the accuracy of the entered position for each IRU on the POS REF page and enter again even if positions are correct.

Boxes display when any IRU in align mode and present position not entered.

Blank except when an IRU in align mode.

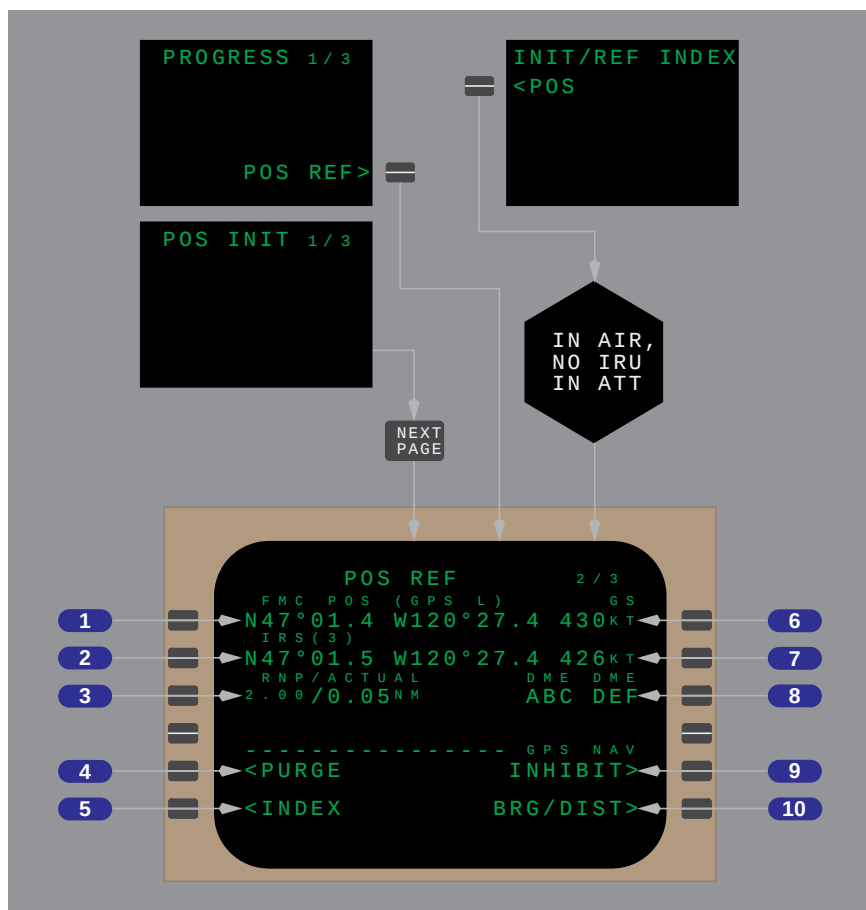
9 ROUTE

Push - displays the ROUTE page.

Position Reference Page 2/3

Position reference page 2 displays the position and ground speed calculated by the FMC and IRS.

GPS position updating can be enabled and inhibited and radio and GPS updates to the FMC position can be purged on this page. The IRS position can be changed to bearing/distance.



1 FMC Position (POS)

Displays the FMC calculated latitude/longitude position.

Line title identifies the source for calculating the FMC position:

- GPS L, GPS R - FMC calculates position using GPS data
- RADIO - FMC calculates position using navigation radio data
- LOC-GPSL, LOC-GPSR - FMC calculates position using localizer and GPS data
- LOC-DD - FMC calculates position using localizer and DME data
- LOC-VD - FMC calculates position using localizer, VOR, and DME data
- LOC - FMC calculates position using localizer data

Displays IRS (X) position when CONFIRM displayed in purge line; becomes active FMC position if purge is confirmed.

2 IRS

Displays the IRS latitude/longitude position.

Following selection of BRG/DIST, displays bearing/distance of IRS position from FMC position.

Blank when FMC receiving no valid IRU data.

3 Required Navigation Performance and Actual Navigation Performance (RNP /ACTUAL)

Displays the RNP and actual navigational performance (ACTUAL) of the FMC.

Displays IRS (X) position accuracy when CONFIRM displayed in purge line.

Default RNP is in small font. Default lateral values (small font) represent a RNP value associated with a specific airspace. Specific logic and values are listed below.

Airspace	RNP Display Logic	Associated RNP Value
Takeoff and Terminal	Below 15,500 feet MSL	1.0 nms
En Route/Domestic	Above 15,500 feet MSL	2.0 nms
Oceanic/Remote Area	Outside of radio (DD or VD) updating range	12.0 nms 4.0 nms (post FANS mod)
En Route/Domestic	Aircraft in range of radio updating	2.0 nms
Terminal	Below 15,500 feet MSL	1.0 nms
Approach	Inside the Key Waypoint	0.5 nms 0.3 nms (post FANS mod)

Manual RNP entry displays in large font; entries clear at flight completion. Deletion of manual entry returns display to default RNP.

Valid RNP entries are in the range 0.01 to 99.9. ACTUAL entry not allowed.

Note: The FMC stops GPS updates if the GPS ACTUAL is twice the RNP. This occurs if the GPS ACTUAL has increased or the flight crew inputs a small RNP value. Subsequently, the FMC changes updates to another system.

4 PURGE

Push -

- displays mixed IRS position on the FMC POS line. Line title displays PURGE and data line displays CONFIRM
- selection of CONFIRM replaces FMC position with mixed IRS position. FMC resumes radio updating when valid stations available. Line title blanks and PURGE prompt displays

Leaving this page on both CDUs with CONFIRM displayed returns the initial display.

5 INDEX

Push - displays INIT/REF INDEX page.

6 GPS Ground Speed (GS)

Displays GPS ground speed.

7 IRS Ground Speed (GS)

Displays IRS ground speed.

Blank if ground speed from IRUs is not valid.

IRU values frozen at engine shutdown; frozen values display until power cycled off to both FMCs or until ground speed exceeds 40 knots.

8 Navigation Station

Displays identifiers of navigation stations in use by FMC for radio position computation.

Line title displays type of radio station, DME-DME or VOR-DME.

Line title displays NAV STA and data line blanks when no radio position computation occurring.

9 GPS Navigation (NAV)

Initially displays INHIBIT. GPS data enabled for FMC position updating.

Push -

- inhibits GPS data for FMC position updating and displays ENABLE. Inhibiting retained through power interruption
- selection when ENABLE displayed enables GPS data for FMC position updating and displays INHIBIT. Defaults to INHIBIT following flight completion

10 Bearing/Distance (BRG/DIST) or Latitude/Longitude (LAT/LON)

Initially displays BRG/DIST.

Push -

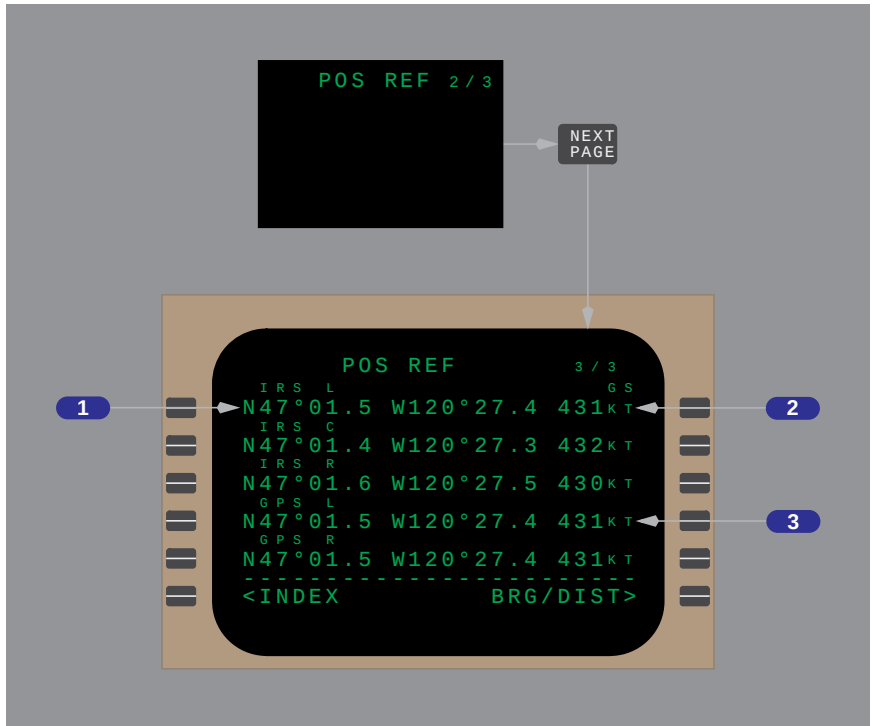
- displays bearing/distance in IRS (X) line relative to FMC position and displays LAT/LON
- if distance is zero, bearing displays 000
- selection when LAT/LON displayed or leaving the POS REF pages on both CDUs returns displays to latitude/longitude and BRG/DIST

The page illustration is shown in the latitude/longitude display format.

Position Reference Page 3/3

On position reference page 3, the flight crew can observe the positions and ground speed from the GPS receivers and the IRUs.

This page can be displayed in the bearing/distance or latitude/longitude format. The bearing/distance format displays the bearing and distance of the position sources relative to the active FMC position on POS REF 2/3 page.



1 IRU, GPS Position

Displays position computed by related system.

GPS data blanks if GPS unavailable or inhibited.

2 IRS Ground Speed (GS)

Displays IRS ground speed.

Blank if ground speed from IRUs is not valid.

IRU values frozen at engine shutdown; frozen values display until power cycled off to both FMCs or until ground speed exceeds 40 knots.

3 GPS Ground Speed (GS)

Displays GPS ground speed.

GPS data blanks if GPS unavailable or inhibited.

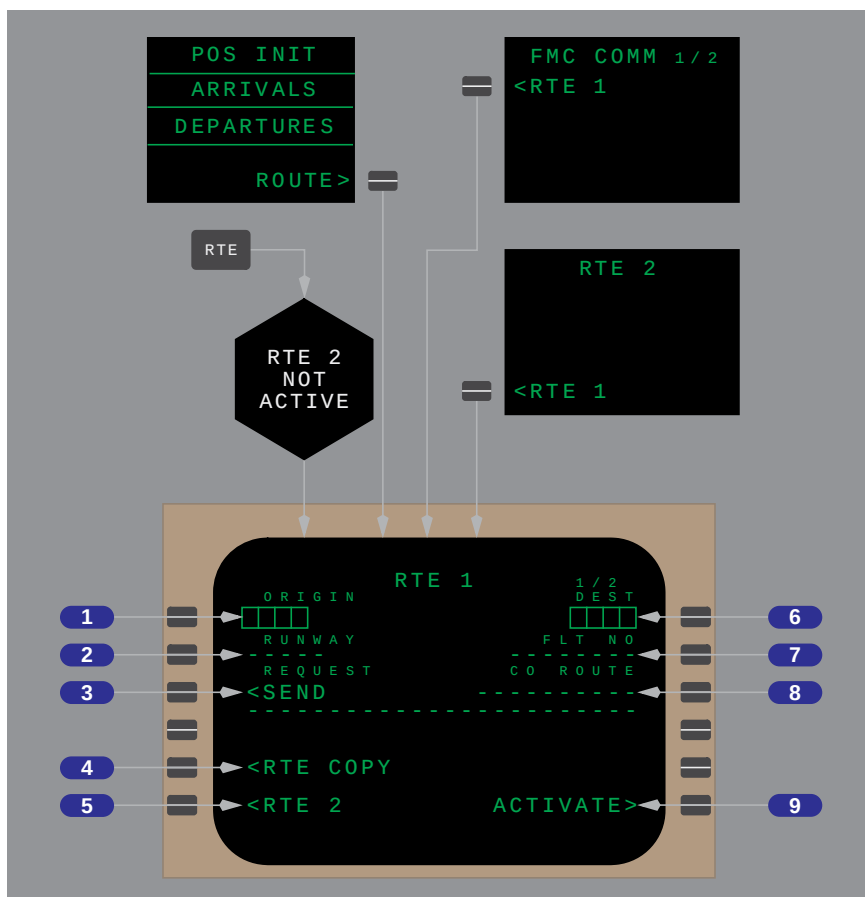
Preflight Pages - Part 1B

Route Page 1/X

Two routes (RTE 1 and RTE 2) can be displayed in air traffic control format. Routes can be entered by the flight crew or uplinked through data link. All routes have two or more pages. The first route page displays origin and destination data. Subsequent route pages display the route segments between waypoints or fixes. ROUTE 1 and ROUTE 2 allow management of alternate or future routes while leaving the active route unmodified. ROUTE 2 has an identical page structure as ROUTE 1. The minimum number of route pages is 2.

When RTE 2 is active, page display logic is the same as RTE 1.

Active Route with Uplink Pending



1 ORIGIN

Valid entries are ICAO airport identifiers in the navigation database.

On the ground, entry of a new origin erases the previous route. In flight, entries are valid on the inactive route.

Enables selection of departure and arrival procedures for the origin airport.

Automatically entered as part of a company route.

2 RUNWAY

Valid entries are origin airport runways in the navigation database.

Automatically entered when part of a company route.

Can be selected on DEPARTURES page.

FMC deletes runway after sequencing the first waypoint.

3 Route REQUEST

Line title displays REQUEST. Line title blank if flight plan load pending.

Flight crew can fill in origin, destination, runway, flight number, company route name, or route definition to qualify request.

Push -

- transmits data link request for a flight plan route uplink
- data line displays SENDING
- upon acknowledgement receipt, data line displays SENDsent

If data link fault occurs, title line displays DATA LINK, data line displays NO COMM, VOICE, or FAIL.

4 Route Copy (RTE COPY)

Push-

- displays when a route is active or is modified
- copies active route into the inactive route
- displays COMPLETE after the route is copied

5 RTE 2

Push -

- displays RTE 2 page 1/X
- data line displays RTE 1

6 Destination (DEST)

Valid entries are ICAO airport identifiers in the navigation database.

Enables selection of arrival procedures for the destination airport.

Automatically entered as part of a company route.

7 Flight Number (FLT NO)

Valid entry is any flight crew entered or uplinked company flight number. FMC sends flight number to each ATC transponder for flight ID function.

Flight crew entered or uplinked.

Flight number displays in PROGRESS page title.

Data line blanks at flight completion.

8 Company (CO) ROUTE

Not used at Delta Air Lines

A company route can be called from the navigation database by entering the route identifier. The data supplied with a company route can include origin and destination airports, departure runway, SID and STAR, and route of flight. All company route data is entered when the route identifier is entered.

Valid entry is any flight crew entered or uplinked company route name. If the name is not contained in the NAV database, entry is allowed and the scratchpad message NOT IN DATABASE displays.

On the ground, entry of a new company route replaces the previous route.

In flight, entry of a new company route manually, or as a result of a route request downlink, may only be accomplished into the inactive route.

9 ACTIVATE

Displays on inactive route pages.

Activation of a route is required for completion of the preflight.

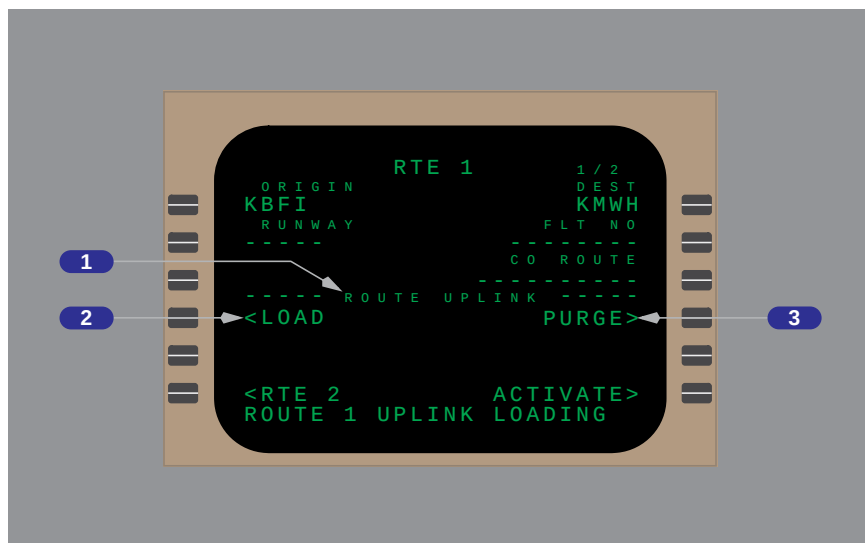
Push - arms the selected route for execution as the active route.

When the EXECUTE key is pushed, the route becomes the active route and the ACTIVATE prompt is replaced with the next required preflight page prompt.

After route activation, the ACTIVATE prompt is replaced by:

- PERF INIT, when the required performance data is incomplete, or
- TAKEOFF when the required performance data is complete

Active Route After Ground Station Uplink



1 ROUTE UPLINK

Displays ROUTE UPLINK when flight plan uplink received; otherwise, dashes.

2 LOAD

Displays LOAD when uplink received and passes error check.

PUSH -

- loads uplinked flight plan
- in flight, when uplinked flight plan applies to active route, EXECUTE light illuminates and ERASE displays at 6L
- when route inactive, blanks PURGE at 4R
- displays scratchpad message ROUTE 1 UPLINK LOADING

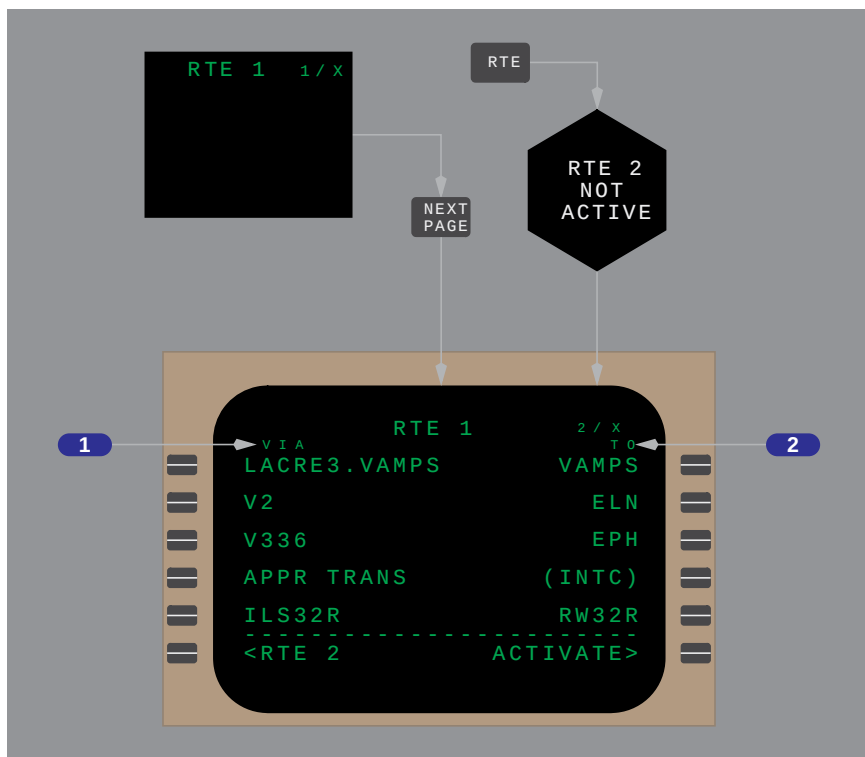
3 PURGE

Displays PURGE when an uplink has been received, passes an error check, and applies to an inactive route.

Push - rejects uplinked flight plan data.

Route Page 2/X

Subsequent route pages 2/X through X/X show the route segments in air traffic control format. Route segments are defined as direct routing, airways, or procedures with start and end points such as waypoints, fixes, navaids, airports, or runways. More waypoints for each route segment display on the RTE LEGS page.



1 VIA

VIA column displays the route segment to the waypoint or termination in the TO column.

Entry of an airway in the VIA column displays boxes in the TO column.

Valid entries can also include procedures or DIRECT. Procedures are usually entered through selections on DEPARTURES and ARRIVALS pages. DIRECT usually results from entering a TO waypoint first.

Valid airways must:

- contain the fix entered in the TO waypoint, and
- contain the previous TO waypoint, or
- intersect the previous VIA route segment

Dashes change to DIRECT if entering the TO waypoint first.

Dashes display for the first VIA beyond the end of the route.

Invalid VIA entries display the scratchpad message INVALID ENTRY.

Invalid VIA entries are:

- airways and company routes which do not contain the TO waypoint of the previous line
- airways not intersecting the previous airway
- airways or company routes not in the navigation database

Entry of a SID or transition enters the VIA and TO data for the route segments of the SID. A SID links to the next route segment when the final SID waypoint is part of the route segment.

When no SID is used, entering an airway on the first line of page 2 initiates an airway intercept and displays boxes in the first line TO waypoint. Entering a waypoint in the boxes:

- replaces the airway with dashes in the first VIA line
- enters the fix preceding the nearest abeam location on the airway in the TO waypoint
- moves the airway to line 2

A route can contain segments formed by the intersection of two airways. Entering two intersecting airways in successive VIA lines without a TO waypoint causes the FMC to create an airway intersection waypoint. The FMC created waypoint intersection (INTC) displays as the first airway segment TO waypoint.

LACRE3.VAMPS is an example of a SID selection made on the DEPARTURES page.

V2 and V336 are examples of airway entries.

APP TRANS is an example of a transition selection made on the APPROACH page.

ILS32R is an example of an approach selection made on the APPROACH page.

2 TO

TO column displays the selected end waypoint or termination of the route segment in the VIA column.

During preflight when entering a runway on RTE page 1 and entering a waypoint in the TO column without first entering a VIA airway displays a DIRECT segment on the first VIA line from the runway threshold. When a runway has not been entered on RTE page 1, dashes display on the first VIA line.

Valid waypoint entries for a DIRECT route segment are any valid waypoint, fix, navaid, airport, or runway.

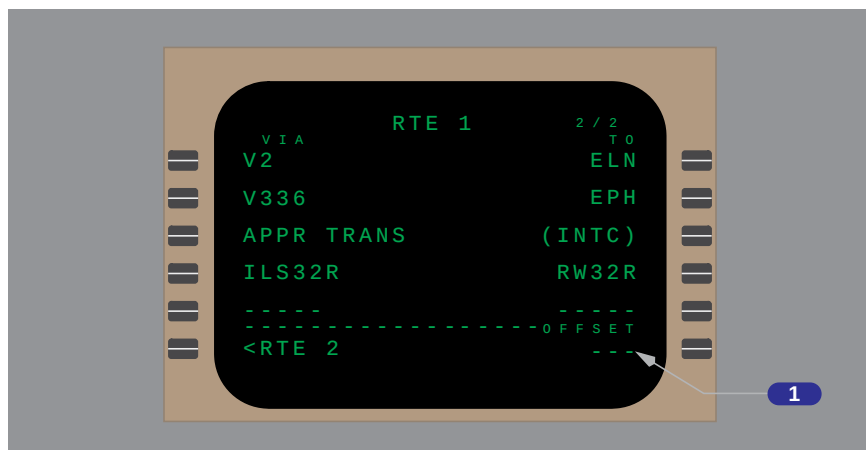
Valid waypoint entries for airways are waypoints or fixes on the airway.

Dashes display on the first TO waypoint after the end of the route.

Route Offset

Select route offsets on RTE page 1. The OFFSET prompt displays when the airplane is in flight and not on a SID, STAR, or transition. The offset route displays as a white dashed line on the ND until the offset modification is executed or erased. After execution, the offset route displays as a dashed magenta line. The original route continues to display as a solid magenta line. When executing the offset modification with LNAV active, the airplane turns to capture the offset course.

When on the route offset, active route waypoints sequence normally. However, during transition to or from an offset route greater than 21 nm, the crosstrack limit is extended to 200 nm.



1 Route Offset

Valid entry is L (left) or R (right) XX (XX is any number between 1 and 99).

Offset propagates along the route to a Standard Terminal Arrival Route (STAR), approach or approach transition, discontinuity, end of route, track change greater than 135 degrees, or holding pattern.

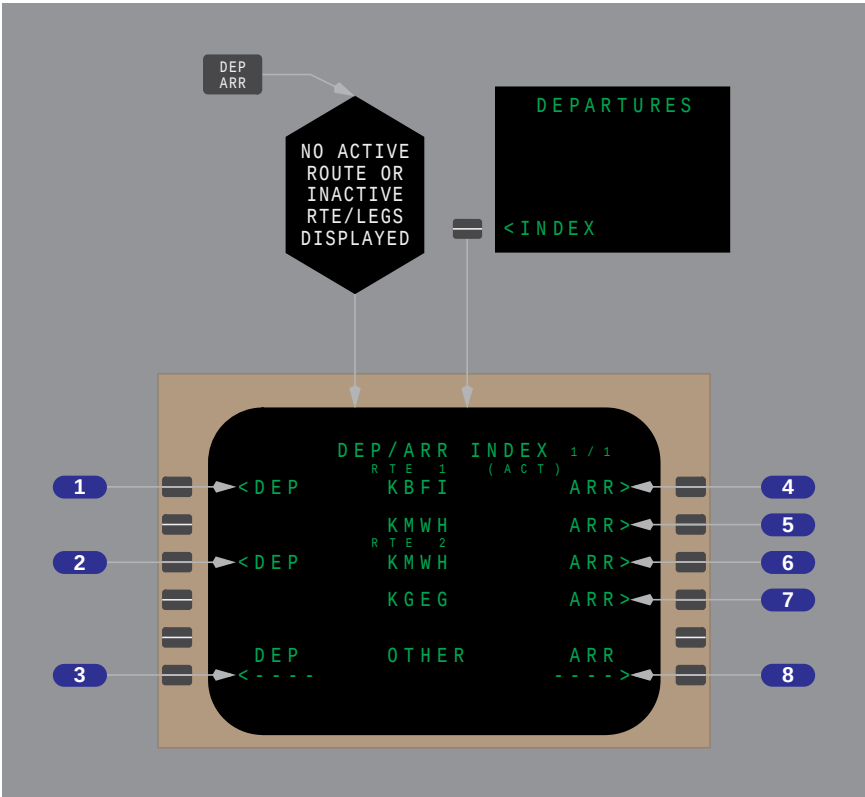
Offset removed by deleting, entering zero, or proceeding direct to a waypoint.

Preflight Pages - Part 1C

Departure/Arrival Index Page

Departure and arrival index page is used to select the departure or arrival page for the origin and destination airports for each route. The index page allows reference to departure or arrival data for any other airport in the navigation database.

Departure and arrival prompts are available for the origin airport. Destination airports have only arrival prompts.



1 Departure (DEP) - Route 1

Push - displays departure page for route 1 origin airport.

2 Departure (DEP) - Route 2

Push - displays departure page for route 2 origin airport.

3 Departure (DEP) -- Other

Displays departure page for the entered airport. Data can be viewed, but not selected because the airport is not in the route. Valid entry is four character ICAO airport identifier in the database.

4 Arrival (ARR) - Route 1 Origin

Push - displays arrival page for route 1 origin airport. Origin airport arrivals selection may be used during an air turnback.

5 Arrival (ARR) - Route 1 Destination

Push - displays arrival page for route 1 destination airport.

6 Arrival (ARR) - Route 2 Origin

Push - displays arrival page for route 2 origin airport. Origin airport arrivals selection may be used during an air turnback.

7 Arrival (ARR) - Route 2 Destination

Push - displays arrival page for route 2 destination airport.

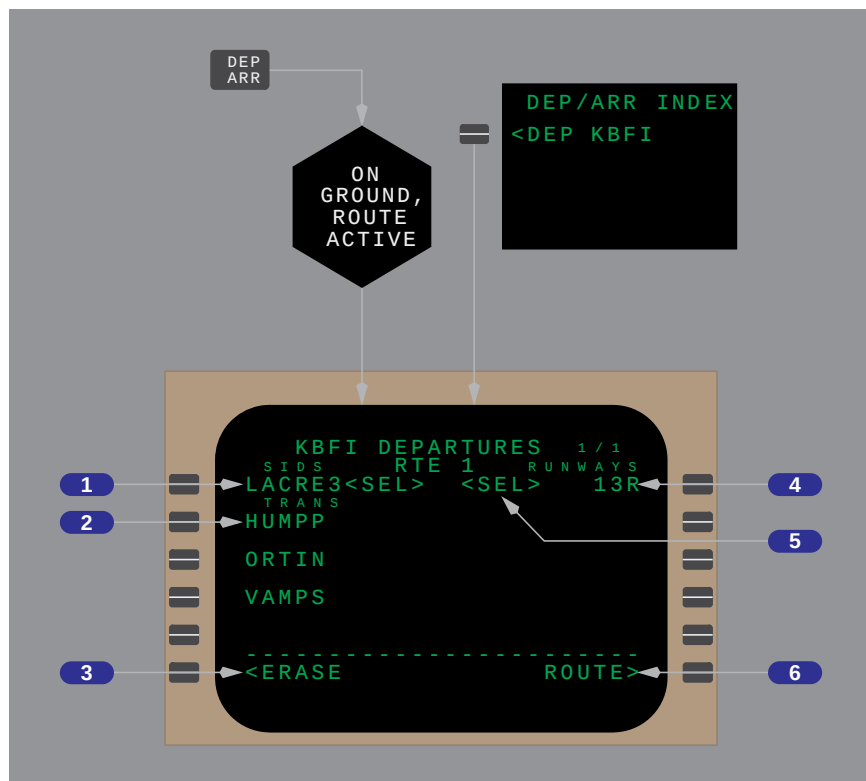
8 Arrival (ARR) - Other

Displays arrival page for the entered airport. Data can be viewed, but not selected because the airport is not on the route. Valid entry is four character ICAO airport identifier in the database.

Departures Page

The departures page is used to select the departure runway, SID, and transition for the route origin airport.

Pushing the DEP ARR function key displays the departures page for the inactive route when an inactive RTE or RTE LEGS page is displayed.



1 Standard Instrument Departures (SIDs)

Displays a list of SIDs for the airport.

Push -

- selects SID for use in the route
- other SIDs no longer display and transitions for the selected SID display
- runways for selected SID remain and others no longer display

2 Transitions (TRANS)

Displays transitions compatible with the selected SID.

Push -

- selects transition for entry into the route
- other transitions no longer display

3 ERASE, INDEX

ERASE displays when a route modification is pending. INDEX displays when no route modification pending.

ERASE -

Push - removes route modifications not executed and displays the original route.

INDEX -

Push - displays DEP/ARR INDEX page.

4 RUNWAYS

Displays a list of runways for the selected airport.

A runway selected on the RTE 1/X page displays as <SEL> or <ACT>.

Push -

- selects runway for use in the route. All other runways no longer display
- SIDs associated with selected runway remain, all others no longer display
- subsequent change of a runway deletes departure procedures previously selected

5 <SEL>, <ACT>

Selecting an option displays <SEL> inboard of the option and creates a route modification. After executing the modification, <SEL> becomes <ACT>.

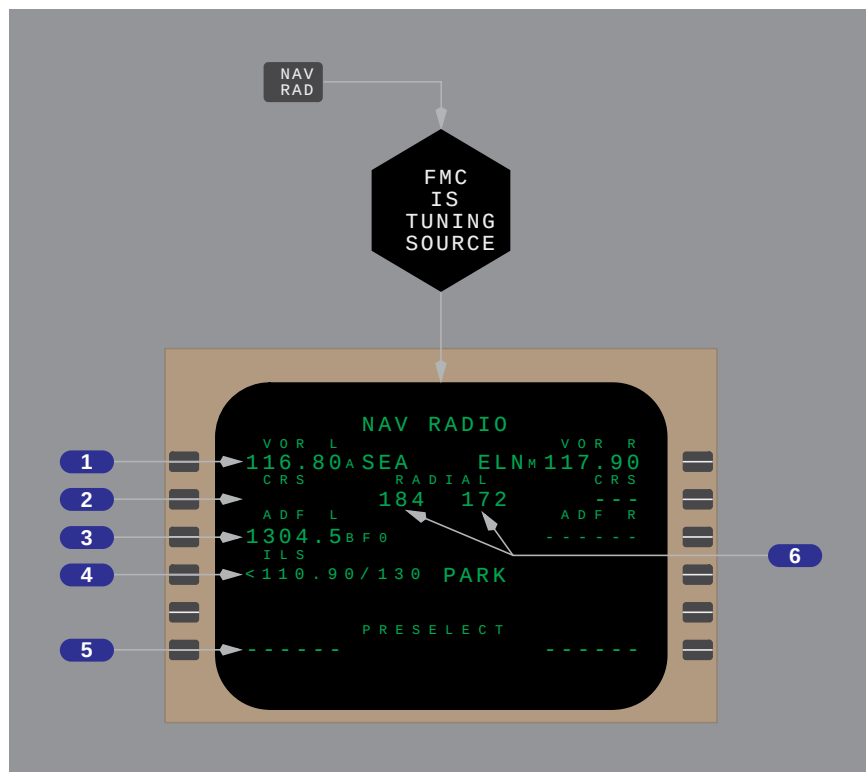
Executing a modification or leaving the page and returning displays all options and <SEL> or <ACT> prompts.

6 ROUTE

Push - displays the respective RTE page.

Navigation Radio Page

VOR and ILS navigation radios are normally autotuned by the FMC. ADF radios are manually tuned. NAV RADIO page displays the VOR, ILS, and ADF radio status and allows manual control of these radios. Entering data on this page tunes the selected navigation radio. VOR courses can also be entered.



1 VOR Frequency and Tune Status

Tuning status displays adjacent to left and right VOR frequencies. Entry of a frequency or identifier manual-tunes a VOR. FMC autotunes VORs for procedure flying and route operations. Tuning status displays are:

- R (route autotuning) - FMC selects navaids on the active route. The navaid is the previous VOR or a downpath VOR within 250 nm of aircraft position
- A (autotuning) - FMC selects a navaid for best position orientation
- M (manual) - VOR is manual-tuned
- P (procedure autotuning) - FMC selects navaids for approach or departure procedure guidance

Manual-tuning takes priority over FMC autotuning. Deletion of a manual-tuned frequency returns system to autotuning.

Valid entries:

- VOR or non-ILS DME identifier or VOR frequency (XXX.X or XXX.XX)
- VOR identifier or frequency/course; the course displays on the CRS line

Tunes respective DME.

Note: When magnetic variation at the airplane and VOR locations are significantly different, the ND VOR radial and ND POS green radial do not point directly to the VOR. This difference decreases as the airplane approaches the VOR.

2 Course (CRS)

Blank when in autotune.

Valid entry is a three-digit course. Data can be entered when dashes or a course display.

With a VOR approach selected, sequencing an IAF/FAF causes the FMC to procedure autotune the VOR frequency. When the approach has a runway waypoint, the FMC selects the inbound course.

3 ADF Frequency and Tune Status

Tuning status displays adjacent to left and right ADF frequencies. Tuning status displays are:

- ANT (antenna) - mode optimizes audio reception and removes ADF bearing data
- BFO (beat frequency oscillator) - mode for audio identification of stations transmitting unmodulated (CW) signals
- none - default tuning mode gives both bearing data and audio

Valid entries are XXX.X or XXXX.X

Entry can be followed by A (ANT), B (BFO), or none, which defaults to the ADF mode. A or B can be entered with a frequency already displayed.

4 ILS Frequency and Course

Tuning status displays adjacent to ILS frequency and course. The ILS receivers operate in FMC autotune or manual-tuning modes. The FMC autotunes ILS frequency and course. When the ILS is not necessary, the FMC sets the ILS to PARK. This removes the displays from the PFD.

ILS autotuning is inhibited for ten minutes after takeoff and during manual-tuning. The ten minute inhibit is canceled when making a change to the active flight plan destination runway. Autotuning and manual-tuning are inhibited when:

- the autopilot is engaged and either the localizer or glideslope is captured
- only the flight director is ON and either the localizer or glideslope is captured and the airplane is below 500 feet radio altitude
- on the ground with the localizer alive, airplane heading within 45 degrees of the localizer front course, and ground speed greater than 40 knots

Manual ILS tuning is enabled when:

- pushing either TOGA switch
- disengaging the autopilot and switching off both flight directors.

Valid entries:

- ILS frequency and front course (XXX.XX/YYYY)
- front course, with a frequency and course already entered (/YYY)

5 PRESELECT

Any valid page data may be entered.

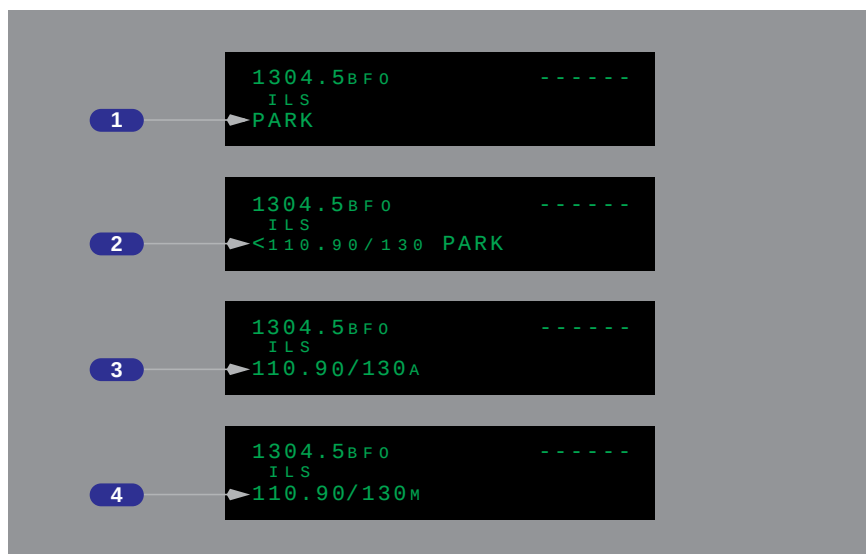
6 RADIAL

Displays radial from left and right VOR stations to the airplane.

ILS Tuning Status

Display initializes to PARK. Tuning status displays are:

- XXX.XX/YYY PARK - ILS autotuned for selected approach but not being used
- A (autotune) - ILS autotuned for approach guidance
- M (manual) - ILS manual-tuned



1 Park

PARK displays when:

- electrical power is first applied
- more than 200 NM from the T/D, or
- less than halfway to the destination

2 Tuning Status - Frequency, Course, and Park

ILS frequency, front course, and PARK display when an ILS, LOC, Back Course; or a VOR, runway, or VFR approach to an ILS/LOC equipped runway is selected, and:

- less than 200 NM from the T/D, or
- more than halfway to the destination, whichever represents the lesser distance to destination

Line selection manually tunes ILS.

3 Tuning Status - Autotune

ILS frequency, front course, and A display when an ILS, LOC, Back Course; or a VOR, runway, or VFR approach to an ILS/LOC equipped runway is selected, and:

- less than 50 NM from the T/D, or
- less than 150 NM from the runway threshold, or
- FMC is in descent mode

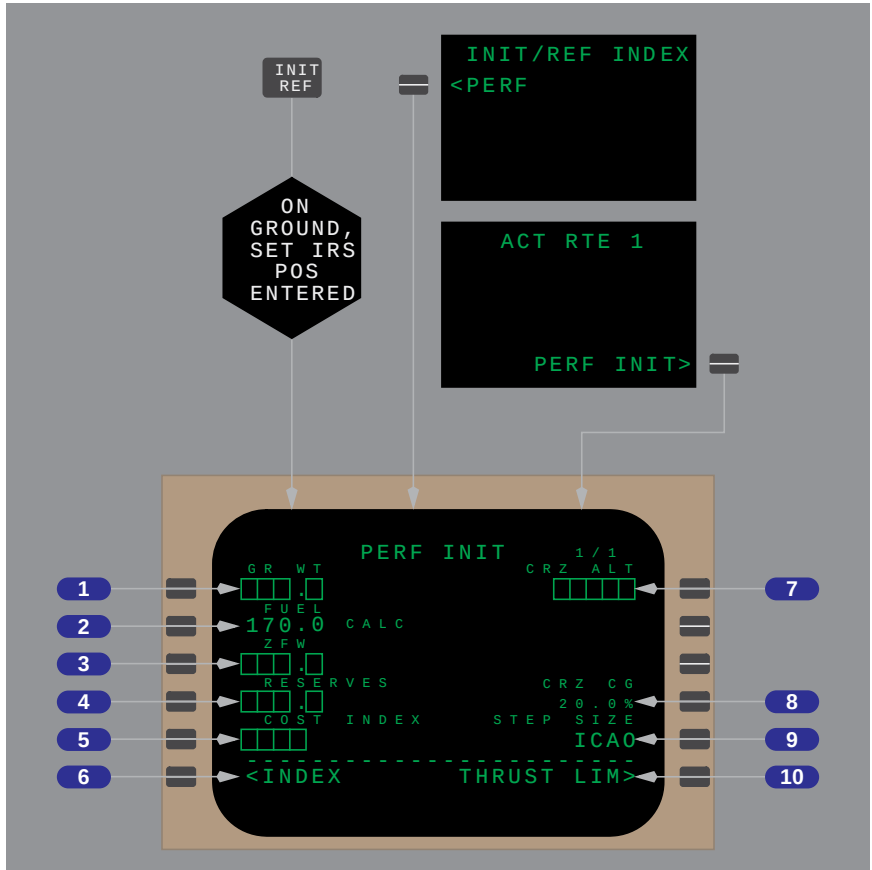
4 Tuning Status- Manual

Receiver tuned manually and valid frequency/course display.

Preflight Pages - Part 2A

Performance Initialization Page

The performance initialization page allows entry of airplane and route data to initialize performance calculations. This data is required for VNAV calculations. Entered values clear with loss of electrical power or at engine shutdown after flight.



1 Gross Weight (GR WT)

Airplane gross weight can be entered by the flight crew or calculated by the FMC after entry of zero fuel weight.

Valid entries are XXX or XXX.X.

Entry of a value after takeoff speeds are selected deletes V speeds and displays the scratchpad message TAKEOFF SPEEDS DELETED.

2 FUEL

Fuel on board displays when fuel totalizer calculations are valid. The source for the display is included in the line:

- **SENSED** - fuel quantity is from the totalizer. Manual entry is not possible
- **CALC** (calculated) - fuel quantity is from FMC calculations. Manual entry is possible
- **MANUAL** - fuel quantity has been manually entered. A manual entry blanks totalizer and displays under **CALCULATED** on **PROGRESS** page 2/3

Definitions of **SENSED** and **CALC** are found on **PROGRESS** page 2/3 in Section 42, FMC Cruise.

Valid entry is **XXX** or **XXX.X**.

Only manual entries can be deleted.

3 Zero Fuel Weight (ZFW)

Normally, **ZFW** is entered from the airplane dispatch papers and the FMC calculates the airplane gross weight.

Valid entry is **XXX** or **XXX.X**.

Calculated zero fuel weight displays when airplane gross weight is entered first and fuel on board is valid.

Entry of a value after takeoff speeds are selected deletes **V** speeds and displays the scratchpad message **TAKEOFF SPEEDS DELETED**.

4 RESERVES

Valid entry is **XXX** or **XXX.X**.

5 COST INDEX

Cost index is used to calculate ECON climb, cruise, and descent speeds. Larger values increase ECON speeds. Entering zero results in maximum range airspeed and minimum trip fuel. Cost index can be entered by the flight crew or from a company route.

Valid entries are 0 to 9999.

6 INDEX

Push - displays the INIT/REF INDEX page.

7 Cruise Altitude (CRZ ALT)

Cruise altitude can be entered by the flight crew or from a company route.

Valid entry is XXX, XXXX, XXXXX, or FLXXX.

Altitude displays in feet or flight level depending on transition altitude.

Entry displays this cruise altitude on the CLB and CRZ pages.

8 Cruise Center of Gravity (CRZ CG)

Not used at Delta Air Lines

Displays default or pilot entered cruise CG value.

Used by FMC to calculate maximum altitude and maneuver margin to buffet.

Default value, 20.0, displays in small font.

A pilot entered value displays in large font. Deletion of a pilot entered value displays the default cruise CG value.

Valid entry is X.X or XX.X in the range 8.5 to 33.0.

9 STEP SIZE

Displays climb altitude increment used for planning the optimum climb profile.
Default display is ICAO.

Valid entries are 0 to 9000 in 1000 foot increments.

For a non-zero entry or ICAO, performance predictions are based on step climbs at calculated step climb points. For a zero entry, performance predictions are based on a constant CRZ ALT.

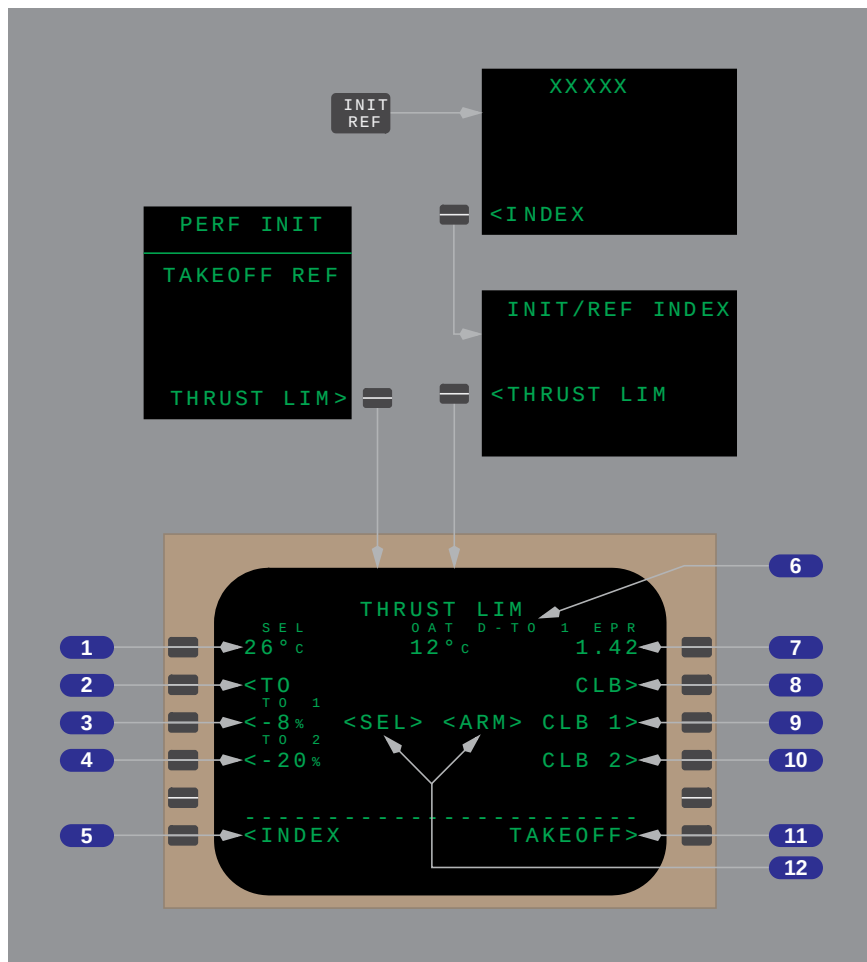
10 Thrust Limit (THRUST LIM)

Push - displays THRUST LIM page.

Preflight Pages - Part 2B

Thrust Limit Page

The thrust limit page allows selection and display of reference thrust for takeoff. Derating takeoff thrust by use of assumed temperature is also accomplished on this page.



1 Assumed Temperature (SEL), Outside Air Temperature (OAT)

Initially blank. Entry of an assumed temperature up to the maximum thrust reduction limit of 25% reduces takeoff thrust and displays D in the thrust reference mode line title. When selecting a temperature higher than the maximum assumed temperature limit, the FMC changes the entered temperature to the maximum temperature which gives a 25% thrust derate.

Valid entries are 0 to 99 degrees Celsius (C) or 32 to 210 degrees F.

Entry in degrees Fahrenheit (F) causes OAT to display degrees F.

Entry of a value after takeoff speeds are selected deletes V speeds and displays the scratchpad message TAKEOFF SPEEDS DELETED.

OAT displays outside air temperature in degrees C. When SEL temperature is in degrees F, the OAT converts to degrees F.

2 Takeoff (TO)

Push - selects full rated (TO) takeoff thrust limit.

Selection of a new rating after takeoff speeds are selected deletes V speeds and displays the scratchpad message TAKEOFF SPEEDS DELETED.

3 Takeoff 1 (TO 1)

Push - selects percentage derate (TO 1) takeoff thrust limit.

4 Takeoff 2 (TO 2)

Not used at Delta Air Lines

Push - selects percentage derate (TO 2) takeoff thrust limit.

5 INDEX

Push - displays INIT/REF INDEX page.

6 Thrust Reference Mode

Displays selected takeoff thrust mode.

7 Takeoff EPR Limit

Displays takeoff EPR calculated by the thrust management system. Displays N1 when engines are operated in the alternate mode.

8 Climb (CLB)

Push - selects the full rated (CLB) climb thrust limit.

Pushing any climb line select key overrides an automatic selection.

9 Climb 1 (CLB 1)

Push - selects a percentage derate (CLB 1) climb thrust limit.

10 Climb 2 (CLB 2)

Push - selects a percentage derate (CLB 2) climb thrust limit.

11 TAKEOFF

Push - displays TAKEOFF REF page.

12 <SEL>, <ACT>

<SEL> - identifies selected takeoff thrust reference mode.

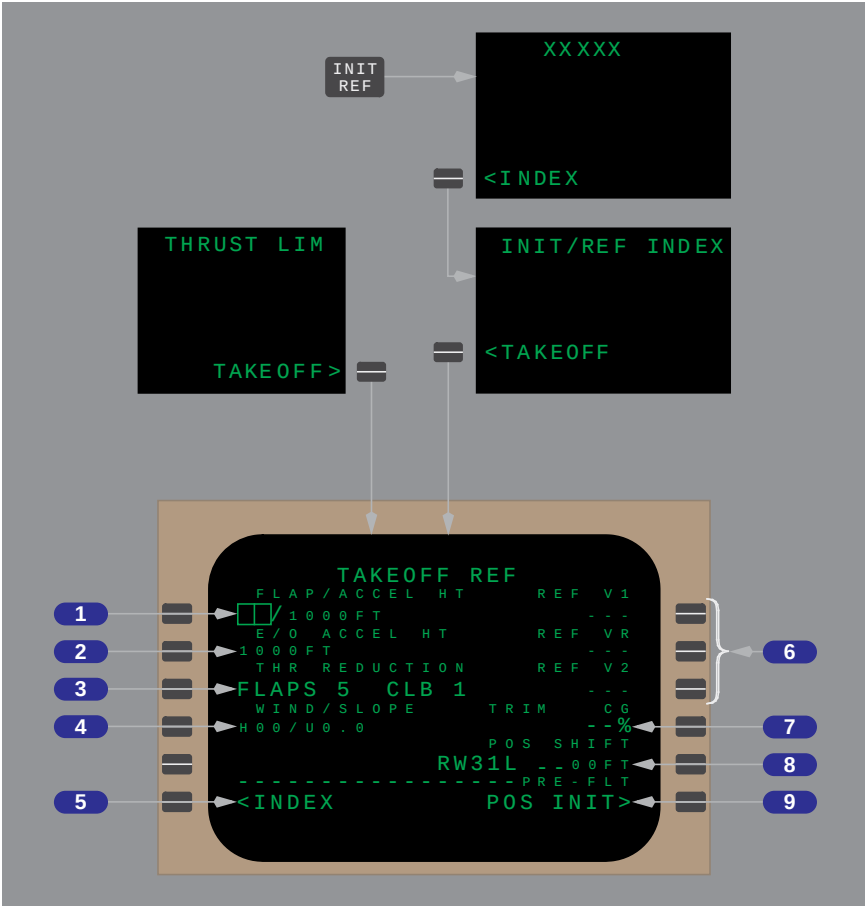
<ARM> - identifies armed climb thrust reference mode. <ARM> changes to

<SEL> - when armed climb mode becomes active.

Takeoff Reference Page

The takeoff reference page displays takeoff data and preflight status. Takeoff flap setting and V speeds are entered and verified. “PRE-FLT” displays in the line title of 6R if other preflight pages are not complete, such as POS INIT, ROUTE, or PERF INIT. When preflight is complete, THRUST LIM> displays allowing selection of other takeoff thrust limits.

Takeoff reference page entries complete the normal preflight.



1 FLAP/Acceleration Height (ACCEL HT)

Displays takeoff flap setting.

Valid entries are 10 or 20.

Flap position is required for takeoff V speed calculations.

Displays acceleration height in Height Above Airport (HAA) for flap retraction.

Valid entry is an HAA height from 400 to 9999 feet. The FMC adds airport elevation to entered HAA acceleration height causing acceleration at an MSL altitude. For example, for an airport elevation of 980 feet, an entry of 2020 acceleration height causes acceleration at 3,000 feet MSL.

Entry of a new flap setting after takeoff speeds are selected deletes V speeds and displays the scratchpad message TAKEOFF SPEEDS DELETED.

2 Engine Out Acceleration Height (E/O ACCEL HT)

Displays acceleration height in HAA for flap retraction with an engine out.

Valid entry is an HAA height from 400 to 9999 feet.

3 Thrust (THR) REDUCTION

Displays flap setting or height in HAA for reduction from selected takeoff thrust to armed climb thrust.

Displays armed climb thrust rating.

Valid entries are:

- 5 for flaps 5, or
- an HAA height from 400 to 9999 feet. The FMC adds airport elevation to entered HAA thrust reduction height causing thrust reduction at an MSL altitude. For example, for an airport elevation of 980 feet, an entry of 1020 thrust reduction height causes thrust reduction at 2,000 feet MSL.

4 WIND/SLOPE

Displays wind and runway slope after crew entry.

Valid entries are:

- WIND - HXX, XX for headwind, TXX for tailwind
- SLOPE - UX.X, X.X for upslope, DX.X for downslope

5 INDEX

Push - displays INIT/REF INDEX page.

6 V Speeds (V1, VR, V2)

Displays dashes when:

- required information not entered
- performance calculations inhibited
- IRUs not aligned

Displays FMC calculated speeds when required information entered.

Flight crew entered or selected speeds display in large font and replace calculated speeds. A manually entered V1 speed less than V1MIN is indicated by display of “V1MIN” in the header line and the value of V1MIN in the data line.

Calculated speeds display in small font.

FMC calculated speeds provide VMCA and VMCG protection.

Push -

- selects V1, VR, and V2 to be sent to using systems, or
- crew entered V speeds replace calculated speeds
- display changes to large font; REF and caret no longer display

If performance data changes:

- FMC replaces existing speeds with FMC calculated speeds in small font
- V speeds are deleted from the PFD
- PFD speed tape message NO V SPD displays
- scratchpad message TAKEOFF SPEEDS DELETED displays

Note: After the third engine is started, any combination of gross weight, OAT, or pressure altitude resulting in a change in any computed speed of more than one knot from the previously calculated speed, causes the FMC to calculate and display revised takeoff speeds. V1, VR, and V2 disappear from view on the TAKEOFF REF page 2 minutes after takeoff.

7 TRIM, Center of Gravity (CG)

Initially displays dashes.

Valid entries are whole numbers of CG expressed as a percentage of MAC within the range 0 to 40.

After CG entered, the FMC:

- calculates and displays stabilizer takeoff setting to the left of the CG entry (trim display is in 0.1 unit increments)
- updates the takeoff green band displayed on stabilizer position indicators

8 Position (POS) SHIFT

Displays the selected takeoff runway and TO/GA “push” distance from the runway threshold.

Valid entries are X, XX in + or - hundreds of feet (3 or 03 is 300 feet beyond the runway threshold; -3 or -03 is 300 feet prior to runway threshold)

Entered value updates FMC position to the TO/GA push point when GPS updating not active.

9 PRE-FLIGHT

Displays PRE-FLIGHT in the header and the title (XXXXX) of incomplete page on the data line when preflight is not complete.

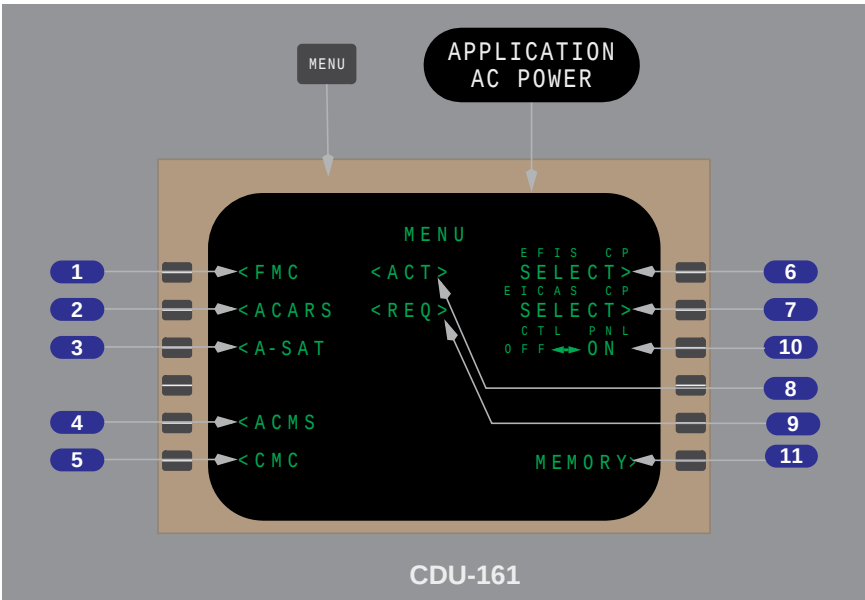
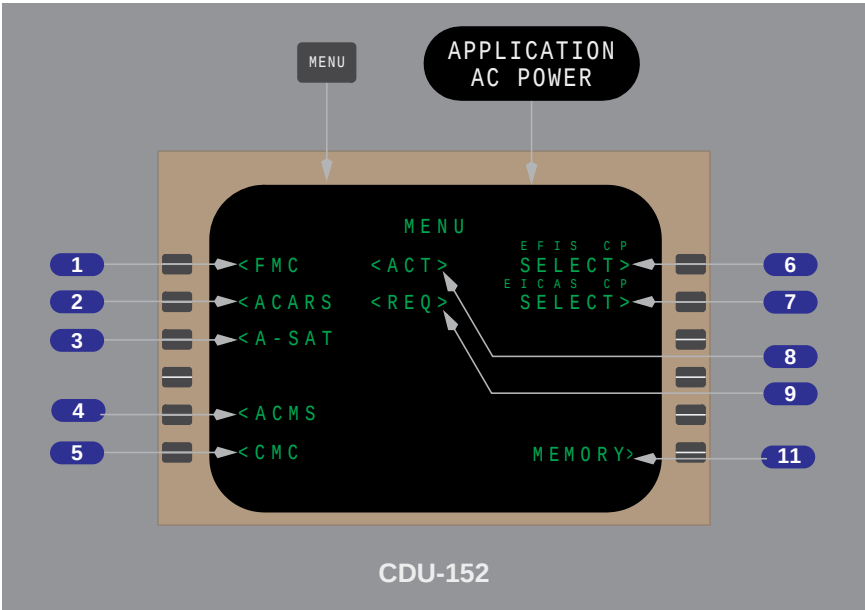
Displays dashes and THRUST LIM when preflight is complete.

Push -

- displays THRUST LIM page when THRUST LIM displayed
- displays incomplete page (XXXXX) when PRE-FLIGHT displayed

Menu Page

Provides access to other systems that use CDU.



1 FMC

Displayed on the left or right CDU

Push -

- connects FMC to the CDU
- displays last page used
- displays INITIALIZATION page on initial application of AC power

2 Aircraft Communication Addressing and Reporting System (ACARS)

Displayed on all 3 CDUs

See Chapter 5, Communications.

3 Satellite Communication System (SATCOM)

Displayed on the left or right CDU

See Chapter 5, Communications.

4 Aircraft Maintenance System (ACMS)

6311-6316

Displays ACMS Maintenance page. Only displays on the center CDU.

Not used by Flight Operations.

5 Central Maintenance Computer (CMC)

Operational on ground and in flight above 10,000 feet.

Push -

- displays CMC menu page
- activates CMC control of the CDU for maintenance use

6 Alternate EFIS Control (CP)

See Chapter 10, Flight Instruments, Displays

7 Alternate EICAS Control (CP)

See Chapter 10, Flight Instruments, Displays

8 Active (ACT)

Indicates active CDU controller.

9 REQ

Indicates non-active CDU controller requires pilot action.

10 Control Panel Switch

See Chapter 10, Flight Instruments, Displays.

11 MEMORY

Accessible only on the ground. For maintenance use only.

Introduction

FMC takeoff phase starts with selection of takeoff/go-around (TO/GA). Preparation for this phase starts in preflight phase and includes entry of TAKEOFF REF page data.

Takeoff phase changes to climb phase when the FMC commands climb thrust. Climb phase continues to the top of climb point, where cruise phase starts.

During takeoff and climb, the specific page listed below is used to:

- TAKEOFF REF page - make changes to the departure runway
- DEPARTURES page - make SID selections
- CLIMB page - modify climb parameters and monitor airplane climb performance
- RTE X LEGS page - modify the route and monitor route progress
- PROGRESS page - monitor the overall progress of the flight
- THRUST LIM page - select fixed thrust climb derate limits
- DEP/ARR INDEX page - select an approach during a turn-back

Takeoff Phase

When changes are made to the departure runway and SID, TAKEOFF REF and DEPARTURES pages must be modified to agree. The modified data are entered the same as during preflight.

With correct takeoff parameters, the FMC commands the selected takeoff thrust when the TO/GA switch is pushed. During takeoff roll, autothrottle commands thrust and the FMC commands acceleration to between V₂+10 and V₂+25 knots, based on rate of rotation.

Usually, LNAV and VNAV are armed before takeoff. When armed before takeoff, LNAV activates at 50 feet above the barometric altitude recorded by the FMC when accelerating through 100 knots and commands roll to fly the active route leg. VNAV activates at 400 feet above the recorded altitude and commands pitch to fly the climb profile.

Climb Phase

At acceleration height or the first movement of the flap handle during flap retraction, VNAV commands acceleration to a speed 5 knots below the flap placard speed for the existing flap setting. When flaps are retracted, VNAV commands the speed displayed on the SPD TRANS line.

At the climb thrust reduction point, the FMC commands a reduction to the armed climb thrust. Passing the transition altitude displayed on the SPD TRANS line, VNAV commands an acceleration to economy climb speed, which is maintained until entering the cruise phase. Waypoint speed constraints take priority, provided they are greater than VREF+100 or the transition speed.

During climb, VNAV complies with LEGS page waypoint altitude and speed constraints. A temporary level-off for a crossing altitude restriction is accomplished at the commanded speed.

When the climb profile fails to reach a waypoint altitude constraint, the FMC displays the CDU scratchpad message UNABLE NEXT ALTITUDE. Deleting climb derates or selecting a reduced climb speed thus giving a steeper climb angle, may enable the airplane to reach the altitude constraint.

Climb Page

The climb page is used to evaluate, monitor, and modify the climb profile. Data on climb page comes from preflight entries made on the route and performance pages.

The climb page is the first of the three pages selected with the VNAV function key. FMC climb can be economy, fixed speed, or engine out.



1 Page Title

The page title displays active (ACT) or modified (MOD) climb. Usually, the title contains ECON for economy climb. Fixed speed and engine out modify the title.

- ACT ECON CLB - speed based on a cost index
- ACT LIM SPD CLB - speed based on airplane configuration limiting speed
- ACT MCP SPD CLB - MCP speed intervention selected
- ACT XXXKT CLB - fixed CAS climb speed profile
- ACT M.XXX CLB - fixed Mach climb speed profile

Fixed climb speeds are for:

- takeoff/climb acceleration segment constraints
- a flight crew selected speed (SEL SPD)
- a speed transition
- a speed restriction associated with an altitude
- waypoint speed constraints

2 Cruise Altitude (CRZ ALT)

Displays cruise altitude entered on PERF INIT page.

Valid entries are: XXX, XXXX, XXXXX, or FLXXX. Altitude displays in feet or flight level depending on transition altitude.

3 Economy Speed (ECON SPD), Selected Speed (SEL SPD)

ECON SPD -

- speed based on cost index in CAS or Mach
- used by the FMC at altitudes above all waypoint speed constraints, speed restrictions, and speed transition altitudes

Valid entries are CAS or Mach.

SEL SPD - displays when flight crew enters speed.

4 Speed Transition (SPD TRANS)

Speed transition line displays the transition speed/altitude from one of these sources:

- the navigation database value for the origin airport
- the greater of the transition speed associated with the origin airport or V30REF+100 knots (example 272/10000)

Not displayed above transition.

Can be deleted.

5 Speed Restriction (SPD RESTR)

Speed restrictions at an altitude less than the cruise altitude and not associated with a waypoint are manually entered on this line.

Displays dashes before entry by flight crew.

Valid entry is a CAS and altitude (example 240/8000).

6 Economy (ECON)

Displays when the climb speed is not ECON.

Push - changes climb speed to ECON.

7 Waypoint Constraint (AT XXXXX)

Displays next airspeed and/or altitude constraint at waypoint XXXXX.

Can also display HOLD AT XXXXX followed by a speed/altitude constraint.

FMC commands the slower of constraint speed or performance speed.

Constraints entered on RTE LEGS page.

Delete here or on RTE LEGS page.

Blank if no constraint exists.

8 ERROR at Waypoint

Displays altitude discrepancy and distance past waypoint where altitude will be reached.

Blank if no error exists.

9 Transition Altitude (TRANS ALT)

Transition altitude for origin airport contained in navigation database. FMC default value is 18,000 feet.

Manually change transition altitude here or on DESCENT FORECAST page.

Valid entries are: XXX, XXXX, XXXXX, or FLXXX.

CDU altitude data changes from altitudes to flight levels above the transition altitude.

10 Maximum Angle (MAX ANGLE)

Displays maximum angle climb speed.

Entry not allowed.

11 Engine Out (ENG OUT)

Push - displays E/O CLB page; deletes climb speed transition and restriction data.

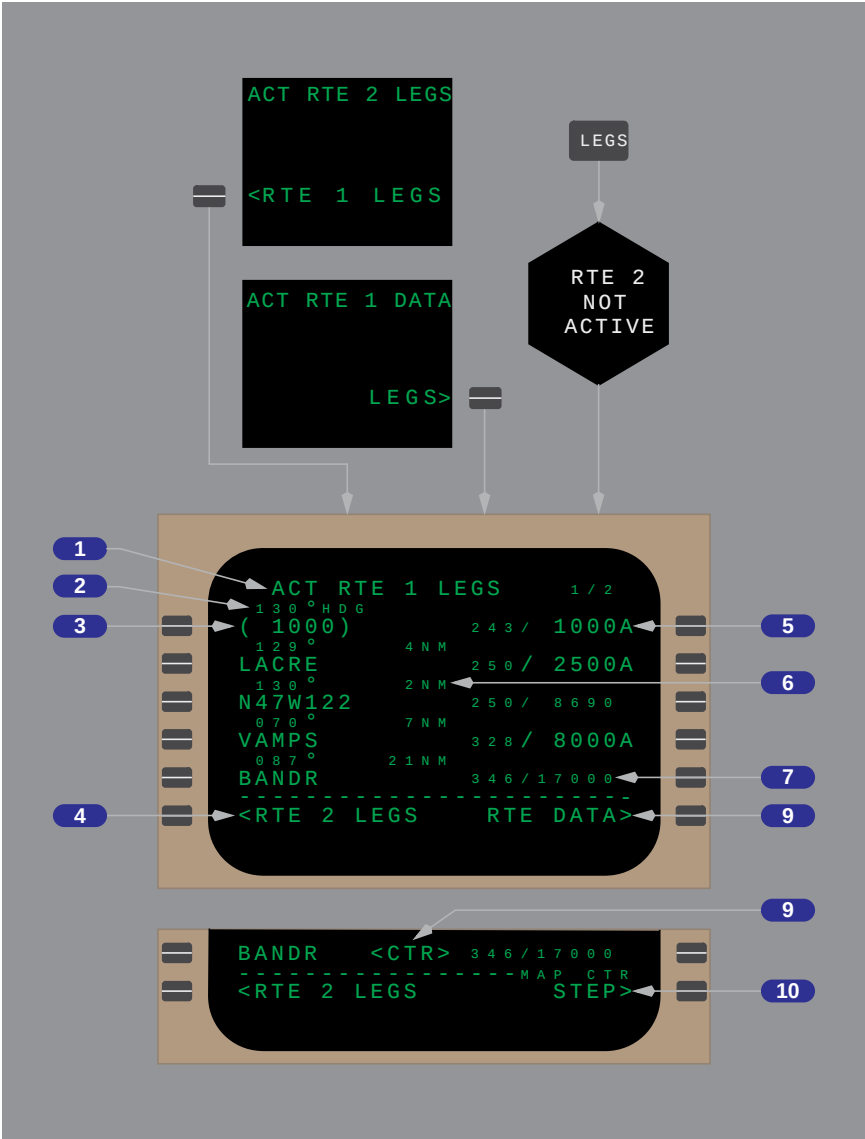
12 Climb Direct (CLB DIR)

Displays when climb altitude constraint exists between current altitude and FMC cruise altitude.

Push - deletes all waypoint altitude constraints between the airplane altitude and the MCP altitude or FMC cruise altitude, whichever is lower. FMC cruise altitude is not affected.

RTE X LEGS Page

Route legs page provides means of entering and displaying details of each leg of the route. Valid entries same as on route pages TO line.



1 Page Title

Title format displays route status:

- RTE X LEGS - inactive route
- ACT RTE X LEGS - active route
- MOD RTE X LEGS - modified active route

2 Leg Direction

Leg segment data in line title:

- computed course to waypoint - XXX°
- specified procedural course/track from database - XXX°
- arcs - arc radius in miles, ARC, turn direction (example: 24 ARC L)
- heading leg segments - XXX° HDG
- track leg segments - XXX° TRK
- special procedural instructions from database - HOLD AT, PROC TURN, or PROC HOLD

Directions are magnetic unless followed by T (131° T).

Calculated great circle route leg directions may be different than chart values.

Dashes display for an undefined course.

3 Waypoint Identifier

Active leg is the first line of the first active RTE X LEGS page.

Active waypoint is on active leg.

All route waypoints display in flight sequence. Airway waypoints display on the route legs page.

Waypoints can be modified. Examples:

- add waypoints
- delete waypoints
- change waypoint sequence
- connect route discontinuities

Displays the waypoint by name or condition.

Boxes display for route discontinuities.

Dashes display after the end of the route.

4 Route 2 Legs (RTE 2 LEGS)

Push -

- displays RTE 2 LEGS page
- when RTE 2 LEGS page displayed, changes to RTE 1 LEGS

5 Waypoint Speed/Altitude Constraints

Waypoint speed or altitude constraints display in large font.

Manual entry allowed in climb or descent phase. Entered by FMC when constraints are part of a procedure.

Speed constraint is assumed to be at or below the displayed speed.

Valid entries are:

- speed only - XXX/. Enter CAS in the range of 1000 to 4000
- altitude only, less than cruise altitude - XXX, XXXA, XXXB, XXXAXXXB, XXXBXXXXA or may include an optional leading "/". Enter FL190 or 19,000 feet as 190. Enter FL090 or 9,000 feet as 090
- speed/altitude - XXX/XXXX

Altitude constraint suffixes:

- blank - cross at altitude
- A - cross at or above altitude
- B - cross at or below altitude
- both - altitude block. If constraint is to cross between two altitudes when climbing, enter lower altitude followed by "A"; then, enter higher altitude followed by "B". Example: 220A240B. Reverse the order for descent
- S - planned step climb (refer to Flight Management, Navigation, Cruise)

6 Distance to Waypoint

Distance (decreasing) from airplane to active waypoint or distance from waypoint to waypoint. Blank for some leg types (e.g. HDG or VECTORS).

7 Waypoint Speed/Altitude Predictions

Waypoint speed and altitude predictions display in small font.

Dashes display in predicted descent region prior to descent path calculation.

Descent path calculation requires altitude constraint below cruise altitude.

Manual entry allowed in climb or descent phase.

8 ACTIVATE, Route (RTE) DATA

Push -

- ACTIVATE - prepares inactive flight plan for activation; illuminates the EXEC key. Other pages may be accessed and modifications performed before execution. With an active route, ACTIVATE replaced with RTE DATA. In flight, LEGS page displays
- RTE DATA - displays route data page

ACTIVATE displays when RTE and RTE LEGS flight plan is inactive.

9 Center (<CTR>)

Displays when PLAN mode selected.

Displays adjacent to the waypoint around which ND plan mode is centered.

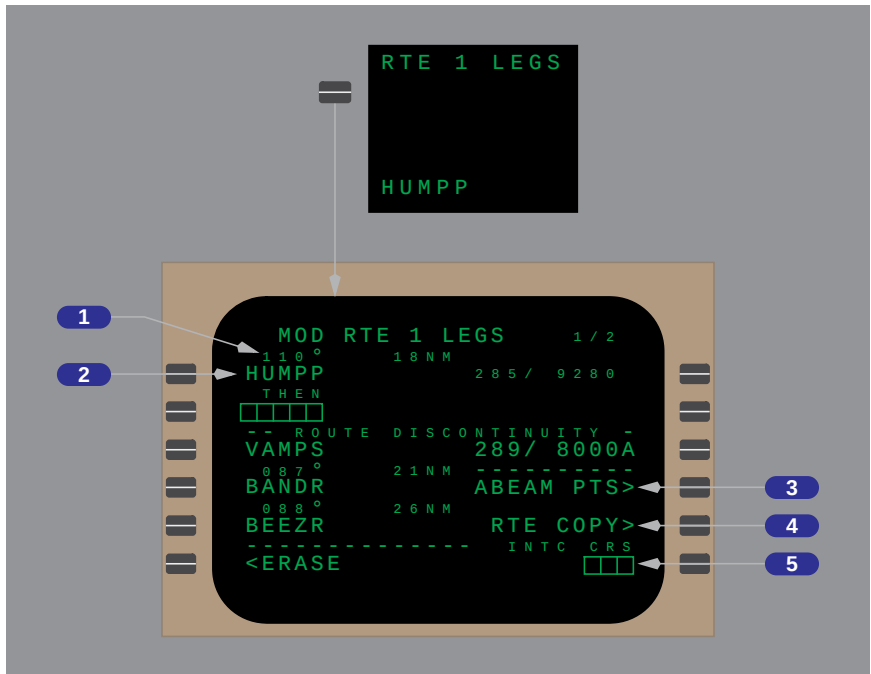
10 MAP Center (CTR) STEP

Replaces ACTIVATE or RTE DATA when PLAN mode selected.

Push - steps <CTR> to next waypoint. ND plan mode recenters.

Direct/Intercept Course

Used to fly direct to or intercept a course to a waypoint. Entering a waypoint over the active waypoint displays direct/intercept prompts.



1 Course to Active Waypoint

Prior to execution, displays direct-to inbound course at waypoint; changed by entry in INTC CRS line or by selecting intercept course.

After execution, displays current required track to fly inbound course to waypoint.

2 Active Waypoint

Displays crew entered direct/intercept waypoint.

3 ABEAM Points (PTS)

Push -

- line title displays ABEAM PTS, data line displays SELECTED
- creates abeam points on new route to indicate waypoints bypassed by direct to function
- abeam points are perpendicular to the waypoints bypassed
- subsequent route modifications remove ABEAM PTS prompt

4 Route (RTE) COPY

Push -

- copies active unmodified route into inactive route
- erases previous inactive route
- line title displays RTE COPY, data line displays COMPLETE
- subsequent route modifications remove RTE COPY prompt

5 Intercept (INTC) Course (CRS)

Displays boxes if entered waypoint not in the active route; valid entry is intercept course from 000° to 360°.

Displays current route course and prompt caret if entered waypoint in the active route.

Push -

- when current route course displayed, selects it as intercept course to active waypoint
- displays entry or current route course as course to active waypoint
- removes ABEAM PTS and RTE COPY prompts

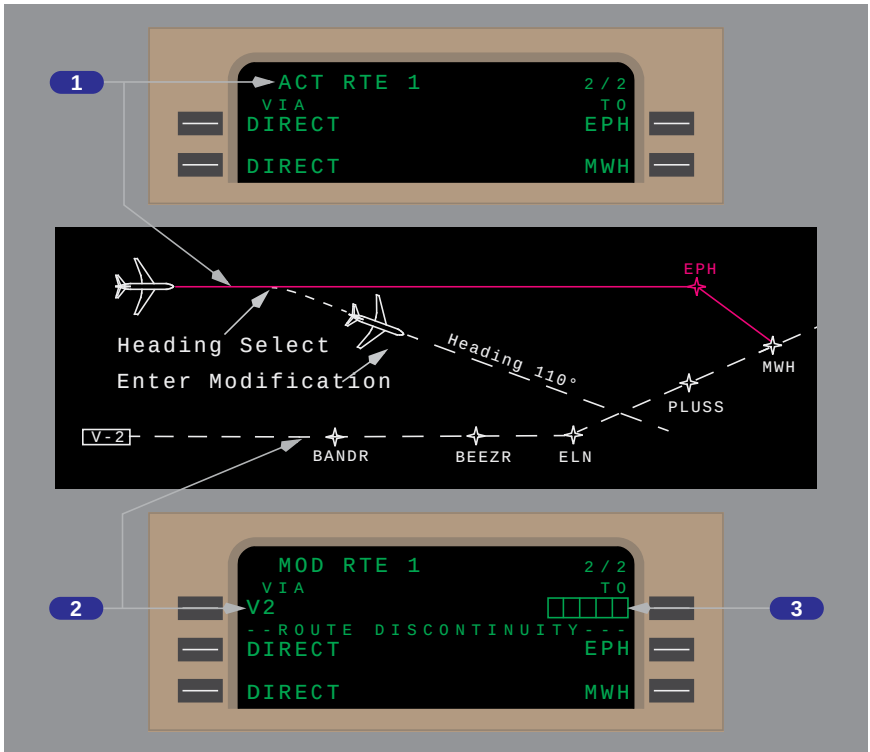
Airway Intercept

LNAV can be used to intercept an airway. An airway intercept changes the active waypoint on the RTE and LEGS pages.

Example

The active route is direct EPH, then direct MWH. ATC clears the airplane to:

- turn right heading 110°
- intercept V2 to MWH



1 Active RTE 1 Page

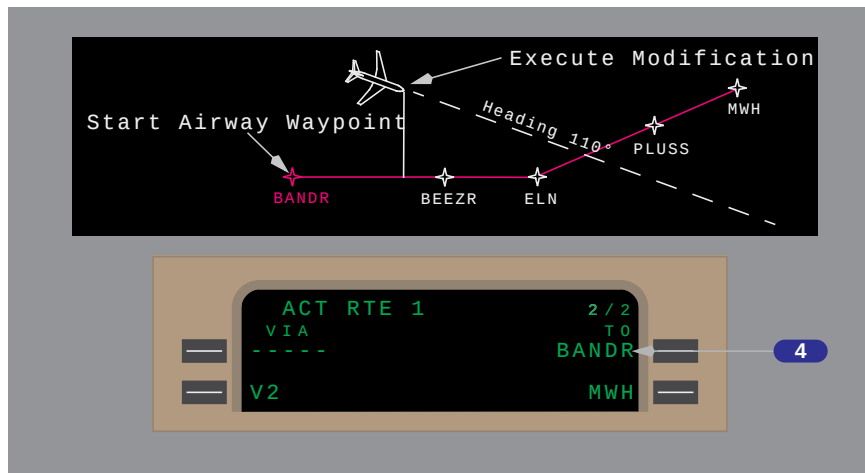
The route page before the ATC clearance.

2 Enter Airway

Enter the airway in the first VIA position on the RTE page. Boxes display in the TO position. A route discontinuity follows on the next line.

3 Airway Exit

Enter desired airway exit point (MWH) in the boxes.



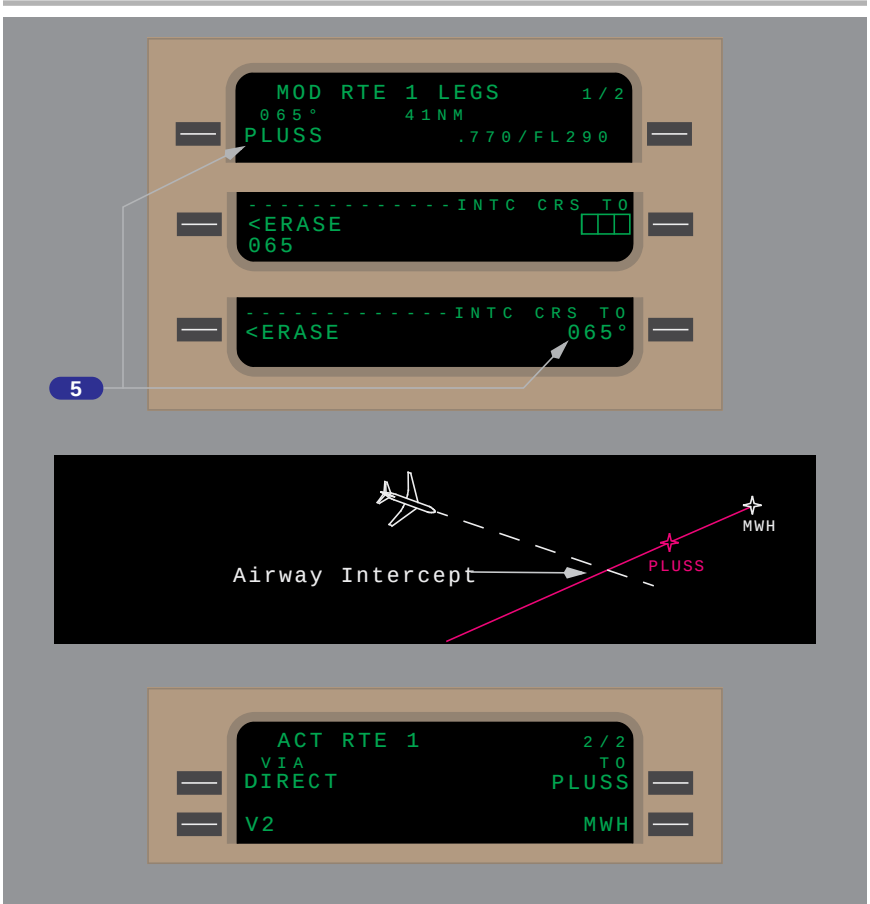
4 Start Airway Waypoint

After entering MWH in the boxes, the FMC selects the waypoint preceding the closest abeam location as the starting waypoint of the new airway. This waypoint displays under TO on line 1R. The entered airway and the selected exit point display on line 2. Executing the modification makes the FMC selected first waypoint the active waypoint; BANDR in this example. If the clearance heading intercepts the new route before the next downtrack waypoint (BEEZR), LNAV can be armed and will capture the new route. The active waypoint will sequence to next downtrack waypoint (BEEZR). Since the clearance heading will not intercept V2 prior to the next downtrack waypoint (BEEZR), use the intercept course procedure to make the inbound course to the next waypoint after the V2 crossing point the active leg segment.

The LEGS page displays this waypoint sequence:

- BANDR - the active waypoint
- BEEZR
- ELN
- PLUSS
- MWH - the V2 exit waypoint

The intercept heading crosses the V2 between ELN and PLUSS. Modify the LEGS page using a course intercept to the waypoint after the airway crossing, PLUSS, making PLUSS the active waypoint on the V2 airway. If the clearance heading does not intercept the new active leg segment, the NOT ON INTERCEPT HEADING scratchpad message displays.



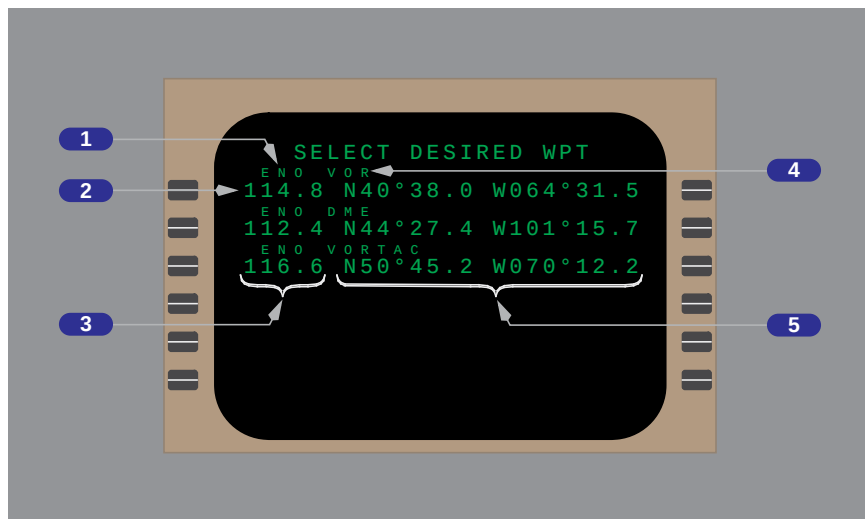
5 Airway Exit

On the LEGS page, move PLUSS to the scratchpad, then to 1L. The INTC CRS TO displays boxes. Enter the V2 inbound course to PLUSS.

Following the course intercept to PLUSS modification and execution, the LEGS page displays PLUSS as the active waypoint. LNAV can be armed and the airway intercept can be completed.

Select Desired Waypoint Page

The SELECT DESIRED WPT page displays after a waypoint entry when the FMC encounters more than one location for the same waypoint name. Selection of a waypoint returns the display to the previous page.



1 Identifier

Displays the identifier for the duplicate named waypoints.

2 Waypoint Lines

Display a sorted list of waypoints with identifier, navaid type, frequency, and coordinates;

- when page is accessed as a result of a flight plan modification, sort is based on proximity to the waypoint preceding the entered waypoint
- when page is accessed as a result of a DIR/INTC or REF NAV DATA entry, sort is based on proximity to current aircraft position

Push - selects waypoint location for use and returns display to page previously in use.

Pushing any CDU function key exits page without selecting a waypoint.

3 Frequency

Displays the frequency of the navaid.

Blank if the waypoint is not a navaid.

4 Type

Displays the type of navaid for each duplicate name.

Blank if the waypoint is not a navaid.

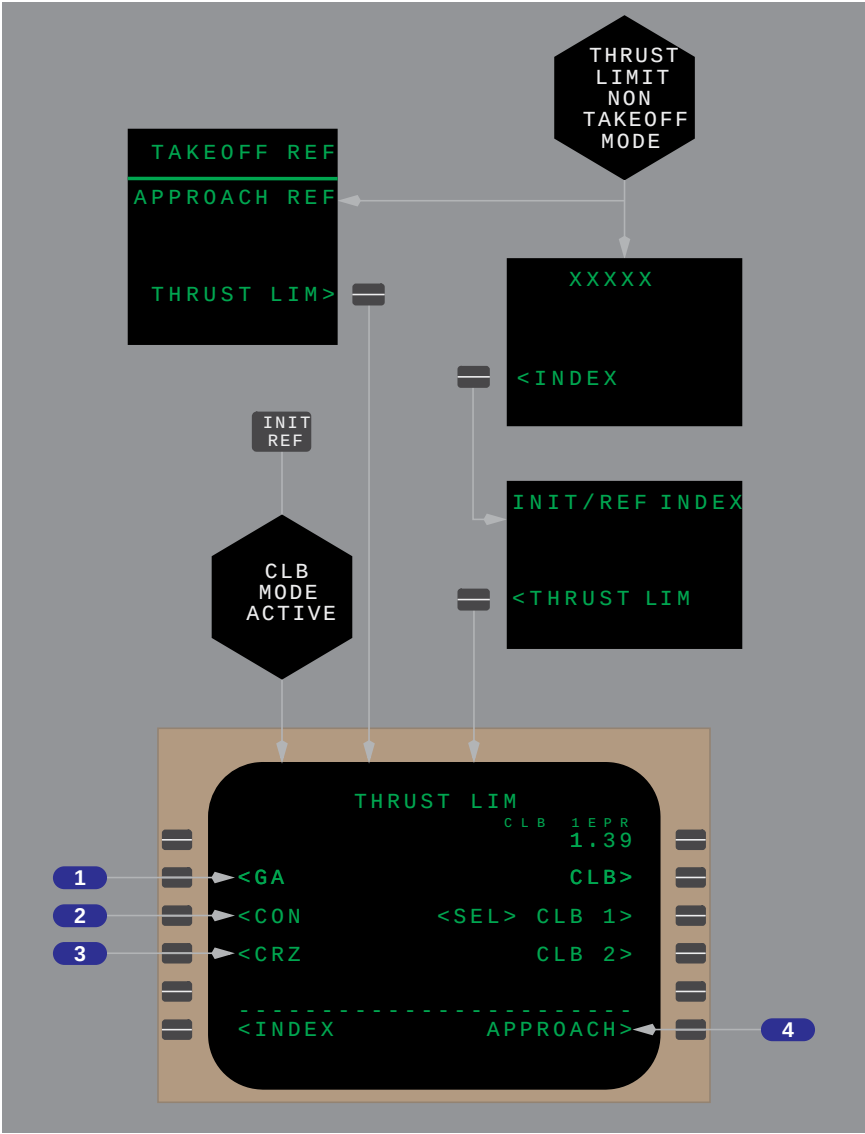
5 Latitude/Longitude

Displays the latitude/longitude for each duplicate name.

Thrust Limit Page

Thrust limits are selected on the thrust limit page. In flight, this display replaces the takeoff thrust limits with applicable thrust limits for climb. The selected limits display here and on the EICAS Display.

Fixed thrust derates can be selected for climb. Go-around, continuous, and cruise thrust limits are available also.



1 Go-Around (GA)

Push - selects go-around thrust limit.

2 Continuous (CON)

Push - selects maximum continuous thrust limit.

3 Cruise (CRZ)

Push - selects cruise thrust limit.

4 APPROACH

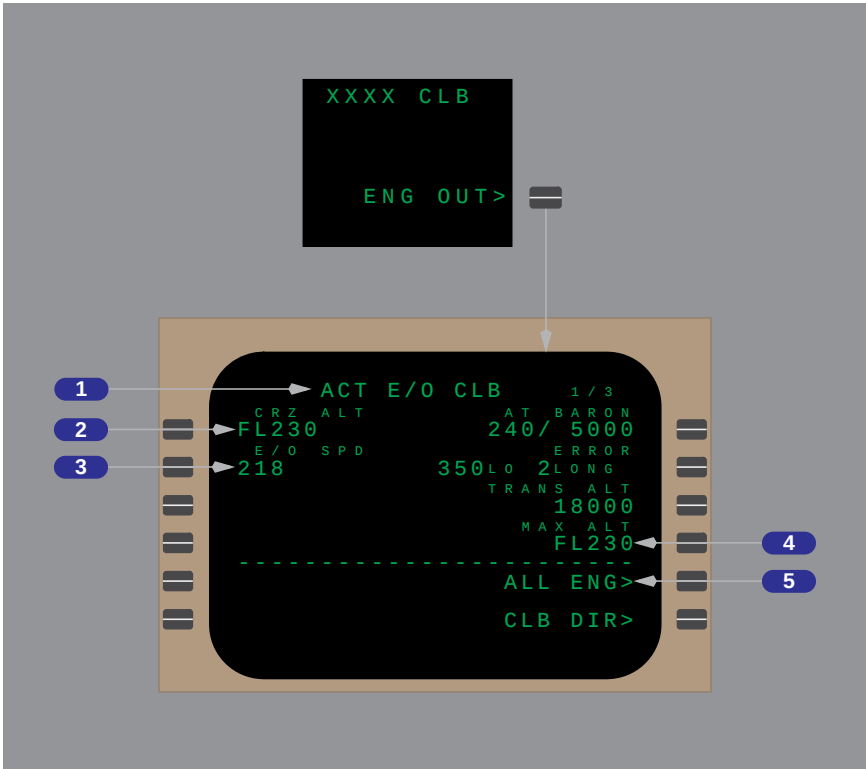
Push - displays APPROACH REF page.

Engine Out Climb

Engine out (E/O) VNAV climb guidance displays on the E/O CLB page. The E/O CLB page must be selected and executed by the flight crew. Engine out data is available with all engines operating. Engine out climb changes to engine out cruise at the top of climb.

E/O CLB Page

The modified page displays engine out performance data based on one or two engines out. Manual entries are allowed. After execution, VNAV gives E/O guidance in the climb and reference thrust limit changes to CON.



1 Page Title

Page title displays active (ACT) or modified (MOD) climb. Usually, the title contains ECON for economy climb.

Page titles include:

- ACT E/O CLB - engine out selected with minimum drag climb speed
- ACT E/O MCP CLB - MCP speed intervention selected

-
- ACT E/O XXXKT CLB - fixed CAS climb speed selected
 - ACT E/O M.XXX CLB - fixed Mach climb speed selected

2 Cruise Altitude (CRZ ALT)

Displays cruise altitude if less than MAX ALT.

Displays EO MAX ALT if less than cruise altitude.

Manual entry is allowed.

3 Engine Out Speed (E/O SPD)

Displays engine out climb speed.

Valid entry is XXX for CAS.

Valid entry is 0.XXX for Mach. Trailing zeros can be omitted.

A manual entry may cause MAX ALT to change.

4 Maximum Altitude (MAX ALT)

Displays lower of maximum altitude at engine out climb speed or cruise speed.

Entry not allowed.

5 ALL ENG

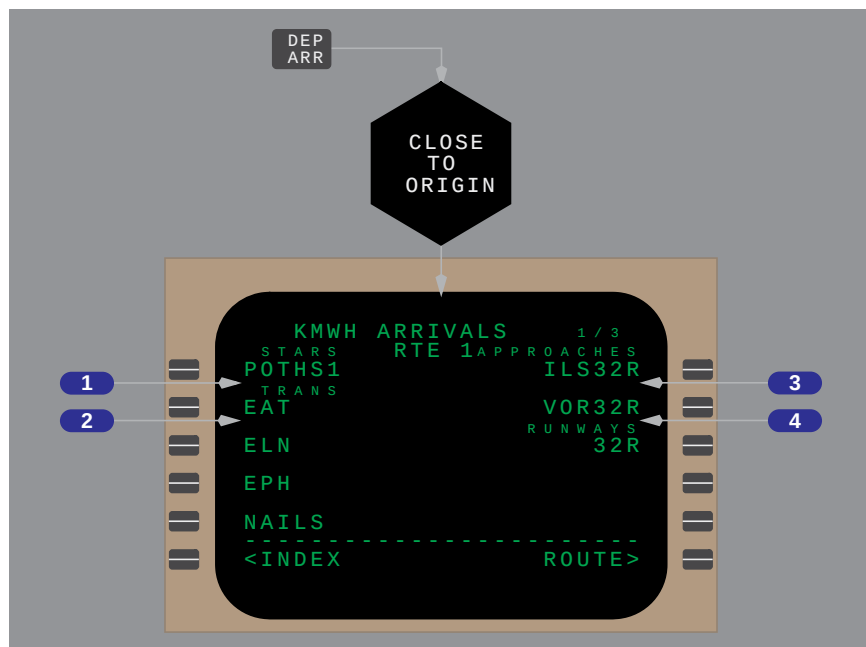
Push - modifies page to display all engine (ALL ENG) performance data.

Air Turnback

Arrivals Page

During a turn-back situation, the flight crew requires quick access to the arrivals data for the origin airport. The arrivals page allows access without changing the destination on the route page.

During climb, less than 400 miles from the origin, and while nearer to the origin than the destination, pushing the DEP ARR function key displays the ARRIVALS page for the origin airport.



1 Standard Terminal Arrival Routes/Profile Descents (STARS)

Displays STARS for origin airport.

2 Transitions (TRANS)

Displays transitions for the selected arrival procedure.

3 APPROACHES

Displays approaches for origin airport.

4 RUNWAYS

Displays runways for origin airport.

Intentionally
Blank

Introduction

Cruise phase starts at top of climb.

During cruise, the primary FMC pages are:

- RTE X LEGS
- CRZ
- PROGRESS

RTE LEGS pages are described in section 11.41. CRZ pages display VNAV related data. PROGRESS pages display flight progress data. During cruise, the specific page listed below is used to:

- POS REF page - verify the FMC position
 - RTE DATA page - display progress data for each waypoint on the RTE LEGS page
 - WINDS page - enter forecast wind and temperature
 - REF NAV DATA page - display data about waypoints, nav aids, airports, or runways, and can be used to inhibit nav aids
 - RTE X page - use to select a route offset
 - FIX INFO page - display data about waypoints. Page data can be transferred to other pages to create new waypoints and fixes
 - SELECT DESIRED WAYPOINT page - shows a list of duplicate waypoints from the navigation database. The flight crew selects the correct waypoint from the list
 - POS REPORT page -display data for a position report
- FANS/CPDLC Modified Aircraft**
- POS REPORT page -display data for a position report; described in Chapter 5.33

CLB page changes to CRZ at top of climb. CRZ CLB and CRZ DES pages change to CRZ at the new cruise altitude. CRZ page changes to DES at top of descent.

LNAV Modifications

This section describes typical techniques to modify the route. The modifications include:

- add and delete waypoints
- change waypoint's sequence
- remove discontinuities
- intercept a course.

RTE LEGS Page Modifications

When modifications are made to a RTE LEGS page, several prompt or identifying features help the flight crew make the modifications, such as:

- ERASE
- INTC CRS

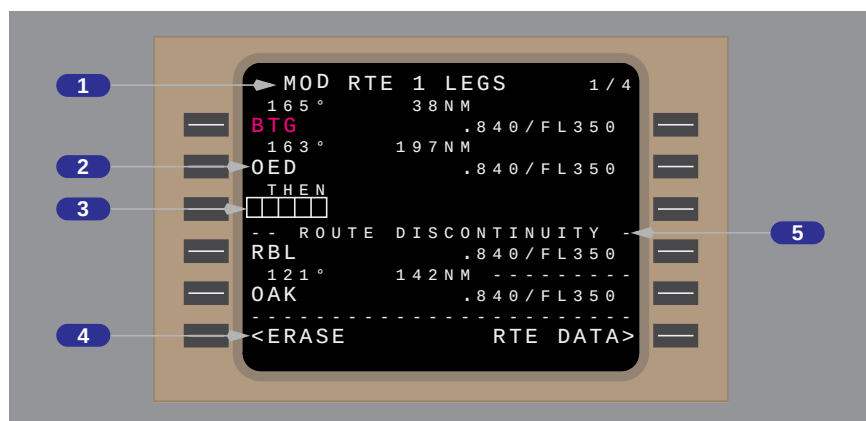
Add Waypoints

Waypoints can be added to the route at any point. Added waypoints are followed by route discontinuities.

First, enter the waypoint name in the scratchpad.

Second, locate the desired line in the flight plan and push the adjacent line select key. The scratchpad waypoint name is put into the selected line. The entered waypoint is connected to the waypoint above it via a direct route. A route discontinuity follows the waypoint.

To comply, OED is typed into the scratchpad. Push line select key 2L to put OED into line 2. The FMC assumes BTG direct OED. RBL and the rest of the flight plan follow the route discontinuity.



1 Page Title

MOD – replaces ACT when modification in progress.

ACT (white) – replaces MOD when ERASE selected or execute key pushed.

2 Modified Waypoint

OED waypoint entered into the route after BTG. Modification creates a route discontinuity because OED was not in active route. The FMC now requires routing beyond OED.

3 Discontinuity Waypoint

Discontinuity is removed when applicable waypoint is entered in boxes.

4 ERASE

Push – removes all modifications and shows active data.

Displays when the FMC contains modified data.

Removed when selected or modifications executed.

5 ROUTE DISCONTINUITY

Line title separates route segments when there is a discontinuity.

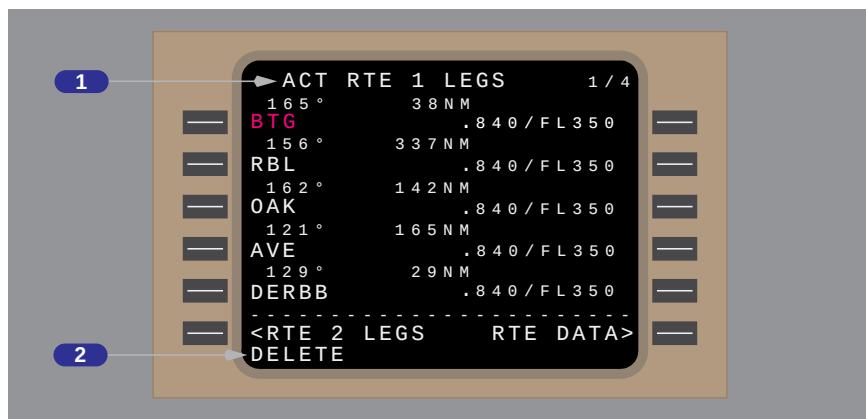
Note: Performance predictions to destination on the PROGRESS page are calculated assuming the route of flight is direct between waypoints on either side of a route discontinuity.

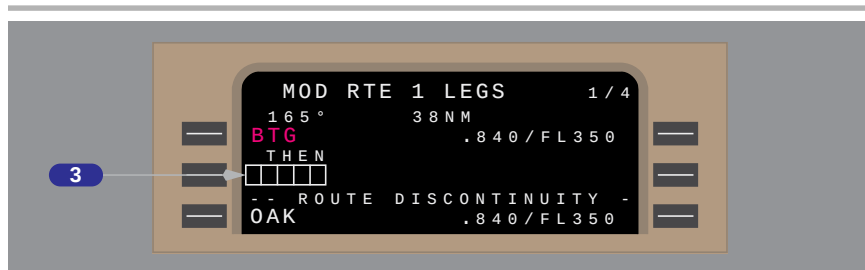
Delete Waypoints

Use the RTE LEGS page to remove waypoints from the route. The active waypoint can not be deleted. Two methods to remove a waypoint are:

- delete the waypoint with the DELETE function key
- change the waypoint's sequence.

The data in the route before and after the deleted waypoint does not change. A discontinuity is put in the route when the DELETE function key is used to remove a waypoint.





1 Active Route

The active route shows RBL followed by OAK and AVE.

2 DELETE Entry

Pushing the DEL function key arms the delete function and selects DELETE to the scratchpad.

3 Route Discontinuity

With DELETE in the scratchpad, pushing the line select key for RBL deletes the waypoint. Boxes replace RBL and a route discontinuity displays.

Change Waypoint Sequence

Waypoints moved from one position in the flight plan to another do not cause route discontinuities.

The waypoint may be typed in the scratchpad or copied from the flight plan. To copy a waypoint from the flight plan, find the applicable waypoint on one of the RTE LEGS pages. Push the line select key adjacent to the waypoint.

The example below shows the flight plan being modified to fly from BTG direct OAK. Push the line select key adjacent to OAK to put OAK in the scratchpad. Push the line select key adjacent to RBL. RBL is removed from the flight plan and the routing is direct from BTG to OAK to AVE. The modification does not cause a route discontinuity. Several waypoints can be removed from the flight plan at a time with this method.



1 Active Route

The active route shows RBL followed by OAK and AVE. The clearance is to fly from BTG direct OAK. The OAK waypoint is selected to the scratchpad.

2 Change OAK's Sequence

OAK is selected to the waypoint after BTG. RBL is removed with no discontinuity.

Remove Discontinuities

A discontinuity exists when two waypoints are not connected by a route segment. Connect a route segment after the discontinuity to the route segment before the discontinuity to remove the discontinuity.

Copy the subsequent waypoint from the route into the scratchpad and enter it into the discontinuity, just as when adding a waypoint.



1 Route Discontinuity

The active route has a discontinuity after BTG. The example shows how to fly direct from BTG to OAK. Copy OAK to the scratchpad. Any subsequent waypoint in the route can be selected to the scratchpad to remove the discontinuity.

2 Continuous Route

Select OAK to the boxes to remove the discontinuity.

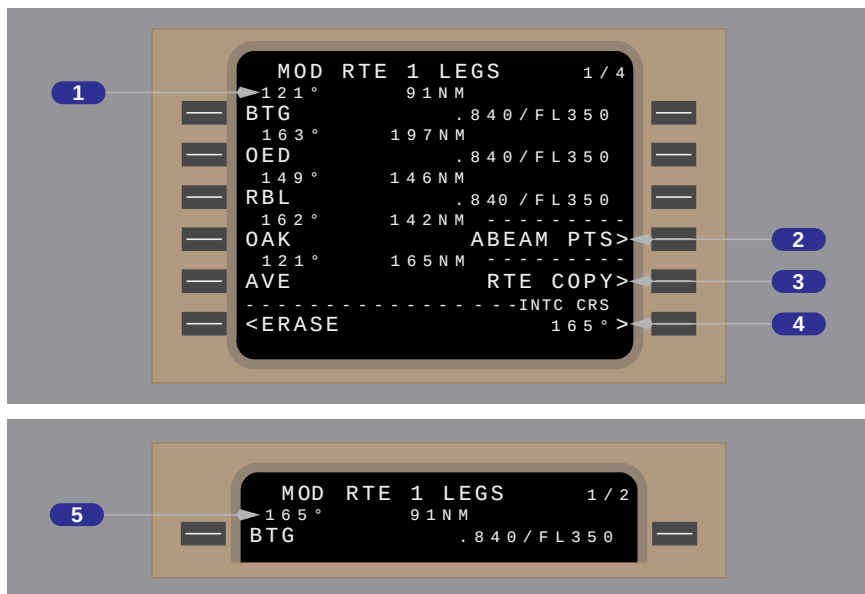
Entering a waypoint in the boxes which does not already exist on the route moves the discontinuity one waypoint further down the route.

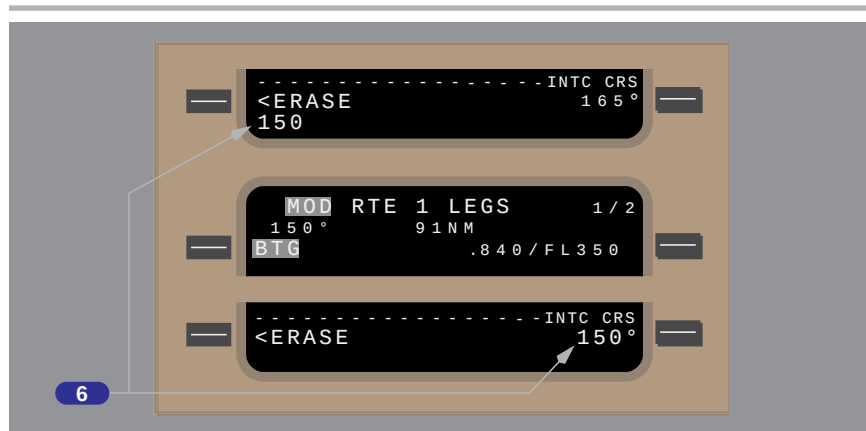
Direct To And Intercept Course To

If the airplane passes the last active route waypoint (or offset) or the last waypoint prior to a route discontinuity, LNAV maintains the current heading and a scratchpad message displays. If LNAV is not active, activation can be accomplished in the following three ways:

- When the airplane is within 2.5 miles of the active leg and on an intercept heading to the active leg, pushing the LNAV switch activates LNAV. The airplane turns to intercept the active leg. If the intercept angle is large, the airplane may overshoot the active leg.
- When more than 2.5 miles from the active leg, pushing the LNAV switch when the airplane is on an intercept heading to the active leg arms LNAV. Activation occurs as necessary to intercept the active leg with no overshoot. The intercept heading must intersect the active leg inbound before the active waypoint.
- Fly direct to a waypoint or intercept a course to a waypoint. Enter a waypoint in the RTE LEGS page active waypoint line to fly direct. Use the INTC CRS prompt in line 6R to create an intercept course to the waypoint. Pushing the LNAV switch arms or activates LNAV, depending on the distance to the active leg.

The example below depicts the airplane being off course to the right, followed by a modification to fly direct to BTG.





1 Leg Direction

Direct course from airplane present position to entered waypoint.

Execute to proceed direct to active waypoint.

2 Abeam Points (ABEAM PTS)

Push –

- creates place bearing distance waypoint on the Direct To leg abeam the bypassed waypoint if the bypassed waypoint was a database airport, navaid, NDB, or waypoint
- creates latitude/longitude waypoint on the Direct To leg abeam the bypassed waypoint if the bypassed waypoint was a latitude/longitude waypoint
- creates a new place bearing distance waypoint based on the original “place” on the Direct To leg abeam the bypassed waypoint if the bypassed waypoint was a place bearing distance waypoint
- creates a new latitude/longitude reporting point on the Direct To leg based on the entered latitude or longitude reporting point.
- line title displays ABEAM PTS and line data displays SELECTED
- altitude/speed constraints for bypassed waypoints are removed

ABEAM PTS prompt displays whenever the active waypoint name is modified, usually for direct-to routing.

3 Route Copy (RTE COPY)

Push –

- copies the active route (prior to modification) into the inactive route
- erases previous inactive route
- line title displays RTE COPY and line data displays COMPLETE
- subsequent route modifications remove RTE COPY prompt.

4 Intercept Course (INTC CRS) – Select

Displays whenever the active waypoint name is modified.

Displays boxes if entered waypoint not in the active route.

Displays current route course and prompt caret if entered waypoint in the active route.

When boxes displayed, valid entry is intercept course from 000° through 360°. May be changed until executed. Entered or selected value displays in large font.

Push –

- when current route course (165°) displayed, selects it as intercept course to active waypoint
- displays entry or current route course as course to active waypoint
- removes ABEAM PTS and RTE COPY prompts.

5 Intercept Course

After pushing INTC CRS and prior to execution, displays direct-to inbound course at the waypoint; changed by entry in intercept course to (INTC CRS) line or by selecting intercept course to. After execution, displays current required track to fly inbound course to the waypoint.

6 Intercept Course (INTC CRS)

To change intercept course:

- enter the inbound intercept course (150°) in the scratchpad
- select the INTC CRS line to change the leg direction; intercept course to BTG of 150° is entered in the INTC CRS line and above the active waypoint.

Intercept Course From

The steps to create an intercept course from a waypoint are like the steps for an intercept course to. The waypoint name in the scratchpad is suffixed with the outbound course.

An intercept course can be created outbound from a waypoint in the navigation data base or from present position. The waypoint does not have to be in the route. Entering a waypoint and course pair in the active waypoint line displays the INTC CRS FROM prompt. The FMC calculates a route leg with the waypoint as the origin of the entered course.

The example shows a 090° course from BTG, entered as BTG090. When this course intercept is line selected to the active waypoint line, the course (090°) displays in the leg direction and the waypoint displays as a conditional waypoint consisting of a course intercept (090°).



The following steps illustrate the process of creating an intercept course from a waypoint in the FMC:

- Step 1:** The FMC displays the active route (RTE 1) with legs. The active waypoint line shows "BTG" in red. The scratchpad displays "<RTE 2 LEGS RTE DATA> BTG090".
- Step 2:** The scratchpad displays "<RTE 2 LEGS RTE DATA> BTG090/100".
- Step 3:** The FMC displays the modified route (MOD RTE 1) with legs. The active waypoint line shows "BTG01". The scratchpad displays "THEN" followed by a grid of empty boxes.
- Step 4:** The FMC displays the modified route (MOD RTE 1) with legs. The active waypoint line shows "OAK". The scratchpad displays "OED" followed by a grid of empty boxes. The intercept course (INTC CRS) is displayed as "090°".

1 Waypoint and Outbound Course

Enter the waypoint name and outbound course in the scratchpad.

2 Present Position and Outbound Course

Create a waypoint along the intended route.

3 Active Waypoint Entry

After the active waypoint line is entered in the scratchpad, select LSK 1L. The point will be renamed (e.g., BTG01).

For example, BTG090 is entered into the active waypoint line. The FMC calculates a new route leg with BTG as the origin on a outbound course of 090°.

4 Intercept Course (INTC CRS)

Displays inbound course from entered waypoint.

Shows the active waypoint name is modified with a waypoint outbound entry.

Valid input is any course from 000° through 360°. May be changed until executed.

Select Desired Waypoint Page

The SELECT DESIRED WPT page displays after a waypoint entry when the FMC encounters more than one location for the same waypoint name. Selection of a waypoint returns the display to the previous page.



1 Identifier

Displays the identifier for the duplicate named waypoints. Select the correct waypoint by pushing the applicable left or right line select key.

2 Waypoint Lines

Display a sorted list of waypoints with identifier, navaid type, frequency, and coordinates;

- when page is accessed as a result of a flight plan modification, sort is based on proximity to the waypoint preceding the entered waypoint
- when page is accessed as a result of a DIR/INTC or REF NAV DATA entry, sort is based on proximity to current aircraft position.

Push - selects waypoint location for use; returns display to page previously in use.

Pushing any CDU function key exits page without selecting a waypoint.

3 Frequency

Displays frequency of the navaid.

Blank if the waypoint is not a navaid.

4 Type

Displays the type of navaid for each duplicate name.

Blank if the waypoint is not a navaid.

5 Latitude/Longitude

Displays the latitude/longitude for each duplicate name.

Airway Intercept

Just as in intercept to/from, LNAV can be used to intercept an airway. An airway intercept changes the active waypoint on the RTE and LEGS pages.

Enter the airway identifier under VIA on line 1 of the RTE page. Boxes display under TO. Enter the desired airway exit waypoint in the boxes. For this open-ended airway intercept, the FMC selects the waypoint preceding the closest abeam location as the starting waypoint of the airway. This waypoint displays on line 1. The entered airway and the desired exit point display on line 2. Executing the modification makes the leg to the FMC selected airway start waypoint the active leg segment.

If the clearance heading intercepts the active leg segment, LNAV can be armed and the intercept will occur. In most airway intercept situations, the commanded heading will not intercept the active leg.

If the clearance heading does not intercept the active leg segment, use the intercept–course–to procedure to make the course inbound to the waypoint (after the crossing location) the active leg segment.

Example

The active route is direct to EPH, then direct to MWH. ATC clears the airplane to:

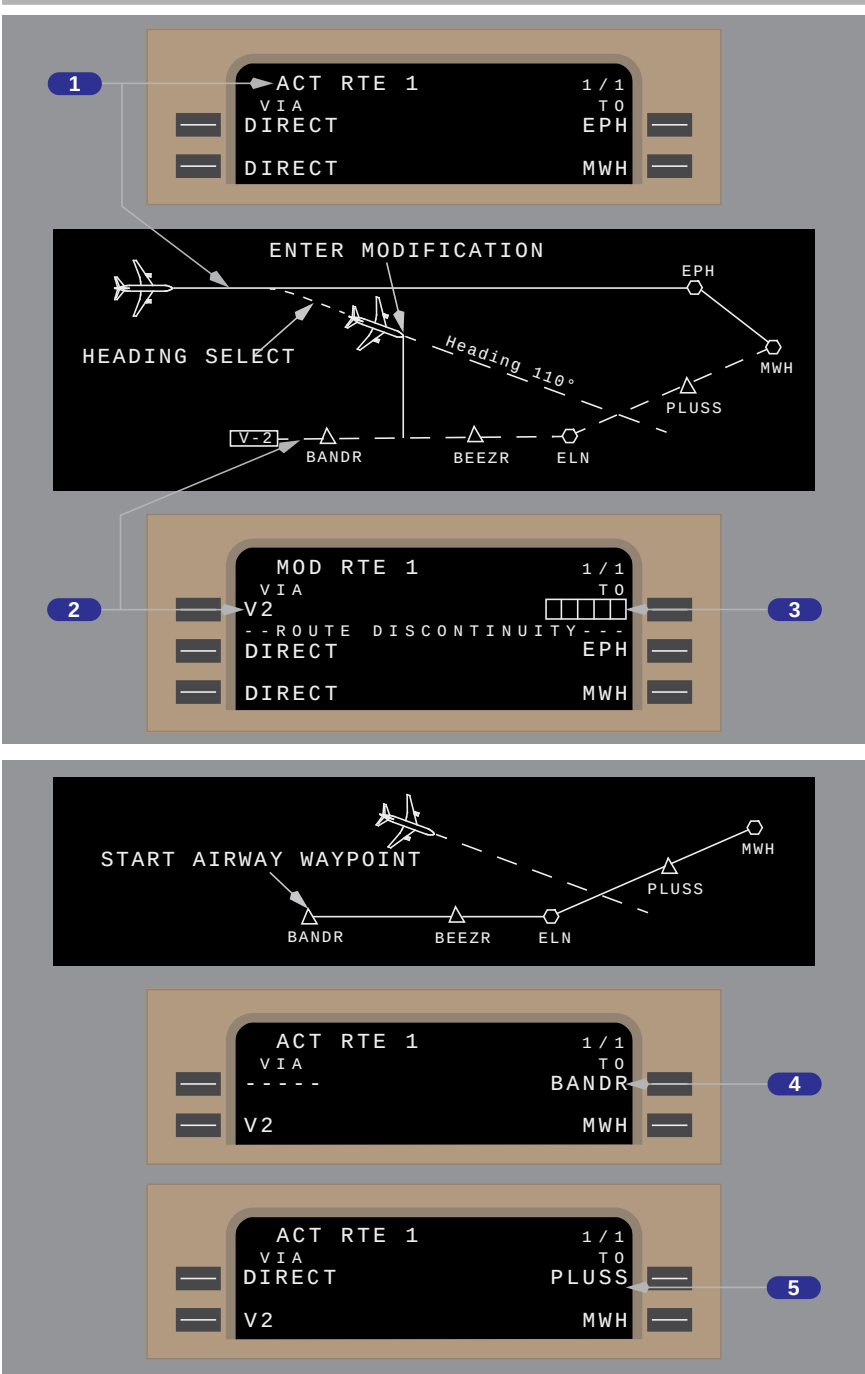
- turn right heading 110°
- intercept V2 to MWH.

Following the V2 modification to MWH and execution, the LEGS page displays this waypoint sequence:

- BANDR
- BEEZR
- ELN
- PLUSS
- MWH.

Modify the LEGS page using a course intercept to the waypoint after the crossing location. In this case, it would be PLUSS. PLUSS becomes the active waypoint on the V2 airway. The LEGS page now displays:

- PLUSS
- MWH



1 Active RTE 1 Page

The route page before the ATC clearance.

2 Input Airway

Enter the airway in the first VIA position on the RTE page. Boxes display in the TO position. A route discontinuity follows on the next line.

3 Airway Exit

Enter desired airway exit point in the boxes.

4 Start Airway Waypoint

After entering MWH in the boxes:

- the FMC selects BANDR as the airway start waypoint
- the airway line moves down one line
- dashes display in the VIA to the start airway waypoint.

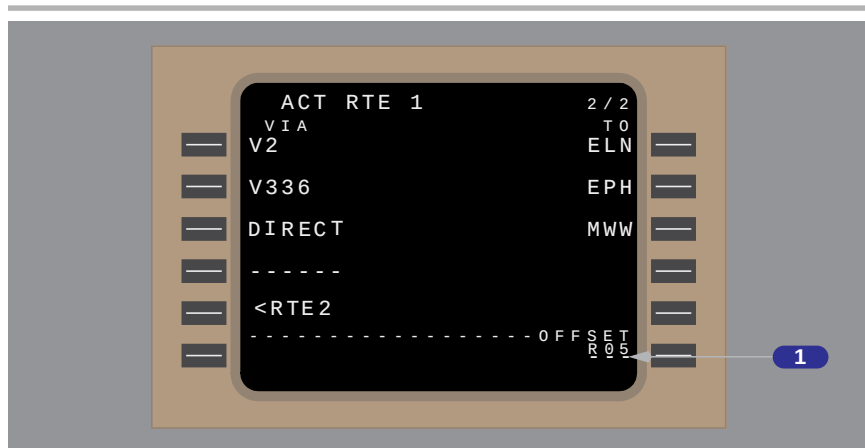
5 New Active Waypoint

Following modification and execution of the course intercept procedure to PLUSS, the LEGS page displays PLUSS as the active waypoint. LNAV can be armed and the airway intercept can be completed.

Route Offset

Select route offsets on the RTE page 1. The OFFSET prompt displays when the airplane is in flight and not on a SID, STAR, or transition. The offset displays as a white dashed line on the ND until the offset modification is executed or erased. After execution, the offset route displays as a dashed magenta line. The original route continues to display as a solid magenta line. When executing the offset modification with LNAV active, the airplane turns to capture the offset course.

When on the route offset, active route waypoints sequence normally. However, during transition to or from an offset route greater than 21 nm, the crosstrack limit is extended to 200 nm.



1 OFFSET

Enter the necessary offset. When executed, the CDU OFST light illuminates.

Valid entries are L (left) or R (right) XX (XX is any number from 0 to 99 nm).

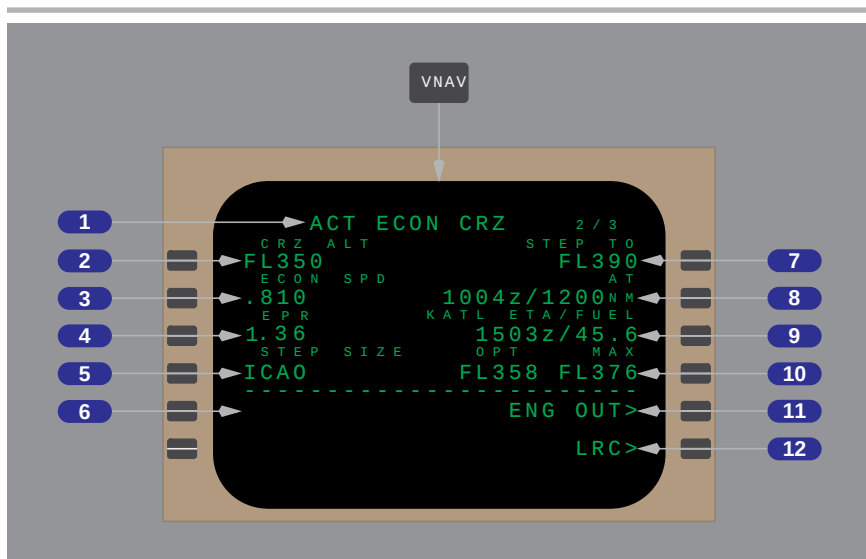
An offset propagates along the route to a Standard Terminal Arrival Route (STAR), approach or approach transition, discontinuity, end of route, track change greater than 135°, or holding pattern. An offset can be removed by deleting the offset, entering an offset value of zero, or proceeding direct to a waypoint. Offsets can be removed by deleting the offset value, entering zero under the OFFSET prompt at 6R, or proceeding direct to a waypoint.

Cruise Page

All Engine Cruise

The cruise page is used to monitor and change cruise altitude and speed. Speed changes can be manually entered or selected using speed intervention while in VNAV modes. Cruise climbs, cruise descents, and step climbs can be accomplished from the cruise page.

When using VNAV in economy mode, page data is based on operating at ECON SPD. Economy cruise speed is based on cost index. When the flight crew enters a selected speed, page data changes. When the FMC is in engine out mode, the data reflects airplane capabilities with one engines inoperative. The long range cruise (LRC) mode calculates speeds to maximize airplane range.



1 Page Title

Page title displays active (ACT) or modified (MOD) cruise. Usually, the title contains ECON for economy cruise. Fixed speed, engine out, and long range cruise modify the title.

Page titles include:

- ACT ECON CRZ - speed based on cost index
- ACT LIM SPD CRZ - speed based on an airplane configuration limiting speed
- ACT MCP SPD CRZ - MCP speed intervention selected
- ACT XXXKT CRZ - fixed CAS cruise speed
- ACT M.XXX CRZ - fixed Mach cruise speed
- ACT ECON CRZ CLB or CRZ DES - cruise climb or descent with ECON speed
- ECON LRC CRZ - long range cruise selected

Fixed cruise speeds are for:

- a flight crew selected speed (SEL SPD)
- a speed restriction associated with an altitude
- waypoint speed constraints

2 Cruise Altitude (CRZ ALT)

Displays cruise altitude entered on the PERF INIT page.

Valid entries are: XXX, XXXX, XXXXX, or FLXXX. Altitude displays in feet or flight level depending on the transition altitude.

A new entry changes the page title to CRZ CLB or CRZ DES when climb or descent initiated.

Changing the MCP altitude and pushing the Altitude selector enters the MCP altitude as the active cruise altitude, without creating a modification.

3 Economy Speed (ECON SPD), Selected Speed (SEL SPD)

Displays the command speed or Mach.

Valid entries are CAS or Mach.

SEL SPD - displays when flight crew enters speed.

LRC - displays when LRC selected.

4 EPR

Displays EPR to maintain level flight at command airspeed.

5 STEP SIZE

Displays climb altitude increment used by FMC to calculate optimum step climb.

Defaults to ICAO.

Valid entries are 0 to 9000 feet in increments of 1000 feet.

6 Economy (ECON)

Push - selects economy cruise speed.

Displays when speed or Mach entered manually; or, when LRC selected.

7 STEP TO Altitude

Line title displays STEP TO when all of the following are true:

- an active route exists and there is no pending activation or flight plan modification
- the airplane is more than 200 nm from the T/D
- the airplane is more than 500 nm from the destination

Displays calculated step climb altitude based on STEP SIZE. May be overwritten with manual entry above CRZ ALT.

Valid entry is FLXXX or XXX (flight level), or XXXXX (feet).

Displays STEP TO altitudes entered on LEGS page. These altitudes may be greater or less than CRZ ALT and cannot be overwritten on the CRZ page.

Blank when no active flight plan or when within 200 miles of T/D.

Note: Calculated STEP TO altitude is always higher than OPT altitude.

When using ICAO STEP SIZE, the STEP TO altitude is the next higher altitude above OPT altitude corresponding to the direction of flight determined by the CRZ ALT entered before takeoff. For example: with an ICAO STEP SIZE, a CRZ ALT of FL280 entered before takeoff, and an OPT altitude of FL337; the STEP TO altitude will be FL350. In-flight changes to CRZ ALT will not affect the calculation of STEP TO altitudes when using ICAO step size. However, if an alternate route (for example, Route 2) is activated in flight, the hemispheric altitude will be calculated based on the current CRZ ALT.

When using an altitude increment STEP SIZE, the STEP TO altitude is the next higher altitude above OPT altitude calculated by adding the STEP SIZE increment to the current CRZ ALT.

8 AT

Displays ETA and distance to go to the optimum step point where a climb to the STEP TO altitude minimizes either trip cost (ECON CRZ) or fuel (other CRZ speeds).

Displays NOW passing the optimum step climb point.

Line title changes to AVAIL AT when STEP TO altitude entered at a waypoint on the LEGS page and MAX altitude at the waypoint is less than the STEP TO altitude. AVAIL AT indicates where MAX altitude will be equal to the STEP TO altitude.

Line title changes to TO T/D within 200 miles of T/D. ETA and distance are to T/D.

9 Destination ETA/FUEL

Estimated time of arrival and calculated fuel remaining at the destination assuming step climbs are made at optimum points to the STEP TO altitude. Calculations are based on optimum and planned step climbs and cruise altitudes.

10 Optimum Altitude and Maximum Altitude (OPT, MAX)

OPT -

- displays altitude which minimizes trip cost when ECON speed selected
- displays altitude which minimizes trip fuel when LRC or SEL speed selected

MAX - displays the maximum cruise altitude based on:

- current gross weight
- number of engines operating
- selected speed option
- disregarding any altitude or speed constraints
- residual rate of climb set by airline (range: 0 to 500 feet per minute; default is 100)

Post RTA Modification

Note: OPT and MAX are blank with RTA activation (in use).

11 Engine Out (ENG OUT)

Push -

- displays MOD XXX CRZ page title; XXX is the active all engine CRZ speed mode before ENG OUT is selected
- changes command speed line title to LRC SPD
- below engine-out maximum altitude; upon execution, thrust reference limit changes to CON and page title becomes ACT E/O LRC CRZ
- above engine-out maximum altitude; sets CRZ ALT to engine-out long range cruise maximum altitude; and upon execution, thrust reference limit changes to con and page title becomes ACT E/O LRC D/D

12 Long Range Cruise (LRC)

Push - displays LRC CRZ page; also displays LRC CRZ when EO or SEL SPD is the active mode.

Engine Out Cruise

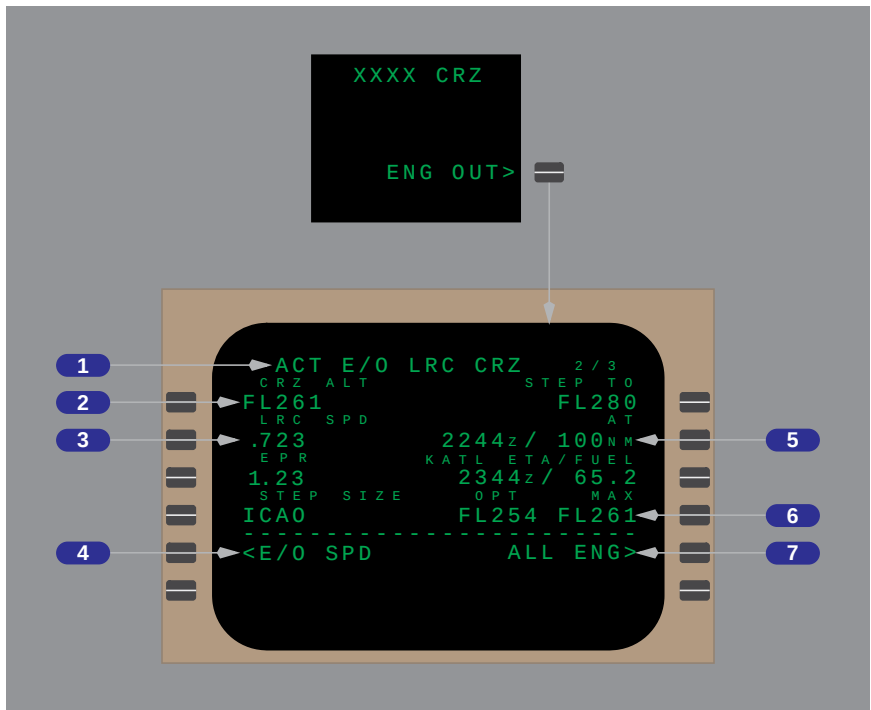
Engine out (E/O) VNAV cruise guidance displays on E/O CRZ page. E/O CRZ page must be selected and executed by the flight crew. Engine out data is also available with all engines operating.

EO Cruise Page

Following selection of the ENG OUT prompt on the ECON CRZ page, the modified page displays engine out performance information based on one engine out. Manual entries are allowed. When above the maximum engine out cruise altitude, VNAV calculates engine out guidance for drift down (D/D). This graphic is shown under VNAV Cruise (Engine Out above EO Max Alt), 11.31. The E/O LRC (long range cruise) D/D page changes to the E/O LRC CRZ page when reaching the engine out cruise altitude (shown below).

As the airplane gross weight decreases, maximum altitude increases. A step climb may be possible under these conditions.

The following example uses a cruise altitude above the maximum engine out altitude.



1 Page Title

The page title displays active (ACT) and modified (MOD) cruise.

Page titles include:

- ACT E/O CRZ - minimum drag speed
- E/O LIM SPD - speed based on airplane configuration limiting speed
- ACT E/O MCP SPD - MCP speed intervention selected
- ACT E/O XXXKT CRZ - fixed CAS descent speed
- ACT E/O M.XXX CRZ - fixed Mach descent speed
- ACT E/O LRC D/D - airplane is above MAX altitude
- ACT E/O LRC CRZ - airplane is level at CRZ ALT; less than MAX
- ACT E/O CRZ CLB/DES - cruise climbs or descends when the CRZ ALT is below MAX altitude

2 Cruise Altitude (CRZ ALT)

Displays altitude from MAX ALT line when current CRZ ALT above MAX ALT.

Displays CRZ ALT from all engine cruise page if ENG OUT executed prior to engine shutdown.

Valid entries are the same as all engine cruise page.

3 Long Range Cruise Speed (LRC SPD)

Displays computed engine out LRC speed.

Valid entries are the same as all engine cruise page.

SEL SPD - displays when flight crew enters speed.

E/O SPD - displays when E/O SPD prompt selected.

Manual entries may change MAX altitude.

4 Engine Out (EO SPD)

Push - enables execution of engine out minimum drag speed profile.

Displays when LRC or SEL SPD is the active speed mode.

5 AT

Same as all engine display.

Displays time and distance to reach cruise altitude during driftdown.

6 Optimum Altitude and Maximum Altitude (OPT, MAX)

OPT - displays optimum altitude at speed displayed on speed line.

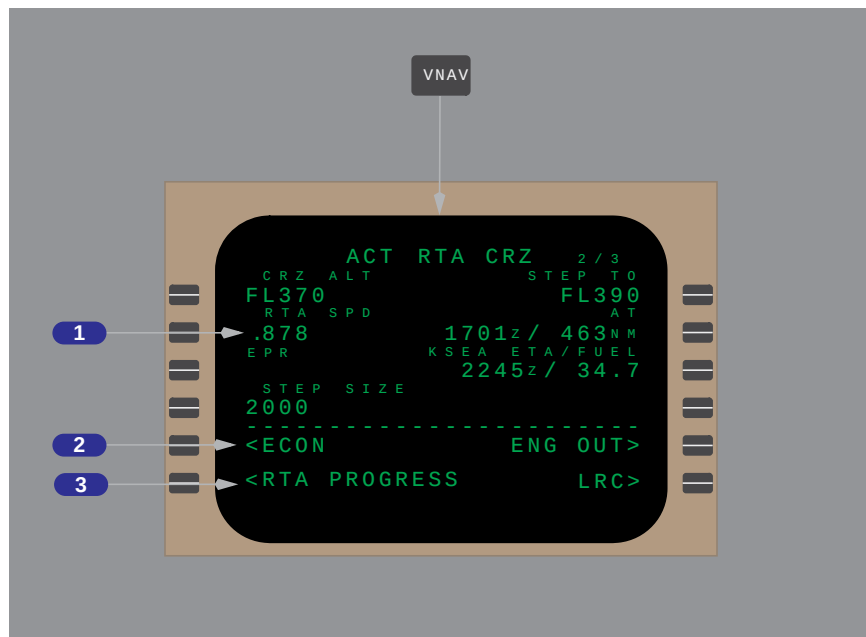
MAX - displays the maximum cruise altitude based on the same parameters as MAX for all engines.

7 ALL Engine (ENG)

Push - displays and enables execution of MOD XXX CRZ page with performance based on all engines operating.

Required Time of Arrival (RTA) Cruise

The required time of arrival cruise page is available after entry of Fix and Time on RTA PROG page. This page provides cruise speed required to accomplish RTA.



1 Required Time of Arrival Speed (RTA SPD)

Displays FMC computed cruise speed to accomplish RTA.

2 Economy Speed (ECON)

Displays when LRC, SPD SEL, or RTA SPD displayed in 2L.

Push -

- selects ECON CRZ page
- execution activates ECON CRZ and terminates RTA function

3 RTA PROGRESS, ERASE

RTA PROGRESS (displays when no modification pending).

Push - displays RTA PROGRESS page.

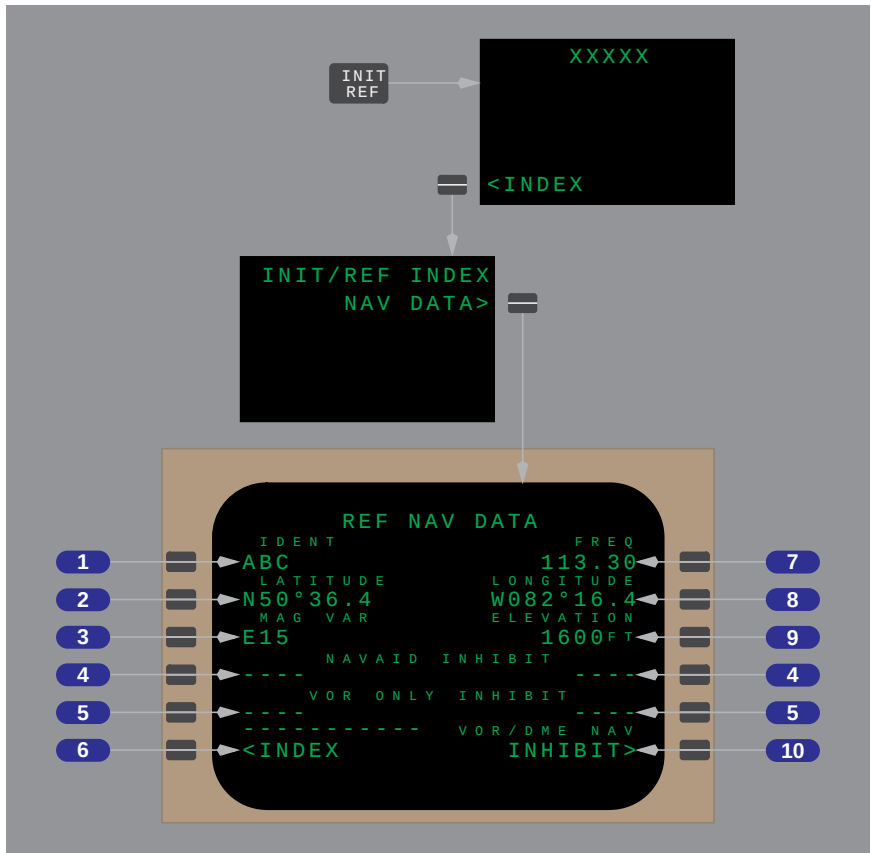
ERASE (displays when modification pending).

Push - erases pending modification.

Navigation Data

Reference Navigation Data Page

Reference navigation data page displays data about waypoints, nav aids, airports, and runways. This page is used to inhibit FMC position updates from radio nav aids. The nav aids are available for manual, route, and procedure tuning.



1 Identification (IDENT)

Valid entries are any waypoint, nav aid, airport, or runway from the navigation database.

Entry changes to dashes when page is exited and then reselected.

2 LATITUDE

Displays latitude of entered identifier.

3 Magnetic Variation (MAG VAR), LENGTH

MAG VAR - displays magnetic variation when entered identifier is a navaid.

LENGTH - displays runway length when entered identifier is a runway.

4 NAVAID INHIBIT

Valid entries are: VOR, VOR/DME, VORTAC, or DME identifiers from the navigation data base.

Inhibits use of entered nav aids for updating by both FMCs.

Entries blank at flight completion.

Deleting or overwriting removes a previous inhibit.

5 VOR ONLY INHIBIT

Valid entries are VOR identifiers from the navigation database.

Inhibits use of only the VOR portion of entered navaid for updating by both FMCs.

Entries blank at flight completion.

Deleting or overwriting removes a previous inhibit.

6 INDEX

Push - displays INIT/REF INDEX page.

7 Frequency (FREQ)

Displays frequency of entered identifier when it is a navaid.

8 LONGITUDE

Displays longitude of entered identifier.

9 ELEVATION

Displays elevation of entered identifier when it is a navaid, airport, or runway.

10 VOR/DME NAV INHIBIT, ENABLE

INHIBIT -

Push -

- inhibits both FMCs from using VOR/DME radio position updating
- displays ENABLE
- does not affect DME/DME radio position updating
- overwrites VOR ONLY INHIBIT entries and displays ALL
- entries clear at flight completion and INHIBIT displays

ENABLE -

Push -

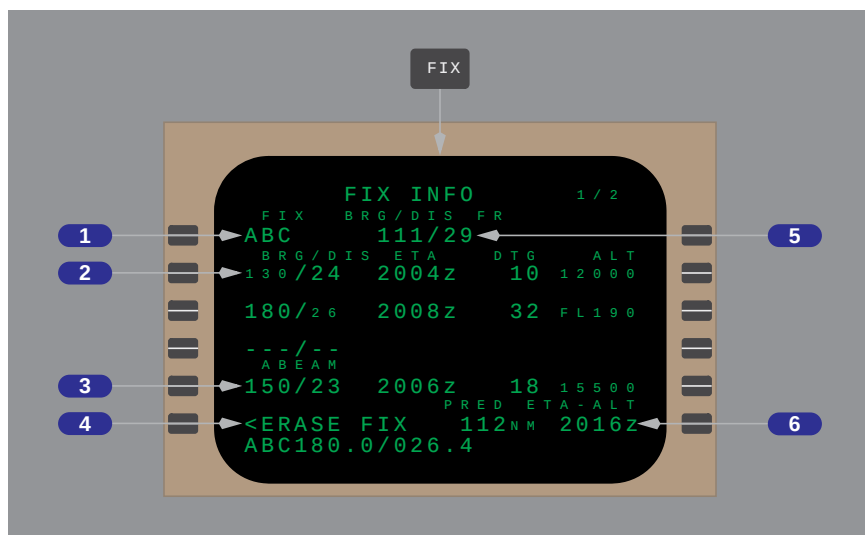
- allows VOR/DME radio position updating
- displays INHIBIT

Fix Information Page

Two identical fix information pages are used to create waypoint fixes and waypoints for the ND. Some of the created waypoints can be copied into the route.

Magnetic/True Bearing

Magnetic or true fix bearings depend on airplane location. Refer to FMC Polar Operations, Flight Management Navigation, section 31.



1 FIX

Valid entries are airports, navaids, and waypoints from the navigation database. Selected fix displays on the ND.

2 Bearing/Distance (BRG/DIS), ETA, DTG, ALT

Distance Entry:

- valid entry is /YYY
- leading zeros can be omitted for distance entries

Distances from the fix display on the ND as a circle around the fix.

When the distance intersects the active route, the ETA, DTG, and altitude at the closest intersection.

Bearing Entry:

- valid entry is a bearing from the fix, XXX
- slash (/) not required

Bearings from the fix display on the ND as radial lines from the fix.

When the bearing intersects the active route, the ETA, DTG, and altitude at the closest intersection display.

ETA - displays the estimated time of arrival to the intersection point.

DTG - displays the distance to go to the intersection point.

ALT - displays the predicted altitude at the intersection point.

Bearing/distance entries do not display ETA, DTG, or predicted altitude.

Line selection copies the fix place/bearing/distance into the scratchpad. Distance displays to the nearest tenth of a nautical mile. This fix can be placed in the route on a LEGS or RTE page as a waypoint.

3 ABEAM

Displays ABEAM prompt.

Push - displays bearing and distance from the fix perpendicular to the nearest segment of the flight plan path, and ETA, DTG, and altitude at the intersection point.

Second push - copies the fix place/bearing/distance definition into the scratchpad. This fix can be placed in the route on a LEGS or RTE page as a waypoint.

4 ERASE FIX

Push - removes all fix data from the page and the ND.

5 Bearing/Distance From (BRG/DIS FR)

Displays the bearing and distance of the airplane from the fix.

6 Predicted Distance to ETA or Altitude (PRED ETA-ALT)

Valid entry is altitude, flight level, or time. Time entry must be followed by “Z”.

Entering an altitude or flight level displays the predicted along track distance and altitude or flight level on this line. The predicted airplane position displays on the ND route line as a green circle with the entered altitude/flight level.

Entering a time displays the predicted along track distance and the time on this line. The predicted airplane position displays on the ND route line as a green circle with the entered ETA.

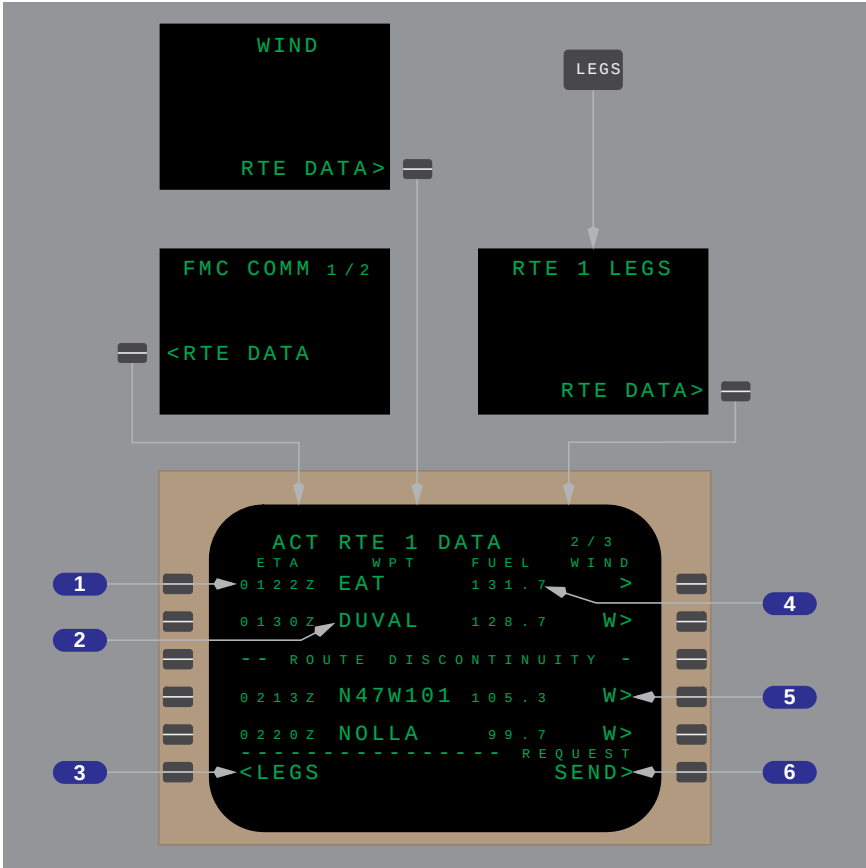
Route and Waypoint Data

Route Data Page

The route data page displays data for each waypoint on ACT RTE X LEGS page. This page also allows access to the WIND page. This page is available only for the active route.

The ETA and calculated fuel remaining display for each waypoint. Manual entry is not possible.

This page allows a downlink request for enroute wind information and allows review of uplinked enroute wind information.



1 ETA

Displays ETA for waypoint.

2 Waypoint (WPT)

Displays identifier for waypoint.

3 LEGS, ERASE

FANS/CPDLC Equipped Aircraft

LEGS -

Push - displays RTE LEGS page.

Displays ERASE prompt when an uplink containing enroute wind data is loaded.

ERASE -

Push -

- rejects uplinked enroute wind data
- displays LEGS prompt

4 FUEL

Displays the FMC calculated fuel remaining at the waypoint.

Note: ETA and estimated fuel calculations assume a direct flight across route discontinuities.

5 WIND (W>/>)

W> - indicates waypoint winds have been entered.

> - winds not entered.

Push - displays WIND page for the selected waypoint.

6 REQUEST SEND, WIND DATA LOAD

Blank when airplane is active on descent or approach.

Displays SEND prompt when datalink ready and airplane is not active on descent or approach.

Displays LOAD prompt when uplink containing enroute wind data received and error checks passed.

SEND -

Push -

- transmits a datalink request for wind and descent forecast data
- displays LOAD prompt and scratchpad message WIND DATA UPLINK READY when an uplink containing enroute wind data received and error checks passed
- displays scratchpad message DES FORECST UPLINK READY and displays LOAD and PURGE prompts on the DESCENT FORECAST page when an uplink containing descent forecast uplink data received and error checks passed

LOAD -

Push -

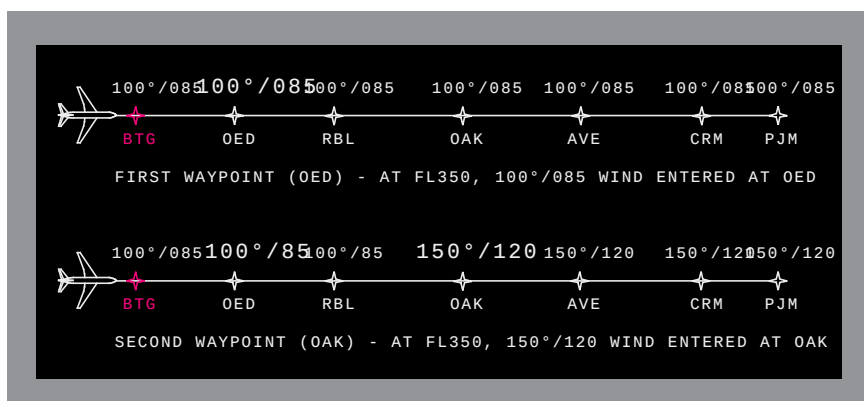
- applies enroute wind data to route and results in a modification
- displays ERASE and SEND prompts

Wind Data

The FMC uses temperature, altitude, and wind direction/speed to improve performance prediction accuracy.

The FMC applies the first entered wind data to all waypoints in the flight plan. Wind data entered at another waypoint (at the same altitude) changes wind data downtrack from the second entered waypoint either to the end of the track or to the next entered wind. The wind data before the second entered waypoint does not change. Therefore, wind data for waypoints closest to the airplane should be entered first, then wind data for downtrack waypoints can be entered.

For example: at FL 350, 100°/085 is entered at waypoint OED. All waypoints in the route have the OED wind data. Then, additional wind data entered at OAK changes the wind data at OAK through the end of the route.



Entered wind data are mixed with sensed wind data for performance predictions. The FMC uses entered winds for predictions far ahead of the airplane and sensed winds close to the airplane. At 200 nm in front of the airplane, the FMC uses 50% predicted winds and 50% sensed winds. Sensed winds display on the progress page 2.

Inaccurate forecast wind and temperature information degrades the accuracy of the recommended altitude displayed on the cruise page.

The FMC adjusts ECON climb speed and top of climb using entered and/or sensed wind data. FMC calculated ECON climb speed may fluctuate if top of climb is near a waypoint with approximately a 45 degree or larger track change and if a significant wind velocity has been entered or is predicted for that waypoint. This fluctuation does not occur when using a manually entered climb speed or speed intervention.

Wind Page

The wind page is used to enter forecast winds and temperatures at waypoints for up to four altitudes to enhance VNAV performance.

Wind speed and direction are entered for the specific altitudes.

- Uplinked or manually entered.

OAT can be entered for any altitude. The FMC calculates the temperature for the entered altitudes using the standard lapse rate.



1 Page Title

Displays XXXXX, where XXXXX is the waypoint for which winds display.

2 Altitude (ALT)

Valid entry is altitude or flight level on line 1L.

After entry, data are sorted by altitude and display in lines 1 through 4. Dashes display on right side of line for wind direction and speed entry.

When all four lines have data, one must be deleted before new altitude can be entered.

3 OAT

Data entry not possible.

OAT displays the outside air temperature. Entries made using the ALT/OAT line display in large font. Calculated OAT based on standard lapse rate display in small font.

4 Direction and Speed (DIR/SPD)

Displays dashes after altitude/flight level entered in the ALT line.

Valid entries are wind direction and speed.

Displays wind direction and speed for related altitude.

Manual entries display in large font.

Values propagate in both directions for the first wind entered and downtrack for other entered winds. Propagated values display in small font.

5 Altitude/Outside Air Temperature (ALT/OAT)

Valid entries are altitude or flight level/and OAT. OAT is a one-to-three digit entry, including the sign; plus or minus signs are optional. Valid range is -99 to 60.

OATs display in OAT column.

The altitude for OAT does not have to be one of the wind altitudes. The FMC uses standard lapse rate to calculate and display the temperature at the other altitudes.

6 Route Data (RTE DATA)

Push - displays RTE DATA page.

Progress Pages

XXX Progress Page 1/3

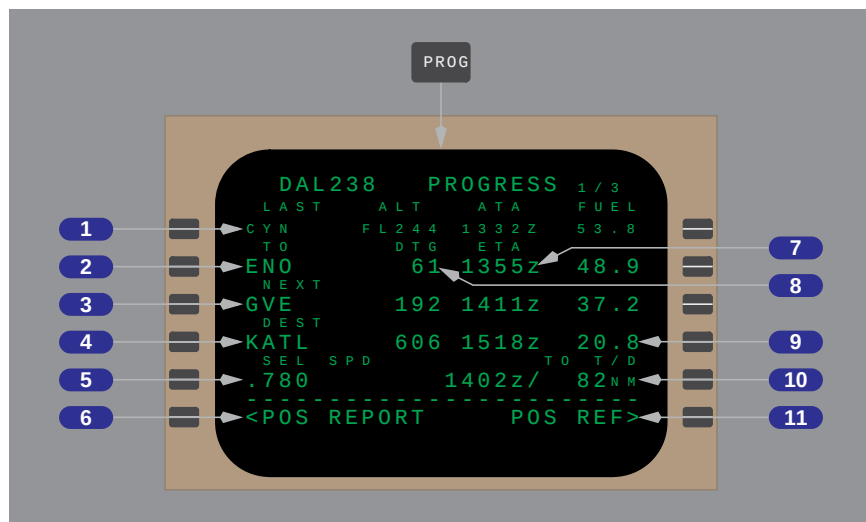
Progress page displays general flight progress data. The FMC Communication section of Chapter 02, FANS describes CDU position reports.

The page title displays the company flight number entered on the RTE page.

- FMC speed

Page one of the progress pages displays general data about:

- waypoints (last, active, and next)
- T/C, T/D, etc.
- destination data



1 LAST

Displays last waypoint identifier and altitude (ALT), actual time of arrival (ATA), and lesser of calculated or totalizer fuel remaining at LAST waypoint.

2 TO

Displays active waypoint identifier.

3 NEXT

Displays waypoint identifier of waypoint after the active waypoint.

4 Destination (DEST)

Displays destination identifier.

Valid entry is any airport or waypoint in navigation database or waypoint in the flight plan. The line titles are:

- DEST - performance predictions to destination. Default display
- DIR TO ALTERNATE - performance predictions to alternate. Line data based on flying direct to the alternate
- EN ROUTE WPT - when entered waypoint is in flight plan. Line data based on flying the flight plan route to the waypoint
- MOD - a modification has been made on another page. Performance predictions include modification

Remove entries with DELETE key or change all CDUs to a different page.

5 Selected Speed (SEL SPD)

Displays active command speed and mode.

The active speed mode is the same as displayed on the active VNAV page, unless changed by the MCP or a limit. The speed modes are:

- ECON SPD - economy speed
- LRC SPD - long range cruise speed
- SEL SPD - selected speed manually entered on the CDU
- EO SPD - engine out speed
- LIM SPD - speed is limited by VMO, MMO, flap limit, or alpha limit
- MCP SPD - MCP speed entered on the MCP IAS/MACH indicator
- V30REF +100 - engine out during takeoff, engine out not selected, and speed not restricted by limit speed (e.g., flap placard)
- RTA SPD - RTA SPD when RTA mode active

6 Position Report (POS REPORT)

Push - displays the POS REPORT page.

7 ETA

Displays estimated time of arrival at waypoint or destination.

8 Distance To Go (DTG)

Displays distance to go to waypoint or destination.

9 FUEL

Displays estimated fuel remaining at waypoint or destination.

10 TO T/D

Data line displays ETA and DTG to line title point.

Line titles are:

- T/C - top of climb data
- STEP CLB - step climb data
- T/D - top of descent data
- E/D - end of descent data
- LEVEL AT - time and distance to level off when drift down active

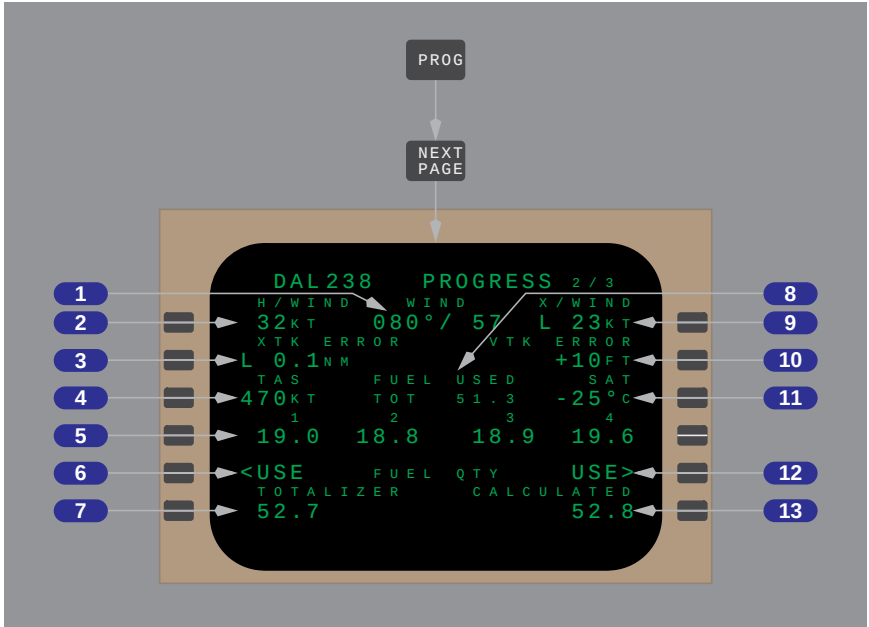
11 Position Reference (POS REF)

Push - displays position reference page 2/3.

Progress Page 2/3

Progress page two contains:

- wind data
- fuel data
- static air temperature
- true airspeed
- track error data



1 WIND

Displays current wind direction and speed referenced to true north.

2 Headwind (H/WIND), Tailwind (T/WIND)

Displays headwind (H/WIND) or tailwind (T/WIND) component.

Wind component data is relative to airplane heading.

3 Crosstrack Error (XTK ERROR)

Displays crosstrack (XTK) error in nautical miles left or right of the active route.

4 TAS

Displays airplane true airspeed.

5 FUEL USED 1, 2, 3, 4

Displays fuel used by engines 1, 2, 3, 4 sensed by fuel flow meters.

6 USE TOTALIZER

Displays USE prompt and scratchpad message FUEL DISAGREE - PROG 2/3 if a difference of 9,000 lbs or more exists between TOTALIZER and CALCULATED fuel quantity for 5 minutes.

Push -

- FMC uses fuel quantity processor computations to determine fuel quantity
- blanks CALCULATED and FUEL USED displays
- PERF INIT page fuel quantity retitled SENSED

7 FUEL Quantity (QTY) TOTALIZER

Displays fuel quantity calculated by fuel quantity processor.

Blank if fuel value manually entered on PERF INIT page.

8 FUEL USED Total (TOT)

Displays total fuel used as calculated from fuel flow.

9 Crosswind (X/WIND)

Displays left (L) or right (R) crosswind component relative to airplane heading.

10 Vertical Track Error (VTK ERROR)

Displays vertical path (VTK) error above (+) or below (-) vertical path.

Blank when vertical-track error is invalid or both routes are inactive.

11 Static Air Temperature (SAT)

Displays outside static air temperature.

12 USE CALCULATED

Displays USE prompt and scratchpad message FUEL DISAGREE - PROG 2 if a difference of 9,000 lbs or more exists between TOTALIZER and CALCULATED fuel quantity.

Push -

- FMC uses calculated fuel quantity values
- blanks TOTALIZER display

13 FUEL Quantity (QTY) CALCULATED

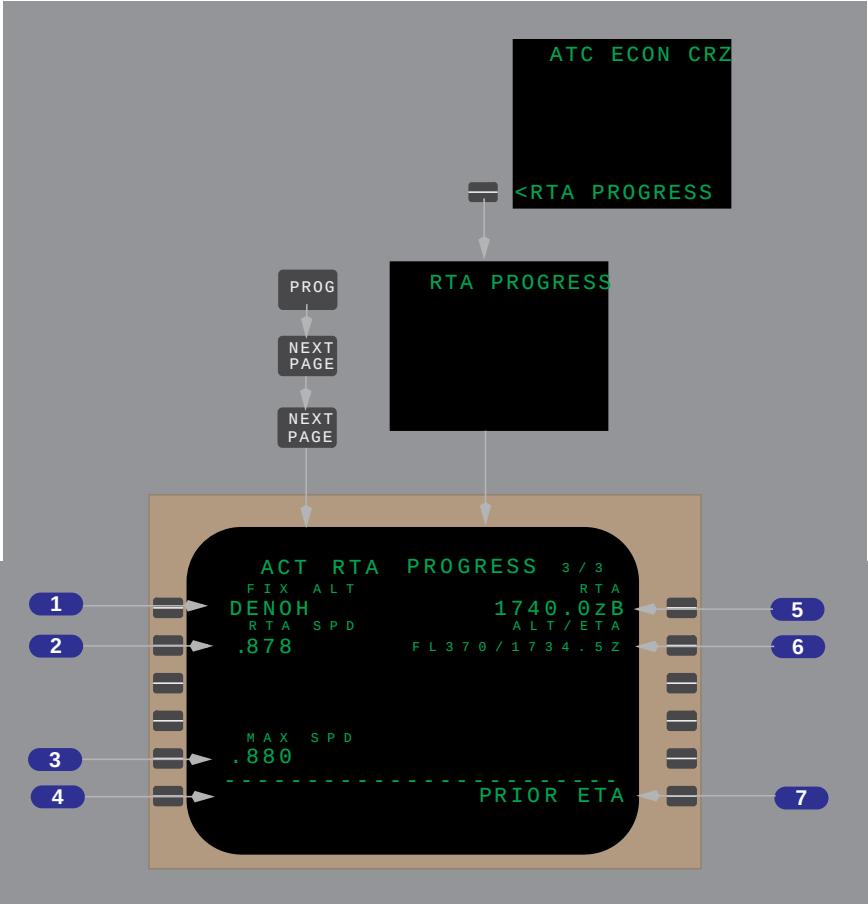
Fuel remaining as calculated by the FMC:

- before engine start, displays fuel quantity calculated by fuel quantity system totalizer
- after engine start, displays fuel quantity at engine start decreased by total fuel flow (FUEL USED)
- after fuel jettison or after all engines are shut down, CALCULATED resets to fuel quantity system totalizer

The fuel remaining line displays two independent fuel remaining values, TOTALIZER and CALCULATED. They can be compared to validate FMC calculations. Fuel flow rate sensing tolerances may allow the CALCULATED and the TOTALIZER fuel quantities to be different by as much as 60 to 85 pounds per hour.

RTA Progress Page 3/3

Progress page three is used to enter data for required time of arrival (RTA). RTA can be entered or changed during preflight or in flight. Creating an RTA changes PROGRESS and CRZ page titles to include RTA. RTA operates only in cruise.



1 FIX

Valid entry is a waypoint in the active or pending active route. Waypoints defined by coordinates must be down selected to the scratchpad, then selected to the FIX line.

Entry by flight crew or datalink.

Entry displays ALT/ETA data in line 2R. When RTA active, deletion of FIX terminates RTA mode and resumes ECON. Display returns to boxes.

When RTA not active, deletion of FIX erases a pending RTA MOD. Display returns to boxes.

Displays boxes when an active or modified route exists.

Displays blank if engine out has been selected.

2 Required Time of Arrival Speed (RTA SPD)

Displays FMC computed cruise speed to accomplish RTA.

Blank if no RTA fix or time entered.

3 Maximum Speed (MAX SPD)

Valid entry is Mach .100 to .99; displays in large font.

Deletion of entered value displays default Mach .880 in small font.

4 ERASE

Displays ERASE when modification pending.

Push - displays previous unmodified page, or if no previous active values, deletes RTA in 1R.

5 Required Time of Arrival (RTA)

Boxes display after entry of FIX in 1L.

Valid entry is time from 0000.0 to 2359.9. Decimal entry of .0 is optional.

Suffix to RTA indicates:

- no suffix - arrive at entered time
- A - arrive at or after entered time
- B - arrive at or before entered time

Deletion terminates RTA and returns ECON as cruise mode.

6 Altitude/ETA (ALT/ETA)

Displays predicted altitude and ETA at RTA fix after entry of FIX in 1L.

Blank until performance data is entered.

7 PRIOR ETA

Displays when prior RTA fix and time exists.

Push -

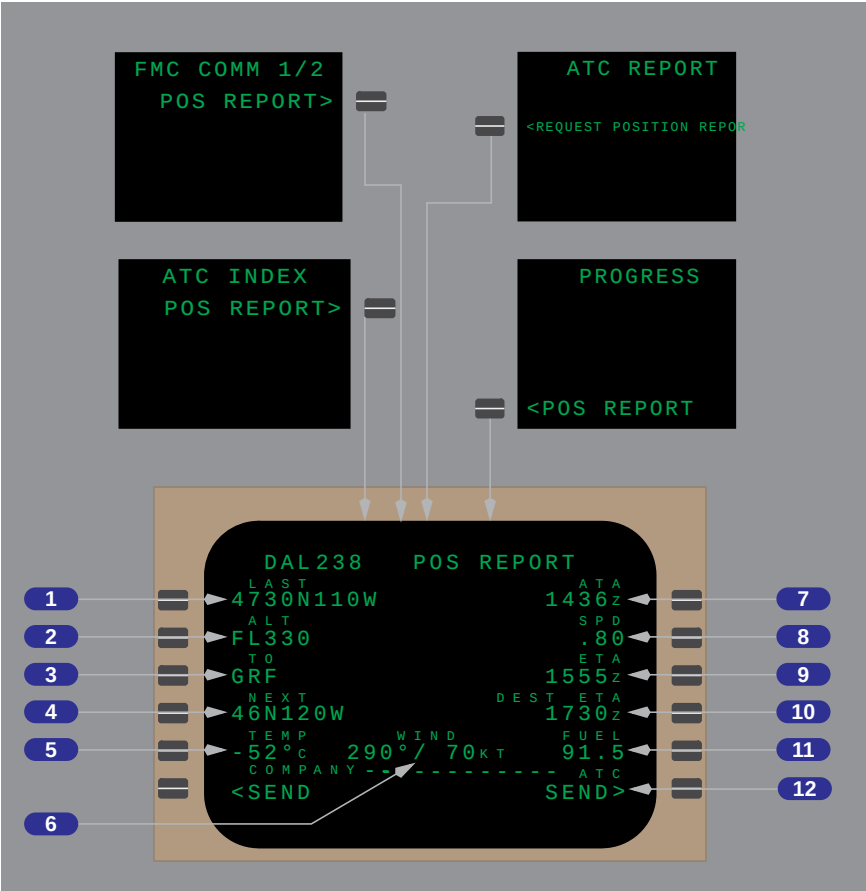
- displays previous RTA fix and time
- initiates RTA flight plan modification

Execution activates RTA function.

Position Report

XXXX Position Report Page

The XXXX POS REPORT page allows review of the position report before transmitting to ATC.



1 LAST Waypoint

Displays waypoint identifier for last sequenced leg.

2 Altitude (ALT)

Displays current altitude.

3 TO Waypoint

Displays waypoint identifier of current leg.

4 NEXT Waypoint

Displays waypoint identifier of leg following the TO leg.

5 Temperature (TEMP)

Displays current static air temperature.

6 WIND

Displays current wind direction and magnitude.

7 Actual Time of Arrival (ATA)

Displays ATA at last sequenced waypoint.

8 Speed (SPD)

Displays current airspeed/Mach.

9 Estimated Time of Arrival (ETA)

Displays ETA at TO waypoint.

10 Destination Estimated Time of Arrival (DEST ETA)

Displays ETA at destination.

11 FUEL

Displays lesser of calculated or totalizer fuel remaining at LAST waypoint.

12 ATC SEND Select Key

Push initiates downlink position report to ATC.

Standard send information.

Report is not forwarded to the company.

Intentionally
Blank

Introduction

The descent phase starts at the top of descent point and continues to the end of descent point. Planning for descent phase starts during cruise.

The approach phase starts at the end of descent point and continues to touchdown or missed approach. If a go-around is accomplished, the FMC climb mode activates.

Early Descent

An early descent is a descent started prior to the T/D. The VNAV descent page becomes active.

During cruise, setting an altitude below the current cruise altitude in the MCP altitude window and pushing the altitude selector activates the DES NOW function when the aircraft is within 50 nm of the T/D or if the MCP altitude is set below the highest descent altitude constraint in the VNAV descent profile.

Descent

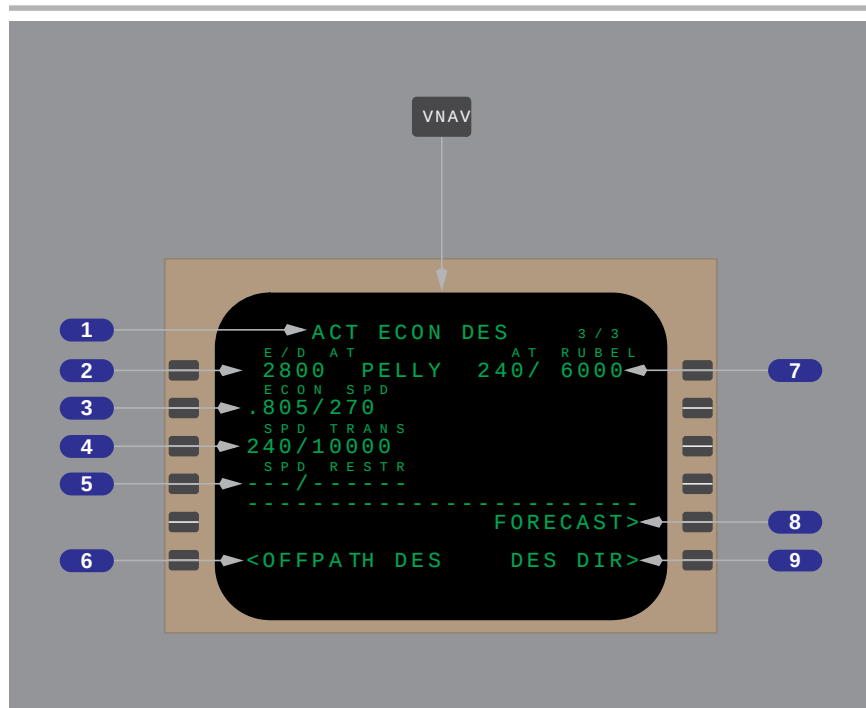
During descent, the RTE LEGS and PROGRESS pages are used to control the lateral route. The DES page is used to control the vertical descent profile.

The additional descent pages listed below are used to:

- DESCENT FORECAST page - enter forecast wind data to aid descent planning
- OFFPATH DES page - analyze descent performance with and without the use of speedbrakes

Descent Page

The DES page is used to monitor and revise the descent path. Descent speeds are economy (ECON) and selected speed (SEL). The default VNAV descent speed is ECON. A selected speed descent is flown when speed intervention is used or a speed is entered on the DES page. The DES page is blank with DES as the title until an altitude constraint below the cruise altitude is entered.



1 Page Title

The page title displays active (ACT) or modified (MOD) descent. Usually, the title contains ECON for economy descent. Other fixed or selected speeds modify the title.

The page title displays the type of descent:

- ACT ECON DES - speed based on a cost index
- ACT LIM SPD DES - speed based on airplane configuration limiting speed
- ACT MCP SPD DES - MCP speed intervention is selected
- ACT XXXKT DES - fixed CAS descent speed profile
- ACT M.XXX DES - fixed Mach descent speed profile
- ACT END OF DES - E/D AT waypoint reached if not followed by a climb segment

Fixed or selected descent speeds are for:

- a flight crew selected speed (SEL SPD)
- a speed transition
- a speed restriction associated with an altitude constraint
- waypoint speed constraints

2 End Of Descent At (E/D AT)

Displays end of descent altitude and waypoint.

End of descent point is a point in descent phase with the lowest altitude constraint.

Page is blank if no E/D point exists.

3 Economy Speed (ECON SPD), Selected Speed (SEL SPD)

Both CAS and Mach values display.

ECON SPD -

- economy speed based on cost index
- displays CAS and Mach values

SEL SPD -

- displays when transitioning from ECON speed into a selected speed segment (waypoint speed constraint, SPD RESTR, or SPD TRANS)
- displays when flight crew enters speed
- valid entries are CAS or Mach value

4 Speed Transition (SPD TRANS)

Transition speed is usually 10 knots less than the destination airport limiting speed from the navigation database. When no airport limit speed exists, the default speed of 240 knots displays. Transition altitude is the point transition speed is active for the destination airport. When no altitude exists in the navigation database, the default of 10,000 feet displays.

Blanks below SPD TRANS altitude.

Deleting causes the airplane to fly economy or selected speed if not limited by a waypoint constraint or speed restriction.

5 Speed Restriction (SPD RESTR)

Speed restrictions at an altitude higher than E/D altitude and not associated with specific waypoints are manually entered on this line.

Displays dashes before entry by flight crew.

Valid entry is a CAS and altitude (example: 240/8000).

6 Off Path Descent (OFFPATH DES)

Push - displays OFFPATH DES page.

7 AT XXXXX

Displays the next waypoint constraint from RTE LEGS page.

XXXX is:

- the waypoint identifier
- HOLD AT XXXXX
- AT VECTORS
- AT (INTC)

The constraint is speed/altitude. Blank when no constraint exists.

Can be deleted on this page.

VNAV commands the lesser of constraint speed or present performance speed.

8 FORECAST

Push - displays DESCENT FORECAST page.

9 Descend Direct (DES DIR), Descend Now (DES NOW)

DES DIR -

Displays in descent phase with altitude constraint between airplane and E/D.

Push - deletes all waypoint altitude constraints between the airplane altitude and the MCP altitude. FMC cruise altitude is not affected.

DES NOW -

Displays when T/D created and the descent phase is not active.

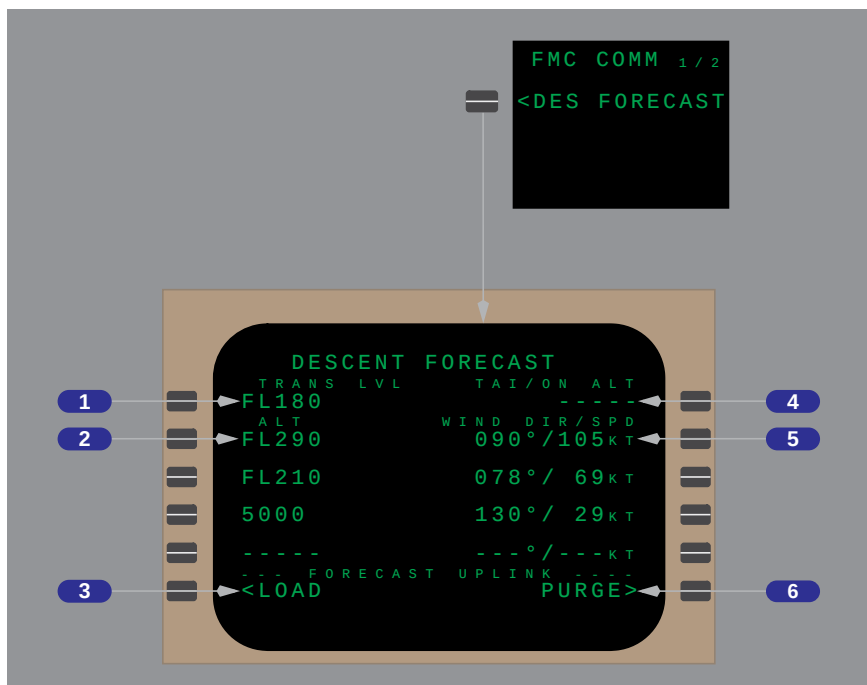
Push -

- provides guidance to descend at approximately 1,250 feet per minute using the active descent speed schedule. Thrust levers may be manually repositioned to adjust vertical speed. Upon intercepting the planned descent path, the airplane transitions to the planned descent path
- activates FMC descent phase

Descent Forecast Page

Descent forecast page is used to enter wind data for descent, and the altitude at which anti-ice use is anticipated for more accurate descent path calculation.

Primary entries are wind direction and speed for up to four descent altitudes, and the altitude anti-ice is to be turned on. Entries can be manual or uplinked.



1 Transition Level (TRANS LVL)

Transition level can be specified by the arrival procedure. The default transition level is FL180.

Valid entry is an altitude or flight level.

The FMC uses transition level to change displays between FL and feet.

2 Altitude (ALT)

Valid entries are altitudes and flight levels.

Altitudes and flight levels can be entered in any order. Entries are not sorted.

3 REQUEST SEND, FORECAST UPLINK LOAD, DATALINK

Displays SEND prompt when datalink READY and no uplink pending.

SEND -

Push -

- transmits datalink request for descent wind data
- displays scratchpad message DES FORECAST UPLINK READY and displays LOAD and PURGE prompts when an uplink containing descent forecast uplink data received and error checks passed

LOAD -

Push -

- accepts and displays request for descent wind data
- displays SEND prompt
- changes PURGE prompt to DES prompt

Displays DATA LINK and data line NO COMM, VOICE, or FAIL if datalink is not READY.

4 Thermal Anti-Ice On Altitude (TAI/ON ALT)

Valid entry is altitude or flight level where anti-ice is to be first turned on during the descent.

5 Wind Direction/Speed (WIND DIR/SPD)

Valid entry is wind direction/speed for the specified altitude. Initial entry must have wind direction and speed, subsequent entries may have one or the other.

6 FORECAST UPLINK PURGE, Descent (DES)

Displays PURGE prompt when an uplink containing descent forecast uplink data received and error checks passed.

PURGE -

Push - rejects uplinked descent forecast data.

DES -

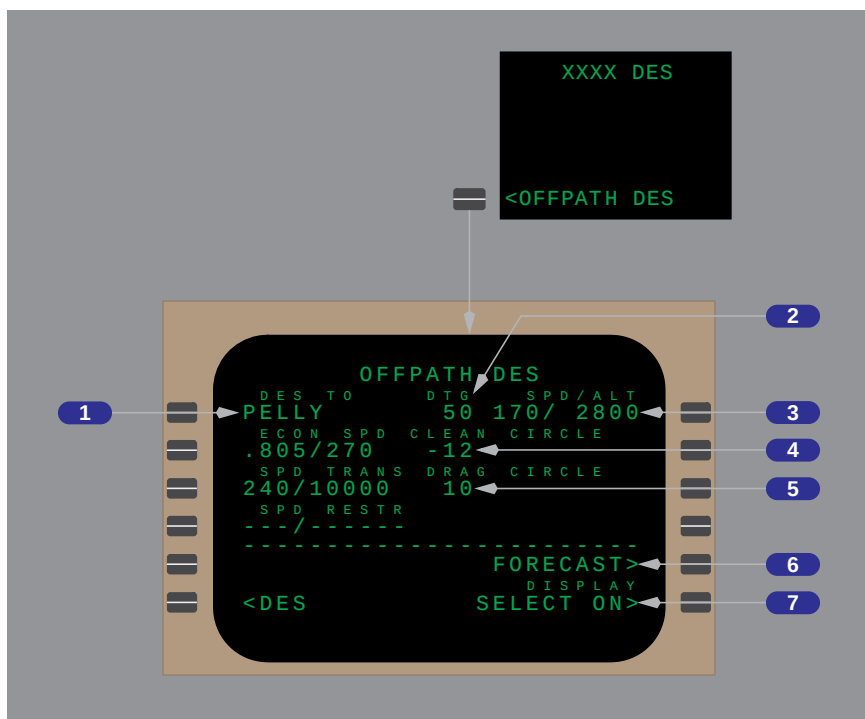
Push - displays the DES page.

Offpath Descent Page

Offpath descent page allows the analysis of descent performance direct to a selected waypoint. Data entered displays clean and drag descent ranges on the page and on the ND. Ranges are based on an entered waypoint and altitude constraint. Range can be used to determine if the altitude constraint can be met in a direct descent to the waypoint.

The FMC displays the last descent waypoint with an altitude constraint in DES TO.

The ECON SPD, SPD TRANS, SPD RESTR, and DES data are the same as the DES page.



1 Descend To (DES TO)

The waypoint for a direct-to descent. Usually, this is the E/D waypoint from the DES page. DTG calculations are for a descent direct to the DES TO waypoint.

Valid entry is any navigation data base waypoint.

When within 150 feet of the DES TO waypoint altitude for a waypoint other than the E/D waypoint, the display changes from DES TO waypoint to the E/D waypoint from DES page.

2 Distance To Go (DTG)

Displays straight line distance to the entered waypoint.

3 Speed/Altitude (SPD/ALT)

Displays the speed/altitude constraint from the E/D waypoint on the DES page or from an entered active waypoint which has a speed/altitude constraint. Other entries cause prompt boxes to display.

4 CLEAN CIRCLE (blue)

Displays distance to the clean descent circle. Distance is negative when a clean descent is no longer possible.

A clean circle assumes no drag devices are used for descent.

A direct descent to the DES TO waypoint at a SPD/ALT constraint is possible when the airplane is outside the clean circle.

5 DRAG CIRCLE (white)

Displays distance to the drag descent circle. Distance is negative when a drag descent is no longer possible.

A drag circle assumes speedbrakes are UP for descent.

A direct descent to the DES TO waypoint at a SPD/ALT constraint is possible when the airplane is outside the drag circle.

6 FORECAST

PUSH - displays DESCENT FORECAST page.

7 DISPLAY SELECT ON, SELECT OFF

SELECT ON -

Push -

- displays CLEAN CIRCLE (blue) on ND
- displays DRAG CIRCLE (white) on ND after aircraft inside CLEAN CIRCLE

SELECT OFF -

Push - removes clean and drag circles from the ND.

Engine Out Descent

There are no specific engine out pages for descent. Use the all-engine descent planning features and pages.

Approach

During an ILS or LOC approach, roll and pitch modes change to approach guidance supplied by navigation radios. The FMC continues to calculate and display present position and can supply LNAV and VNAV approach guidance for certain types of approaches when radio navigation is not used.

RTE LEGS and PROGRESS pages are used to manage the airplane until other approach guidance becomes active.

During approach, the specific page listed below is used to:

- APPROACH REF page - specify approach flap settings and set the approach VREF
- ARRIVALS page - select arrival and approach procedures
- HOLD page - manage holding patterns

Accessing the arrivals page more than 400 NM from the departure airport, more than halfway along the active route, beyond the top of climb and within two minutes of top of descent, or beyond the top of descent, displays arrivals for the destination airport. Prior to sequencing any of these points, accessing the arrivals page displays arrivals for the departure airport.

Sequencing any of the above points also causes the FMC to send landing altitude data to the cabin altitude controller. Until an arrival approach has been selected into the active flight plan, the destination airport altitude is used by the cabin altitude controller.

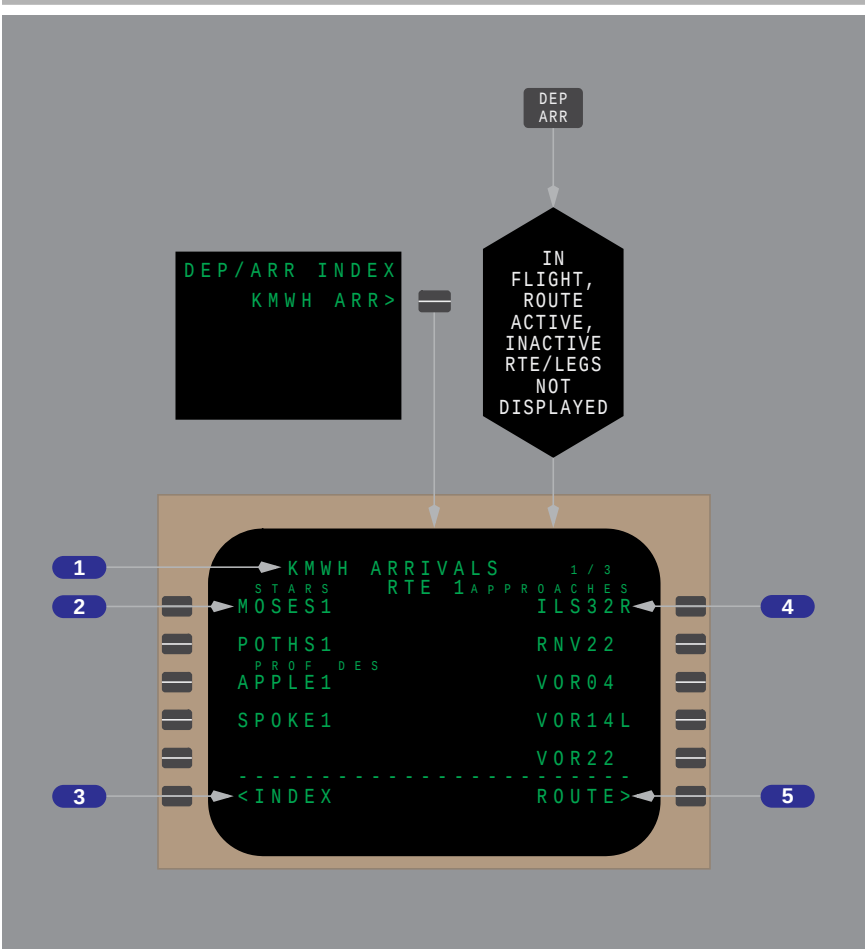
Arrivals Page - IFR Approaches

The arrivals page allows selection of an approach, standard terminal arrival route (STAR), and an arrival transition to the destination airport. This page can also be used to view data about a selected airport that is not the destination. Route 1 and route 2 have separate arrival pages.

The approaches, STARS/profile descents, and transitions are displayed and selected on this page.

Selecting Options

Selecting a runway, approach, approach transition, STAR/profile descent, or descent transition option shows <SEL> inboard of the selection, and makes a route modification. The other options within the same category are removed from the list. When executing the modification, <SEL> changes to <ACT>. Selecting another page and returning to ARRIVALS displays all options; the applicable <SEL> or <ACT> prompts are displayed.



1 Page Title

The destination airport identifier displays in the title.

Second line displays route number.

Airports with more than 5 runways or STARs produce multiple arrivals pages.

2 Standard Terminal Arrivals (STARs), Profile Descents (PROF DES)

STARs display in a list under the STAR line title. Profile descents display below STARs under the PROF DES line title.

NONE displays when no STARs in the database.

Push -

- selects STAR or PROF DES for entry into the route, <SEL> displays
- all other arrival procedures no longer display and transitions for the selected procedure display
- deletes a previously selected procedure
- displays ERASE prompt

3 INDEX

Push - displays the DEP/ARR INDEX page.

4 APPROACHES

Displays the destination airport approaches.

Push -

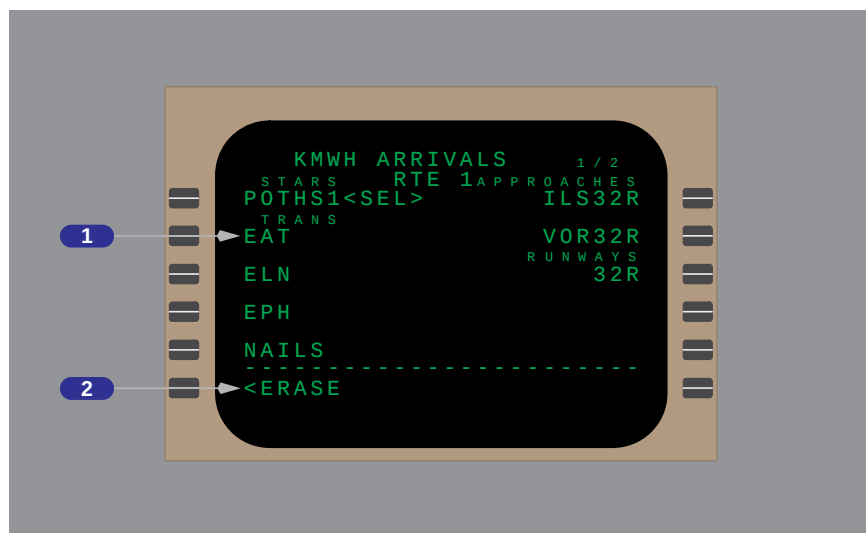
- selects approach for entry into the route, <SEL> displays
- all other approaches and runways no longer display; transitions and profile descents for the selected approach display
- displays INTC prompt for selected approach
- displays ERASE prompt

5 ROUTE

Push -

- displays route page for related route
- displays only on ground or for inactive route

Arrivals Page With STAR Selected



1 STAR Transitions (TRANS)

Displays list of transitions for the selected arrival procedure.

Push -

- selects transition for entry into the route
- all other transitions no longer display

2 ERASE

Displayed when STAR, PROF DES, or APPROACH selected.

Push -

- deletes selections made to active route
- displays lists of STARS, PROF DES, APPROACHES, and RUNWAYS
- displays INDEX prompt

Arrivals Page With STAR, STAR Transition, and Approach Selected



1 Approach Transitions (TRANS)

Displays list of transitions for the selected approach procedure.

Approach transitions include IAFs, feeder fixes, and fixes providing routing to the FAF.

When transition not selected, approach will be a straight-in approach starting at a waypoint 4 to 8 miles outside the FAF. Waypoint may be a charted fix or CFXXX (XXX is the runway number).

Push -

- selects transition for entry into the route
- all other transitions no longer display
- displays INTC prompt for selected transition

2 Approach Intercept

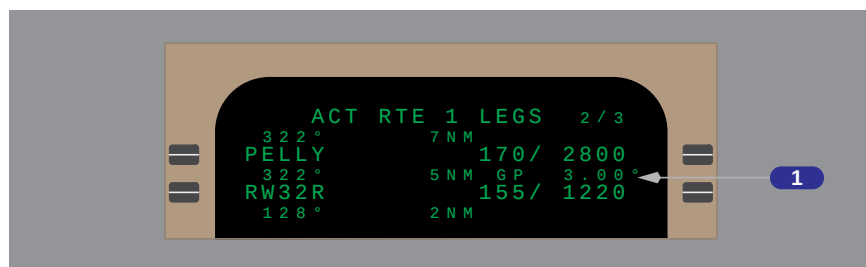
Selecting an arrival runway or approach displays an approach intercept waypoint on the approach course for selected approach or runway.

Following selection of a transition, the charted fix or CFXXX is replaced with the final approach fix (FAF) intercept (example: PELLY INTC).

Push -

- displays RTE LEGS page and modifies route with approach intercept fix as the active waypoint
- selects approach course for selected approach as inbound course to approach intercept fix on LEGS page

Active Route Legs Page With Glide Path (GP) Angle



1 GP Display

Displays the navigation database GP angle for ILS, GPS, LOC, RNV, and VOR approaches. When AFDS pitch mode VNAV PTH is active, vertical path guidance is provided at the displayed GP angle.

Arrivals Page - VFR Approaches



1 RUNWAYS

Displays list of runways for destination airport.

Push -

- selects runway for entry into the route; <SEL> displays
- deletes previously selected approach
- displays VFR APP and runway extension when enabled in the navigation database
- no longer displays other runways and approaches
- displays approach intercept fix for selected runway

Arrivals Page With Runway Selected



1 VFR Approach (VFR APPR)

Push - following discontinuity, enters straight-in VFR approach.

VFR approach begins with a VFR Final Approach Fix (FAXXX) 8 miles from runway threshold with airspeed/altitude constraint of 170 kts/2,000 feet above runway elevation.

VFR approach ends with a runway altitude constraint of 50 feet.

Displays RWY EXT 8.0 NM.

Displays FPA 3.0°.

2 Runway Extension (RWY EXT)

Allows entry of end of descent target for VNAV guidance.

Creates a runway extension fix along runway centerline for LNAV guidance.

Valid entry is 1.0 nm to 25.0 nm.

Entry deletes VFR APPR prompt.

Arrivals Page With VFR Approach Selected



1 Runway Extension (RWY EXT)

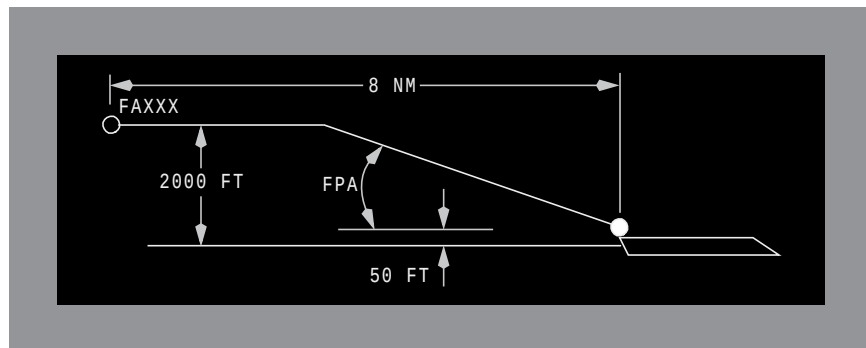
Displays RWY EXT 8.0. FAXXX is part of VFR APPR and distance cannot be changed.

2 Flight Path Angle (FPA)

Displays descent path angle to 50 foot runway waypoint. Default is 3.0°.

Valid entry is 2.4° to 3.7°.

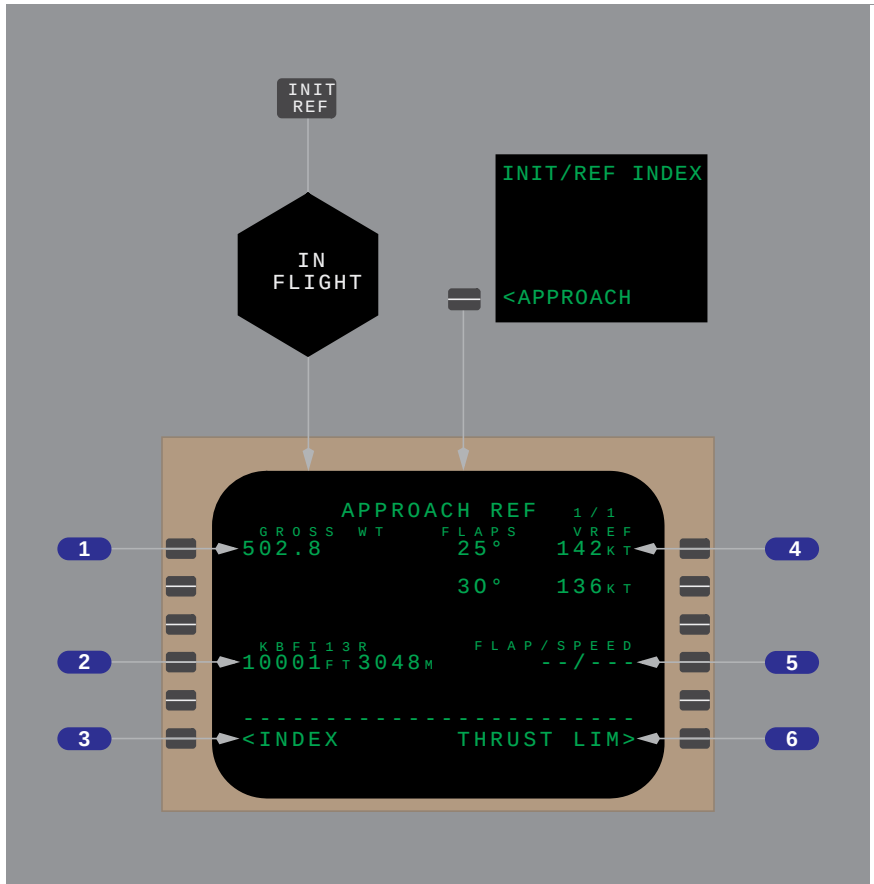
VFR Approach Path



The VFR approach is a level path until the VNAV descent path is intercepted. It terminates at the runway threshold at 50 feet (and 170 knots). Default values display in RWY EXT and FPA.

Approach Reference Page

The approach reference page displays approach planning data and the approach reference speed (VREF) selection.



1 Gross Weight (GROSS WT)

Displays FMC calculated airplane gross weight.

Displays boxes when gross weight is not available from FMC.

Valid entry is XXX.X. Leaving this page and returning displays the FMC calculated gross weight.

2 Runway Length

Displays length of departure runway until destination runway or approach entered into active route and airplane is 50 NM from departure airport or halfway to destination.

Displays runway length in feet and meters.

Display clears at flight completion.

3 INDEX

Push - displays INT/REF INDEX page.

4 FLAPS VREF

Displays computed VREF for the indicated landing flap settings at displayed gross weight. Blank until gross weight entered.

Push - displays flaps/VREF in scratchpad for entry in 4R.

5 FLAP/SPEED

Valid entries are: XX/YYY, /YYY, or YYY. XX is flap setting, YYY is airspeed.

Entry displays VREF speed on PFD. Entry of an airspeed greater than VREF increases the entire flap speed schedule by the increased amount. If no VREF is selected or an entry is not made, displayed flap speeds are based on flap position increments above VREF 30 for the current gross weight.

Deletion of data removes VREF from PFD.

6 Thrust Limit (THRUST LIM)

Push - displays THRUST LIM page.

Holding

The FMC computes holding patterns with constant radius turns based on current wind and FMC commanded airspeed. The pattern size is limited to FAA or ICAO protected airspace. In LNAV, the AFDS tracks the holding pattern using up to a 30 degree bank angle. Strong winds or airspeed in excess of FAA or ICAO entry speeds may result in the airplane flying outside the protected airspace.

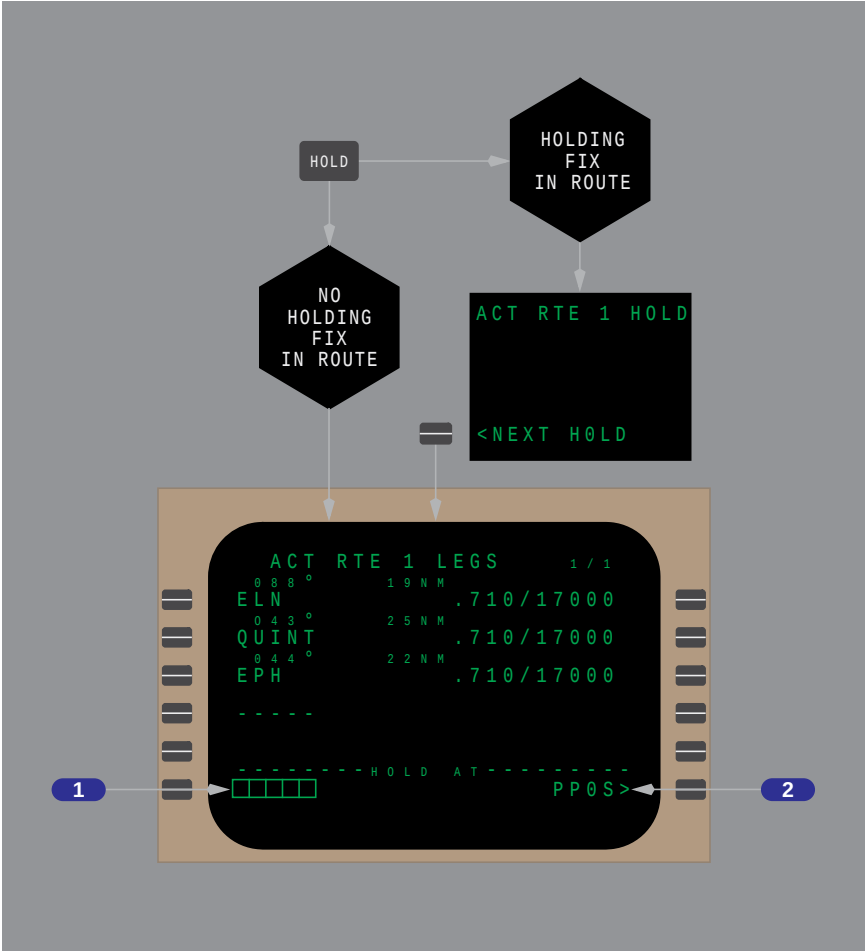
With LNAV active before sequencing the holding fix, holding pattern entries are determined by the following:

- airplane track, not heading or direction from which the active route approaches the holding pattern, determines the entry method used (parallel, teardrop, or direct entry)
- the airplane flies the initial outbound leg a computed distance from the holding fix, rather than a specific time. The computed distance is a function of the command airspeed and computed wind at the time the holding pattern becomes active
- teardrop entries use a 40 degree offset angle
- parallel and teardrop entries may cause the airplane to fly beyond the displayed holding pattern; however, the airplane remains in protected FAA or ICAO limits.

The route hold page is used to enter holding information in the route or to view or modify an existing holding pattern. Modifications made to a holding pattern while active in the hold become effective on the next crossing of the holding fix.

Route Hold Page With No Holding Fix in Route

When no hold exists in route, pushing the HOLD key displays RTE LEGS page. RTE LEGS page displays prompts to enter the holding fix as a route waypoint or at present position.



1 HOLD AT Boxes

Boxes can be displayed on any RTE LEGS page.

Valid entry is any RTE LEGS waypoint, database waypoint, or pilot-defined waypoint.

Along-track waypoints must be entered over the original waypoint, then in the boxes.

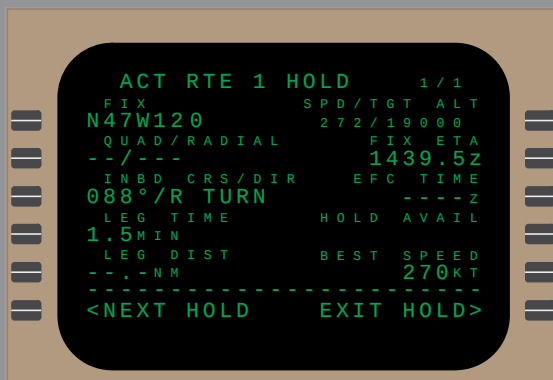
If holding fix not in active route, waypoint is entered in scratch pad, then selected to HOLD AT boxes. HOLD AT XXXXX displays in scratch pad. Selecting HOLD AT XXXX to desired line displays RTE HOLD page; cannot be selected as the active waypoint.

2 HOLD AT PPOS

Push -

- creates holding pattern at present position
- execution establishes the holding fix at the position when EXEC is pushed and displays RTE HOLD page

Route Hold Page After Pushing PPOS And Executing



Route Hold Page With Holding Fix in Route

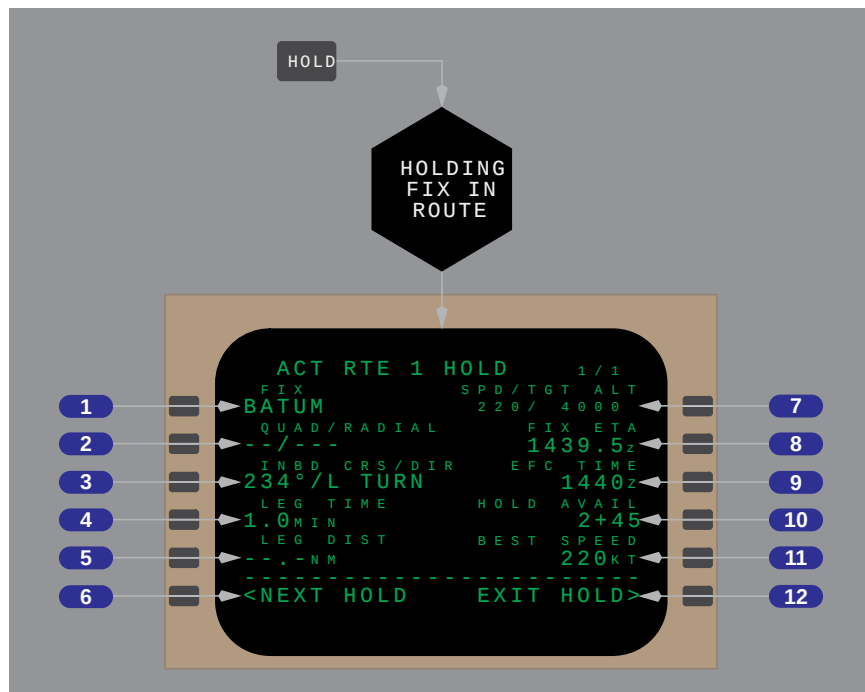
When a hold(s) exists in the route, hold page 1/X displays first existing hold. When more than one hold exists, pushing NEXT PAGE displays succeeding holds.

Most holding patterns are part of a procedure or airway and remain active until the flight crew executes an exit from holding. This may be accomplished in one of two ways:

- on the ACT RTE LEGS page, deleting or bypassing the HOLD AT waypoint causes LNAV to command a direct to the next waypoint
- on the ACT RTE HOLD page, selecting and executing EXIT HOLD> causes LNAV to command the airplane to continue in the holding pattern until arriving at the holding fix, at which time the airplane exits the holding pattern

The FMC automatically commands an exit from some holding patterns in procedures under the following conditions:

- for instrument approach holding patterns designed as a course reversal in lieu of a procedure turn, the airplane exits holding upon arrival at the holding fix inbound. Header at 1L displays PROC HOLD
- for some holding patterns in SIDs, the airplane exits holding when arriving at an altitude. Header at 1L displays HOLD AT



1 Holding FIX

Displays the holding fix.

2 Quadrant/Radial (QUAD/RADIAL)

Normally displays dashes.

Valid entry is X/XXX OR XX/XXX, or /XXX. Example: NW/330.

Entry changes INBD CRS/DIR to agree.

3 Inbound Course/Direction (INBD CRS/DIR)

Displays inbound course and direction of turn.

Valid entry is XXX (course), XXX/X, /X, or X (turn direction).

Entry changes QUAD/RADIAL to agree.

4 LEG TIME

Displays 1.0 MIN (minute) at or below 14,000 feet.

Displays 1.5 MIN above 14,000 feet.

Displays dashes when entry made on LEG DIST line.

Valid entry is XXX.X.

Entry displays dashes on LEG DIST line.

When climbing/descending through 14,000 feet with VNAV active and the SPD/TGT ALT at 1R displays in large font, the FMC adjusts the leg time (1.0 MIN at or below 14,000 feet; 1.5 MIN above 14,000 feet).

5 LEG Distance (DIST)

Normally displays dashes. Allows entry of leg distance for hold.

Valid entry is XX.X or X.X.

Entry displays dashes on LEG TIME line.

6 NEXT HOLD, ERASE

NEXT HOLD -

Push - displays prompts for entering another hold in route.

ERASE -

Displayed when hold modified.

Push -

- erases modification to hold
- displays NEXT HOLD prompt

7 Speed/Target Altitude (SPD/TGT ALT)

Displays dashes or fix target speed/altitude from RTE LEGS page.

Display is small font for FMC predictions, large font for constraints or manual entries.

Valid entry is XXX/ (speed); YYY, YYYY, or YYYYYY (target altitude), or a combination of speed/target altitude.

- speed entry requires altitude constraint
- altitude entry must be below cruise altitude

Entry displays on HOLD AT waypoint on RTE LEGS page.

During cruise, entry of a target altitude lower than CRZ ALT modifies DESCENT page and displays a T/D. After T/D, the DESCENT page remains active unless a new cruise altitude is entered.

8 FIX ETA

With no EFC TIME entry, displays time the airplane will next pass the holding fix.

With EFC TIME entry, displays time the airplane will pass the holding fix after the EFC time. The FMC uses this time to calculate downtrack ETAs and fuel values based on departing the holding fix at the new FIX ETA.

9 Expect Further Clearance Time (EFC TIME)

Normally displays dashes.

Valid entry is XXXX (time).

Entry changes ETA and fuel predictions for the route after holding.

10 HOLD Available (HOLD)

Displays holding time available before requiring reserve fuel to reach the destination.

11 BEST SPEED

Displays best holding speed for airplane gross weight, altitude, and flap setting.

Note: BEST SPEED may exceed regulatory maximum holding speeds.

12 EXIT HOLD, EXIT ARMED

EXIT HOLD -

Push -

- arms a holding pattern exit
- displays EXIT ARMED prompt

EXIT ARMED -

When executed, airplane returns to the fix via the inbound course and exits holding pattern.

Intentionally
Blank

Introduction

The CDUs can be used as an alternate navigation system if both FMCs fail. The CDUs perform lateral navigation computations; however, LNAV, VNAV, and autothrottle are not available. The CDU can be used to tune navigation radios.

During normal FMC operation, all system capabilities are contained within the FMCs. During alternate navigation operation, the CDUs use their own internal memory and computing capability.

Each CDU performs its calculations based on inputs from its own IRU. Usually, the left CDU provides information to the left ND map and the right CDU provides information to the right ND map. The center CDU can be selected as an alternate to the left or right CDU.

Alternate Navigation Waypoints

The CDUs do not have a performance or navigation database. The CDUs continuously copy the active route from the FMC. If both FMCs fail, the CDUs retain flight plan waypoints except for conditional waypoints, offsets, and holding patterns. Waypoints on the copied route can be referenced by either their identifier, or latitude and longitude.

New waypoints can only be entered in latitude and longitude. This includes waypoints the flight crew has deleted from the copied route.

Waypoint Operations

Waypoint operations include:

- add new waypoints (latitude/longitude entry only)
- remove existing waypoints
- change the sequence of existing waypoints
- connect discontinuities.

Alternate Lateral Navigation

All CDU calculations are based on a great-circle course between waypoints.

Route Changes

Route changes are made on ALTERNATE NAVIGATION LEGS page in almost the same manner as normal FMC operations. All courses between waypoints are direct routes. When the active waypoint is modified, the only navigational choice is present position direct to the modified active waypoint.

A route change to any one CDU does not change the other two. The Captain may view the route entered in either the left or center CDU on the ND using the NAV source select switch. The First Officer may view the route entered in either the right or center CDU on the ND using the NAV source select switch.

When displaying center CDU data on the First Officer's ND, the ND range selector must agree with the range selected on the Captain's selector. If different, the message MAP RANGE DISAGREE displays on the First Officer's ND.

Course Reference

The IRU supplies magnetic variation for present position. Only the active waypoint course can be referenced to magnetic north. All subsequent waypoint courses are true courses. Each CDU operates independently with its respective IRU.

Alternate Navigation Radio Tuning

The radios must be manually tuned (frequency only) on each CDU in alternate navigation. The left CDU tunes the left VOR, DME, ADF, and left ILS. The right CDU tunes the right VOR, DME, ADF, and right ILS. The center CDU tunes the center ILS. Manual tuning is accomplished on the ALTERNATE NAVIGATION RADIO page.

Alternate Navigation CDU Pages

Alternate navigation is accomplished from three CDU pages:

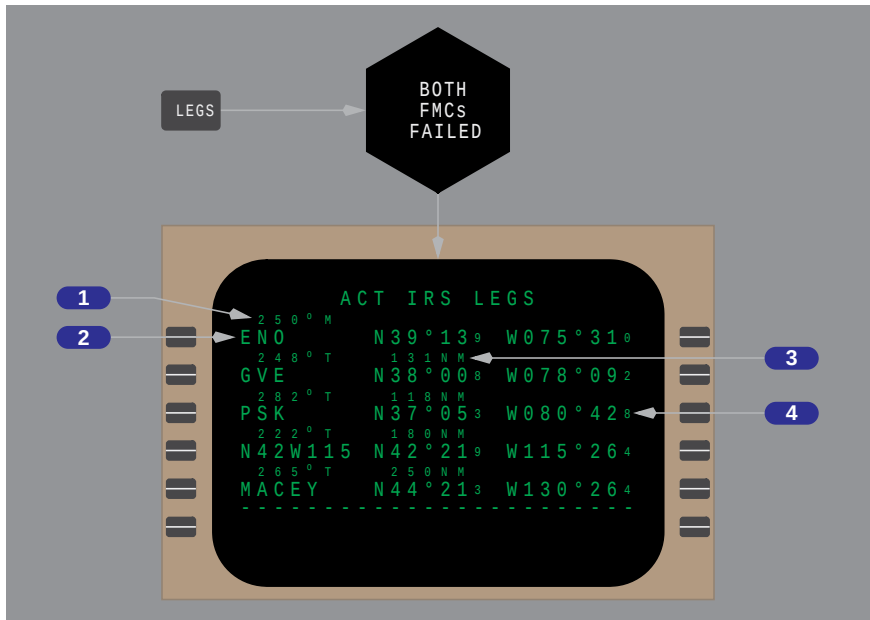
- ALTERNATE NAVIGATION LEGS
- ALTERNATE NAVIGATION PROGRESS
- ALTERNATE NAVIGATION RADIO

Failure of the primary FMC causes both CDUs to display the MENU page and display of the scratchpad message TIME OUT - RESELECT. Failure of the secondary FMC displays the respective CDU MENU page and the scratchpad message TIME OUT - RESELECT. Rotating the related Navigation Source Selector to the operable FMC restores the CDU display and NDs to normal.

If both FMCs fail, the IRS LEGS, IRS PROGRESS, and ALTN NAV RADIO pages are available on all CDUs. Rotating Navigation Source Selectors to a CDU position restores NDs and the alternate navigation pages.

Alternate Navigation Legs Page

This page displays data about each leg of the route. The route can be modified. Waypoint speed and altitude restrictions are not displayed because performance data is not available.



1 Leg Direction

Displays course to the waypoint.

Course reference is M for magnetic, T for true.

Active waypoint leg direction can be magnetic or true. Subsequent waypoint leg directions are true.

2 Waypoint Identifier

Displays the waypoint by name or latitude/longitude.

Valid entries are waypoints currently in the route or latitude/longitude for new waypoints.

3 Distance to Waypoint

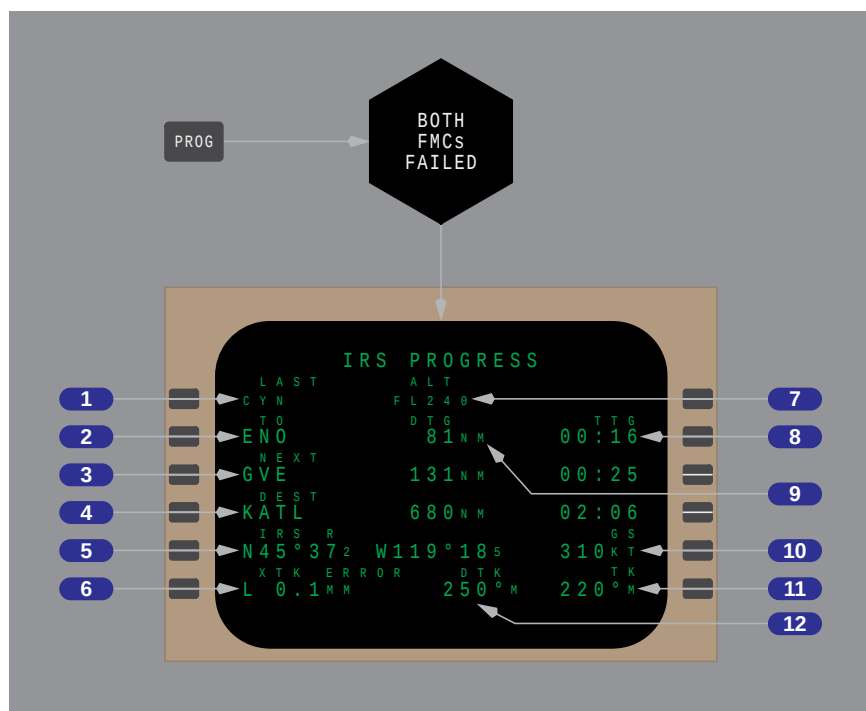
Displays the great circle distance between waypoints.

4 Waypoint Coordinates

Displays the waypoint coordinates.

Alternate Navigation Progress Page

This page displays general data about flight progress.



1 LAST

Displays the identifier of the last waypoint.

2 TO

Displays the active waypoint on the route.

3 NEXT

Displays the waypoint after the TO waypoint.

4 Destination (DEST)

Displays identifier for route destination waypoint or airport. Any waypoint on or off the route can be entered. Time and distance data temporarily displays for that waypoint.

Display options:

- destination airport identifier; distance and time to go along track to the destination airport
- entry of an existing flight plan waypoint (identifier or latitude/longitude) causes the line title to change to ENROUTE WPT. Time and distance to go are from the present position direct to the new waypoint
- entry of a waypoint not in the flight plan causes the line title to change to DIR TO ALTERNATE. Time and distance to go are from the present position direct to the new waypoint

5 Inertial Position (INERTIAL POS)

Displays IRU present position.

Line title displays IRU source for position.

6 Cross Track Error (XTK ERROR)

Displays airplane left or right cross-track error in nautical miles from the active route track.

7 Altitude (ALT)

Displays airplane altitude when the LAST waypoint was crossed.

8 Time to Go (TTG)

Displays time to go to waypoint or destination.

9 Distance to Go (DTG)

Displays distance to go to waypoint or destination.

10 Ground Speed (GS)

Displays IRU groundspeed.

11 Track (TK)

Displays airplane track angle relative to the true or magnetic reference selected on the HEADING REFERENCE switch.

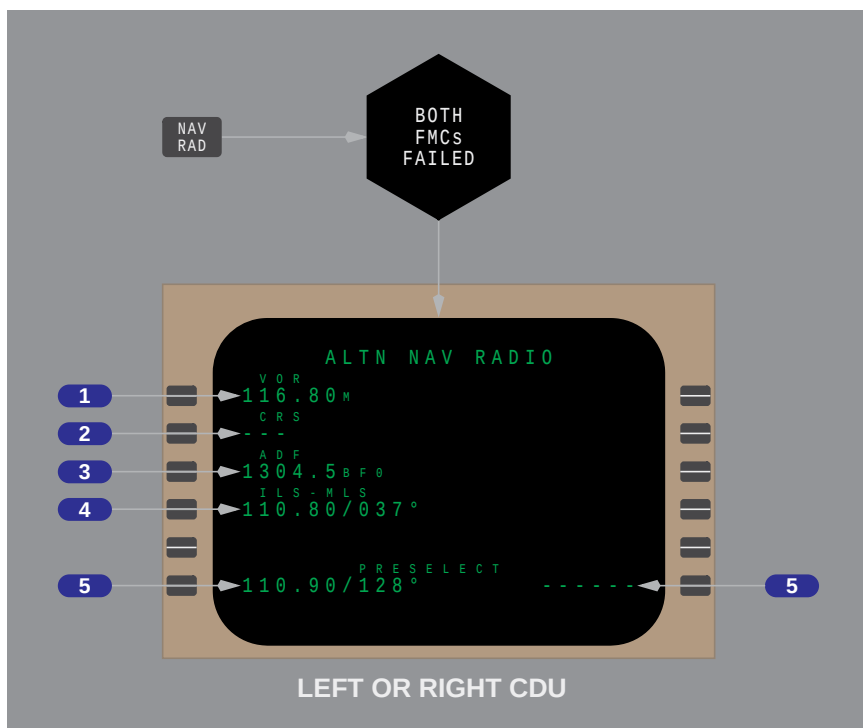
12 Desired Track (DTK)

Displays desired track angle relative to the true or magnetic reference selected on the HEADING REFERENCE switch.

Alternate Navigation Radio Page

Navigation radios are tuned on this page and related parameters display. Autotune is not available. The CDUs operate independently for navigation radio tuning:

- the left CDU tunes the left radios
- the right CDU tunes the right radios
- the center CDU tunes the center ILS



1 VOR

Displays last selected VOR frequency. Tuning status displays as manual (M).

Display is blank on center CDU.

Valid entry is VOR frequency or VOR frequency/course.

Entry tunes related DME frequency.

2 Course (CRS)

Displays selected VOR course.

Display is blank on center CDU.

Valid entry is VOR course or VOR frequency/course.

3 ADF

Displays ADF frequency. Tuning status displays as ANT or BFO.

Displays dashes if no ADF frequency entered on NAV RAD or ALTN NAV RAD pages after initial power up.

Valid entry is ADF frequency or ADF frequency suffixed with A or B. Suffix may be changed after entry.

4 ILS

Displays last selected ILS frequency, ILS frequency and course, or PARK.

Valid entries are:

- ILS frequency
- ILS frequency/front course
- front course only (a frequency must already be displayed)

Front course defaults to runway course if runway on active route and only frequency entered. Otherwise, front course defaults to 000 or the last entered front course.

Note: If ILS was in autotune at the time of the FMC failure, the frequency and course are copied to the ALTN NAV RADIO page.

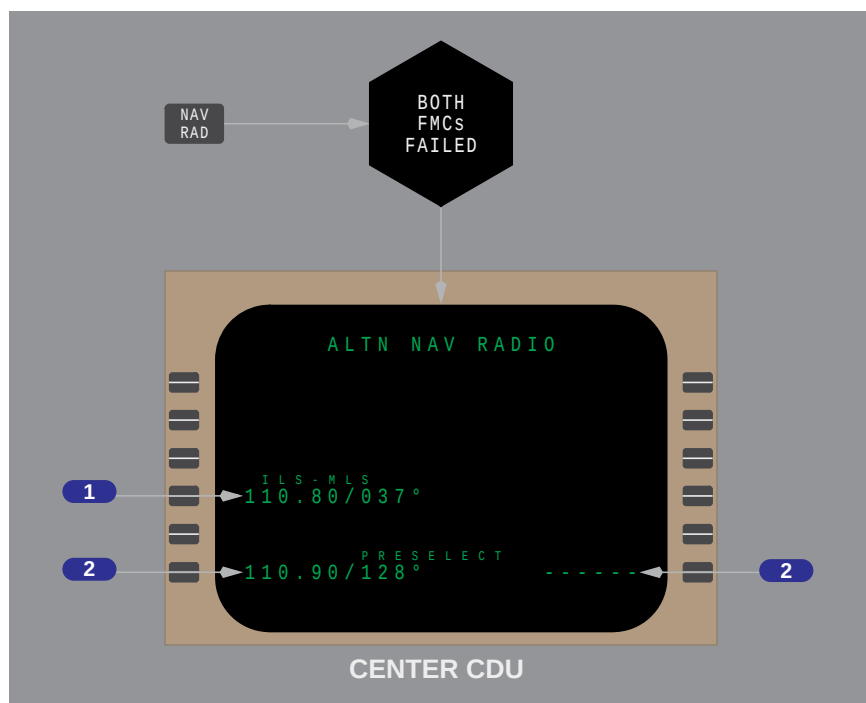
Note: The ILS frequency displays PARK when no frequency is tuned. Deleting the ILS frequency parks a tuned ILS.

Note: ILS course and frequency must be entered on the left, center, and right ALTN NAV RADIO page.

5 PRESELECT

Allows entry of two separate preselected frequencies and/or frequencies/courses.

Valid entries are any of the entries that can be made on the other lines.



1 ILS

Displays last selected ILS frequency, ILS frequency and course, or PARK.

Valid entries are:

- ILS frequency
- ILS frequency/front course
- front course only (a frequency must already be displayed)

Front course defaults to runway course if runway on active route and only frequency entered. Otherwise, front course defaults to 000 or the last entered front course.

Note: If ILS was in autotune at the time of the FMC failure, the frequency and course are copied to the ALTN NAV RADIO page.

Note: The ILS frequency displays PARK when no frequency is tuned. Deleting the ILS frequency parks a tuned ILS.

Note: ILS course and frequency must be entered on the left, center, and right ALTN NAV RADIO page.

2 PRESELECT

Allows entry of two separate preselected frequencies and/or frequencies/courses. Valid entries are any of the entries that can be made on the other lines.

Air Traffic Control Datalink

FANS/CPDLC Equipped Aircraft

For airplanes with the Air Traffic Control (ATC) datalink function installed, these functions are accomplished on the CDU. These functions include Air Traffic Services Facilities Notification, Automatic Dependent Surveillance (ADS), and ATC Datalink.

The ATC LOGON/STATUS page provides the capability to initiate an AFN downlink to a specified ATS facility and to display the ADS, ATC DL, and datalink status.

The ATC UPLINK pages display messages uplinked by an ATS facility and provide the capability to respond to uplinked messages and to load clearances which contain loadable data. Display of the EICAS memo message ATC MESSAGE and a low level aural chime announce uplinked messages to the flight crew.

The ATC REQUEST pages provide capability to create downlink requests for vertical and speed clearances, lateral offsets, and route changes.

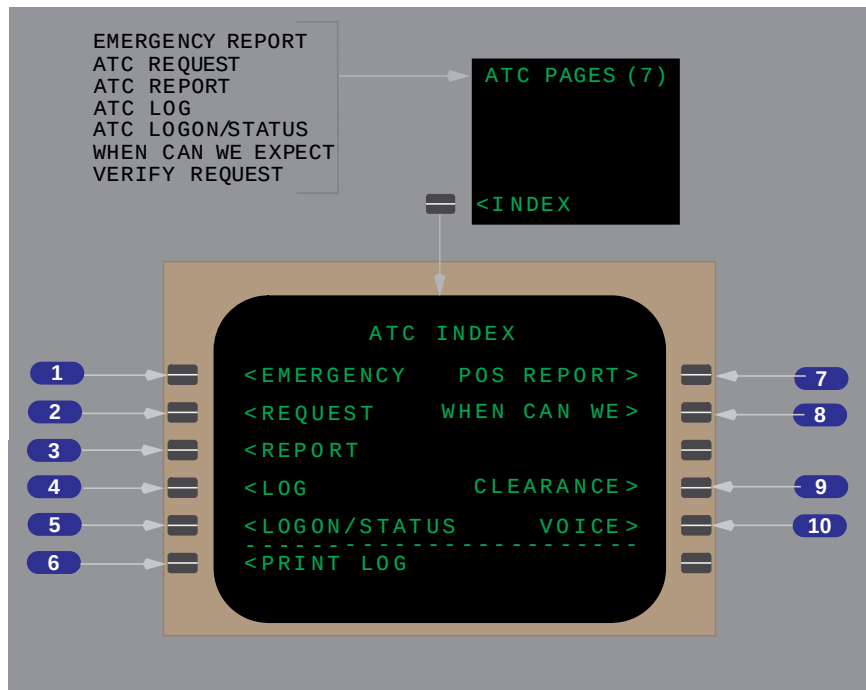
The FMC formats reports in response to requests from an ATS facility for reports and confirmation. These reports are accessible via the ATC REPORT page and display for review or modification on the VERIFY REPORT pages.

The ATC LOG page provides a list of all uplinks and downlinks stored in the ATC Log and provides access to the XXXXz ATC UPLINK, XXXXz ATC REQUEST, XXXXz ATC REPORT, and XXXXz EMERGENCY pages corresponding to each logged uplink or downlink.

To accomplish Automatic Dependent Surveillance, the FMC can simultaneously receive requests from four ATC centers and one airline center. Airline ADS addresses are stored in the airline policy file. The ADS functions include periodic, event, and on-demand reporting. The type and content of a report is initiated by uplink request. These functions are automatic. The flight crew can disable this function on the ATC LOGON/STATUS page.

ATC Index Page

The ATC INDEX CDU page provides access to pages used for ATC datalink functions.



1 EMERGENCY

Push - displays EMERGENCY REPORT page.

2 REQUEST

Push - displays ATC REQUEST page.

3 REPORT

Push - displays ATC REPORT page.

4 LOG

Push - displays ATC LOG page.

5 LOGON/STATUS

Push - displays ATC LOGON/STATUS page.

6 PRINT LOG

Push - transmits contents of ATC log to printer.

7 Position (POS) REPORT

Push - displays POS REPORT page.

8 WHEN CAN WE EXPECT

Push - displays WHEN CAN WE EXPECT page.

9 CLEARANCE

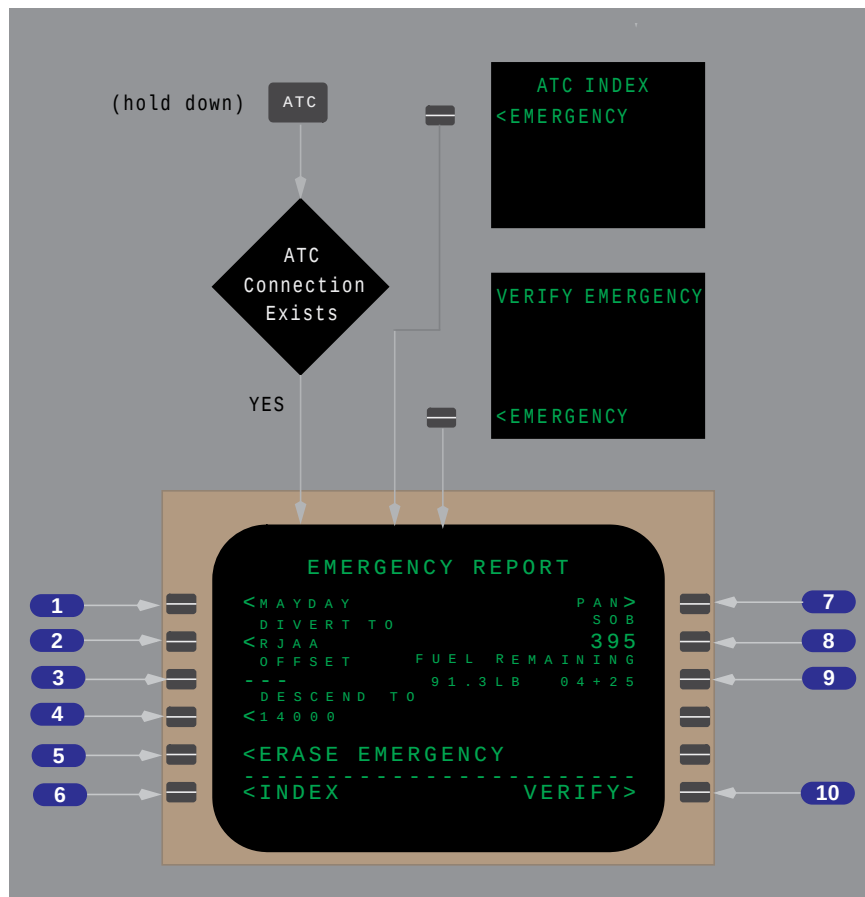
Push - displays VERIFY REQUEST pages for clearance request.

10 VOICE

Push - displays VERIFY REQUEST page for voice contact request.

Emergency Report Page

The EMERGENCY REPORT pages provide the capability to create downlink messages to alert an ATS facility to an aircraft emergency and to the lateral and vertical maneuvers the flight crew intend to execute.



1 MAYDAY

Push -

- displays VERIFY EMERGENCY page
- displays MAYDAY MAYDAY MAYDAY message
- selects, but does not display, additional POSITION REPORT message elements for inclusion in the emergency report downlink.
- when current altitude more than 150 feet above altitude in 4L, displays DESCENDING TO on VERIFY EMERGENCY page.

2 DIVERT TO

Displays active destination airport.

Valid entries are: waypoint, navaid, airport, latitude-longitude, or place bearing/distance.

Entered position may be deleted.

Push -

- message includes remainder of route if active destination airport displayed
- message includes direct to routing if entered position displayed.

3 OFFSET

Valid entry is L (or R) XX. (XX is any number from 1 to 99).

Message includes entered offset.

Entered offset may be deleted.

4 DESCEND TO

Displays MCP altitude.

Valid entry is XXX or FLXXX (flight level), XXXXX (feet), or XXXXXm.

Entered altitude may be deleted.

Push - message indicates crew intention to descend to displayed altitude.

5 ERASE EMERGENCY, CANCEL EMERGENCY

Initial display is blank.

Entry or selection of data on any line displays ERASE EMERGENCY.

Displays CANCEL EMERGENCY after EMERGENCY REPORT sent.

ERASE EMERGENCY -

Push - erases all emergency data.

CANCEL EMERGENCY -

Push - selects CANCEL EMERGENCY message.

6 INDEX

Push - displays ATC INDEX page.

7 PAN

Push -

- displays VERIFY EMERGENCY page
- displays PAN PAN PAN message.

8 Souls On Board (SOB)

Entry of number of persons on airplane displays the lesser of the totalizer or FMC computed fuel remaining and souls on board message elements for inclusion in the emergency report downlink.

Causes remaining fuel quantity to display.

Deletion of SOB deselects the message element.

9 FUEL REMAINING

Initial display is blank.

Displays FMC computed fuel remaining in quantity and time when a SOB number is entered.

Valid entry is HH+MM (hours and minutes).

10 VERIFY

Push - displays VERIFY EMERGENCY page.

Verify Emergency Page 1/X

The VERIFY EMERGENCY page displays the text of the EMERGENCY REPORT which will be downlinked to ATC. The page allows entering free text in the downlink message.



1 Lines 1 - 5

Pages 1/X to X/X display data from the EMERGENCY REPORT page and provide at least one line for free text entry.

Page 1/X line 1 displays MAYDAY MAYDAY MAYDAY message or PAN PAN PAN message as selected on EMERGENCY REPORT page.

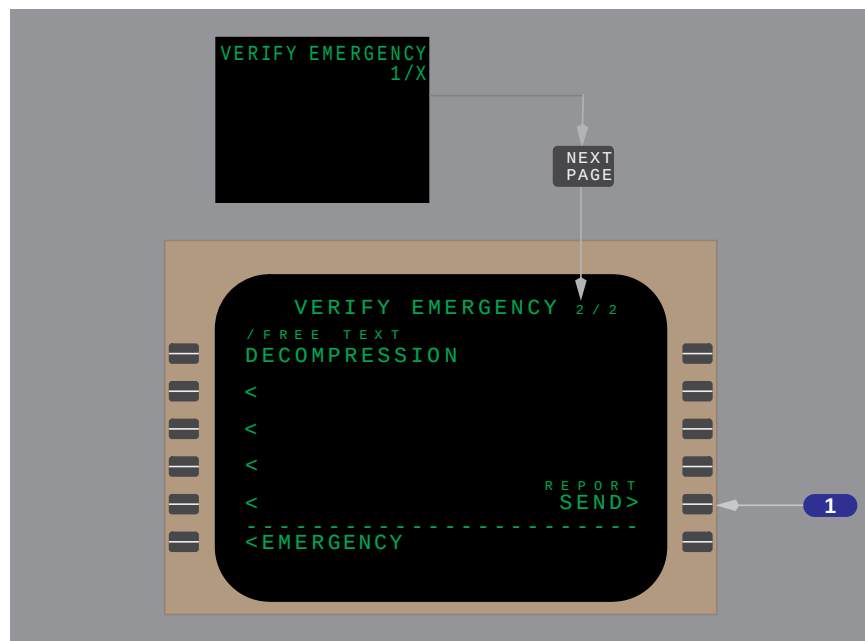
- MAYDAY MAYDAY MAYDAY message and PAN PAN PAN messages may be deleted
- deletion of MAYDAY MAYDAY MAYDAY message deletes DESCENDING TO line.

2 EMERGENCY

Push - displays EMERGENCY REPORT page.

Verify Emergency Page X/X

Pages X/X are available when lines 1 - 5 are filled on page 1/X.



1 REPORT SEND

Push - displays XXXXz EMERGENCY REPORT page.

- transmits an emergency report message containing the information on the VERIFY EMERGENCY page
- creates log entry of transmitted message
- when MAYDAY selected and when enabled in airline policy file:
transmits POSITION REPORT, activates ADS in emergency mode, and
transmits an AOC emergency report

When CANCEL EMERGENCY displayed in 5L:

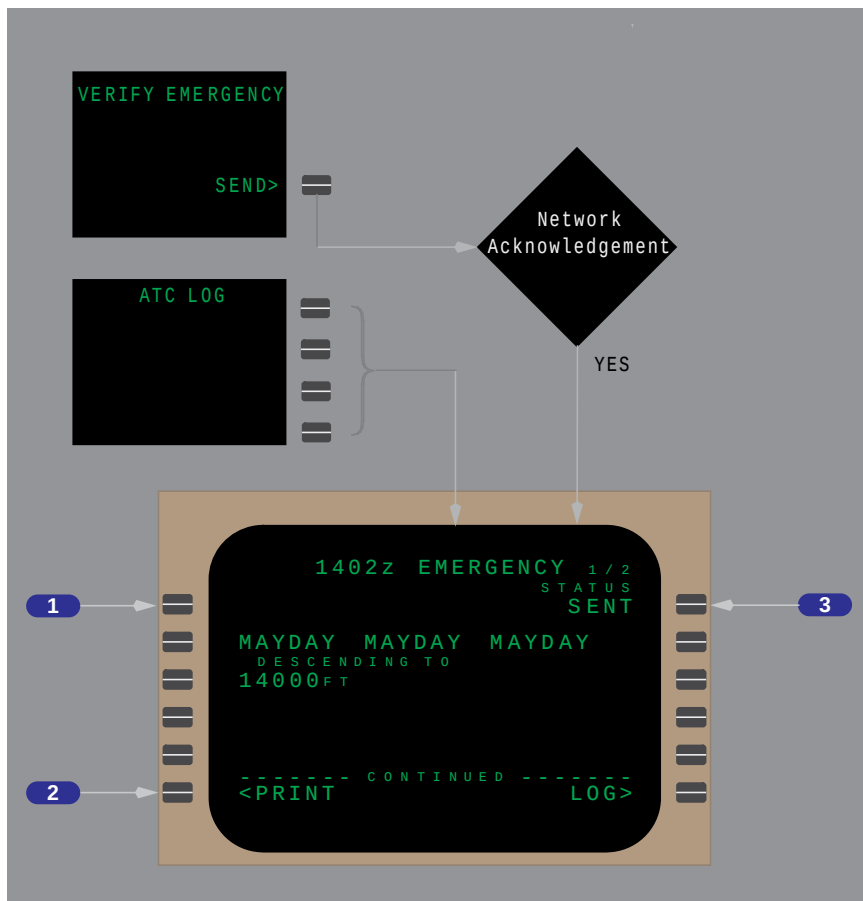
Push -

- sends CANCEL EMERGENCY message
- deactivates ADS emergency mode
- creates ATC LOG entry of transmitted message
- displays SENDING before network acknowledgement within time limit
- displays RESEND when no network acknowledgement within time limit
- displays SEND upon network acknowledgment

- displays NO ATC COMM when datalink READY and no ATC connection
- displays DATA LINK header and NO ATC COMM, VOICE, or FAIL as appropriate for datalink fault

XXXXz Emergency Page X/X

XXXXz EMERGENCY page displays the transmitted report. XXXXz is the time the report was transmitted.



1 Lines 1 - 5

Pages 1/X to X/X display message transmitted to ATC at time of page title. Line 1 is blank on page 1/X.

2 PRINT, PRINT ERROR, PRINTING, BUSY, FAIL

Displays on last XXXXz EMERGENCY page.

PRINT displayed - printer READY.

PRINT ERROR displayed - printer state ERROR.

PRINTING displayed - printing displayed page.

BUSY displayed - printing other than displayed page.

FAIL displayed - printer failed.

PRINT -

Push - prints XXXXz EMERGENCY report.

PRINT ERROR -

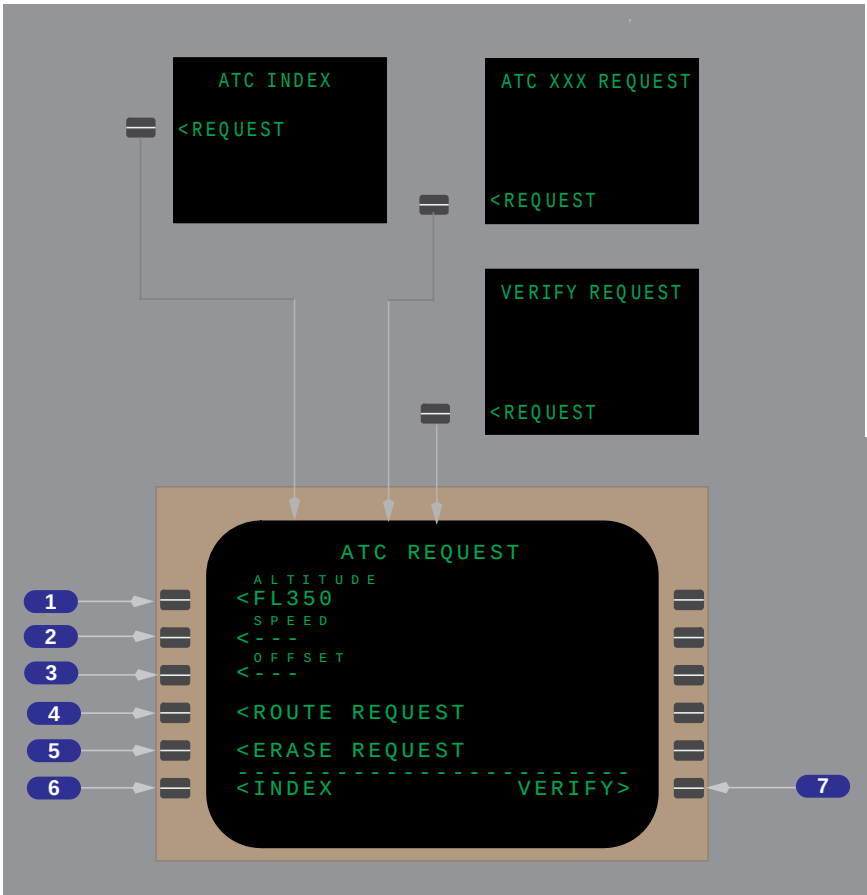
Push - prints XXXXz EMERGENCY report.

3 STATUS

Displays emergency report status from ATC LOG page.

ATC Request Page

The ATC REQUEST page allows entry of altitude, speed, and offset direction and distance requests.



1 ALTITUDE

Initially displays dashes.

Valid entries are XXX of FLXXX (flight level), XXXXX (feet), XXXXXM (meters), XXXXX/XXXXX, FLXXX/FLXXX, or XXXXXM/XXXXXM.

Entry may be deleted.

Push -

- with altitude/flight level entered, displays ATC ALT REQUEST page with altitude/flight level on altitude line
- with dashes displayed, displays ATC ALT REQUEST page with dashes on altitude line.

2 SPEED

Initially displays dashes.

Valid entry is IAS (100-380 inclusive) or Mach (.61 - .91 inclusive).

Entry may be deleted.

Push -

- with speed/Mach entered, displays ATC SPEED REQUEST page with speed/Mach on speed line
- with dashes displayed, displays ATC SPEED REQUEST page with dashes on speed line.

3 OFFSET

Initially displays dashes.

Valid entry format denotes offset left, right, or either side and the offset distance: LXX, RXX, or XX for either side (where XX is any number between 0 and 99 nautical miles).

Entry may be deleted.

Push -

- with offset entered, displays ATC OFFSET REQUEST page with offset on offset line
- with dashes displayed, displays blank ATC OFFSET REQUEST page.

4 ROUTE REQUEST

Push - displays ATC ROUTE REQUEST page.

5 ERASE REQUEST

Push - erases all entered or selected data and any of the four ATC REQUEST pages.

6 INDEX

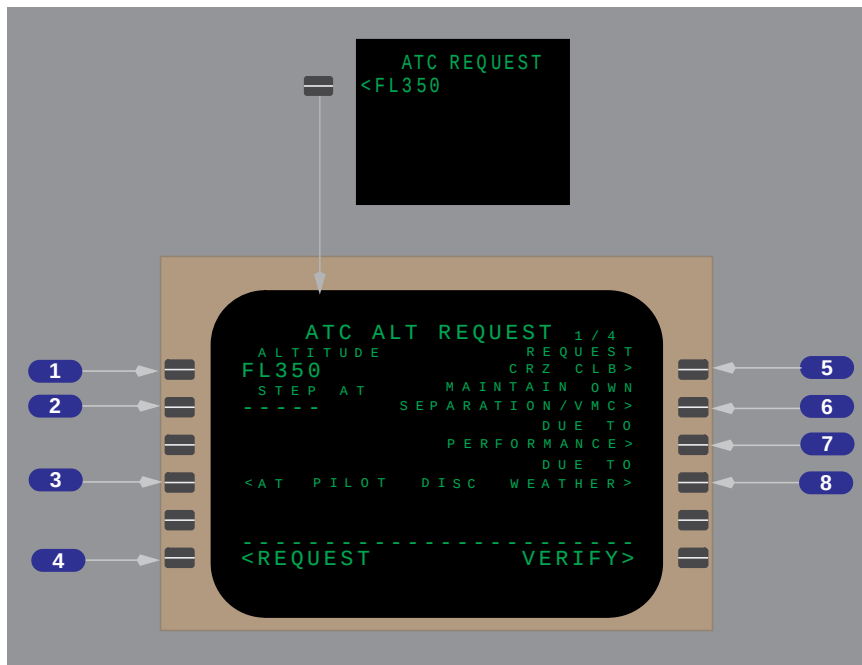
Push - displays ATC INDEX page.

7 VERIFY

Push - displays VERIFY REQUEST page.

ATC Altitude Request Page 1/4

The ATC ALT REQUEST page 1/4 allows downlink requests for altitude changes.



1 ALTITUDE

Initially displays dashes or altitude requested on ATC REQUEST page.

Valid entries are XXX or FLXXX (flight level), XXXXX (feet), XXXXXM (meters), XXXXX/XXXXX, FLXXX/FLXXX, or XXXXXM/XXXXXM.

Entry selects a message requesting a level altitude, climb or descend based on current altitude.

Altitude may be deleted.

2 STEP AT

Initially displays dashes.

Valid entries are: fix name, navaid, airport, latitude-longitude, place bearing/distance, or time.

Entry of a position or time with an altitude request selects a message requesting a step up or down at a specified time based on current altitude.

Entry may be deleted.

3 AT PILOT Discretion (DISC)

Push - displays AT PILOTS DISCRETION in large font and selects as message element.

Selection may be deleted.

4 REQUEST

Push - displays ATC REQUEST page.

5 REQUEST Cruise Climb (CRZ CLB)

Push - displays CRZ CLB in large font and selects message requesting cruise climb to entered altitude.

Selection may be deleted.

6 MAINTAIN OWN SEPARATION/VMC

Push - displays SEPARATION/VMC in large font and selects MAINTAIN OWN SEPARATION/VMC message element.

Selection may be deleted.

7 DUE TO PERFORMANCE

Push - displays PERFORMANCE in large font and selects DUE TO PERFORMANCE message element.

Selection may be deleted.

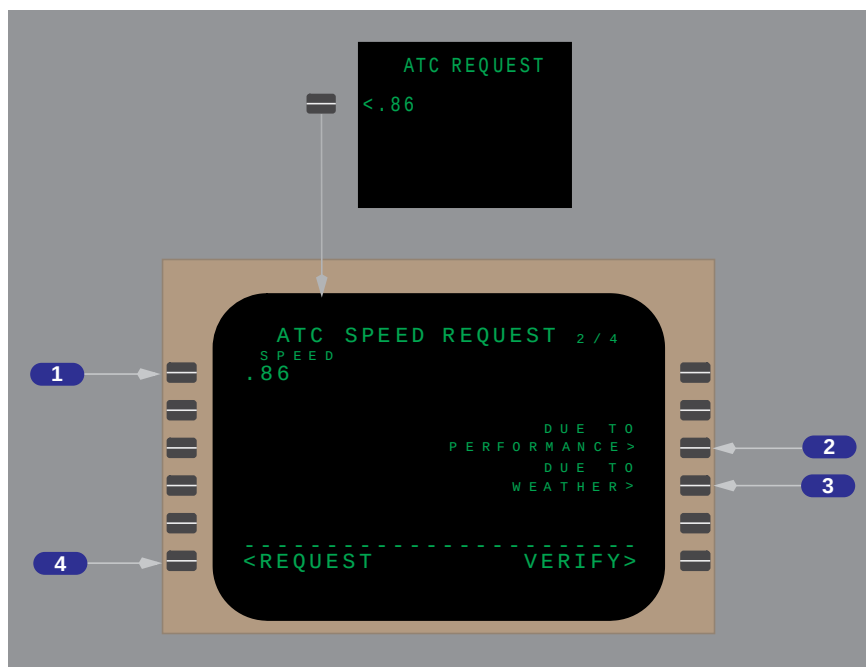
8 DUE TO WEATHER

Push - displays WEATHER in large font and selects DUE TO WEATHER message element.

Selection may be deleted.

ATC Speed Request Page 2/4

The ATC SPEED REQUEST page 2/4 allows downlink requests for speed changes.



1 SPEED

Initially displays dashes or speed/Mach requested on ATC REQUEST page.

Valid entry is IAS or Mach.

Entry selects a message requesting the speed or Mach

Entry may be deleted.

2 DUE TO PERFORMANCE

Push - displays PERFORMANCE in large font and selects DUE TO PERFORMANCE message element.

Selection may be deleted.

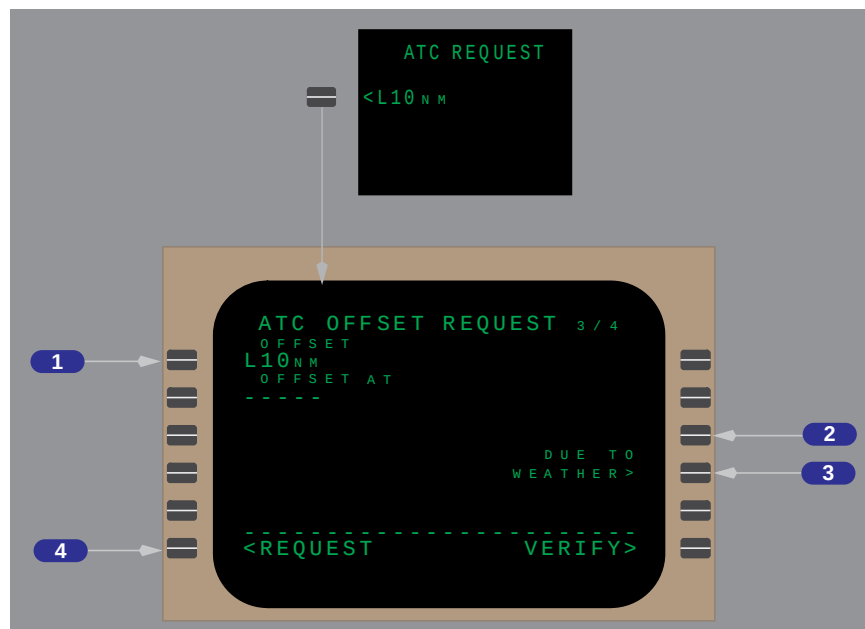
3 DUE TO WEATHER

Push - displays WEATHER in large font and selects DUE TO WEATHER as message element.

Selection may be deleted.

ATC Offset Requested Page 3/4

The ATC OFFSET REQUEST page 3/4 allows downlink requests for later offsets.



1 OFFSET

Initially displays dashes or offset requested on ATC REQUEST page.

Valid entry format denotes offset left, right, or either side and the offset distance: LXX, RXX, or XX for either side (where XX is any number between 0 and 99 nautical miles). A valid entry creates a message requesting the offset.

Entry selects a message requesting an offset from the active route.

Entry may be deleted.

2 OFFSET AT

Entry of a position or time with an offset request selects a message requesting an offset at the specified position or time.

Valid entries are: fix name, navaid, airport, latitude-longitude, place bearing/distance, or time.

Entry may be deleted.

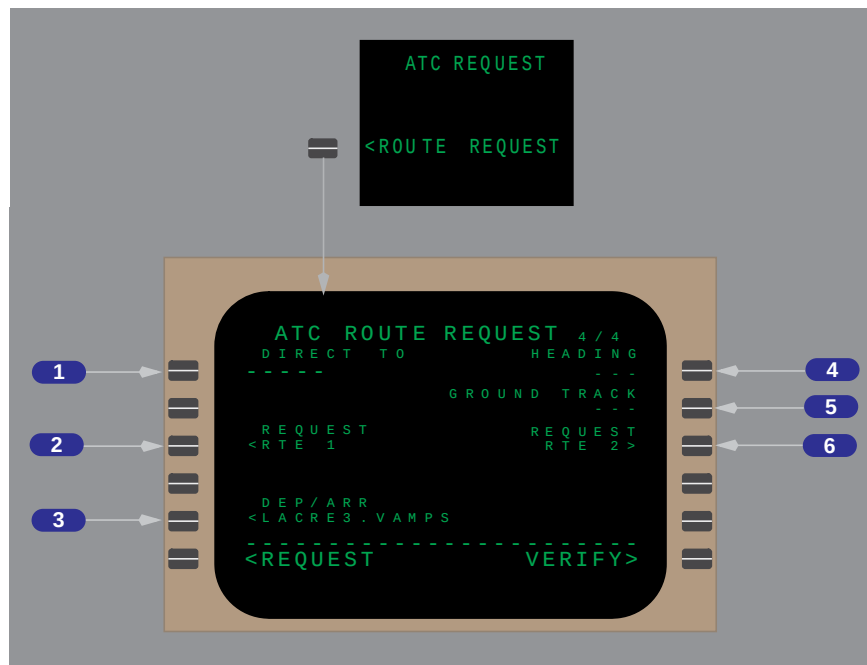
3 DUE TO WEATHER

Push - displays WEATHER in large font and selects REQUEST WEATHER
DEVIATION UP TO entered as message element.

Selection may be deleted.

ATC Route Request Page 4/4

The ATC ROUTE REQUEST page 4/4 allows downlink requests for route changes.



1 DIRECT TO

Entry selects a message requesting a clearance direct to the position.

Valid entries are: fix name, navaid, airport, latitude-longitude, place bearing/distance, or time.

Entry may be deleted.

2 REQUEST Route 1 (RTE 1)

Push - selects route stored in RTE 1 for route request. When RTE 1 has a pending modification, the modified route is requested.

Selection may be deleted.

3 Departure/Arrival/Transition (DEP/ARR)

Initially displays dashes or selections made on DEPP/ARR page.

Valid entry is departure or arrival, or departure or arrival and transition.

Entry may be deleted.

Push - displays selected entry in large font and selects a message element requesting the selected entry.

4 HEADING

Entry selects a message requesting the specified heading.

Valid entry is XXX (heading).

Entry may be deleted.

5 GROUND TRACK

Entry selects a message requesting the specified ground track.

Valid entry is XXX (ground track).

Entry may be deleted.

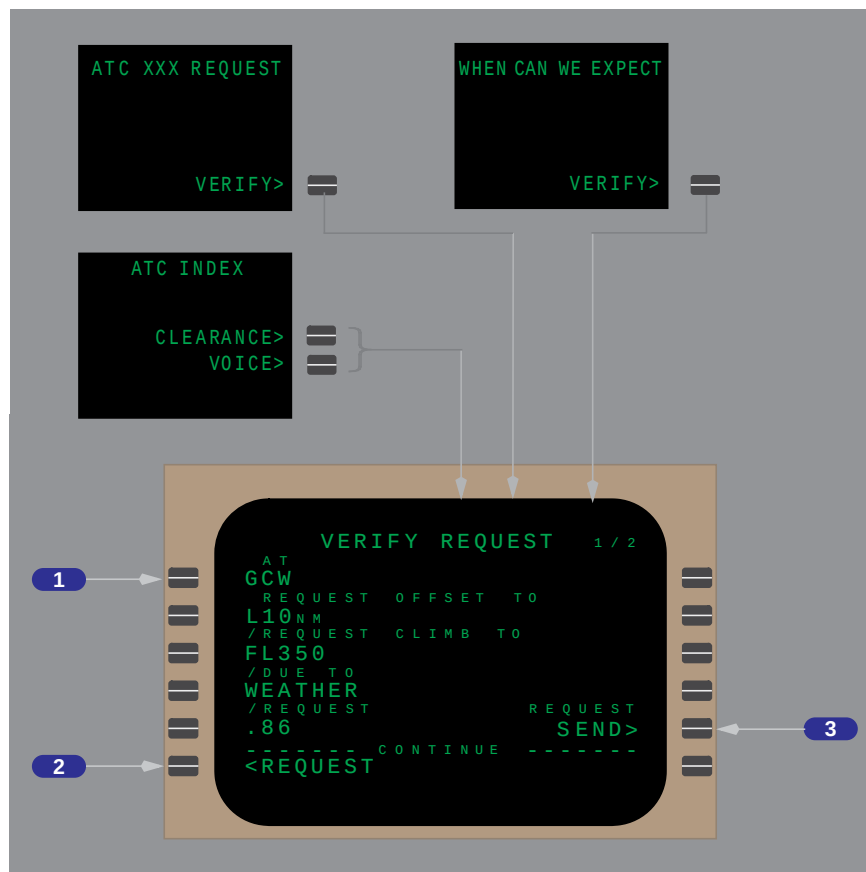
6 REQUEST Route 2 (RTE 2)

Push - selects route stored in RTE 2 for route request. When RTE 2 has a pending modification, the modified route is requested.

Selection may be deleted.

Verify Request Page X/X

The VERIFY REQUEST pages display the request for review before it is sent.



1 Lines 1-5

Pages 1/X to X/X display data which reflect the request and provide at least one line for free text entry.

Any entered free text included in downlink request.

2 REQUEST, INDEX, WHEN CAN WE

Displays REQUEST when page accessed from ATC REQUEST page.

Displays INDEX when page accessed from ATC INDEX page.

Displays WHEN CAN WE when page accessed from WHEN CAN WE EXPECT page.

REQUEST -

Push - displays ATC REQUEST page.

INDEX -

Push - displays ATC INDEX page.

WHEN CAN WE -

Push - displays WHEN CAN WE REQUEST page.

3 REQUEST SEND

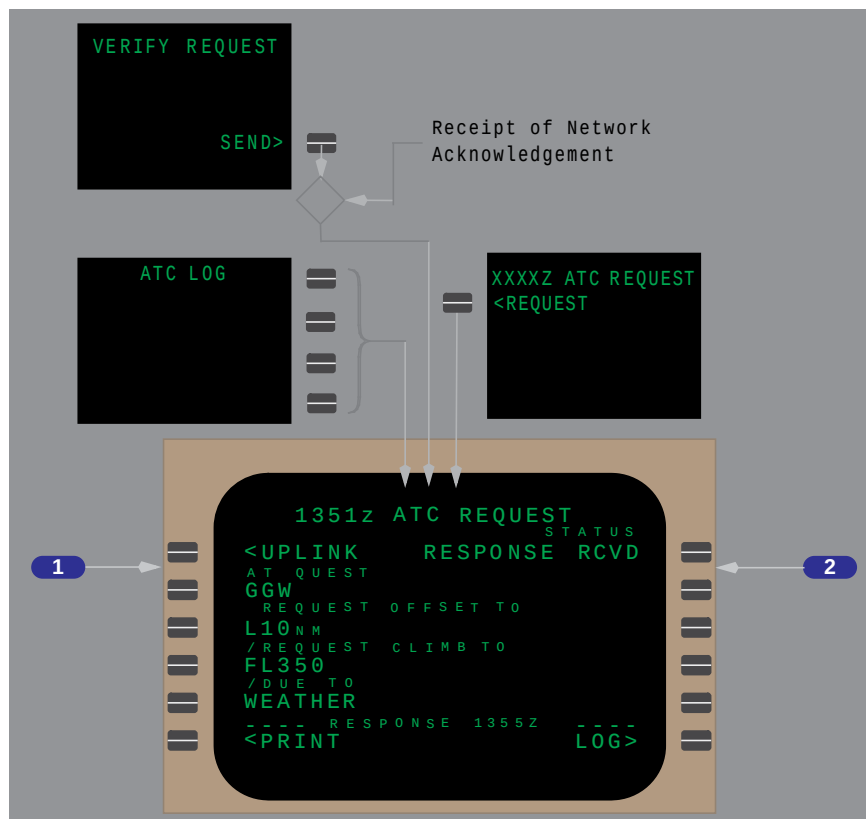
Displays on last VERIFY REQUEST page.

Push -

- initiates ATC request containing the information displayed on the VERIFY REQUEST page
- creates ATC LOG entry of transmitted message
- displays SENDING before network acknowledgement within time limit
- displays RESEND when no network acknowledgement within time limit
- displays SEND upon network acknowledgement
- displays NO ATC COM when datalink READY and no ATC connection
- displays DATA LINK header and NO COMM, VOICE, or FAIL as appropriate for datalink fault.

XXXXz ATC Request Page X/X

The ATC REQUEST pages display the transmitted request. XXXXz is the time request was transmitted.



1 Lines 1-5

Pages 1/X to X/X display data transmitted to ATC at the time in page title.

Page 1/X line 1 displays UPLINK when ATC response to displayed downlink request exists.

Response time of ATC uplink displays following text.

UPLINK -

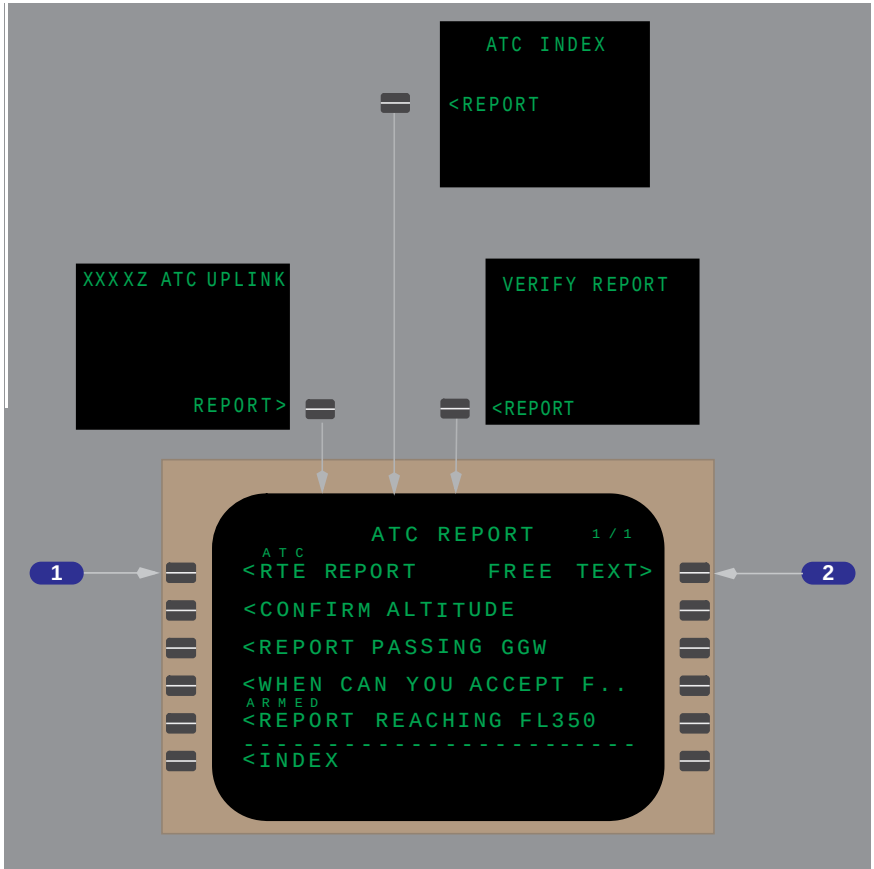
Push - displays the XXXXz ATC UPLINK 1/X page displaying ATC uplink to displayed request.

2 STATUS

Displays request downlink message from ATC LOG page.

ATC Report Page X/X

The ATC REPORT pages provide access to VERIFY REPORT pages for ATC RTE REPORT and ATC request reports and confirmations.



1 Lines 1-5

Pages 1/X to X/X lines 1 to 5 uplinked report or confirmation requests transmitted by ATC. Long messages are abbreviated and followed by two periods.

Page 1/X line 1 displays ATC RTE REPORT.

Title displays ARMED when report armed for automatic transmission.

ATC RTE REPORT -

Push - displays VERIFY REPORT page for the ATC RTE REPORT.

Report or confirmation request -

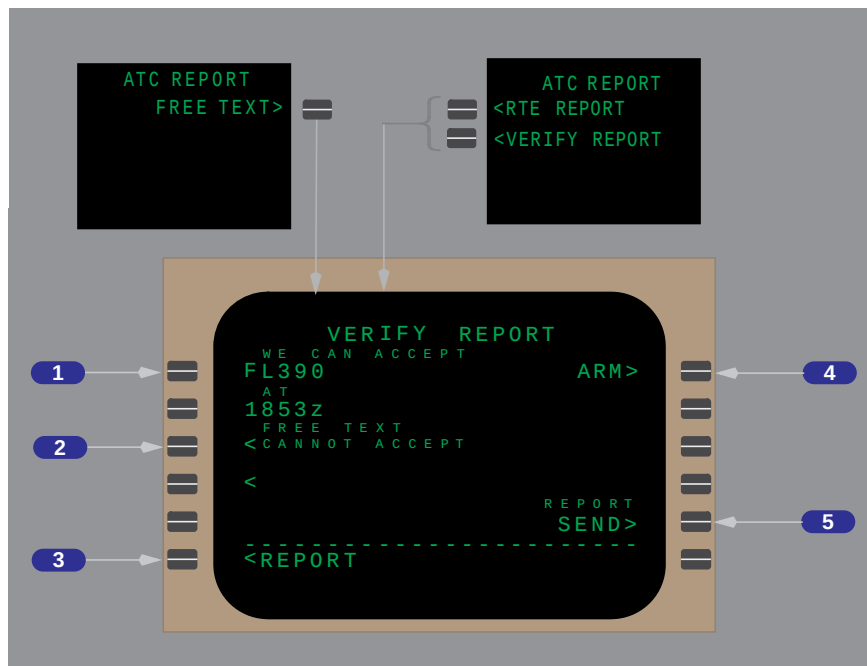
Push - displays ATC requested report or confirmation VERIFY REPORT page.

2 FREE TEXT

Push - displays a clear VERIFY REPORT page.

Verify Report Page

The VERIFY REPORT page displays reports in clearance language and allows review/modification and entry of free text before report is sent.



1 Lines 1-4

Display message text and data for each message.

Display boxes for pilot entry.

Entry includes data in report message.

Entry may be deleted.

At least one line is available for free text entry.

2 CANNOT ACCEPT

Displays in response to WHEN CAN YOU ACCEPT uplinks.

Push - selects a CANNOT ACCEPT message.

Selection may be deleted.

3 REPORT

Push - displays ATC REPORT page.

4 ARM

Push -

- arms report for transmission when condition is satisfied
- displays ARMED
- ARMED may be deleted.

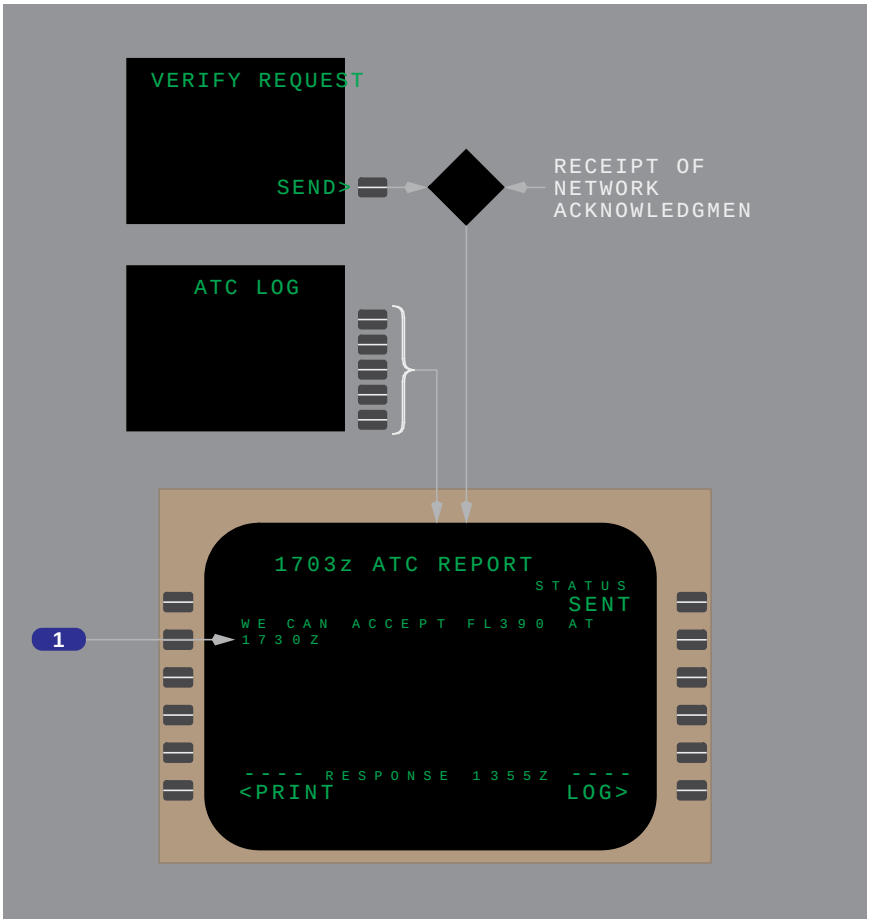
5 SEND

Push -

- transmits ATC REPORT
- creates ATC LOG entry of transmitted message
- displays SENDING before network acknowledgement within time limit
- displays RESEND when no network acknowledgement within time limit
- displays SENT upon network acknowledgement
- displays NO ATC COMM when datalink READY and no ATC connection
- displays DATA LINK header and NO COMM, VOICE, or FAIL as appropriate for datalink fault.

XXXXz ATC Report Page

The ATC REPORT page displays the text of the report downlinked to ATC.

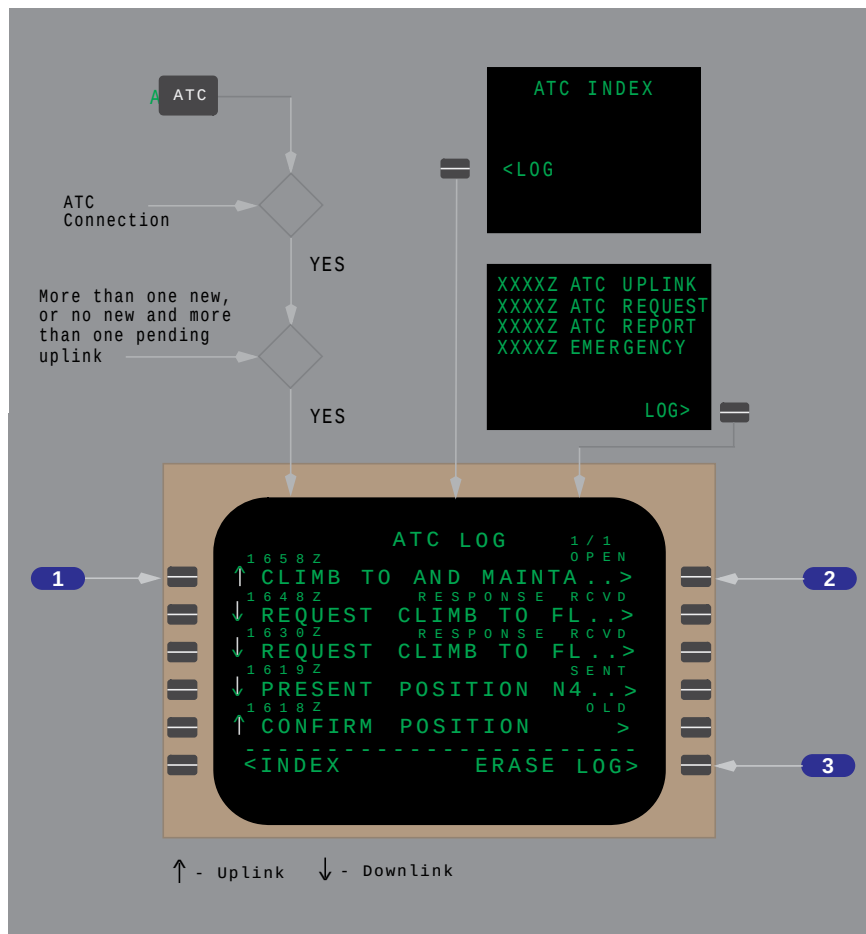


1 Report Text Lines 2-5

The text of the transmitted report or confirmation displays in Lines 2-5 in the order in which they have been displayed on the VERIFY REPORT page.

ATC Log Page X/X

The ATC LOG pages display stored uplinks and downlinks. Log automatically erases after flight completion.



1 Lines 1-5

Display text of uplink and downlink messages. Long messages abbreviated and followed by two periods.

Deleting a line deletes the log entry.

Title displays message receipt (uplink) or transmission (downlink) time.

2 Message Status

Title displays one of six possible uplink or seven possible downlink states:

Uplink -

- NEW - message not reviewed by crew; message considered pending
- OLD - message reviewed by crew and message does not require a response; message considered non-pending
- OPEN - message reviewed by crew, message requires response, crew has not sent response or has sent STANDBY; message considered pending
- ACCEPTED - message reviewed by crew, message requires response sent, network acknowledgement of positive response received; message considered non-pending
- REJECTED - message reviewed by crew, message requires response, negative response sent, network acknowledgement of negative response received; message considered non-pending
- ABORTED - message pending when all terminations terminated or transfer of communications occurred.

Downlink -

- SENDING - SEND or RESEND prompt selected, network acknowledgement not yet received, message considered pending. Displays SENDING in field 5R on page downlink was initiated
- NO ACK - SEND or RESEND prompt selected, network acknowledgement not received within time-out period; message considered non-pending. Displays SENDING in field 5R on page downlink was initiated
- SENT - SEND or RESEND prompt selected, network acknowledgement received, message does not require response; message considered non-pending
- OPEN - SEND or RESEND prompt selected, network acknowledgement received, message requires response, response not received or STANDBY response received, message considered pending
- DEFERRED - SEND or RESEND prompt selected, network acknowledgement received, message requires response, REQUEST DEFERRED response received; message considered pending
- RESPONSE RCVD - SEND or RESEND prompt selected, network acknowledgement received, message requires response, response other than STANDBY or REQUEST DEFERRED received; message considered non-pending
- ABORTED - message pending when all connections terminated.

Push - displays XXXXz: ATC UPLINK, ATC REQUEST, ATC REPORT, or EMERGENCY page related to line selected

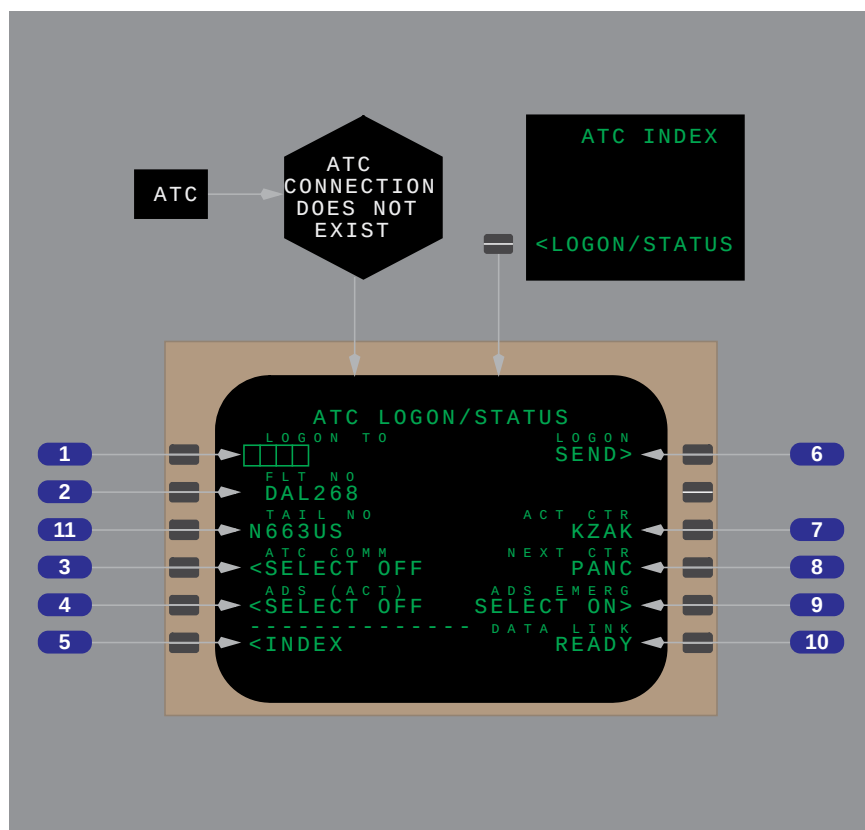
3 Erase Log

Push -

- arms deletion of all non-pending messages in the ATC Log
- displays CONFIRM
- selection of CONFIRM deletes all non-pending messages in the ATC log
- leaving the ATC Log page when CONFIRM is displayed cancels the ERASE selection

ATC Logon/Status Page

The ATC LOGON/STATUS page is used to initiate an ATC connection. The page displays ADS, ATC DL, and datalink status.



1 LOGON TO

Initial display is boxes.

Valid entry is a four letter ATC identifier.

Entry of an identifier and a flight number displays send in 1R when datalink status is ready.

Deletion of identifier displays boxes and blanks SEND.

Displays dashes when ATC COMM established.

2 Flight Number (FLT NO)

Displays flight number route page.

Valid entry is flight number.

Display clears at flight completion.

3 ATC COMM

Display is blank when no ATC connection exists.

Displays SELECT OFF when ATC connection exists.

Push - terminates active ATC DL connection and next if it exists.

4 ADS (ARM), (ACT), (OFF)

ADS (ARM) -

- ADS on and no ADS connection exists.
- Displays SELECT OFF prompt.

Push -

- no ADS reporting
- displays ADS (OFF)
- displays ADS SELECT ARM prompt.

ADS (ACT) -

- ADS armed and one or more ADS connection exists
- displays SELECT OFF prompt.

Push -

- terminates all ADS connections and ADS reporting
- displays ADS (OFF)
- displays ADS SELECT ARM prompt.

ADS (OFF)

- ADS selected off
- displays ADS SELECT ARM prompt.

Push -

- arms ADS reporting
- displays SELECT OFF prompt.

5 INDEX

Push - displays ATC INDEX page.

6 LOGON SEND

Push -

- sends logon message to ATC center
- displays SENDING before network acknowledgement received
- displays SENT after network acknowledgement received
- displays RESEND if no network acknowledgement within time limit
- displays ACCEPTED or REJECTED after ATC response.

7 Active Center (ACT CTR)

Displays four character identifier of active ATC center.

8 Next Center (NEXT CTR)

Displays four character identifier of next ATC center when known; otherwise, blank.

9 ADS Emergency (EMER)

Displays SELECT ON when ADS not in emergency mode.

Displays SELECT OFF when ADS in emergency mode.

Display is blank when ADS selected off.

SELECT ON -

Push - initiates ADS emergency mode.

SELECT OFF - Push - terminates ADS emergency mode.

10 DATA LINK Status

Displays status: READY, NO COMM, VOICE, or FAIL.

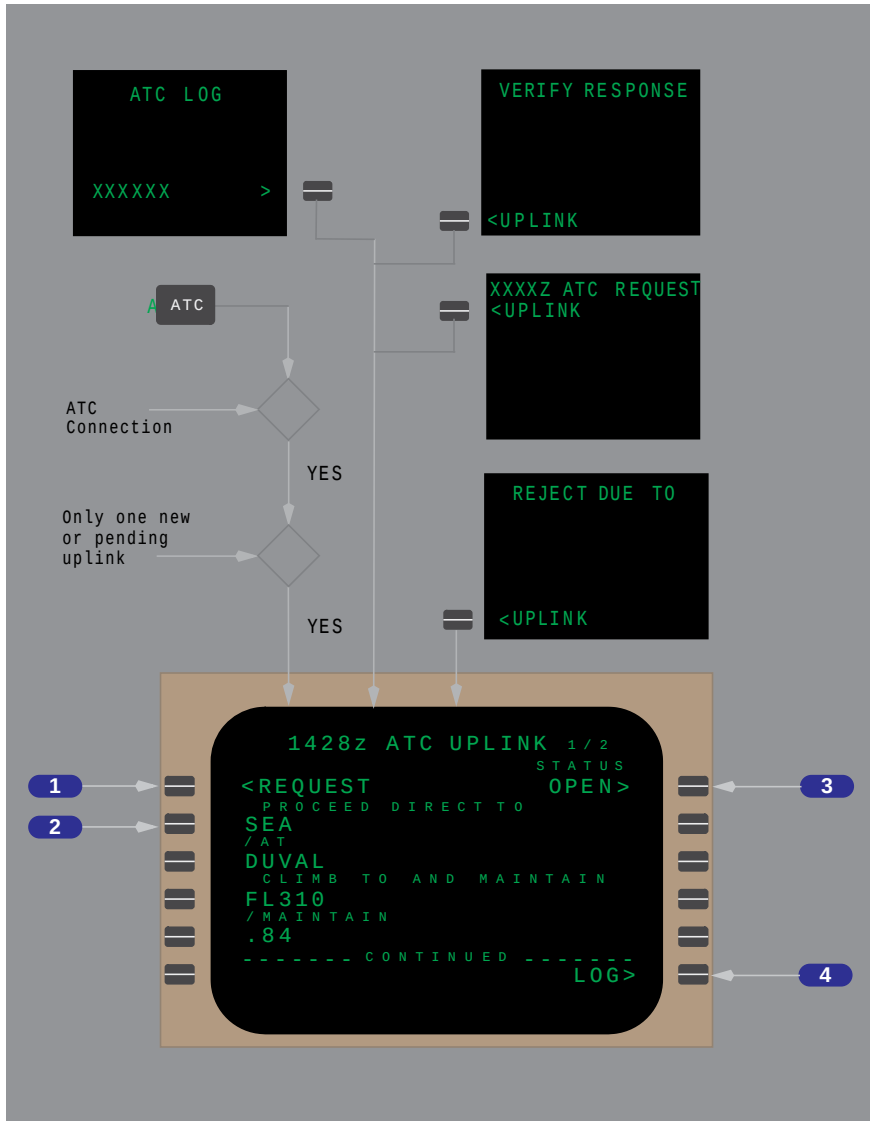
11 Tail Number

Displays tail number (registration number) stored in FMC.

Valid entry is one to seven alphanumeric tail number characters shown on the flight deck placard.

XXXXz ATC Uplink Page 1/X

The ATC UPLINK pages display messages uplinked by ATC. The pages provide the capability to respond to uplinked messages and to load clearances.



1 REQUEST

Displays REQUEST when displayed uplink is on response to a downlink request not deleted from the ATC log

Push - displays the related XXXZ ATC REQUEST page.

Title displays message receipt (uplink) or transmission (downlink) time.

2 Message Text

Lines 2 to 5 of XXXXz ATC Uplink page 1/X display text of uplinked ATC message. When the uplink message cannot be fully displayed on lines 2 to 5, the message can be printed to review the full message.

3 STATUS

Displays (on first page only) status of ATC uplink message from ATC log page.

4 LOG, REPORT

Displays LOG when uplink message does not include a REPORT, CONFIRM, or WHEN CAN YOU ACCEPT request.

Displays REPORT when uplink message includes a REPORT, CONFIRM or WHEN CAN YOU ACCEPT request.

LOG -

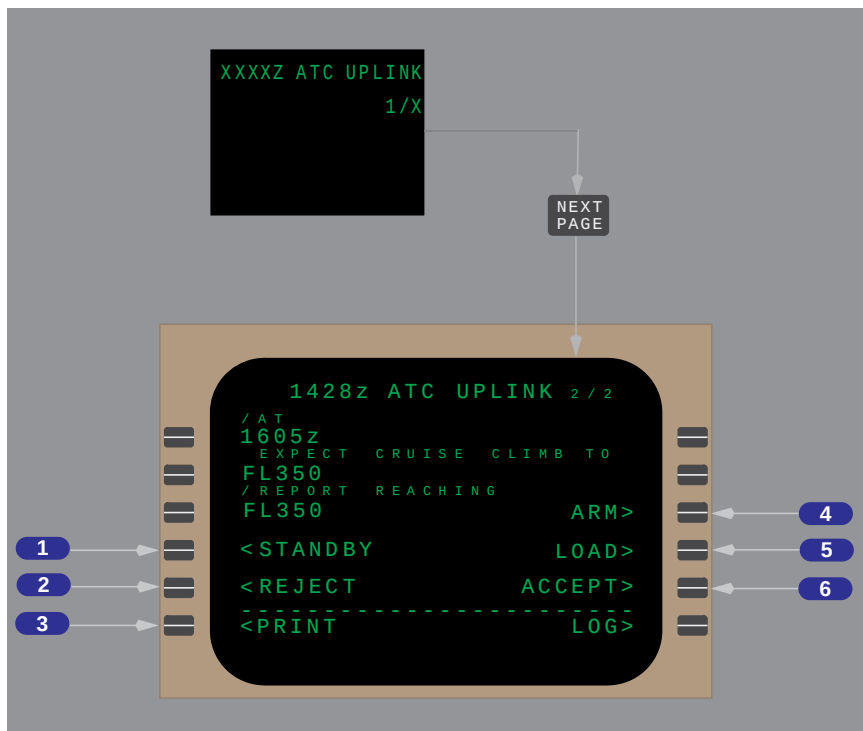
Push - displays ATC LOG page.

REPORT -

Push - displays ATC REPORT page.

XXXXz ATC Uplink Page X/X

Last XXXXz ATC UPLINK page continues text of uplinked ATC message. Page provides capability to respond to uplinked messages and to load clearances.



1 STANDBY

Displays STANDBY when response is required until response has been made.

Push - displays VERIFY RESPONSE page with STANDBY in 1L.

2 REJECT

Displays REJECT when UNABLE or NEGATIVE is a valid response until response has been made.

Push - displays REJECT DUE TO page,

3 PRINT, PRINTERERROR, PRINTING, BUSY, FAIL

Displays on last page.

PRINT displayed - printer is READY.

PRINTERERROR displayed - printer state is ERROR.

PRINTING displayed - printing displayed page.

BUSY displayed - printing other than displayed page.

FAIL displayed - printer is failed.

PRINT -

Push - prints XXXZ ATC UPLINK text.

PRINT ERROR -

Push - prints XXXXZ ATC UPLINK text

4 ARM, ARMED

Displays ARM when report is armable.

Push -

- arms report for transmission
- displays ARMED
- deleting ARMED displays ARM and disarms report transmission

5 LOAD

Displays LOAD when uplink message has loadable data.

Push - loads data into route.

6 ACCEPT

Displays ACCEPT when WILCO, ROGER, or AFFIRM is a valid response until response has been made.

Push - displays VERIFY RESPONSE page with WILCO, ROGER, AFFIRM in 1L.

Reject Due To Page

The REJECT DUE TO page is used to include a reason for rejection of an ATC UPLINK message.



1 DUE TO PERFORMANCE

Initially displays PERFORMANCE in small font.

Push - selects DUE TO AIRCRAFT PERFORMANCE message element in response downlink message.

2 FREE TEXT

Text entered in lines 2 to 4 are included in response message.

Initial display is blank with a caret.

3 UPLINK

Push - displays XXXXz ATC UPLINK page.

4 DUE TO WEATHER

Initially displays WEATHER in small font.

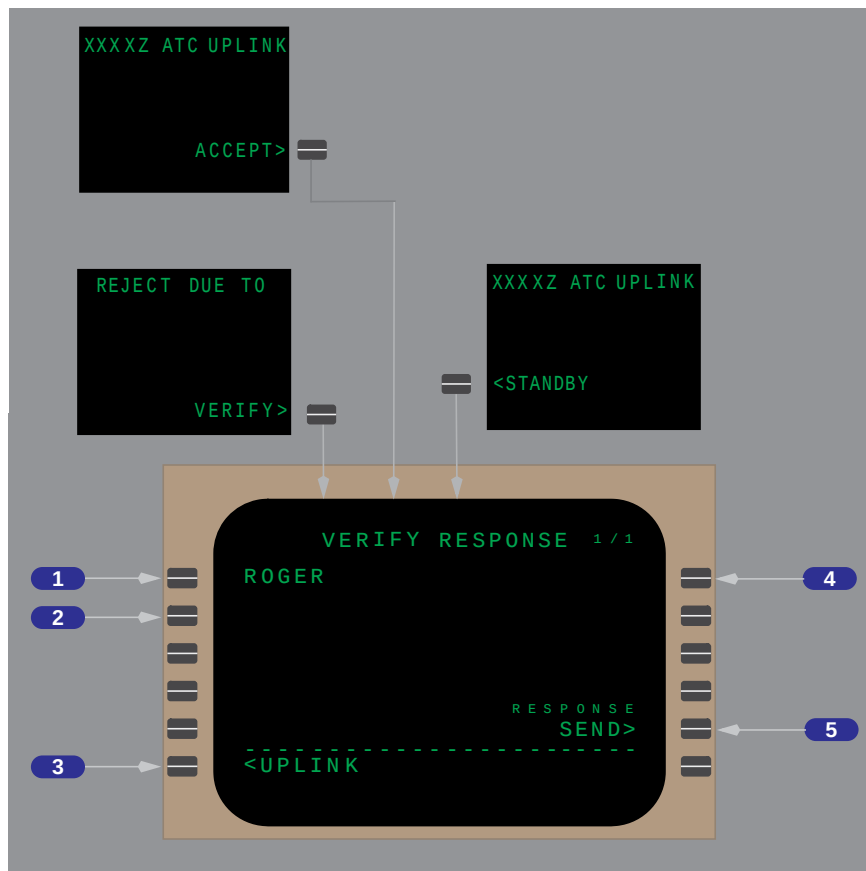
Push - selects DUE TO WEATHER message element in response downlink message.

5 VERIFY

Push - displays VERIFY RESPONSE.

Verify Response Page

The VERIFY RESPONSE page provides capability to respond to uplinked messages.



1 ROGER, WILCO, AFFIRM, UNABLE, NEGATIVE, STANDBY

Displays ROGER, WILCO, or AFFIRM, as appropriate, when ACCEPT is selected on XXXXz ATC UPLINK page.

Displays UNABLE or NEGATIVE, as appropriate, when VERIFY is selected on REJECT DUE TO page.

Displays STANDBY when STANDBY selected on XXXXz ATC UPLINK page.

2 Lines 2-4

Display free text from REJECT DUE TO page.

3 UPLINK, REJECT DUE TO

Displays UPLINK when 1L is ROGER, WILCO, AFFIRM, or STANDBY.

Displays REJECT DUE TO when 1L is UNABLE or NEGATIVE.

UPLINK -

Push - displays XXXXz ATC UPLINK page.

REJECT DUE TO -

Push - displays REJECT DUE TO page.

4 STATUS ACCEPTED

Displays STATUS ACCEPTED when ATC acknowledges receipt of message.

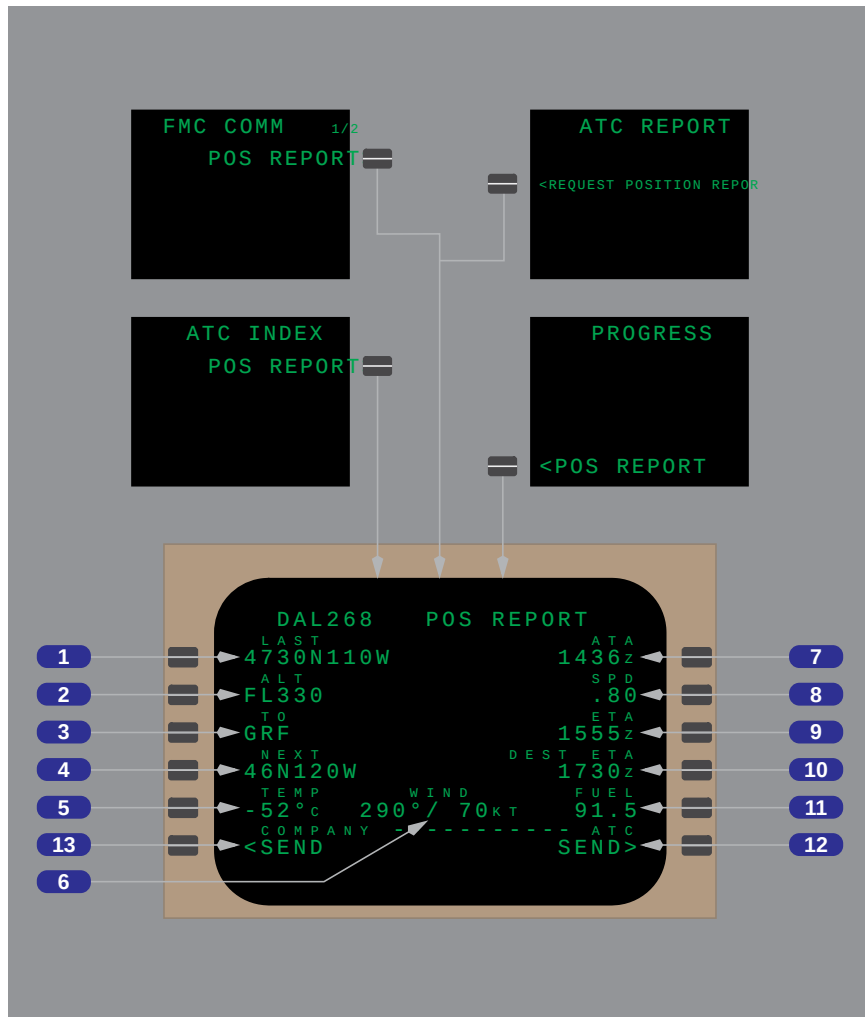
5 RESPONSE SEND

Push -

- transmits downlink response to ATC uplink message
- creates ATC LOG entry of transmitted message
- displays SENDING
- displays RESEND when no network acknowledgement within time limit
- displays SEND upon network acknowledgment
- displays NO ATC COMM when datalink READY and no ATC connection
- displays DATA LINK header and NO COMM, VOICE, or FAIL as appropriate for datalink fault.

XXXX Position Report Page

The XXXX POS REPORT page allows review and sending of position report to company and/or ATC. Entered data is sent to ATC only. XXXX is the flight number.



1 LAST Waypoint

Displays waypoint identifier for last sequenced leg.

2 Altitude (ATL)

Displays current altitude.

3 TO Waypoint

Displays waypoint identifier of current leg.

Valid entries are waypoint identifiers in the active flight plan.

Entry overrides displayed waypoint.

Deletion of entry returns current leg waypoint

4 NEXT Waypoint

Displays waypoint identifier of leg following the TO leg.

Valid entries are waypoint identifiers in the active flight plan.

Entry overrides displayed waypoint.

Deletion of entry returns default waypoint.

6 WIND

Displays current wind direction and magnitude.

7 Actual Time of Arrival (ATA)

Displays ATA at last sequenced waypoint.

8 Speed (SPD)

Displays current Mach.

Valid entry is airspeed or Mach; "xx".

Entry overrides displayed Mach.

Deletion or page change returns default Mach.

9 Estimated Time of Arrival (ETA)

Displays ETA at TO waypoint.

Valid entry is XXXXz.

Entry overrides displayed time.

Deletion of entry returns default time.

10 Destination Estimated Time of Arrival (DEST ETA)

Displays ETA at destination.

Valid entry is XXXXz.

Entry overrides displayed time.

Deletion of entry returns default time.

11 FUEL

Displays lesser of calculated or totalizer fuel remaining at LAST waypoint.

12 ATC SEND

Push -

- sends downlink position report to ATC
- creates ATC LOG entry of transmitted message
- displays SENDING before network acknowledgement within time limit
- displays RESEND when no network acknowledgement within time limit
- displays SENT upon network acknowledgement
- reset to SEND (from SENDING or SENT) when TO waypoint sequenced or flight plan modification made which changes the TO waypoint
- displays NO ATC COMM when datalink READY and no ATC connection
- displays DATA LINK header and NO COMM, VOICE, or FAIL as appropriate for datalink fault.

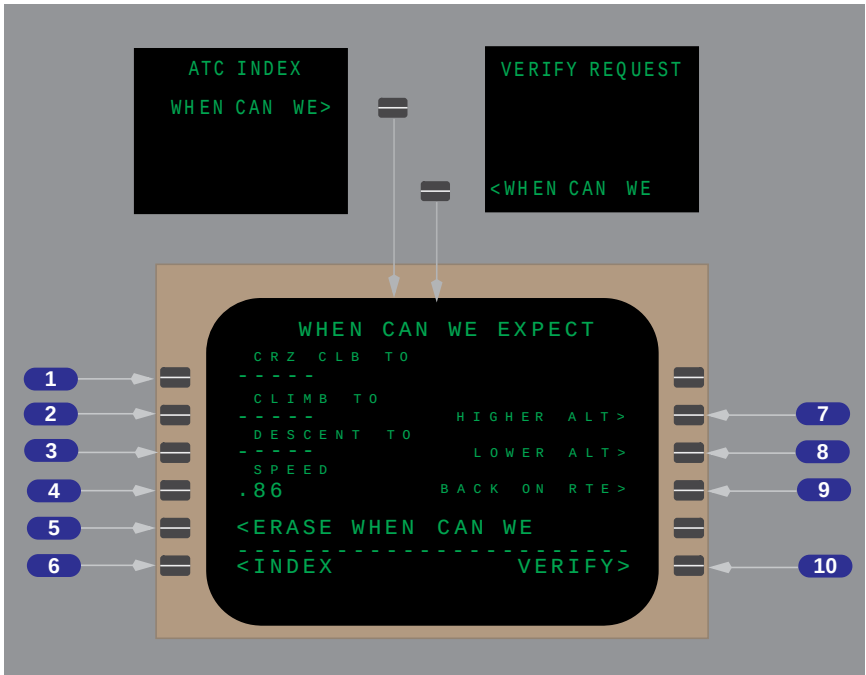
13 COMPANY SEND

Push -

- sends downlink position report to company
- default values are used for TO, NEXT, SPD, and ETA
- creates ATC LOG entry of transmitted message
- displays SENDING before network acknowledgement within time limit
- displays SEND when no network acknowledgement
- displays SENDSENT upon network acknowledgement
- displays DATA LINK header and NO COMM, VOICE, or FAIL as appropriate for datalink fault.

When Can We Expect Page

The WHEN CAN WE EXPECT page allows query to ATC about when to expect a certain clearance.



1 Cruise Climb To (CRZ CLB TO)

Entry of an altitude selects a message querying ATC when to expect a cruise climb to the entered altitude.

Valid entry is XXX or FLXXX (flight level), XXXXX (feet), or XXXXXM (meters).

Entry may be deleted.

2 CLIMB TO

Entry of an altitude selects a message querying ATC when to expect a climb to the entered altitude.

Valid entry is XXX or FLXXX (flight level), XXXXX (feet), or XXXXXM (meters).

Entry may be deleted.

3 DESCENT TO

Entry of an altitude selects a message querying ATC when to expect a descent to the entered altitude.

Valid entry is XXX or FLXXX (flight level), XXXXX (feet), or XXXXXm (meters).

Entry may be deleted.

4 SPEED

Entry of a speed selects a message querying ATC when to expect the entered speed.

Valid entry is IAS or Mach.

Entry may be deleted.

5 ERASE WHEN CAN WE

Push - erases all entered or selected data and returns default values.

6 INDEX

Push - displays ATC INDEX page.

7 HIGHER Altitude (ALT)

Push - selects a message querying ATC when to expect a higher altitude.

Selection may be deleted.

8 LOWER Altitude (ALT)

Push - selects a message querying ATC when to expect a lower altitude.

Selection may be deleted.

9 BACK ON Route (RTE)

Push - selects a message querying ATC when to expect to be cleared back on route.

Selection may be deleted.

10 VERIFY

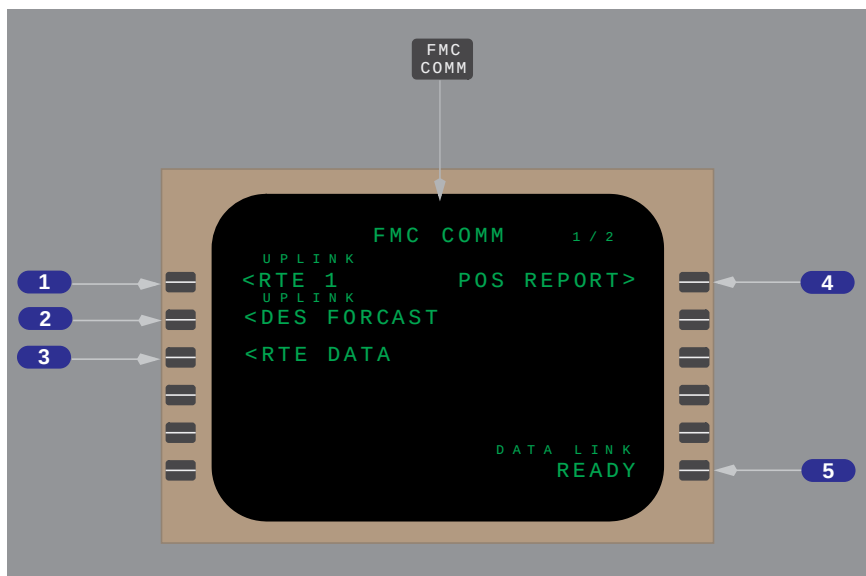
Push - displays VERIFY REQUEST page.

Company Datalink

The airplane communication system enables two-way datalink communications between the FMC and airline operations. A downlink occurs when data is transferred from the FMC and transmitted through the airplane communications system to a receiver on the ground. Data may be downlinked from the FMC either manually or automatically. An uplink is the opposite of a downlink; data is transmitted from a ground station for input to the FMC. Data may be uplinked at the discretion of the airline operations dispatcher or in response to a downlink request.

FMC Communications Page 1/2

FMC COMM page 1/2 provides access to pages used for company datalink functions.



1 UPLINK Route (RTE)

Displays UPLINK in line title when an uplink containing flight plan information has been received.

Push - displays ROUTE page.

2 UPLINK Descent (DES) FORECAST

Displays UPLINK in line title when an uplink containing descent forecast data has been received.

Push - displays DESCENT FORECAST page.

3 Route (RTE) DATA

Display is blank when there is no active route.

Displays UPLINK in line title when an uplink containing route wind information has been received.

Push - displays ROUTE DATA page.

4 Position (POS) REPORT

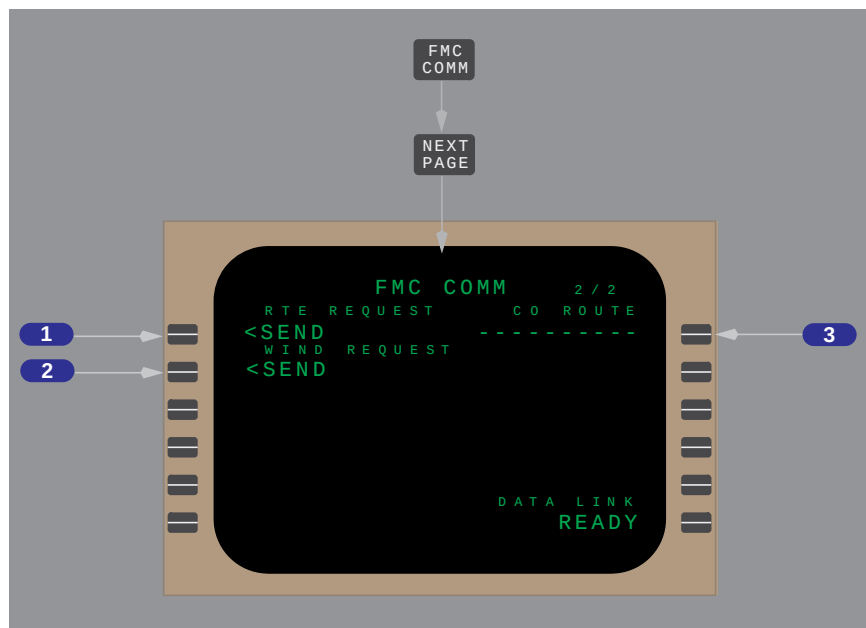
Push - displays POS REPORT page.

5 DATA LINK

Displays datalink status: READY, NO COMM, VOICE, or FAIL.

FMC Communications Page 2/2

FMC COMM page 2/2 allows writing a downlink request for flight plan information or wind data.



1 Route (RTE) REQUEST

Push -

- initiates downlink request for flight plan information
- when company route identifier displayed, the request includes the company route
- displays SENDING
- after network acknowledgement, displays SENDsent.

2 WIND REQUEST

Push -

- initiates downlink request for wind information and descent forecast data
- displays SENDING
- after network acknowledgement, displays SENDsent.

3 Company (CO) ROUTE

Not Used At Delta Air Lines

Valid entry is a company route request identifier. The identifier need not be in the navigation database.

Deletion invalidates company route request and resets downlink request status to SEND.

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Blank

Flight Management, Navigation EICAS Messages

The following EICAS messages can display.

EICAS Alert Messages

Message	Level	Aural	Message Logic
FMC LEFT, RIGHT	Advisory		Affected FMC has failed.
>FMC MESSAGE	Advisory		High priority FMC message exists.
>GPS	Advisory		Dual GPS failure.
>GPS LEFT, RIGHT	Advisory		GPS sensor fault.
ILS ANTENNA	Caution	Beeper	Glide slope or localizer antenna fails to switch.
IRS CENTER, LEFT, RIGHT	Advisory		IRU fault detected.
>IRS AC CENTER, LEFT, RIGHT	Advisory		IRU AC power failure.
>IRS DC CENTER, LEFT, RIGHT	Advisory		IRU backup DC power failure.
IRS MOTION	Advisory		Excessive airplane motion detected during alignment.
>SNGL SOURCE ILS	Caution	Beeper	Both pilots' displays referenced to the same localizer or glideslope receiver.

Message	Level	Aural	Message Logic
>TRANSPONDER L, R	Advisory		Affected ATC transponder has failed.
UNABLE RNP	Advisory		Navigation performance does not meet required accuracy during navigation phases other than approach. Inhibited in polar region.
UNABLE RNP	Caution	Beeper	Navigation performance does not meet required accuracy during navigation approach phase. Inhibited in polar region.

EICAS Memo Messages

Message	Message Logic
IRS ALIGN MODE C, L, R	IRS in align mode. Message no longer displayed when all IRUs enter navigation mode.
ATC MESSAGE	ATC uplinked message received.
HF DATA OFF	Selected HF radio in voice mode and not available for ACARS data communication.
PRINTER MESSAGE	ACARS message printing.
VHF DATA OFF	VHF C radios in voice mode are not available for ACARS data communication.

FMC Messages

FMC messages indicate degraded system operation or data input errors. The messages are categorized as alert messages and advisory messages.

FMC messages also indicate data link status.

The scratchpad messages display according to their level of importance. A less important message replaces another message in the scratchpad when the CLEAR key is pushed or the condition is corrected.

FMC alert messages display the EICAS message FMC MESSAGE. All FMC messages illuminate the CDU message (MSG) light. Pushing the CLEAR key or correcting the condition cancels the message.

FMC Alert Messages

ATC COMM ESTABLISHED - ATC COMM available or control passed to a new ATC center.

ATC COMM TERMINATED - ATC datalink is terminated.

ATC MSG NOT ACKNOWLEDGED - ATC message has been transmitted and no network acknowledgement is received.

ATC REPORT LIST FULL - nine reports have been generated and are awaiting transmission and a tenth report request has been received.

CHECK ALT TGT - VNAV activates when airplane between MCP and FMC target altitudes. VNAV maintains level flight.

CYCLE IRS OFF-NAV - IRS align problem requires cycling IRS mode switch OFF, then back to NAV.

DESCENT PATH DELETED - VNAV active and all waypoint altitude constraints defining descent path deleted.

DES FORECAST UPLINK READY - receipt of an uplink message containing descent forecast data which passes error checks and is ready to be loaded on the DESCENT FORECAST page.

DISCONTINUITY - LNAV active and airplane enters route discontinuity. AFDS maintains last heading.

DRAW REQUIRED - VNAV active and additional drag required or autothrottle off and less thrust required to maintain descent path.

END OF OFFSET - LNAV active and 5 NM prior to end of active route offset. AFDS maintains last heading if active route offset overflown.

END OF ROUTE - LNAV active and end of active route overflown. AFDS maintains last heading.

ENTER IRS POSITION - the flight crew-entered present position did not pass an IRS comparison check or the IRS is ready to enter the navigation mode and a present position has not been entered.

FLT NUMBER UPLINK - receipt of an uplink message containing flight number data which passes error checks and is inserted in the flight plan.

FMC L/R OUTPUT DATA LOSS - some information used by systems other than the FMS is not available.

FUEL DISAGREE - PROG 2 - fuel totalizer and calculated values disagree by 9,000 pounds or more. This may indicate an engine fuel leak.

ILS TUNE INHIBITED - MCP - flight control computers inhibiting changes in ILS tuning, and either a manual operation in the ILS tuning field attempted or a new arrival ILS approach activated.

INSUFFICIENT FUEL - estimated fuel at destination less than entered RESERVES value. This may indicate an engine fuel leak.

IRS NAV ONLY - FMC navigating without continuous radio updating.

IRS ONLY - FMS in IRS only mode for navigation.

INVALID ATC UPLINK - ATC uplink message received by FMC contains format or other errors. FMC rejects the uplink and sends a downlink response to ATC center.

INVALID FLT NO UPLINK - receipt of an uplink message containing route data, which is at least partially loaded, and flight number data which fails error checks and is rejected or upon receipt of an uplink message containing only flight number data which fails error checks and is rejected. FMC sends a downlink response rejecting the message and explaining why.

INVALID FORECAST UPLINK - receipt of an uplink message containing only descent forecast data in which all data fails error checks and is rejected, or receipt of an uplink message containing waypoint wind data which is loaded into the flight plan and descent forecast data in which all data fails error check and is rejected. FMC sends a downlink response rejecting the message and explaining why.

INVALID ROUTE UPLINK - receipt of an uplink message containing route data which fails error checks and is rejected. FMC sends a downlink response rejecting the message and explaining why.

INVALID WIND DATA UPLINK - receipt of an uplink message in which all waypoint wind data is invalid and cannot be loaded into the flight plan. FMC sends a downlink response rejecting the message and explaining why.

IRS POS/ORIGIN DISAGREE - valid IRS position differs from active origin airport.

LIMIT ALT FLXXX - VNAV active and cruise altitude greater than VNAV limit altitude.

MESSAGE LIMIT EXCEEDED - attempted selection of a sixth request of an ATC request.

NAV DATA OUT OF DATE - clock calendar date exceeds navigation data base valid (active) calendar cycle.

NAV INVALID-TUNE AAA (AAA = required navaid) - signals not received from navaid required for approach procedure.

NO ACTIVE ROUTE - LNAV selected, but no active route activated.

PARTIAL CLEARANCE LOADED - FMC was able to load only a portion of the loadable data in an uplink message. If pilot unable to determine which portion of the clearance did not load, REJECT the corresponding uplink message.

PARTIAL ROUTE X UPLINK - receipt of a flight plan uplink message containing route data errors which do not cause total rejection, and part of the route data has been loaded into RTE 1 or RTE 2, as appropriate. FMC sends a downlink response rejecting the message and explaining why.

PERF/VNAV UNAVAILABLE - VNAV selected without gross weight, cost index, or cruise altitude entered.

PURGE UPDATES - POS 2 - incorrect FMC position results in raw radio data being rejected due to DME reasonableness checks.

RE-LOGON TO ATC COMM - ATC LOGON message was sent from the airplane and ATC did not respond within the required time, or ATC sent a negative response or, an error occurs which causes ATC center in communication to be disconnected without ATC COMM transferring to another ATC center.

RESET MCP ALT - two minutes prior to T/D point with VNAV active and MCP not set to altitude below cruise altitude.

RESYNC FAIL - SINGLE FMC - resynchronization is unsuccessful and one FMC has shutdown.

RESPOND TO ATC UPLNIKS - ATC uplink received and causes storage to be full or uplink received when storage is full.

RESYNCING OTHER FMC - FMC synchronization in progress.

ROUTE X UPLINK LOADING - uplinked (company or ATC DL) route data being loaded into RTE 1 or RTE 2, as appropriate; or uplink message containing route data being loaded into RTE 1 or RTE 2, as appropriate, and a CDU button is pushed.

ROUTE X UPLINK READY - receipt of a flight plan uplink message that contains route data which has passed error checks and is ready to be loaded into RTE 1 or RTE 2, as appropriate.

RTA FIX DELETED - RTA fix has been deleted from the modified flight plan.

RW/ ILS FREQ ERROR - selected ILS frequency does not match the frequency for destination runway in the active route.

RW/ILS CRS ERROR - selected ILS course does not match course for destination runway in the active route or valid course data not received.

SET CLOCK TO UTC TIME - UTC from GPS is more than 12 seconds different from captain's (or FO's if captain's failed) flight deck clock.

SINGLE FMC OPERATION - one FMC data not available.

SPLIT IRS OPERATION - FMCs have selected single IRU position updating while operating in polar latitudes or with significant position or velocity differences.

THRUST REQUIRED - VNAV active, autothrottle disconnected, and additional thrust required to track descent path and maintain speed.

UNABLE FLXXX AT RTA FIX - Predicted crossing altitude at the RTA fix is less than FLXXX, but the predicted ETA is still within the tolerance.

UNABLE NEXT ALT - VNAV active and climb not sufficient to comply with waypoint altitude constraint.

UNABLE RTA - RTA is not achievable within the acceptable arrival time tolerance.

UNABLE TO LOAD CLEARANCE - FMC unable to load any of the loadable data in an uplink message.

UNABLE TO SEND MESSAGE - transmission of a downlink message has been initiated and cannot be delivered to the ACARS MU.

VERIFY POSITION - computed radio and FMC positions or left and right FMC positions differ.

VERIFY RNP - POS REF 2 - RNP option is selected in the APF, the default (based on phase of flight) RNP changes, and the manually entered RNP exceeds the new default RNP value.

VERIFY TAIL NUMBER - the entered tail number disagrees with the tail number contained in the FMC database.

WIND DATA UPLINK READY - receipt of an uplink message containing waypoint wind data which passes error checks and is ready to be loaded into RTE DATA page.

FMC Advisory Messages

ARR N/A FOR RUNWAY - runway/approach selected not compatible with arrival selected.

CRS REVERSAL AT FA FIX - entered route contains a course reversal at final approach fix and does not contain a procedure turn.

DELETE - DELETE key pushed.

INVALID DELETE - deletion of data displayed in selected field not allowed.

INVALID ENTRY - entry format or range is incorrect for the selected field or, the entered airway or TO waypoint does not coincide with the nav data base.

KEY/FUNCTION INOP - function selected is not available in existing FMC data base.

MAX ALT FL### - entered cruise altitude greater than performance maximum altitude.

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 active leg.

ROUTE FULL - last route modification fills FMC beyond its capacity of 120 waypoints. Last selection not entered in route.

RUNWAY N/A FOR SID - runway not compatible with SID.

STANDBY ONE - FMC requires more than four seconds to display data.

TAKEOFF SPEEDS DELETED - selected V speeds are invalid.

TIME OUT - RESELECT - communications with selected system have failed. Menu page displayed. Systems with a caret symbol are available for selection. Selecting < FMC displays last page used.

UNABLE CRZ ALT - entered cruise altitude results in climb intersecting the descent path or the time in cruise prior to top of descent less than minimum allowable.

VERIFY RNP ENTRY - RNP option selected in the APF and the manually entered RNP exceeds the default RNP value or is less than the ANP.

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Fuel

Chapter 12

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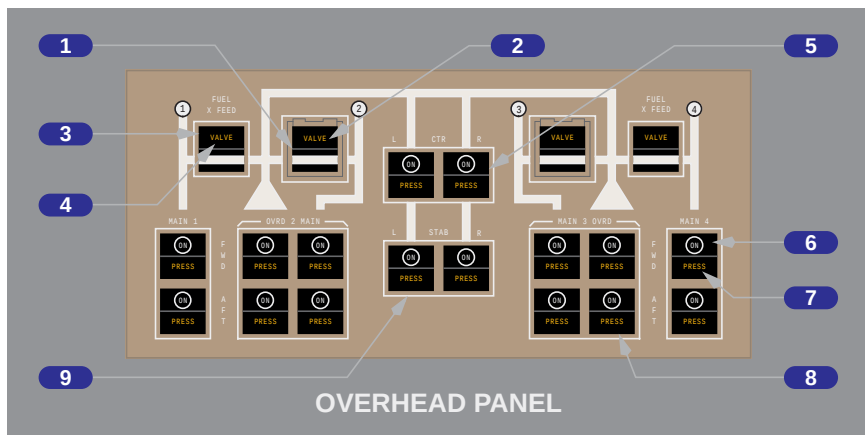
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Fuel Controls and Indicators

Chapter 12 Section 10

Fuel System



1 Crossfeed (X FEED) Valve Switches 2 and 3

ON (bar visible) - crossfeed valve opens when commanded by system logic.

ON (bar remains visible) - crossfeed valves close when airplane is on the ground and flaps are in takeoff position (flaps 10 or 20); valves open in flight after flaps are retracted to flaps 5.

Off (blank) - crossfeed valve manually closed.

2 Crossfeed VALVE Lights 2 and 3

Illuminated (amber) - crossfeed valve not in system logic commanded position.

3 Crossfeed (X FEED) Valve Switches 1 and 4

ON (bar visible) - crossfeed valve opens.

Off (blank) - crossfeed valve manually closed.

4 Crossfeed VALVE Lights 1 and 4

Illuminated (amber) - crossfeed valve position does not agree with switch position.

5 Center (CTR) Wing Tank Pump Switches

ON - fuel pump selected ON.

Off (blank) - fuel pump selected OFF.

6 MAIN Pump Switches

ON - fuel pump selected ON.

Off (blank) - fuel pump selected off.

7 Fuel Pressure (PRESS) Lights

Illuminated (amber) - fuel output pressure low.

8 Override (OVRD) Fuel Pump Switches

ON - fuel pump operates when commanded by system logic.

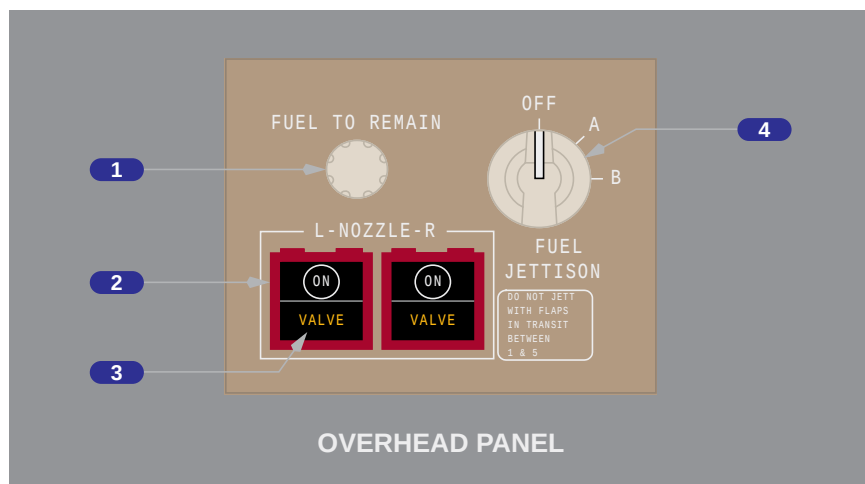
Off (blank) - fuel pump selected off.

9 Stabilizer (STAB) Tank Pump Switches

ON - fuel pump operates when commanded by system logic.

Off (blank) - fuel pump selected off.

Fuel Jettison System



1 FUEL TO REMAIN Selector

Rotate -

- selects fuel to remain after jettison
- displays value on EICAS
- fuel to remain valve replaces fuel temperature on the Primary EICAS
- minimum fuel to remain valve is 28,000 lbs

2 Fuel Jettison NOZZLE Valve Switches

ON -

- jettison nozzle valve selected open
- activates six override/jettison pumps in main tanks 2 and 3 and center tank (pumps must be ON)
- opens four jettison valves
- activates two stabilizer transfer/jettison pumps (pumps must be ON)
- arms the No. 1 and 4 main transfer valves (both open when main tank 2 or 3 reaches 20,000 lbs)

Off (blank) - jettison nozzle valve selected closed.

CAUTION: The jettison nozzle valves can be opened with the nozzle switches even though the FUEL JETTISON selector is in OFF.

3 Fuel Jettison Nozzle VALVE Lights

Illuminated (amber) - jettison nozzle valve not in selected position.

4 Fuel Jettison Selector

OFF -

- disarms jettison system
- removes EICAS fuel to remain indication

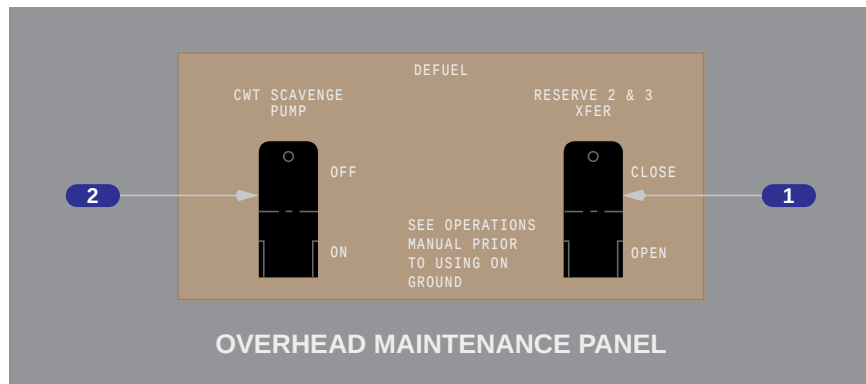
A or B -

- arms jettison system
- displays preselected fuel to remain on EICAS

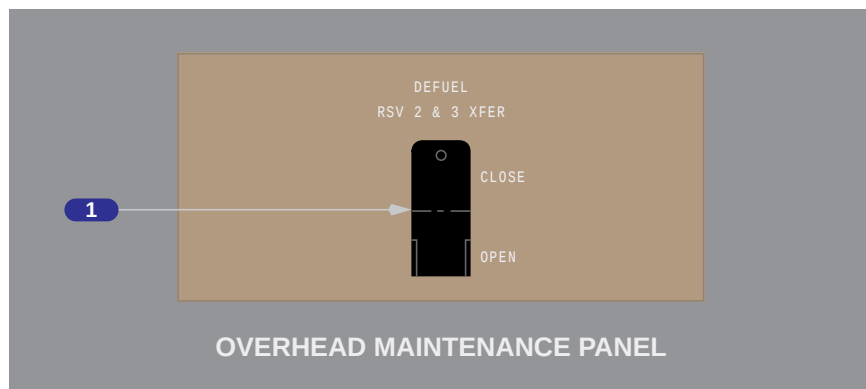
Miscellaneous Fuel Control

Defuel Panel

6301 - 6310



6311 - 6316



1 Reserve (RSV) 2 & 3 Transfer (XFER) Switch

CLOSE -

- reserve 2 and 3 transfer valves closed
- reserve 2 and 3 transfer valves open when commanded by system logic

OPEN - reserve 2 and 3 transfer valves open.

2 Center Wing Tank (CWT) SCAVENGE PUMP

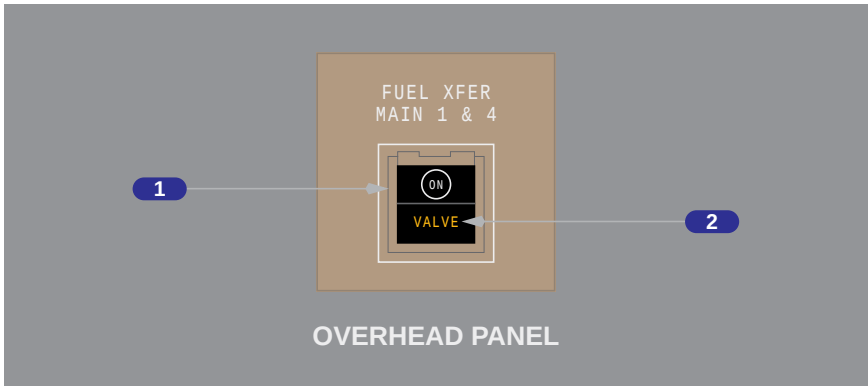
6301 - 6310

ON - pump operates.

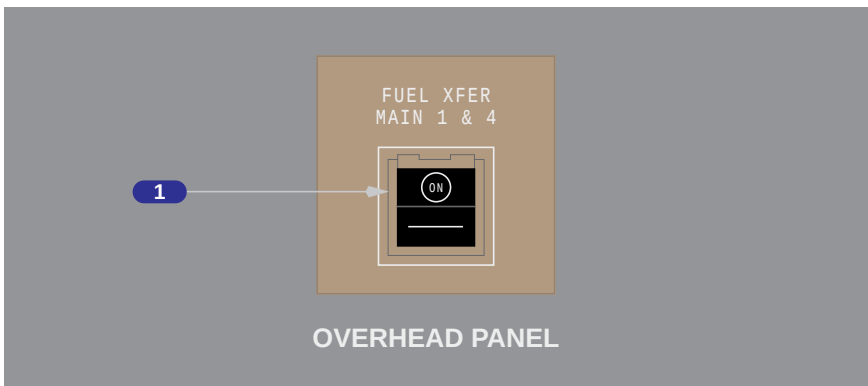
OFF - pump operates when commanded by system logic.

Fuel Transfer Main 1 & 4 Switch

6302 - 6306



6301, 6307 - 6316



1 FUEL Transfer (XFER) MAIN 1 & 4 Switch

ON - main 1 and 4 transfer valves open.

Off -

- main 1 and 4 transfer valves closed
- main 1 and 4 transfer valves open when commanded by system logic

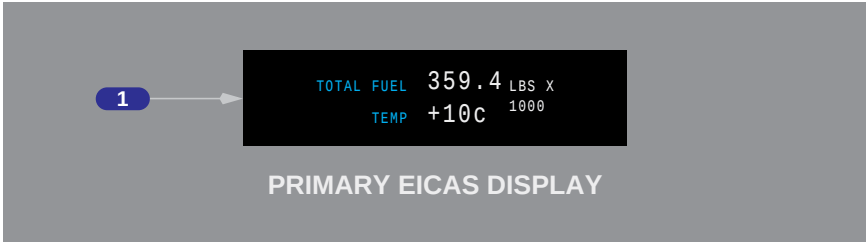
2 Transfer VALVE Light

6302 - 6306

Illuminated (amber) - main 1 and/or 4 transfer valve not in selected position.

Fuel Indications and Displays

Normal Fuel Indications



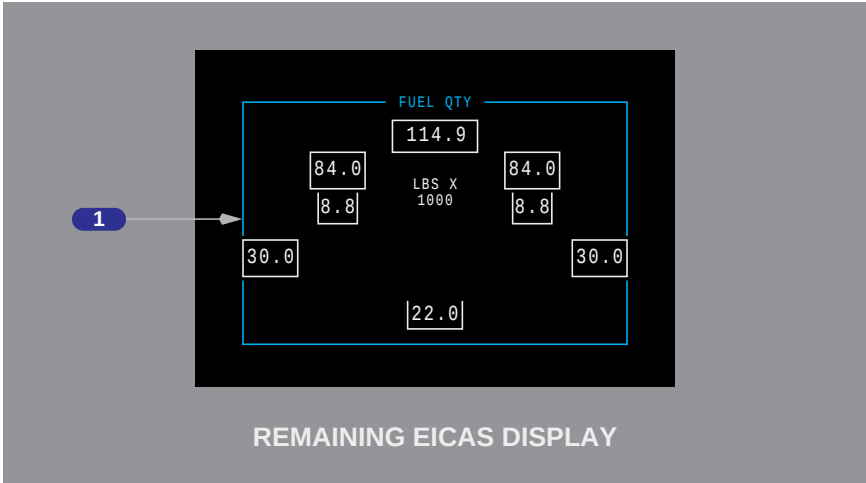
1 Normal Fuel Indications

Total fuel quantity (pounds x 1000).

Fuel temperature (degrees Celsius).

Amber - fuel temperature is -37°C and below.

Compacted Fuel Indications



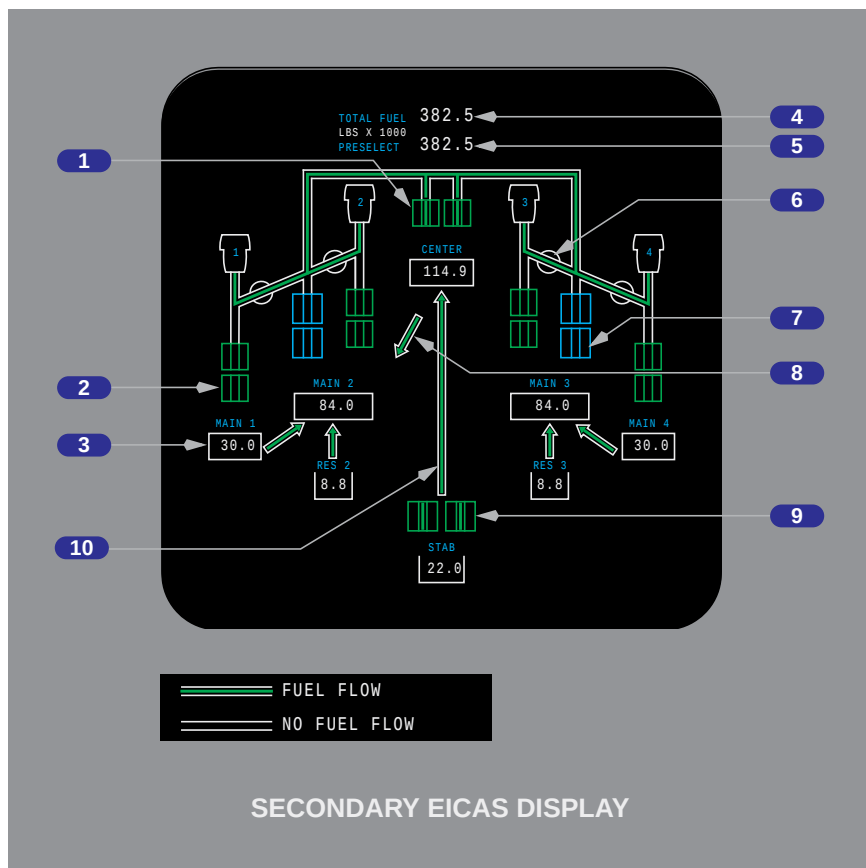
1 Compacted Fuel Indications

Compacted fuel quantity indications display on primary EICAS if only one display is available for EICAS.

Fuel Synoptic Display

The fuel synoptic is displayed by pushing the Fuel Synoptic Display switch on the display select panel. Display select panel operation is described in Chapter 10, Flight Instruments, Displays.

The fuel flow displayed is generated by displayed valve positions and pump status. It does not display actual fuel flow, therefore the display may not represent actual system operation.



1 Center Wing Tank Pump

White - pump switch off.

Green - pump on.

Amber - pump pressure low.

2 Main Pump

White - pump switch off.

Green - pump on.

Amber - pump pressure low/fuel imbalance.

3 Tank Quantity

White - indicates fuel quantity in tank.

Amber (main tank only) - imbalance condition or quantity less than 2,000 pounds.

4 Total Fuel Quantity

White - indicates total fuel quantity.

5 Preselect Fuel Quantity

White - indicates selected total fuel quantity.

Displayed during fueling. No longer displayed when wing fueling panel door closed.

6 Crossfeed Valve

White - indicates open or closed position of crossfeed valve.

Green - indicates open or closed position of crossfeed valve with fuel.

Amber - valve position disagrees with commanded position.

7 Override Pump

White - pump switch off.

Cyan - armed for system logic operation.

Green - pump on.

Amber - pump pressure low.

8 Scavenge Pump Transfer

6301 - 6310

White - pump on

Green - fuel pressure.

9 Stabilizer Tank Pump

White - pump switch off.

Cyan - armed for system logic operation.

Green - pump on.

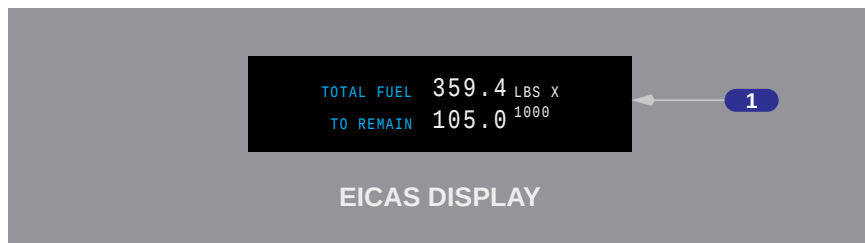
Amber - pump pressure low.

10 Stabilizer Pump Transfer

Green - pump on

Fuel Jettison Indications

Fuel Jettison Indications, Primary EICAS



1 Fuel Jettison Indications

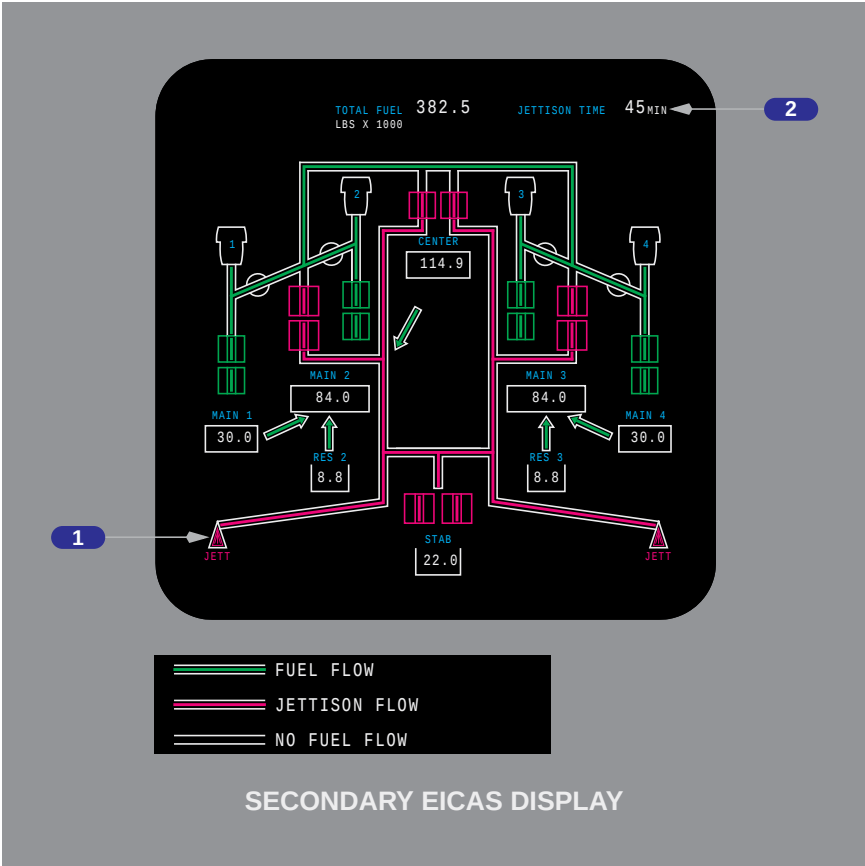
Fuel to remain replaces fuel temperature during jettison operation.

Magenta - indicates fuel to remain at completion of jettison.

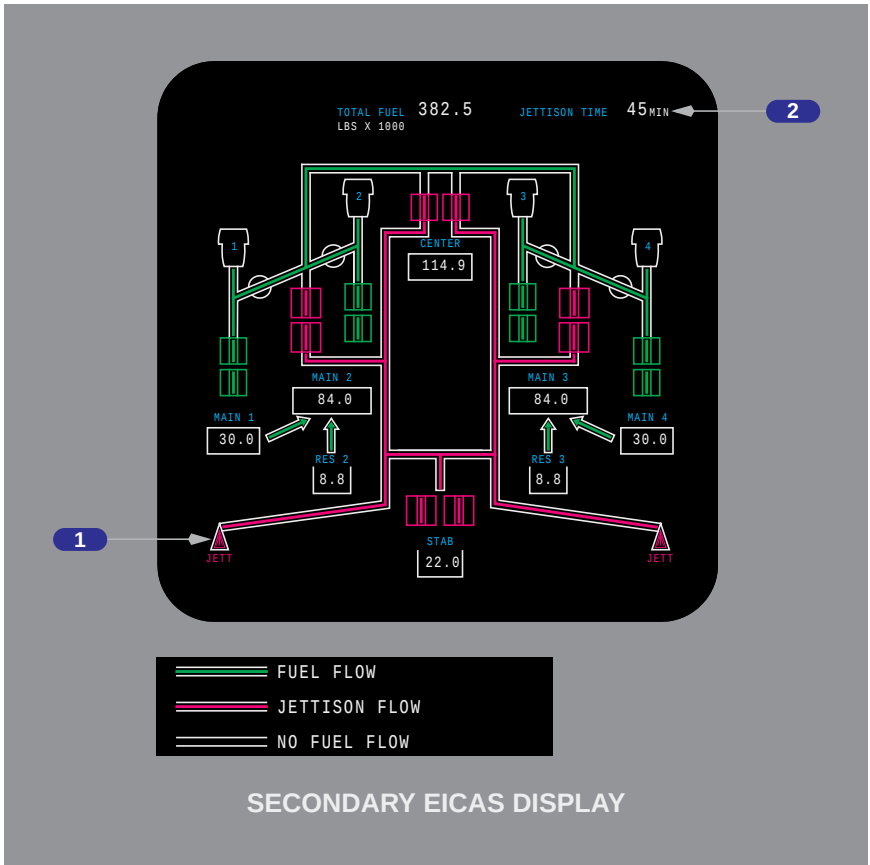
White (flashes for five seconds) - indicates jettison has completed.

Fuel Jettison Indications, Fuel Synoptic

6301 - 6310



6311 - 6316



1 Jettison Nozzle

Magenta - fuel jettison system operating.

2 Time To Complete Jettison

White - time remaining to complete jettison.

Intentionally
Blank

Fuel

System Description

Chapter 12

Section 20

Introduction

The fuel system supplies fuel to the engines and the APU. The fuel is contained in a center wing tank, main tanks 1, 2, 3, 4, reserve tanks 2 and 3, and the horizontal stabilizer tank. Surge tanks are located in the outer portion of each wing and the outer portion of the right horizontal stabilizer.

Refer to Chapter 7, Engines, APU, for a description of the engine and APU fuel systems.

Fuel Quantity

Fuel quantity is measured by sensors in each tank. Total fuel quantity is displayed on the primary EICAS and CDU PROGRESS page 2/2. Individual tank quantities and total fuel quantity display on the fuel synoptic.

Compacted fuel quantity indications display on primary EICAS if only one display is available for EICAS.

Fuel Temperature

Fuel temperature is measured in main tank 1 and displays on primary EICAS. The temperature normally displays in white. It displays in amber when fuel temperature is at or below -37°C. During jettison, the TO REMAIN quantity replaces the EICAS display fuel temperature indication.

Fuel Pumps

Each main tank contains two AC-powered fuel pumps which run continuously when selected ON. A single pump supplies sufficient fuel to operate one engine at takeoff thrust conditions or two engines at cruise thrust. Main tank 2 and main tank 3 also contain two AC-powered override/jettison pumps which can operate to a standpipe level of approximately 7,000 pounds remaining in the tank. Each override/jettison pump supplies sufficient fuel to operate two engines during takeoff and cruise conditions. The override/jettison pump's higher output pressure overrides the main pumps' output.

The two center wing tank (CWT) fuel pumps are also override/jettison pumps. Together, the CWT pumps inhibit 2 and 3 override/jettison pumps and override the main pumps so CWT fuel is used before wing tank fuel. However, one CWT pump alone does not inhibit 2 and 3 override/jettison pumps or override the outboard main pumps.

6301 - 6310

CWT fuel is scavenged by an electric pump activated by system logic at either or both of two separate instances, one when a CWT override/jettison pump has low output pressure and the other when main tank 2 or 3 fuel quantity decreases to 40,200 pounds. After each activation, the pump will operate for approximately two hours or until the scavenge pump pressure is low, whichever occurs first. The scavenged fuel is pumped into main tank 2.

6311 - 6316

CWT fuel is scavenged by four jet pumps, two pumping into each main tank 2 and 3. Scavenge begins when main tank 2 or 3 fuel quantity decreases to approximately 60,000 pounds.

The horizontal stabilizer tank contains two AC-powered transfer/jettison pumps. Each pump can transfer all fuel in the horizontal stabilizer tank to the CWT. If low output pressure is detected, the FUEL PRES STB L or R EICAS message is displayed. If after a brief delay the pump is not selected off, the pump shuts off to protect from overheating.

Suction Feed

When main tank fuel pump pressure is low, each engine can draw fuel from its corresponding main tank through a suction feed line that bypasses the pumps. As the airplane climbs, dissolved air is released from the fuel in the tank due to the decrease in air pressure. This air may collect in the suction feed line and restrict fuel flow. At high altitude, thrust deterioration or engine flameout may occur as a result of the fuel flow reduction.

The dissolved air in the fuel tank will eventually deplete after reaching cruise altitude. The depletion time is dependent upon airplane altitude, fuel temperature, and type of fuel. Once the dissolved air is depleted, the engine may be capable of suction feed operation at cruise power.

Fuel pressure can be provided from a main tank with operating pumps to another engine by opening the appropriate fuel crossfeed valves. Continued crossfeed use will result in a progressive fuel imbalance.

Fuel Crossfeed

A common fuel manifold connects all main tanks and the CWT. There are four crossfeed valves in the fuel manifold. In flight, the combination of active pumps and automatically or manually controlled crossfeed valves direct the flow of fuel from tanks to engines. Crossfeed valve switches 1 and 4 always require pilot action to change the position of the respective crossfeed valve.

Fuel Imbalance

Excessive fuel imbalance adversely affects CG, aerodynamic drag, and fuel economy.

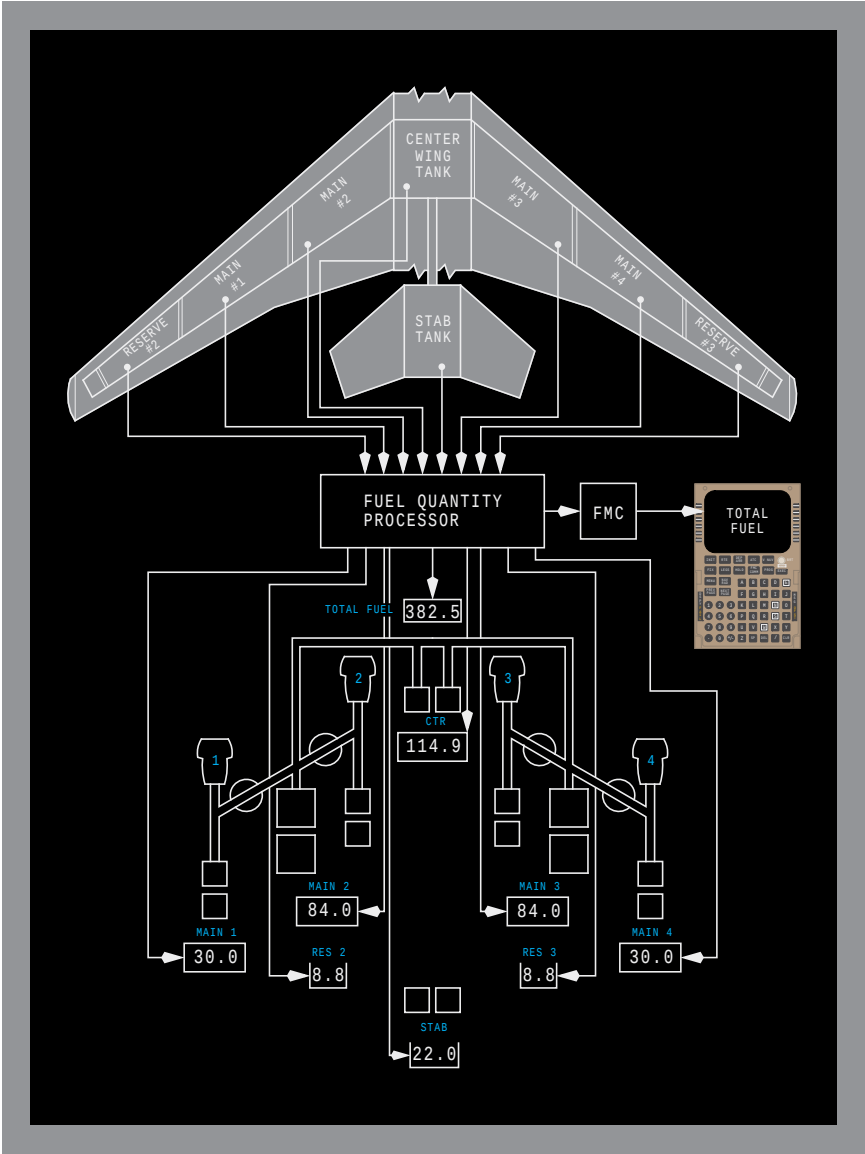
Fuel balancing is accomplished by opening or closing crossfeed valves and turning off and on fuel pump switches.

Fuel Tank Capacities

Tank	U.S. Gallons	Pounds *
1 and 4 Main	8,964	60,058
2 and 3 Main	25,092	168,116
Center	17,164	114,999
Reserves	2,644	17,714
Stabilizer	3,300	22,110
Total	57,164	382,997

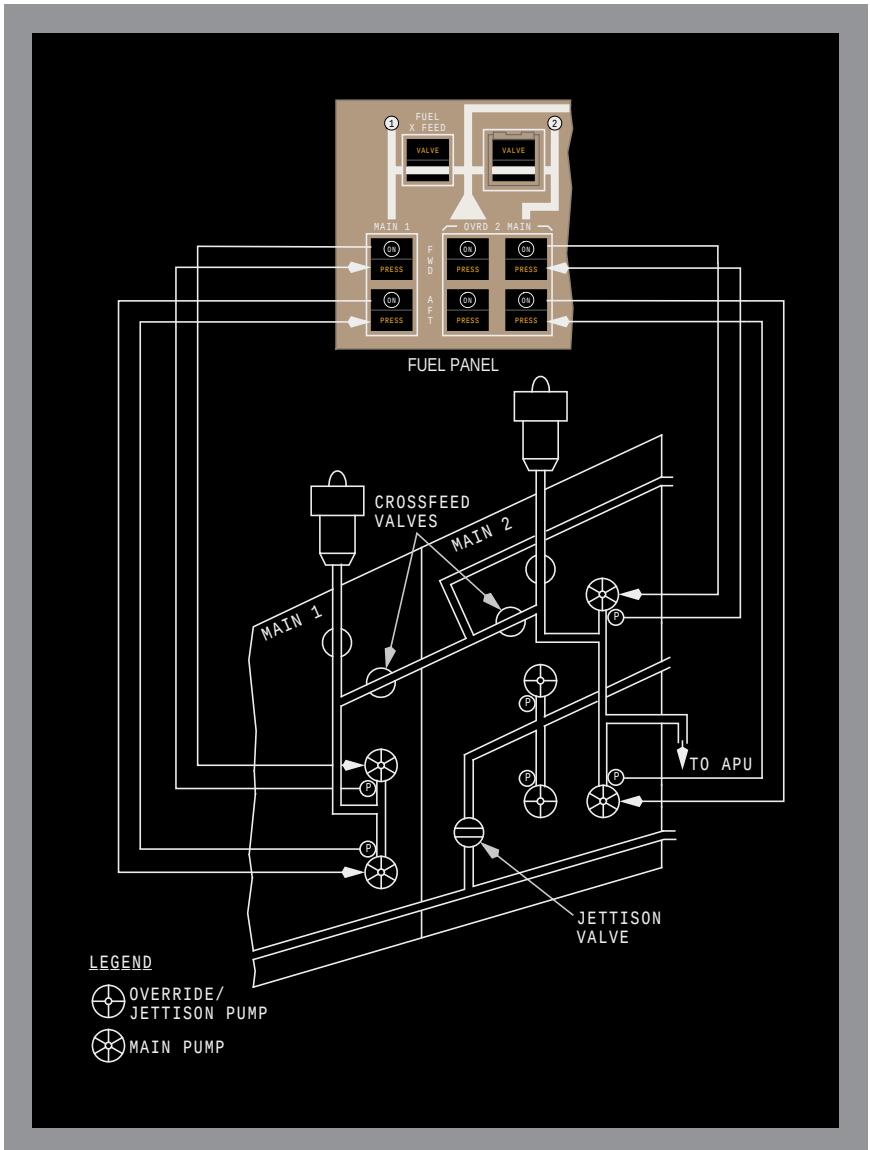
* Usable fuel at level attitude, fuel density = 6.7 pounds per U.S. Gallon.

Fuel Quantity Indication

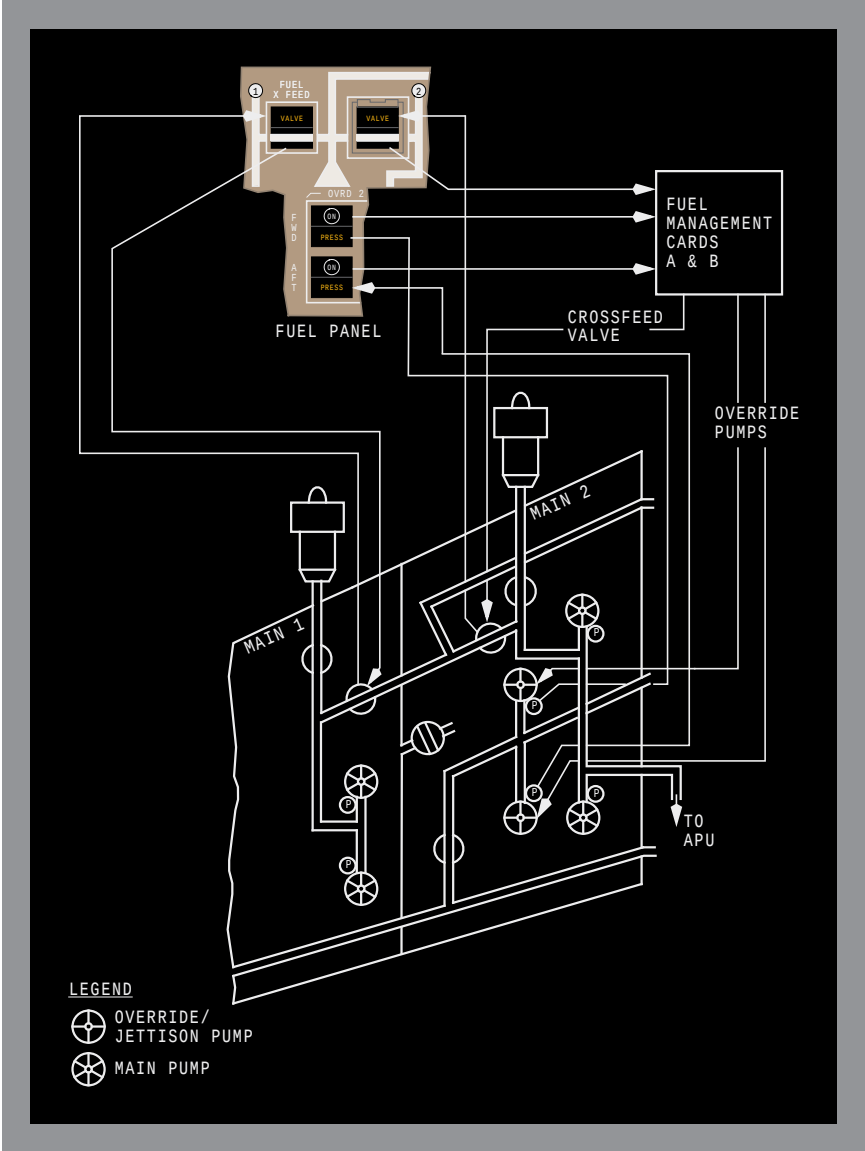


Fuel System Schematics

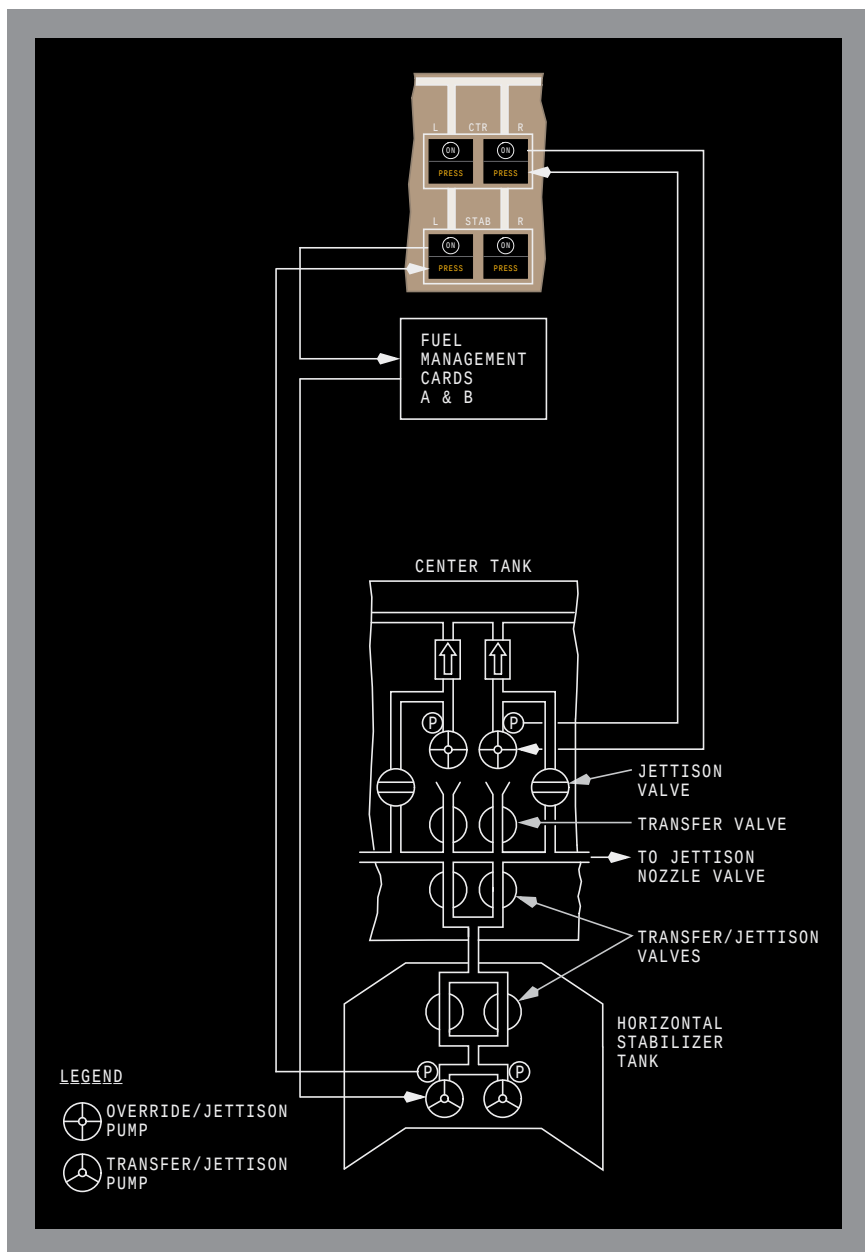
Main Tank Main Pump Schematic



Main Tank Override/Jettison Pump and Fuel Crossfeed Schematic



Center Wing and Horizontal Stabilizer Pump Schematic



Wing Tip Surge Tanks

Fuel collected in a wing tip surge tank flows back to its respective main tank 2 or 3 via gravity. Residual fuel in the horizontal stab surge tank returns via gravity to the horizontal stab tank.

Reserve Tank 2 and 3 Transfer

Each reserve tank contains two transfer valves. The valves open and fuel gravity transfers to the inboard main tanks when main tank 2 or 3 fuel quantity decreases to 40,200 pounds.

Main Tank 1 and 4 Transfer

Main tank 1 and 4 each contain one transfer valve. When the valves open, fuel gravity transfers from the outboard main tanks to the inboard main tanks. Fuel transfers to approximately 7,000 pounds remaining in each outboard main tank.

During fuel jettison, the valves open when either main tank 2 or 3 fuel quantity decreases to 20,000 pounds. The valves may be opened manually using the Fuel Transfer Main 1 & 4 switch on the overhead panel.

APU Fuel Feed

6301 - 6310

APU fuel is normally supplied from main tank 2. When AC power is available, fuel is supplied by main pump 2 aft. The PRESS light will extinguish during pump operation. If AC power is not available, a dedicated DC pump in main tank 2 supplies fuel to the APU.

6311 - 6316

APU fuel is normally supplied from main tank 2. When AC power is available, fuel is supplied by main pump 2 aft; main pump 3 aft operates to prevent tank-to-tank transfer and provides fuel if main pump 2 aft fails. If AC power is not available, a dedicated DC pump in main tank 2 supplies fuel to the APU.

Fuel System Operation

Fuel system management cards (FSMCs) command fuel valves open or closed and fuel pumps on or off according to fuel management logic.

Preflight

When fuel pump switches are off before engine start, low pressure lights are illuminated on the main pump switches and extinguished on the override, CWT, and stabilizer tank pump switches. See Vol 1 NP.10.

Operation With Fuel in Center Wing Tank

With 17,000 pounds or more fuel in the CWT, both CWT pump switches should be ON. The FSMCs close crossfeed valves 2 and 3 when flaps extend to takeoff position on the ground. Override/jettison pumps 2 and 3 are inhibited from operating when pressure is detected from both CWT override/jettison pumps. The CWT override/jettison pumps provide fuel to engines 1 and 4 and main pumps 2 and 3 provide fuel to their related engine.

With less than 17,000 pounds of fuel in the CWT, both CWT pump switches should be off. The FSMCs close crossfeed valves 2 and 3 when flaps extend to takeoff position on the ground. Override/jettison pumps 2 provide fuel to engine 1 and override/jettison pumps 3 provide fuel to engine 4. Main pumps 2 and 3 provide fuel to their related engine.

The FSMCs open crossfeed valves 2 and 3 when the flaps are out of the range of flaps 10 and flaps 20 settings. With the CWT pump switches ON, the CWT override/jettison pumps provide fuel to all engines. With the CWT pump switches OFF, the override/jettison pumps 2 provide fuel to engines 1 and 2 and override/jettison pumps 3 provide fuel to engines 3 and 4.

Stabilizer fuel transfer is enabled in flight when the flaps are retracted out of the range of flaps 10 and flaps 20 settings and the CWT fuel quantity is 80,400 pounds or less.

Note: When CWT quantity drops below approximately 5,000 pounds and total fuel consumption is greater than 15,000 pounds per hour, the CWT override/jettison pumps can no longer provide full override of the outboard main tank pumps. As a result, a shared flow situation between the CWT and outboard main tanks is established. During this shared flow situation, approximately 2,000 pounds of fuel are consumed from each outboard main tank prior to display of the EICAS message FUEL LOW CTR.

The FSMCs activate override/jettison pumps 2 and 3 when low pressure is detected from either CWT override/jettison pump with the CWT pump switches ON or when both CWT pump switches are pushed off. Override/jettison pumps 2 provide fuel to engines 1 and 2 and override/jettison pumps 3 provide fuel to engines 3 and 4.

6301 - 6310

The electrical CWT scavenge pump is automatically activated to pump CWT fuel into main tank 2. The pump is deactivated after 120 minutes, or no pressure, whichever occurs first.

6311 - 6316

CWT fuel is scavenged by four jet pumps, two pumping into each main tank 2 and 3.

In flight, the FSMCs open the reserve transfer valves when main tank 2 or 3 fuel quantity decreases to 40,200 pounds. Fuel transfers from reserve tanks 2 and 3 to the related main tank.

The EICAS message >FUEL TANK/ENG displays when one of the following occurs with the crossfeed valve 1 or 4 open: main tank 2 quantity is equal to or less than main tank 1 quantity, or when main tank 3 quantity is equal to or less than main tank 4 quantity. In the tank-to-engine configuration the main pumps provide fuel to their related engine until engine shutdown.

Note: On the ground, the >FUEL TANK/ENG message can display when the inboard tank quantity is less than or equal to the sum of the adjacent outboard tank plus 1,000 pounds in both wings.

Operation With No Fuel in Center Wing Tank

With no fuel in center wing tank, the FSMCs activate override/jettison pumps 2 and 3. The FSMCs close crossfeed valves 2 and 3 when the flaps extend to takeoff position on the ground. Override/jettisons pumps 2 provide fuel to engine 1 and override/jettison pumps 3 provide fuel to engine 4. Main pumps 2 and 3 provide fuel to their related engine.

The FSMCs open crossfeed valves 2 and 3 when the flaps are out of the range of flaps 10 and flaps 20 settings. Override/jettison pumps 2 provide fuel to engines 1 and 2 and override/jettison pumps 3 provide fuel to engines 3 and 4. Reserve fuel transfer and tank-to-engine configuration are identical to operating with fuel in the CWT.

Note: On the ground, the FUEL TANK/ENG message can display with as much as 1,000 pounds more fuel in an inboard main tank than the adjacent outboard main tank.

Fuel Management

Description

FSMCs command valves open or closed and specific fuel pumps on or off according to fuel management logic after the crew has positioned the appropriate fuel pump and crossfeed valve switches on or off on the overhead fuel control panel.

Preflight Indications

With all sixteen fuel pump switches off before engine start, the only fuel pump low pressure lights (PRESS) that should be illuminated are the eight main tank fuel pumps. If the APU is running: on aircraft 6301-6310 main tank 2 aft pump PRESS light is extinguished; on aircraft 6311 and above main tank 2 and 3 aft pump PRESS lights are extinguished. The CWT, HST, and main tank 2 and 3 override/jettison pump PRESS lights are extinguished.

Override Pump Operation

In November 2002, an Airworthiness Directive (AD) was issued in which the FAA placed restrictions on Center Wing Tank (CWT) pump and Horizontal Stabilizer Tank (HST) pump operation: do not use these pumps if not covered by fuel. EICAS Alert messages encompass the necessary logic so that fuel quantity based EICAS Advisory messages are displayed at the appropriate time, informing the flight crew when to turn the CWT and HST fuel pump on or off. EICAS also provides pressure based EICAS Caution messages so that, if the quantity based Advisory messages are missed, these fuel pumps will be shut off at first indication of low pressure. Additional modification of EICAS software accommodates fuel messages that pertain to auto-shutoff of the HST fuel pumps.

Before engine start, the CWT should only be selected on if tank quantity is greater than 17,000 pounds. If the CWT pumps are off at the time of engine start, EICAS will prompt the crew when to turn on the CWT pumps. HST pumps will be left off until prompted to turn them on by an EICAS message at cruise. Separate EICAS messages will be displayed when the pumps should be turned off.

Fuel Management Situations

The 747-400 fuel system is designed as an interactive system to be operated by the two person flight crew. The following three fuel management situations describe the sequence of operations during fuel management:

Situation 1

All tanks contain usable fuel. The quantity in main tanks 2 and 3 is greater than the quantity in main tanks 1 and 4.

Situation 2

No usable fuel in the CWT or the HST. The quantity in main tanks 2 and 3 is greater than the quantity in main tanks 1 and 4. Reserve tanks are full.

Situation 3

No usable fuel in the CWT or horizontal stabilizer tank. The quantity in main tanks 2 and 3 is less than or equal to the quantity in main tanks 1 and 4.

Situation 1

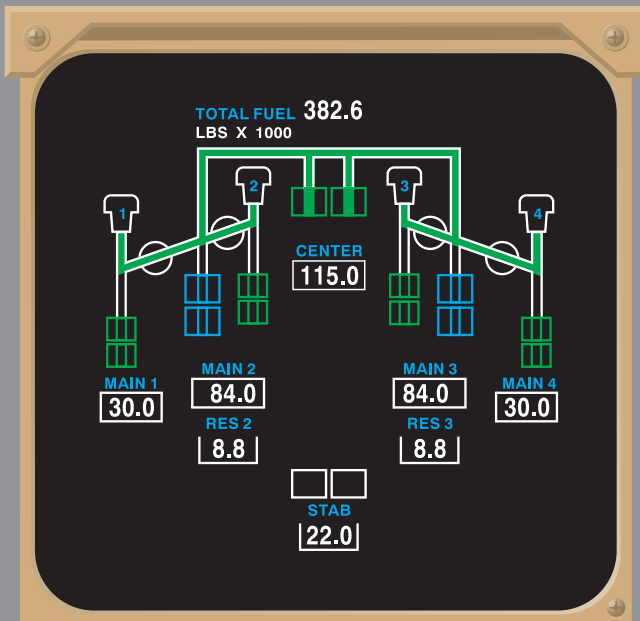
Fuel Distribution

All tanks contain usable fuel. The quantity in main tanks 2 and 3 is greater than the quantity in main tanks 1 and 4.

Before Engine Start or After Engine Start & Flaps Still Retracted

Operation:

- All pumps on except HST
- All crossfeed valves open
- CWT pumps feeding all engines

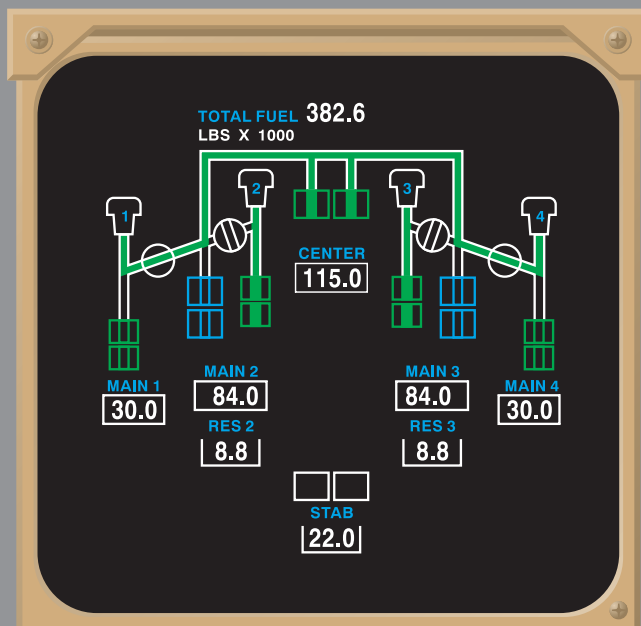


B744R1210esfr_a

T.E Flaps at T/O Position (10°/20°)

Operation:

- Crossfeed valves 2 and 3 closed automatically
- CWT pumps feeding engine 1 and 4
- Main tank pumps 2 feeding engine 2
- Main tank pumps 3 feeding engine 3

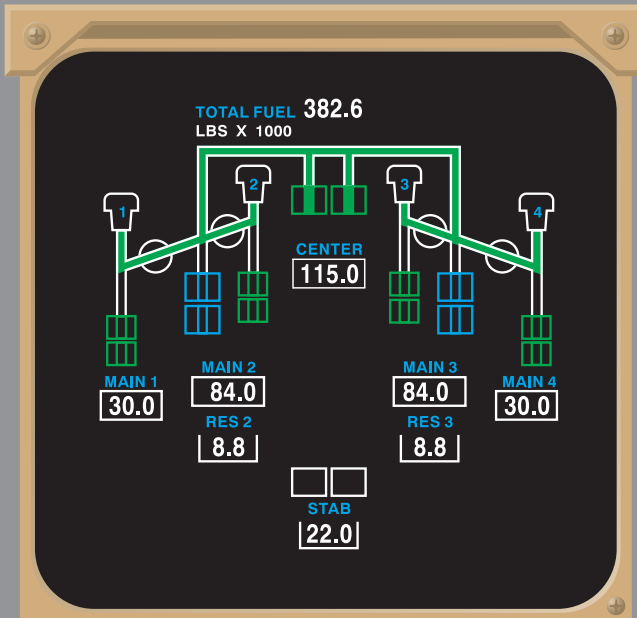


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After T/O and T/E Flaps < 10

Operation:

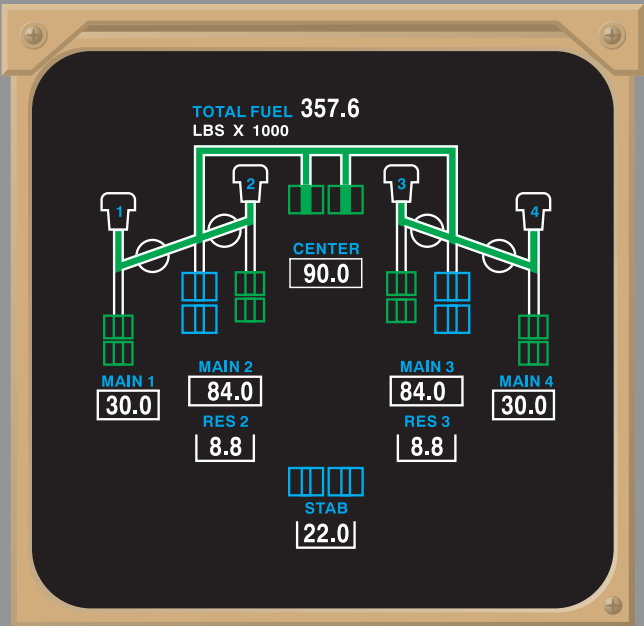
- Crossfeed valves 2 and 3 open automatically
- CWT pumps feeding all engines



B744R1210Desfr_a

30 Minutes After T/O and at Cruise

EICAS messages >FUEL PMP STB L and >FUEL PMP STB R appear. The QRH procedure will direct you to turn on both stabilizer pumps. When fuel quantity in the Center Wing tank is greater than 80,400 pounds the HST pumps will arm.

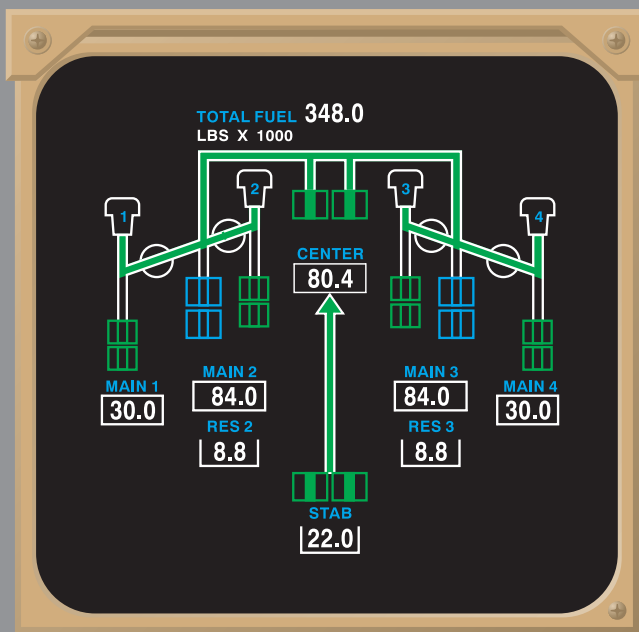


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CWT Containing Less Than 80,400 Pounds

Operation:

- HST pumps activate automatically (if previously armed)
- Transfer valves in CWT and HST open automatically
- HST fuel transfers into CWT
- CWT pumps feed all engines
- >FUEL LO STAB L is displayed at 2,600 pounds
 - Manually switch off left HST pump
- >FUEL LO STAB R is displayed at 1,300 pounds
 - Manually switch off right HST pump
- When HST pumps are turned off, the transfer valves close automatically.



>FUEL LOW CTR (L or R) EICAS Alert Displayed

Condition:

- CWT quantity is equal to or less than 3,000 pounds

Operation:

- CWT pumps should be switched off when >FUEL LOW CTR (L or R) messages are displayed on EICAS.

Remaining fuel in CWT is considered usable because it is scavenged at the appropriate time.

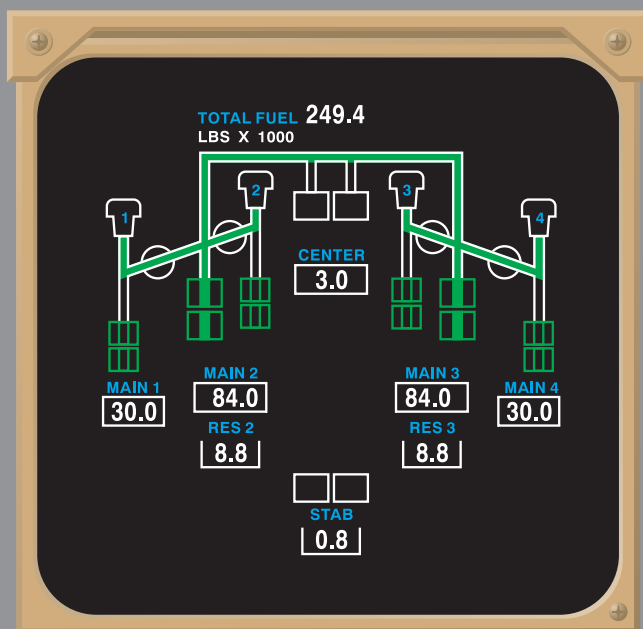
Electric System (6301-6310):

The scavenge pump is automatically activated later in the flight and transfers remaining CWT fuel to Main Tank 2. Pump stops automatically after 120 minutes or no pressure, whichever occurs first. Green arrow depicts electric scavenge pump transfer

Hydro-Mechanical System (6311 and above):

CWT fuel is scavenged by four jet pumps, two pumping into each Main Tank 2 and 3 when CWT quantity is <4,000 pounds and Main 2 or 3 quantity is <60,000 pounds. Scavenge transfer is not depicted by a green arrow.

Override/jettison pumps in main tanks 2 and 3 are automatically activated and feeding all engines.



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Note: When CWT quantity drops below approximately 5,000 pounds and total fuel consumption is greater than 15,000 pounds per hour, the CWT override/jettison pumps can no longer provide full override of the outboard main tank pumps. As a result, a shared flow situation between the CWT and outboard main tanks is established. During this shared flow situation, approximately 2,000 pounds of fuel are consumed from each outboard main tank prior to display of the EICAS advisory message > FUEL LOW CTR (L or R).

Main Tank 2 or 3 Contains 40,000 Pounds

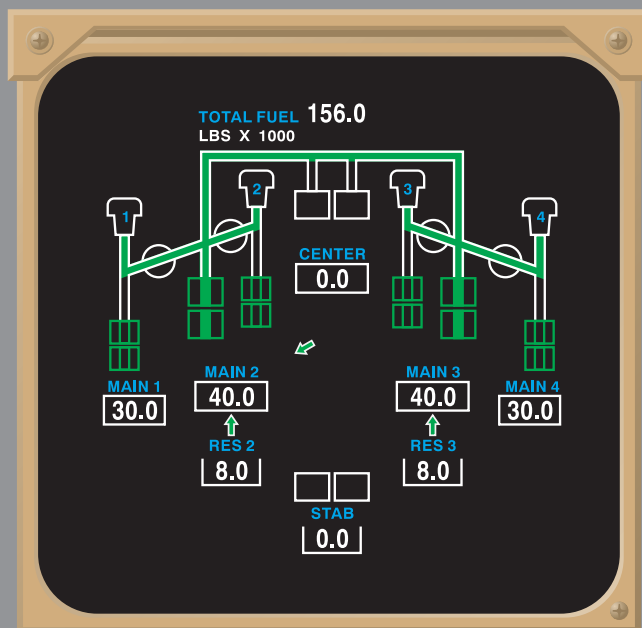
Operation:

- Reserve tanks transfer valves open automatically. Valves remain open until touchdown. Green arrows depict transfer from reserves to Main Tanks 2 and 3.

Electric System (6301-6310)

Scavenge pump in the CWT operates (green arrow displays) to ensure transfer of the remaining CWT fuel into Main Tank 2. Pump stops automatically after 120 minutes or no pressure, whichever occurs first.

Scavenge of fuel from the CWT into Main Tank 2 and/or 3 is continuous as long as the crossfeed manifold is pressurized. No green arrow is depicted.

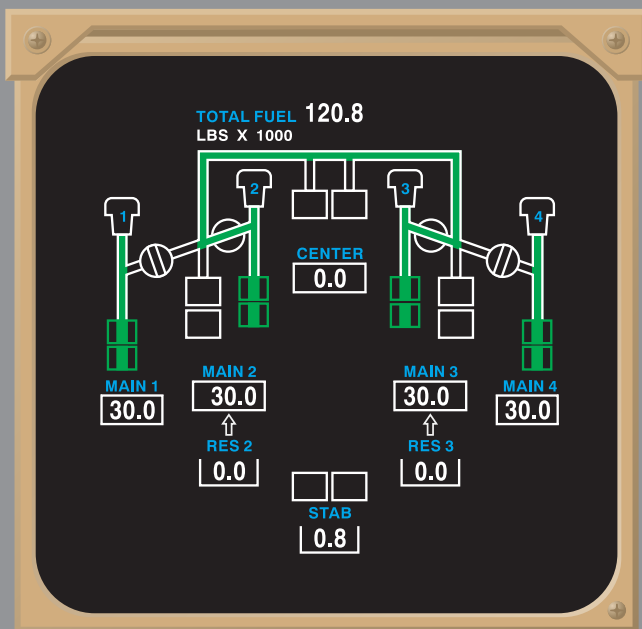


Condition:

- Quantity in Main Tank 2 or 3 is equal to or less than the quantity in Main Tank 1 or 4 respectively.

Operation:

- Switch off Override/Jettison pumps in Main Tanks 2 and 3
- Close crossfeed valves 1 and 4
- Crossfeed manifold remains pressurized with crossfeed valves 2 and 3 open
- Each engine is fed from its own main tank
- >FUEL TANK/ENG EICAS alert disappears
- Land in the fuel configuration



Situation 2

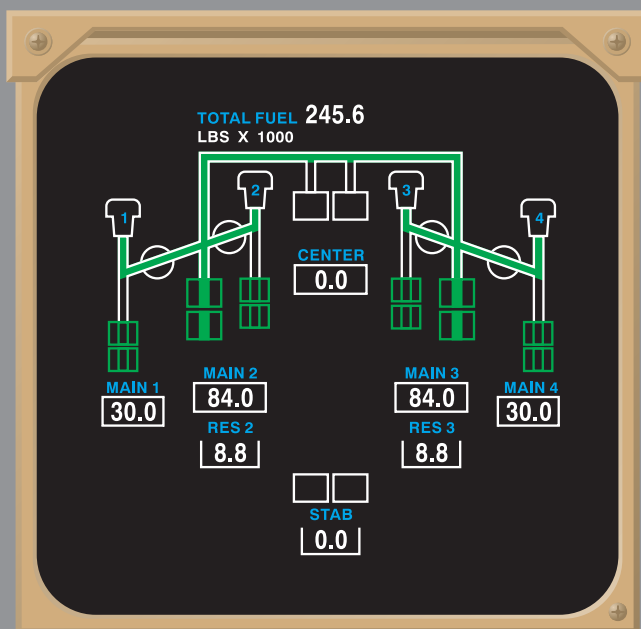
Fuel Distribution

There is no usable fuel in the Center Wing Tank or the Horizontal Stabilizer Tank. The quantity in Main Tanks 2 and 3 is greater than the quantity in Main Tanks 1 and 4.

Before Engine Start or After Engine Start & Flaps Still Retracted

Operation:

- CWT and HST pump switches off
- All Main Tank pumps on
- OVRD pumps 2 and 3 on
- All Crossfeed Valves open
- Override/Jettison pumps in Main Tanks 2 and 3 are automatically activated and feeding all engines.

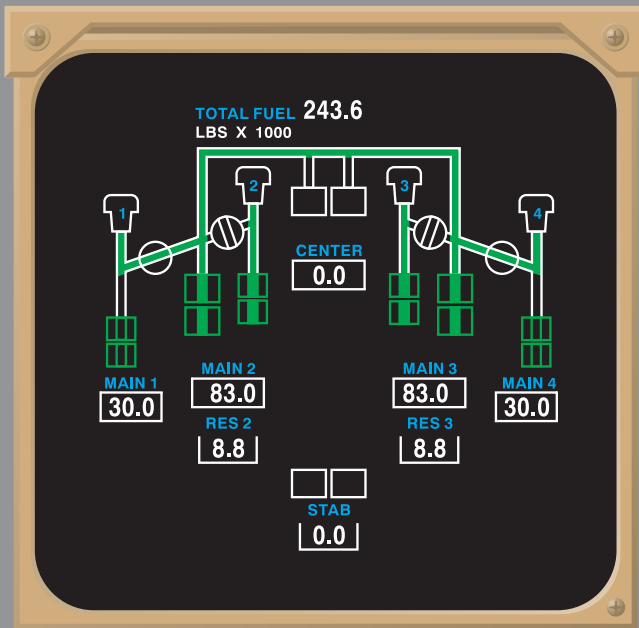


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T.E Flaps at T/O Position (10°/20°)

Operation:

- Crossfeed Valves 2 and 3 automatically closed
- Main pumps in Main Tank 2 feed engine 2
- Main pumps in Main Tank 3 feed engine 3
- Override/Jettison pumps in Main Tank 2 feeds Engine 1
- Override/Jettison pumps in Main Tank 3 feeds Engine 4.

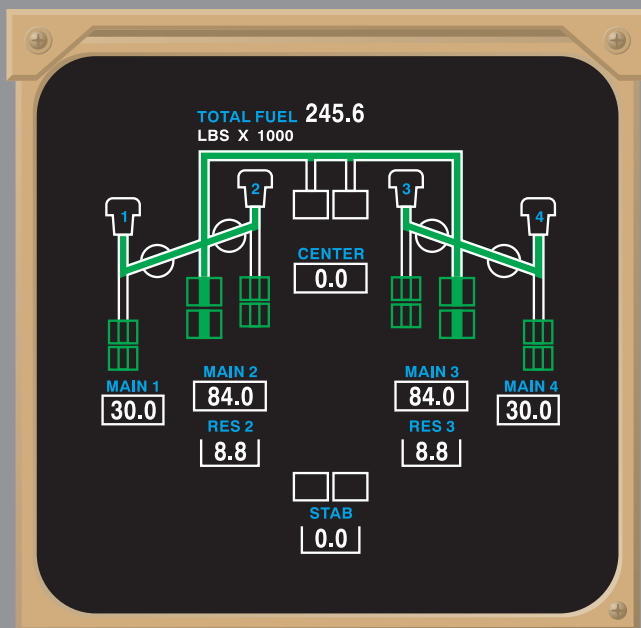


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After T/O and T/E Flaps < 10

Operation:

- Crossfeed valves 2 and 3 open automatically
- Override/Jettison pumps in main tanks 2 and 3 feed all engines.



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Main Tank 2 or 3 Contains 40,000 Pounds

Operation:

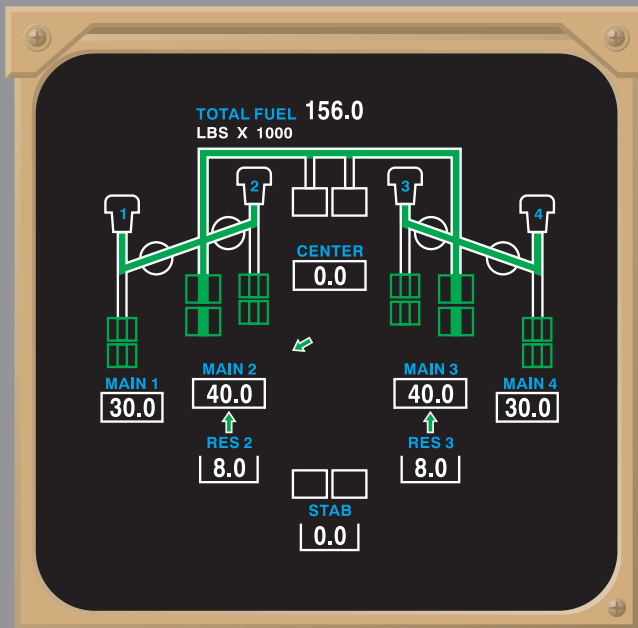
- Reserve tanks transfer valves open automatically. Valves remain open for remainder of flight. Green arrows depict transfer from reserves to Main Tanks 2 and 3.

Electric System (6301-6310)

Scavenge pump in the CWT operates (green arrows displays) to ensure transfer of any residual CWT fuel into Main Tank 2. Pump stops automatically after 120 minutes or no pressure, whichever occurs first.

Hydro-Mechanical System (6311 and above)

Scavenge of fuel from the CWT into Main Tank 2 and/or 3 is continuous as long as the crossfeed manifold is pressurized. No green arrow is depicted.



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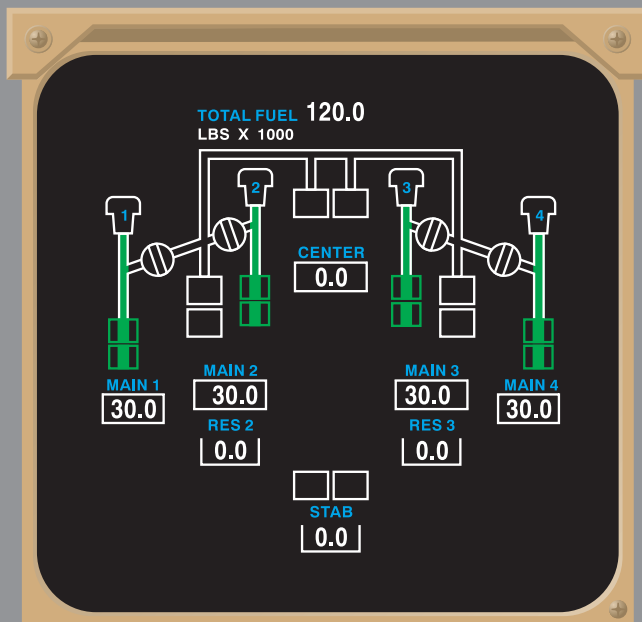
>FUEL TANK/ENG EICAS Alert Displayed

Condition:

- Quantity in Main Tank 2 or 3 is equal to or less than the quantity on Main Tank 1 or 4 respectively.

Operation:

- Switch off Override/Jettison pumps in main tanks 2 and 3
- Close Crossfeed Valves 1 and 4
- Crossfeed manifold remains pressurized with Crossfeed Valves 2 and 3 open
- Each engine is fed from its own main tank
- >FUEL TANK/ENG EICAS alert disappears
- Land in this fuel configuration.



B747B1210feto_a

Situation 3

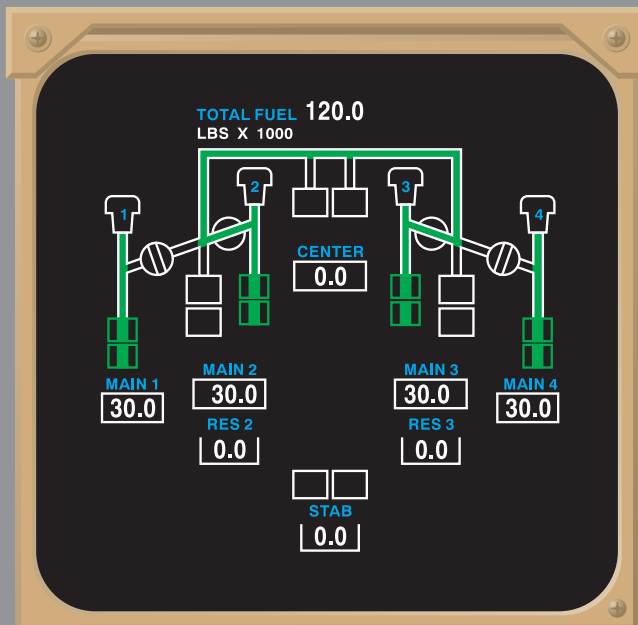
Fuel Distribution

There is no fuel in the Center Wing Tank or the Horizontal Stabilizer Tank. The quantity in Main Tanks 2 and 3 is less than or equal to the quantity in Main Tanks 1 and 4.

Before Engine Start or After Engine Start & Flaps Still Retracted

Operation:

- CWT and HST pump switches off
- All main tank pumps are on
- OVRD pumps in Main Tanks 2 and 3 are off
- Crossfeed Valves 1 and 4 are closed
- Crossfeed Valves 2 and 3 are open
- Each engine is fed from its own main tank.

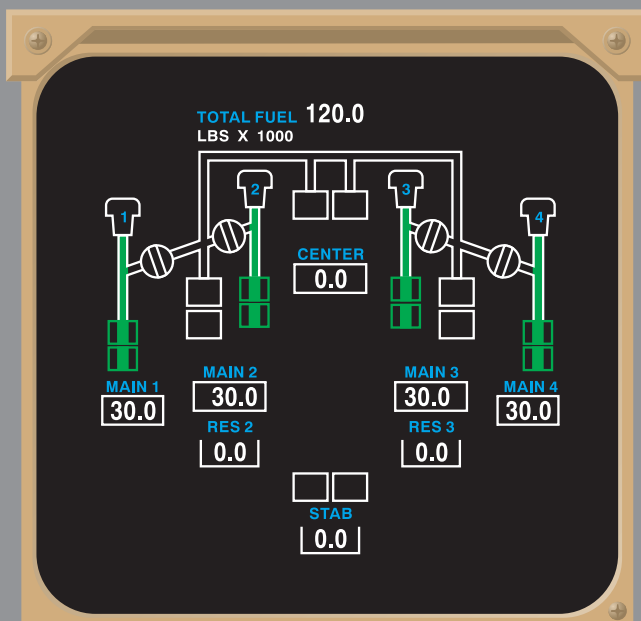


B744R1210Rfe_a

T.E Flaps at T/O Position (10°/20°)

Operation:

- All Main tank pumps are on
- Each engine is fed from its own main tank
- Crossfeed valves 2 and 3 are closed automatically.

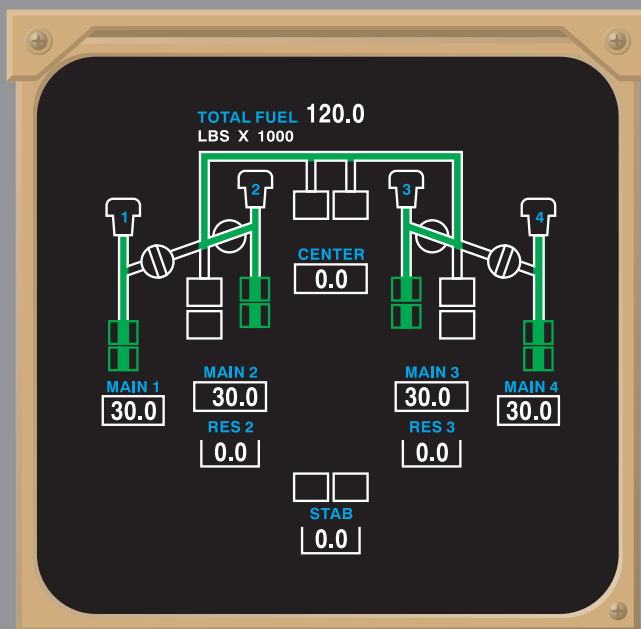


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After T/O and T/E Flaps < 10

Operation:

- All main tank pumps are on
- Each engine is fed from its own main tank
- Crossfeed valves 2 and 3 open automatically
- Continue remainder of the flight and land in this configuration.



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Fuel Jettison

The fuel jettison system allows jettison from all fuel tanks. Override/jettison pumps in main tanks 2 and 3 and the center wing tank pump fuel overboard through the jettison nozzle valves.

Fuel jettison is initiated by rotating the fuel jettison selector to A or B. When a jettison control system is selected, the fuel temperature indication on EICAS is replaced with the fuel to remain quantity indication. The jettison manifold and jettison time display on the fuel synoptic.

Rotating the Fuel To Remain selector decreases or increases the fuel to remain quantity.

Pushing either fuel jettison nozzle valve switch ON activates all override/jettison and transfer/jettison pumps in the tanks containing fuel (pump switches must be ON) and opens the required jettison and transfer/jettison valves. The related jettison nozzle valve also opens. The jettison time is initially estimated using preprogrammed rates. The system begins updating the estimate based on actual fuel quantity rate of change ninety seconds after jettison begins.

If override/jettison pumps 2 and 3 are providing fuel to the engines when jettison begins, the EICAS message FUEL OVRD may be displayed due to reduced pressure caused by the jettison nozzles valves opening. Jettison is verified by observing decreasing tank quantities.

The jettison control system controls fuel balancing between main tanks 2 and 3 as fuel is jettisoned. If fuel balancing is necessary, the override/jettison pumps in the low tank deactivate until the tanks are balanced (changes to a cyan color).

The FSMCs open the reserve transfer valves when main tank 2 or 3 fuel quantity decreases to 40,000 pounds. Fuel transfers from reserve tanks 2 and 3 to the related main tank.

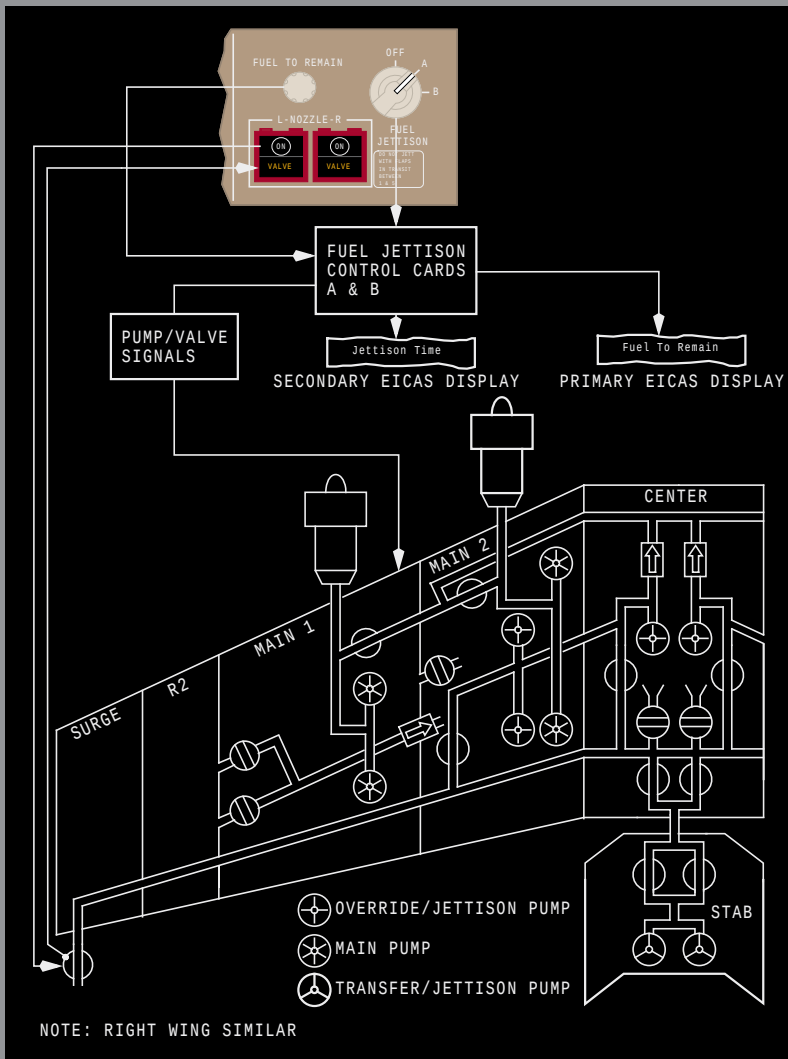
6301 - 6310

The electrical scavenge pump is automatically activated to pump remaining CWT fuel into main tank 2.

When either main tank 2 or 3 fuel quantity decreases to 20,000 pounds during jettison, both main tank 1 and 4 transfer valves open.

Jettison terminates when total fuel quantity decreases to the fuel to remain quantity. The fuel to remain quantity indication changes color from magenta to white and flashes for five seconds. The jettison control system deactivates all operating override/jettison and transfer/jettison pumps. The related FUEL OVRD pump EICAS messages display until the Fuel Jettison selector is OFF.

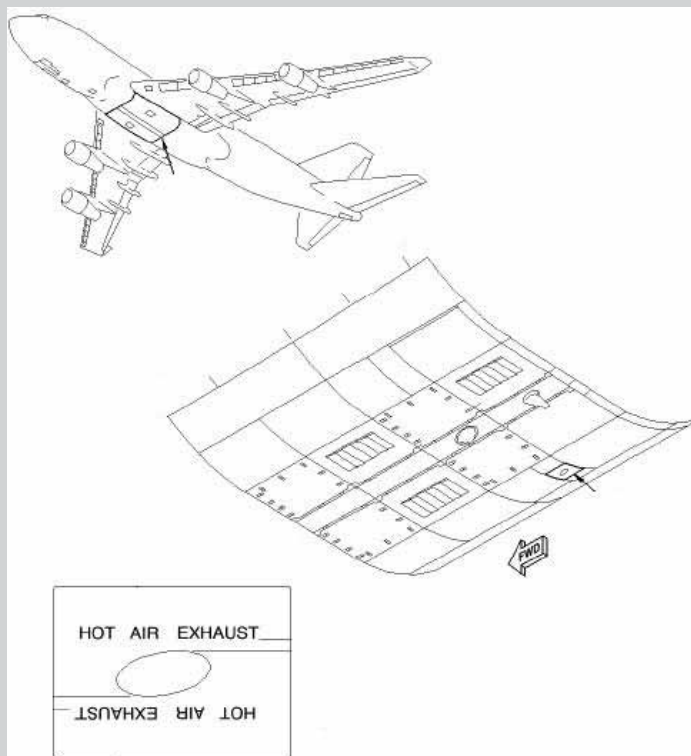
Fuel Jettison Schematic



Nitrogen Generation System (NGS)

The NGS converts bleed air to nitrogen-enriched air to reduce flammability of center wing tank fuel during all phases of flight and for a brief period after landing. To reduce bleed air demand NGS is shut down for engine-out operation. NGS is also shut down when the Equipment Cooling selector is in OVRD, the right bleed air duct is isolated, or a Cargo Fire Arm switch is ARMED.

The only notice of degraded NGS is an EICAS STATUS message. There is no impact on aircraft performance with a degraded/inoperative NGS.



Fuel EICAS Messages

Chapter 12 Section 30

Fuel System EICAS Messages

The following EICAS messages can be displayed.

Message	Level	Aural	Message Logic
FUEL IMBAL 1-4	Advisory		Fuel difference of 3,000 pounds between main tanks 1 and 4. Message no longer displayed when difference less than 1,000 pounds.
FUEL IMBAL 2-3	Advisory		Fuel difference of 6,000 pounds between main tanks 2 and 3. Message no longer displayed when difference less than 1,000 pounds.
FUEL IMBALANCE	Advisory		Fuel difference of 6,000 pounds between inboard main tanks (2 and 3) and outboard main tanks (1 and 4) after reaching FUEL TANK/ENG condition. Message no longer displayed when difference less than 1,000 pounds.
>FUEL JETT A, B	Advisory		Jettison control system has failed. Message inhibited when FUEL JETT SYS message displayed.
FUEL JETT SYS	Caution	Beeper	Fuel total less than fuel to remain and one fuel nozzle valve open or both jettison cards fail.
FUEL OVRD 2, 3 AFT	Advisory		Low pump pressure detected when pump activated. Pump activates by system logic with Override Pump switch ON. Message displays with Override Pump switch OFF before tank-to-engine configuration.

Message	Level	Aural	Message Logic
FUEL OVRD 2, 3 FWD	Advisory		Low pump pressure detected when pump activated. Pump activates by system logic with Override Pump switch ON. Message displays with Override Pump switch OFF before tank-to-engine configuration.
>FUEL LOW CTR L, R	Advisory		Center wing tank quantity less than 17,000 pounds before start with pump switches ON, or center wing tank quantity approximately 7,000 pounds in climb with pump switches ON, or center wing tank quantity approximately 3,000 pounds in cruise with pump switches ON. Message inhibited during jettison.
>FUEL OVD CTR L, R	Advisory		On the ground, center wing tank quantity of 17,000 pounds or more with center wing tank pump switch OFF, or in cruise, center wing tank quantity 4,000 pounds or more in center wing tank with pump switch OFF.
>FUEL PMP STB L	Advisory		Left Stabilizer Tank Pump switch ON on the ground, or stabilizer tank quantity 1,000 pounds or more in cruise with Left Stabilizer Tank Pump switch OFF. Message inhibited when FUEL STAB XFR message displayed.
>FUEL PMP STB R	Advisory		Right Stabilizer Tank Pump switch ON on the ground, or stabilizer tank quantity 1,000 pounds or more in cruise with Right Stabilizer Tank Pump switch OFF.
FUEL PRES STB L, R	Advisory		Low pump pressure detected when pump activated. Pump activates by system logic with Stabilizer Tank Pump switch ON.

Message	Level	Aural	Message Logic
FUEL PRESS CTR L, R	Caution	Beeper	FUEL LOW CTR L, R message displayed for 60 seconds, or low pump pressure detected when pump switch ON. Message inhibited during jettison until fuel in Center Wing Tank is less than 2,000 pounds.
FUEL PRESS ENG 1, 2, 3, 4	Caution	Beeper	Engine on suction feed. Suction feed occurs if both main pumps in a tank fail with the respective crossfeed valve closed.
FUEL PUMP 1, 2, 3, 4 AFT	Advisory		Low pump pressure detected. Message inhibited when FUEL PRESS ENG message displayed.
FUEL PUMP 1, 2, 3, 4 FWD	Advisory		Low pump pressure detected. Message inhibited when FUEL PRESS ENG message displayed.
FUEL QTY LOW	Caution	Beeper	Fuel quantity 2,000 pounds or less in one or more main tanks.
FUEL RES XFR 2, 3	Advisory		Reserve transfer valves not in commanded position.
FUEL STAB XFR	Caution	Beeper	Stabilizer tank fuel transfer function is failed.
>FUEL TANK/ENG	Advisory		With crossfeed valve 1 or 4 open: on the ground after fueling, after initial electrical power established, or after CMC ground test; main tank 2 quantity less than or equal to main tank 1 quantity plus 1,000 pounds and main tank 3 quantity less than or equal to main tank 4 quantity plus 1,000 pounds. in flight, main tank 2 quantity equal to or less than main tank 1 quantity, or main tank 3 quantity equal to or less than main tank 4 quantity. Message inhibited during jettison.
FUEL TEMP LOW	Advisory		Fuel temperature -37°C or less.

Message	Level	Aural	Message Logic
FUEL TEMP SYS	Advisory		Fuel temperature sensing inoperative.
FUEL X FEED 1, 2, 3, 4	Advisory		Fuel crossfeed valve position disagrees with commanded position.
>FUEL XFER 1+4	Advisory		Fuel Transfer Main 1 & 4 switch ON with inboard main tank quantities greater than outboard main tank quantities in flight, or switch ON while airplane on the ground.
>JETT NOZ ON	Advisory		Both fuel jettison nozzle valves open.
>JETT NOZ ON L, R	Advisory		Fuel jettison nozzle valve open. Message inhibited when JETT NOZ ON message displayed.
>JETT NOZZLE L, R	Advisory		Jettison nozzle valve position disagrees with commanded position.
>SCAV PUMP ON	Advisory		Center wing tank scavenge pump operating while airplane on the ground.
>X FEED CONFIG	Advisory		One or more fuel crossfeed valves incorrectly configured. Message displayed when crossfeed valve 1 or 4 closed and main tanks not equal, or crossfeed valve 2 or 3 closed and flaps not in takeoff position.

Hydraulics

Chapter 13

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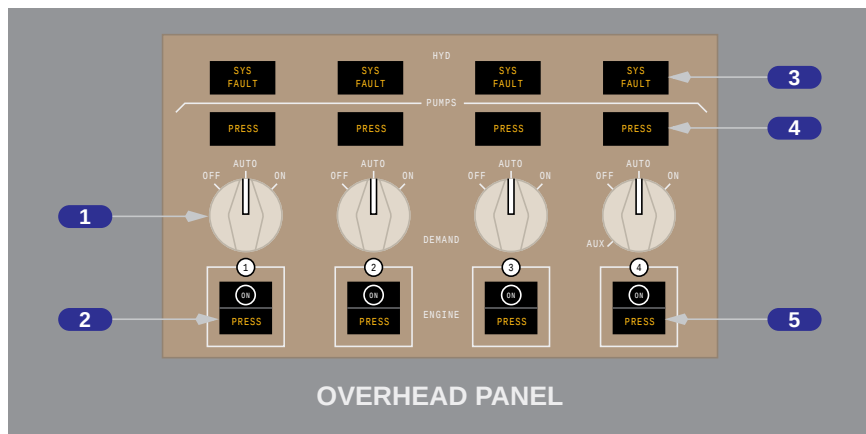
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Hydraulics Controls and Indicators

Chapter 13 Section 10

Hydraulic Panel



1 Hydraulic DEMAND Pump Selector

OFF - demand pump off.

AUTO -

- demand pump operates when related engine pump output pressure is low, or when related fuel control switch is in CUTOFF
- demand pumps 1 & 4 also operate when trailing edge flaps are in transit on the ground, or trailing edge flaps are extended in flight

ON - demand pump operates

Auxiliary (AUX) (System 4) -

- pressurizes system 4 on the ground if the ground handling bus is powered
- auxiliary pump operates on ground until related engine pump pressurizes
- related demand pump off
- does not trip OFF when EDP pressurizes system

2 ENGINE Hydraulic Pump Switch

ON -

- engine hydraulic pump pressurizes system when engine rotates.

OFF (blank) -

- pump depressurizes
- pump circulates fluid for lubrication and cooling

3 Hydraulic System (SYS) Light

Illuminated (amber) -

- low hydraulic system pressure (<1200 psi)
- low hydraulic reservoir quantity (≤ 0.34)
- excessive hydraulic fluid temperature ($> 104^{\circ}\text{C}$)

4 Demand Pump Low PRESS Light

Illuminated (amber) -

- demand pump selector positioned to OFF or AUX
- demand pump operates and output pressure is low
- demand pump fails to operate

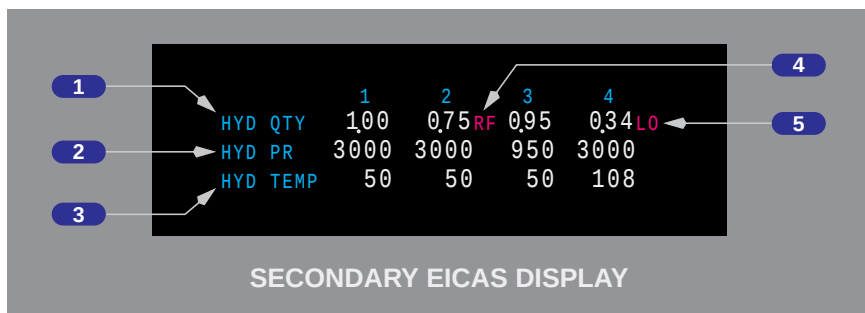
5 ENGINE Hydraulic Pump Low PRESS Light

Illuminated (amber) - low engine hydraulic pump pressure.

Hydraulic System Indications

To view the status display, push the STAT display switch on the display select panel. To view the hydraulic synoptic, push the HYD synoptic display switch on the display select panel. Display select panel operation is described in Chapter 10, Flight Instruments, Displays.

Status Display



1 Hydraulic Fluid Quantity (HYD QTY)

Hydraulic reservoir quantity of each system displays as a percentage of the normal service level (1.00).

WARNING: Do not allow the reservoir to be over-filled (quantity ≥ 1.15). This can cause hydraulic fluid to enter the pneumatic ducting and the air conditioning packs, resulting in smoke and noxious fumes entering the flight deck and cabin.

2 Hydraulic System Pressure (HYD PR)

Hydraulic pressure of each system displays in psi.

3 Hydraulic System Temperature (HYD TEMP)

Hydraulic fluid temperature of each system displays in degrees C.

4 Reservoir Refill

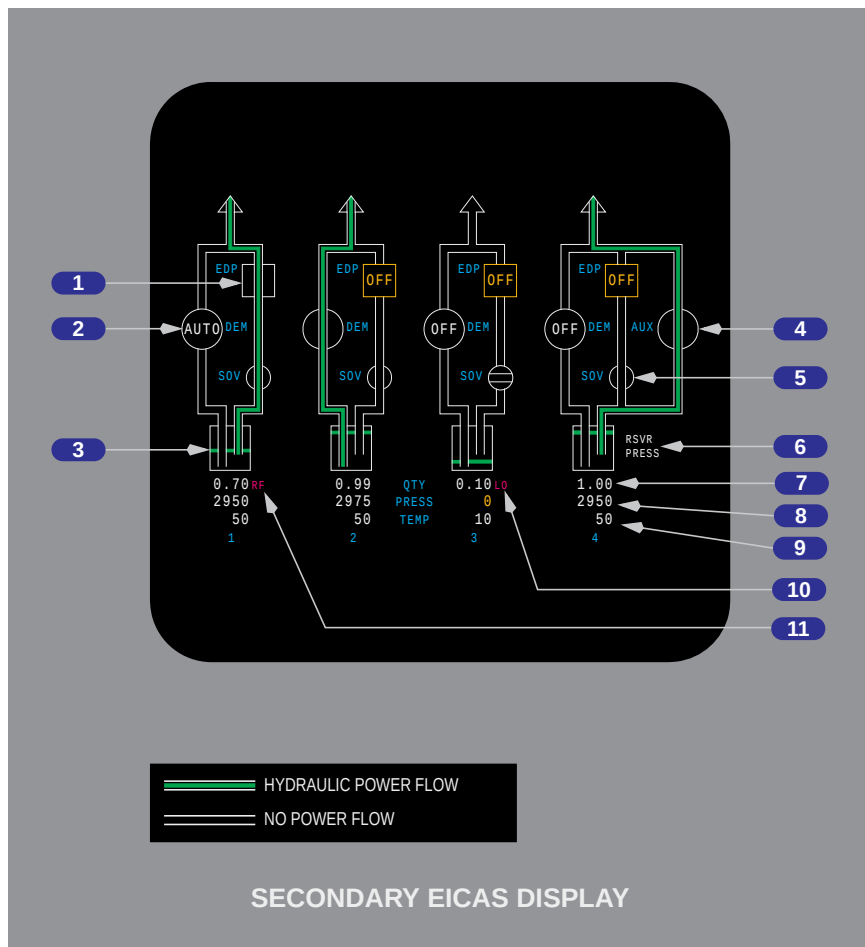
RF (Refill) (magenta) - displays on ground when reservoir requires refill (quantity ≤ 0.75).

5 Low Reservoir Quantity

LO (magenta) - displays when a reservoir quantity is low (quantity ≤ 0.34). The SYS FAULT light on overhead panel will illuminate during this condition.

Hydraulic Synoptic Display

The hydraulic power flow displayed is generated by the displayed valve positions, pump status, and fluid levels. It does not display actual hydraulic power flow, therefore the display may not represent actual system operation.



1 Engine Driven Pump

OFF (amber) - engine driven pump is not operating.

Flowbar (green with white pump) - indicates EDP pump is selected on and operating.

Flowbar (green with amber pump) - indicates EDP pump is selected on and not operating.

2 Demand Pump

OFF - demand pump is not operating.

Flowbar (green with white pump) - indicates demand pump is selected (AUTO or ON) and supplying pressure.

AUTO (blue) - currently armed to operative, indicates DEMAND pump is selected to operate when system demand or flap position require.

3 Hydraulic Reservoir

Fluid Level - displays relative fluid level (green line) in the hydraulic reservoir.

4 Auxiliary Pump

OFF - auxiliary pump is not operating.

Flowbar (green with white pump) - indicates AUX pump is selected on and supplying pressure (demand pump inhibited).

Flowbar (green with blue pump) - switch selected to AUX but pump is armed.

5 Shut Off Valve

Indicates open or closed position of shut off valve.

6 Reservoir Pressure

RSVR PRESS (amber) - displays when reservoir bleed air pressure is low (< 21 psi).

7 Hydraulic Fluid Quantity (HYD QTY)

Hydraulic reservoir quantity of each system displays as a percentage of the normal service level (1.00).

8 Hydraulic System Pressure (HYD PR)

Hydraulic pressure of each system displays in psi. Normal pressure is 3000 psi.

9 Hydraulic System Temperature (HYD TEMP)

Hydraulic fluid temperature of each system displays in degrees C.

10 Low Reservoir Quantity

LO (magenta) - displays when a reservoir quantity is low (quantity ≤ 0.34).

11 Reservoir Refill

RF (Refill) (magenta) - displays on ground when reservoir requires refill (quantity ≤ 0.75).

Hydraulics

System Description

Chapter 13

Section 20

Hydraulic Systems

Each system is powered by an engine driven pump and a demand pump installed in parallel. Normal system pressure is approximately 3,000 psi.

Engine Driven Pumps

Each system has an engine driven pump (EDP). The EDP is pressurized when the engine is running (fire switch is in) and the engine pump switch is ON.

Demand Pumps

The demand pumps supply normal system demands if an engine or EDP fails. Systems 1 and 4 have air driven demand pumps. The bleed air manifold provides pneumatic power for the air driven pumps. Systems 2 and 3 have electric motor driven demand pumps.

Auxiliary Pump

System 4 has an electric auxiliary pump for ground handling operations.

Fluid Supply

Independent reservoirs supply fluid to each hydraulic system. The bleed air system pressurizes the reservoirs to prevent pump cavitation and ensure positive flow during high demand conditions. RSVR PRESS displays next to the synoptic reservoir symbol when reservoir bleed air pressure is low.

Fluid temperature and reservoir quantity are displayed on the EICAS status display and hydraulic synoptic display. The letters RF display next to the reservoir quantity indication when refill is required. RF is inhibited in flight. The letters LO replace RF when a system low quantity exists. Hydraulic quantity levels fluctuate with variations in temperature and as devices that use hydraulic power activate.

Each hydraulic system has a dedicated hydraulic interface module (HYDIM) to process temperature and pressure inputs as well as perform some pump control. Should a HYDIM fail, the following indications may occur on that hydraulic system:

- blank hydraulic pressure and temperature indications on the EICAS status page, HYD synoptic page
- HYD CONTROL X advisory messages

A single Hydraulic Quantity Interface Module (HYQUIM) processes quantity inputs from each reservoir transmitter. Should the HYQUIM fail because of an overvoltage condition, the following false indications may be experienced for all four hydraulic systems:

- hydraulic SYS FAULT lights flashing on and off
- >HYD QTY LOW X advisory messages appearing and disappearing
- EICAS hydraulic quantity indications decreasing and increasing

A hydraulic fluid shutoff valve is installed in the fluid supply line to each EDP. If an engine fire switch is pulled, the respective hydraulic fluid shutoff valve closes, the EDP depressurizes, and the respective demand pump operates.

Load Assignments

Systems 1 and 4 power the trailing edge flaps, landing gear, normal brakes (SYS 4), alternate brakes (SYS 1), steering, and their respective thrust reversers. Systems 1 and 4 also provide redundant power to the primary flight controls.

Systems 2 and 3 power the primary flight controls, stabilizer trim, elevator feel and their respective thrust reversers. System 2 also powers the alternate brakes and lower yaw damper. System 3 powers the upper yaw damper.

Systems 1, 2, and 3 power the respective center, right, and left autopilot servos. Systems 2, 3, and 4 power the spoilers.

Preflight

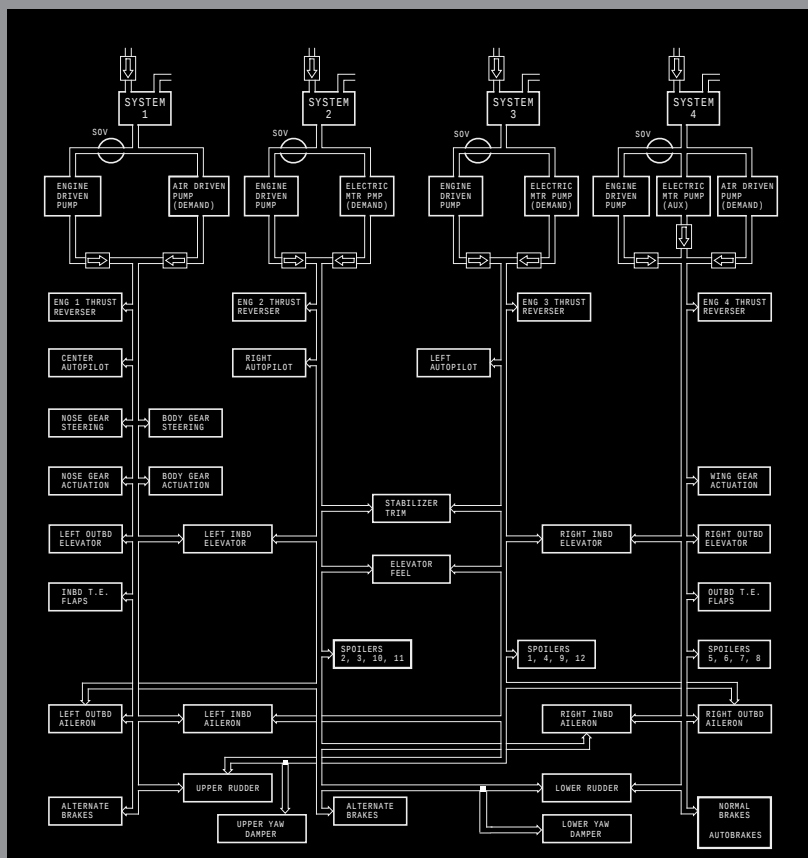
See Volume 1, NP.20, Pushback/Engine Start Procedure for hydraulic panel configuration.

Introduction

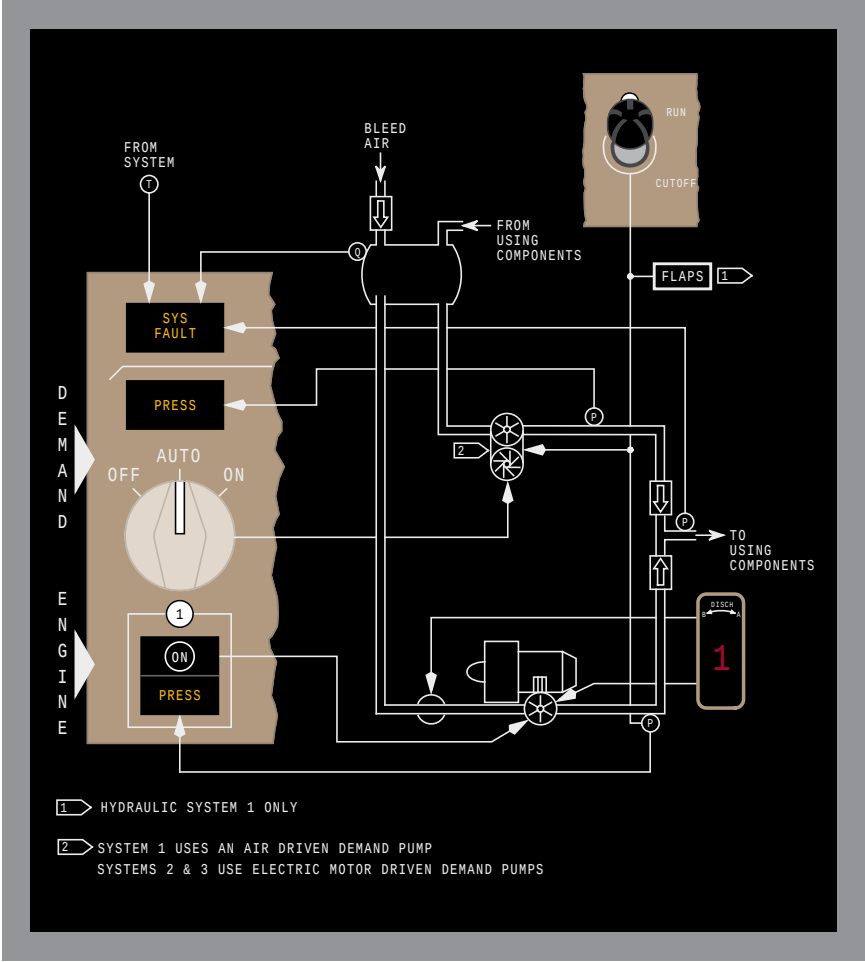
The airplane has four independent hydraulic systems, numbered by the engine which powers it. The hydraulic systems power the:

• primary flight controls	• landing gear
• autopilot servos	• flaps
• spoilers	• brakes
• stabilizer trim	• steering
• elevator feel	• thrust reversers

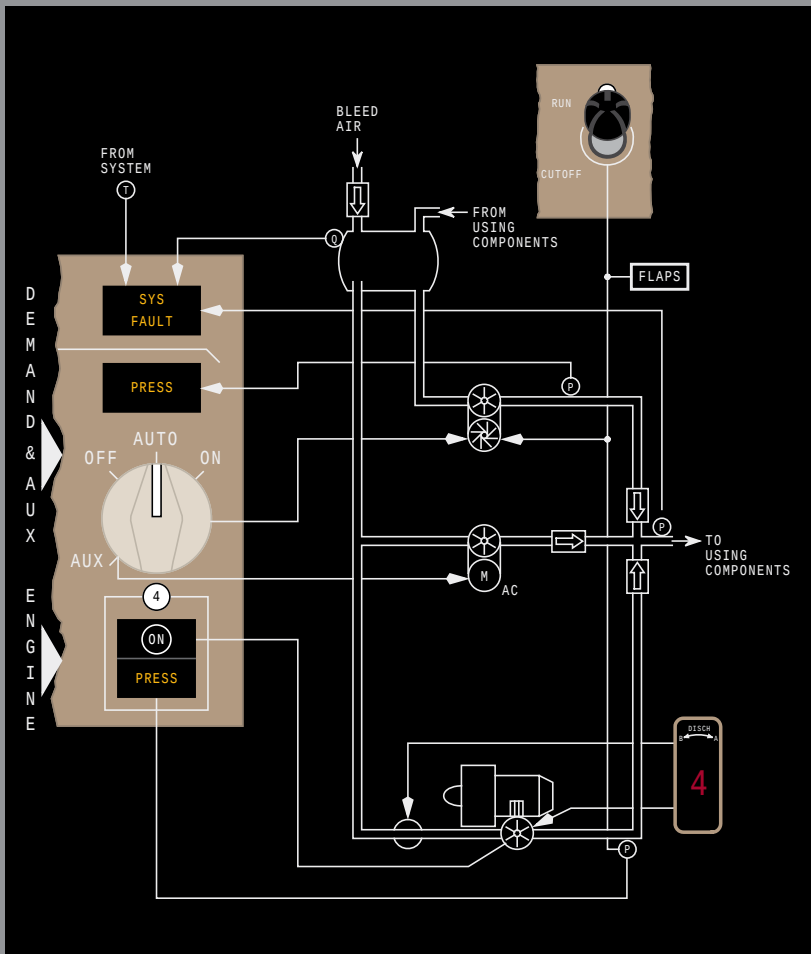
Hydraulic System Diagram



Hydraulic Systems 1, 2, and 3 Diagram



Hydraulic Systems Diagram 4



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Hydraulics EICAS Messages

The following EICAS messages can be displayed.

Message	Level	Aural	Message Logic
HYD CONTROL 1, 4	Advisory		Hydraulic control system inoperative. Demand pump automatic switching and/or hydraulic systems may not be available.
HYD OVHT SYS 1, 2, 3, 4	Advisory		Excessive hydraulic system temperature (>104° C).
HYD PRESS DEM 1, 2, 3, 4	Advisory		Demand pump output pressure low (<1400 psi). Occurs when Demand Pump selector OFF, or demand pump commanded to run and demand pump output pressure low, or system 4 Demand Pump selector is in AUX. Inhibited by HYD PRESS SYS message in a system low pressure condition.
HYD PRESS ENG 1, 2, 3, 4	Advisory		Engine pump output pressure low (<1400 psi). Inhibited by HYD PRESS SYS message in a system low pressure condition.
HYD PRESS SYS 1, 2, 3, 4	Caution	Beeper	Loss of hydraulic system pressure (<1200 psi).
>HYD QTY HALF 1, 2, 3, 4	Advisory		Hydraulic quantity is less than one half normal service level.
>HYD QTY LOW 1, 2, 3, 4	Advisory		Hydraulic quantity low (< 0.34).

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Landing Gear
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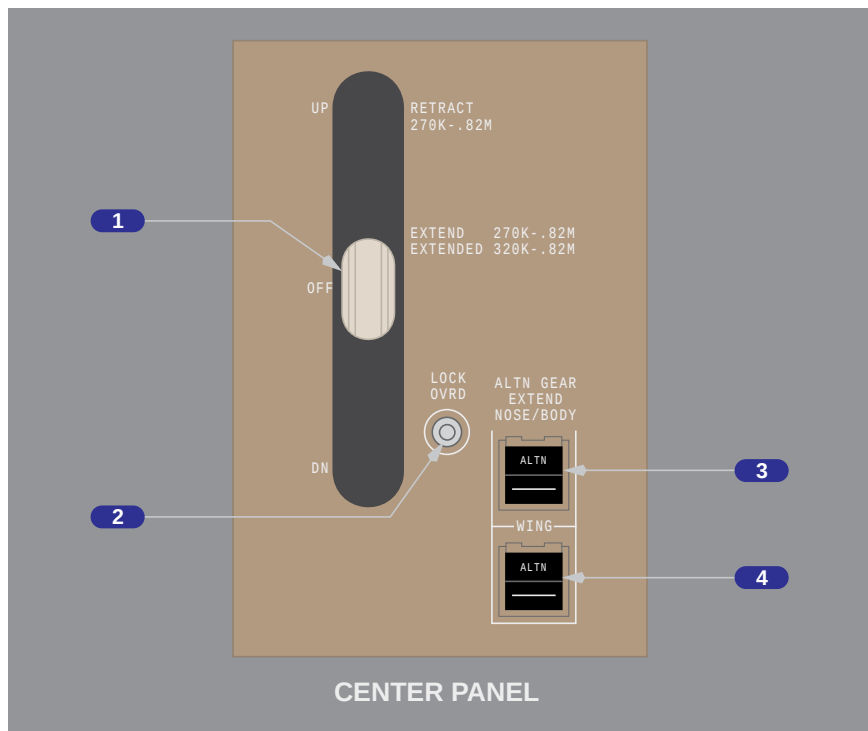
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Landing Gear Controls and Indicators

Chapter 14 Section 10

Landing Gear Panel



1 Landing Gear Lever

UP - landing gear retracts.

OFF - landing gear hydraulic system depressurized.

DN - landing gear extends.

2 Landing Gear Lever LOCK Override (OVRD) switch

Push -releases Landing Gear lever lock.

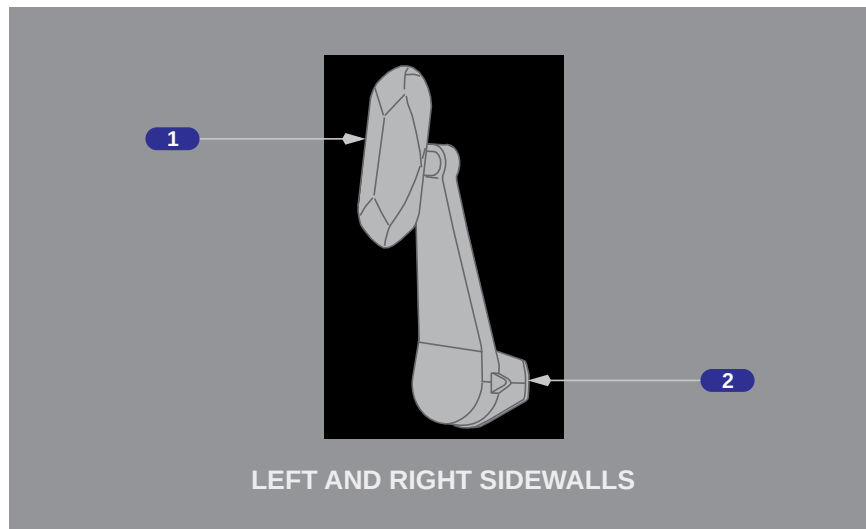
3 NOSE/BODY Alternate (ALTN) GEAR EXTEND switch

ALTN - nose/body landing gear extends by alternate extension system.

4 WING Alternate (ALTN) GEAR EXTEND switch

ALTN - wing landing gear extends by alternate extension system.

Nose Wheel Steering Tiller



1 Nose Wheel Steering Tiller

Rotate -

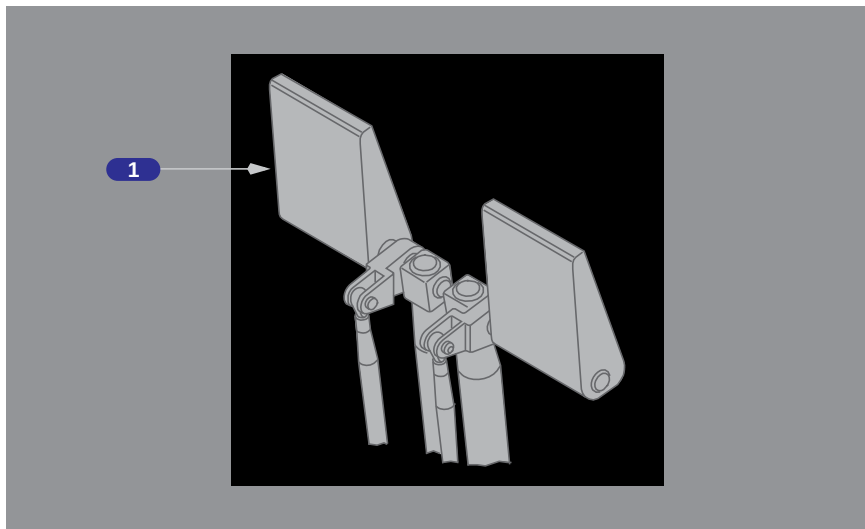
- turns nose wheels up to 70 degrees in either direction
- overrides rudder pedal steering

2 Tiller Position Indicator

Shows tiller displacement from straight-ahead, neutral position.

Brake System

Rudder/Brake Pedals



1 Rudder/Brake Pedals

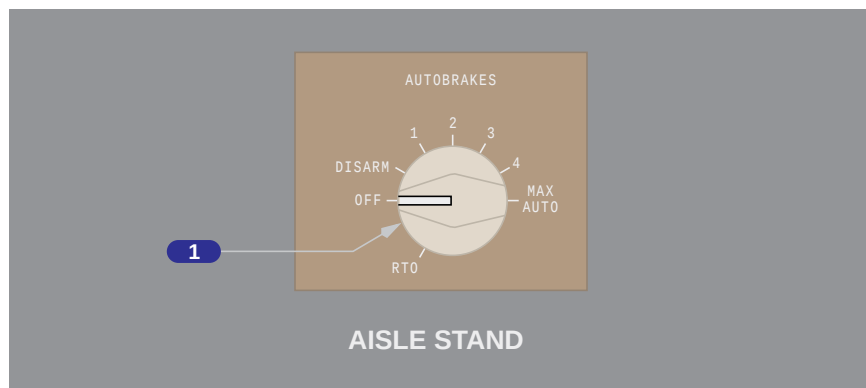
Push full pedal -

- turns nose wheel up to 7 degrees in either direction
- does not activate body gear steering

Push top of pedals - actuates wheel brakes.

Refer to Chapter 9, Flight Controls for the description of rudder operation.

Autobrakes Selector



1 AUTOBRAKES Selector

OFF - deactivates and resets system.

DISARM -

- disengages autobrake
- releases brake pressure

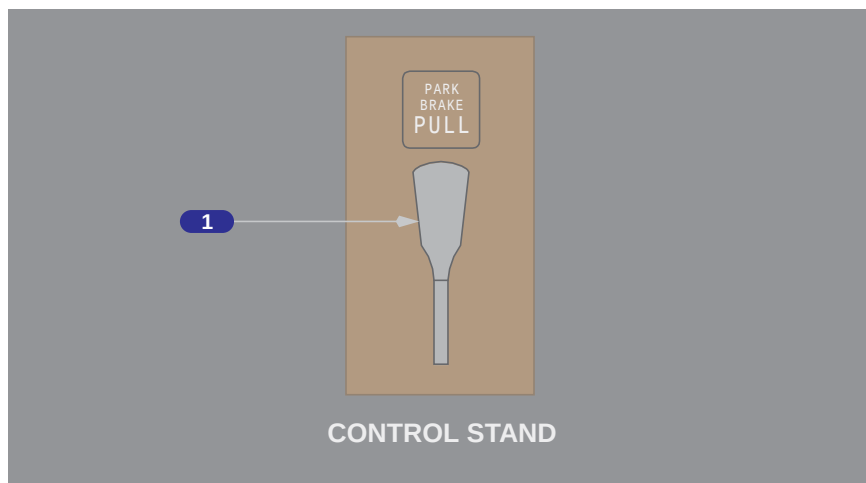
1, 2, 3, 4, MAX AUTO -

- increasing autobrake deceleration rates
- brakes apply at touchdown

RTO -

- rejected takeoff braking
- applies maximum brake pressure when thrust levers retarded to idle above 85 knots
- moves to the OFF position immediately after liftoff
- not available for landing operations

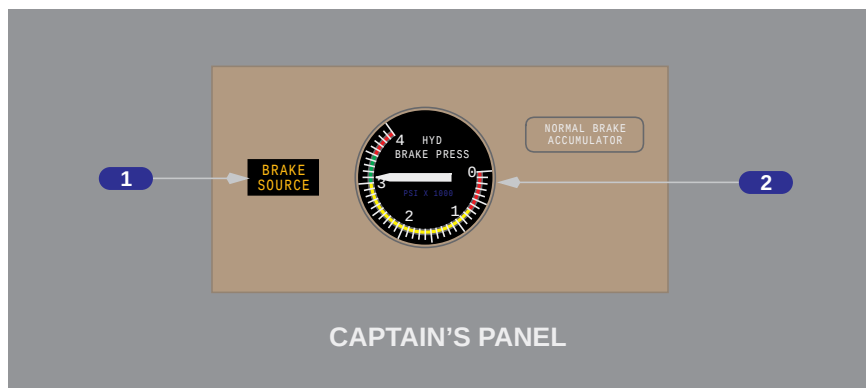
Parking Brake Lever



1 Parking Brake Lever

Pull - sets parking brake when both brake pedals simultaneously depressed.
Releases when both brake pedals simultaneously depressed.

Brake Accumulator Pressure Indicator



1 BRAKE SOURCE Light

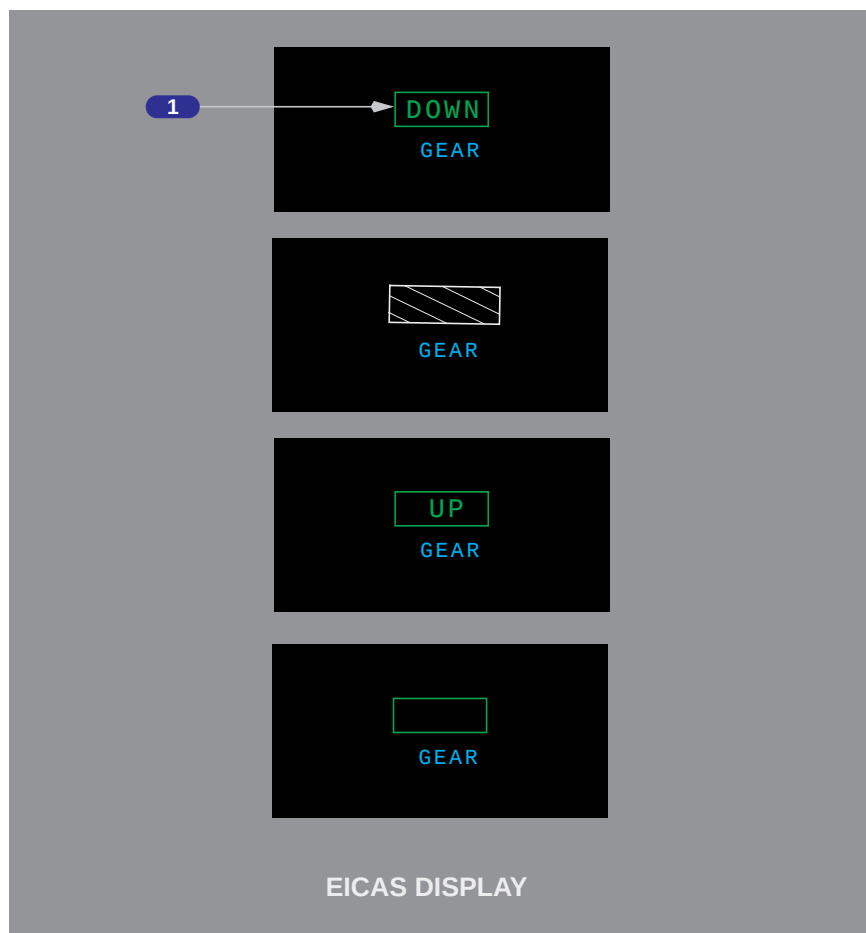
Illuminated (amber) - active brake hydraulic sources (hydraulic systems 4, 1, and 2) have low pressure.

2 BRAKE ACCUMULATOR PRESSURE Indicator

Indicates brake accumulator pressure.

Landing Gear System Indications

Landing Gear Position Indications



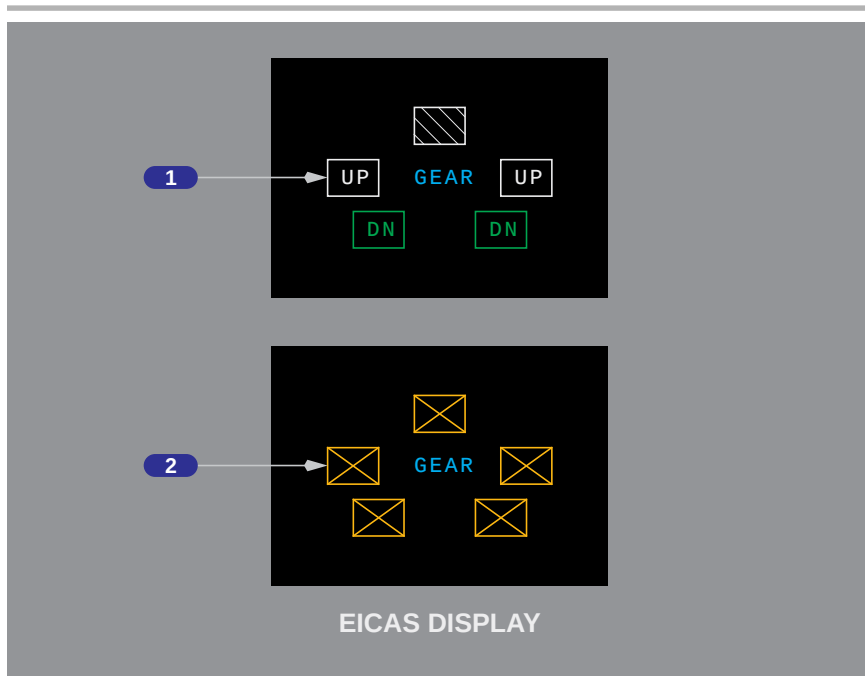
1 Gear Position Indication (Normal Display)

DOWN (green) - all landing gear down and locked.

Crosshatched (white) - one or more landing gear in transit.

UP (white) - all landing gear up and locked (blanks after 10 seconds).

Empty box (white) - all landing gear position indicators inoperative.



1 Expanded Gear Position Indication (Non-Normal Display)

The expanded indication appears on the primary EICAS if any gear position is non-normal or if either alternate gear extend switch is activated.

DN (green) - related landing gear down and locked.

Crosshatched (white) - related landing gear in transit.

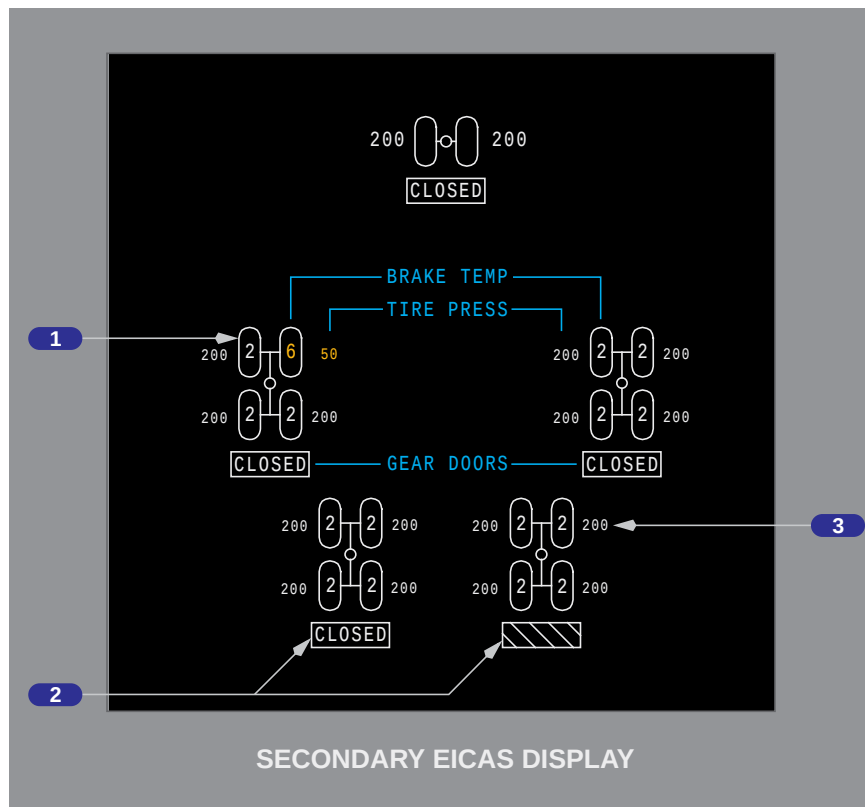
UP (white) - related landing gear up and locked.

2 Expanded Gear Position Indication (Inoperative Display)

X (amber) - landing gear position indicators inoperative.

Gear Synoptic Display

The landing gear synoptic is displayed by pushing the GEAR synoptic display switch on the display select panel. Display select panel operation is described in Chapter 10, Flight Instruments, Displays.



1 Brake Temperature

Indicates a relative value of wheel brake temperature:

- values range from 0 to 9
- white - normal range (0-4)
- amber - high range (5-9)

2 Gear Door Status

Crosshatched - door not closed.

CLOSED (white) - door closed.

Empty box(es) (white) - related landing gear door position indicators inoperative.

3 Tire Pressure Indication

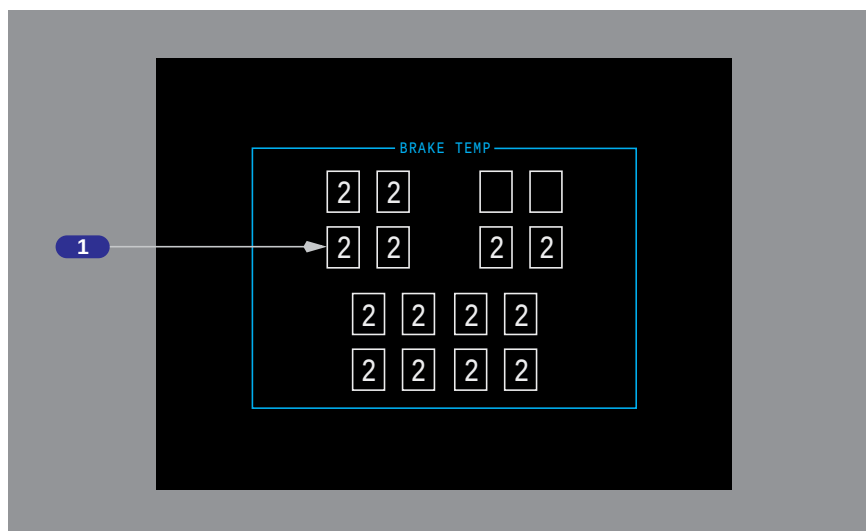
Displays individual tire pressures:

- white - normal range
- amber - abnormal high or low range

Compacted Brake Temperature Indications

Compacted brake temperature indications display if only one display is available for EICAS.

Note: Gear door position and tire pressures are not displayed.



1 Brake Temperature

Indicates a relative value of wheel brake temperature:

- values range from 0 to 9
- white - normal range (0-4)
- amber - high range (5-9)

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Landing Gear System Description

Chapter 14 Section 20

Introduction

The airplane has four main landing gear and a single nose gear. The nose gear is a conventional steerable two-wheel unit. The main gear consist of two steerable body gear and two non-steerable wing gear. Each main gear has four wheels per truck in tandem pairs. The main gear trucks must be tilted and centered to allow retraction into the wheel wells.

Hydraulic power for nose and body gear retraction and extension is supplied by hydraulic system 1. Power to retract and extend the wing gear is provided by hydraulic system 4. An alternate extension system is also provided.

The normal brake system is powered by hydraulic system 4. The alternate brake system is powered by hydraulic system 1 or 2. Pressure-operated selector valves provide automatic brake source selection. Antiskid protection is provided with both systems, but the autobrake system is available only through the normal system.

A brake temperature monitor system and tire pressure indication system displays each brake temperature and tire pressure on the GEAR synoptic display.

Air/Ground Sensing System

In flight and ground operation of various airplane systems are controlled by the air/ground sensing system and a nose gear extension sensing system.

A combination of main gear tilt sensors indicate the gear are tilted (air mode) or not tilted (ground mode) to provide an air/ground signal to relays which control various system functions.

Nose gear extension sensing provides a signal to relays controlling functions in the stall warning and nose gear steering systems.

Landing Gear Operation

The Landing Gear lever normally controls the landing gear. On the ground, an automatic lever lock prevents movement of the lever from OFF to UP. The lever lock can be manually overridden by pushing and holding the Landing Gear Lever Lock Override switch. In flight, the lever lock is released when the main gear are tilted and the body gear is centered.

All four main gear hydraulically tilt as the airplane lifts off the runway. During landing, ground load brings the gear to a level position.

Each wing gear has one hydraulically actuated and one mechanically actuated gear door. Each body gear has one hydraulically actuated and two mechanically actuated gear doors. The nose gear has two hydraulically actuated and two mechanically actuated gear doors.

Landing Gear Retraction

After liftoff, the gear must be tilted and body gear centered for retraction to take place. When this occurs, the main gear tilt sensors and body steering sensors send a signal to the landing gear lever lock to release.

When the Landing Gear lever is moved to UP, the landing gear doors open, automatic braking occurs (provided by the alternate brake system), and the landing gear begin to retract. The EICAS landing gear position indication display changes from a green DOWN indication to a white crosshatch in-transit indication as the landing gear retract into the wheel wells.

After retraction, the main gear are held in the up position by uplocks. The nose gear is mechanically locked in the up position. The EICAS landing gear position indication changes to UP for 10 seconds and then blanks. Positioning the Landing Gear lever to OFF depressurizes the landing gear system.

If any gear is not up and locked up after the normal transit time, the EICAS gear position indication changes to the expanded non-normal format, with the affected gear displayed as in-transit, or down if the gear never unlocked from the down position.

Landing Gear Extension

When the Landing Gear lever is moved to DN, the landing gear doors open, the gear are unlocked, and the in-transit indication is displayed on the EICAS landing gear position indication.

The gear are hydraulically powered to the down and locked position. The downlocks are powered to the locked position, all hydraulically actuated gear doors close, and the main gear trucks hydraulically tilt to the flight position. When all gear are down and locked, the EICAS gear position indication displays DOWN.

If any gear position disagrees with lever position after the normal transit time the EICAS gear position indication changes to the expanded non-normal format, with the affected gear displayed as in transit (or UP if the gear never unlocked from the up position).

Landing Gear Alternate Extension

Alternate gear extension is activated by pushing the Alternate Gear Extend switches. The gear uplocks and gear door latches are electrically released, allowing the gear to free fall. Gravity and airloads extend the gear and springs pull the downlocks into the locked position. Affected gear doors remain open after alternate extension.

The EICAS landing gear position indication displays the expanded gear position indication when the alternate extension system is used.

Nose Wheel and Body Gear Steering

Nose wheel and body gear steering is powered by hydraulic system 1.

Primary low speed steering control is provided by a nose wheel steering tiller for each pilot. Limited steering control is available through the rudder pedals. The tillers can turn the nose wheels up to 70 degrees in either direction. A pointer on the tiller assembly shows tiller position relative to the neutral setting. The rudder pedals can be used to turn the nose wheels up to 7 degrees in either direction. Tiller inputs override rudder pedal inputs.

Body gear steering operates when the nose wheel steering angle exceeds 20 degrees. This reduces tire scrubbing and lets the airplane turn in a minimum radius. Body gear steering is activated when ground speed decreases through 15 knots. The body gear will move in the opposite direction of the nose wheel. As speed increases through 20 knots, the body gear is hydraulically centered and body gear steering is deactivated.

Brake System

Each main gear wheel has a multiple disc carbon brake. The nose wheels have no brakes. The brake system includes:

- normal brake hydraulic system
- alternate brake hydraulic system
- brake accumulator
- antiskid protection
- autobrake system
- parking brake

Normal Brake Hydraulic System

The normal brake hydraulic system is powered by hydraulic system 4. The brake pedals provide independent control of the left and right brakes.

Alternate Brake Hydraulic System

If hydraulic system 4 pressure is low, hydraulic system 1 automatically supplies pressure to the alternate brake hydraulic system. If hydraulic pressure in systems 4 and 1 are low, system 2 automatically powers the alternate brake system.

Loss of hydraulic systems 4, 1, and 2 causes the brake source light to illuminate.

Brake Accumulator

The brake accumulator provides for parking brake application. The accumulator is pressurized by hydraulic system 4.

Antiskid Protection

Antiskid protection is provided in the normal and alternate brake hydraulic systems.

The normal brake hydraulic system provides each main gear wheel with individual antiskid protection. When a wheel speed sensor detects a skid, the associated antiskid valve reduces brake pressure until skidding stops.

The alternate brake hydraulic system provides antiskid protection to lateral wheel pairs (forward and/or aft pair on each truck) rather than to individual wheels.

The antiskid system will protect against brake application at touchdown. Touchdown and hydroplaning protection is provided using airplane inertial ground speed. Locked wheel protection is provided using a comparison with other wheel speeds. Touchdown, hydroplaning, and locked wheel protection are available in both normal and alternate systems.

Brake Torque Limiter

A brake torque sensor is provided at each wheel. The sensors detect excessive torque during braking to prevent damage to landing gear. When excessive torque is detected, a signal is sent to the antiskid valve to release brake pressure to that wheel. If the alternate brake system is used, brake torque is sensed on an individual wheel basis, however the signal is sent to the alternate antiskid valve and brake pressure is released on a laterally paired wheel basis.

Autobrake System

The auto brake system is only available with normal brakes (system 4). The autobrake system provides braking at preselected deceleration rates for landing and full pressure for rejected takeoff. The system operates only when the normal brake system is functioning. Antiskid system protection is provided during autobrake operation.

Rejected Takeoff

Selecting RTO (rejected takeoff) prior to takeoff arms the autobrake system. The RTO mode can be selected only on the ground. The RTO autobrake setting commands maximum braking pressure if:

- the airplane is on the ground
- groundspeed is above 85 knots, and
- all thrust levers are closed

Maximum braking is obtained in this mode. If an RTO is initiated below 85 knots, the RTO autobrake function does not operate.

Landing

Five levels of deceleration can be selected for landing. However, on dry runways, the maximum autobrake deceleration rate in the landing mode is less than that produced by full pedal braking.

After landing, autobrake application begins when:

- all thrust levers are closed,
- ground mode is sensed, and
- the wheels have spun up

To maintain the selected airplane deceleration rate, autobrake pressure is reduced as other controls, such as thrust reversers and spoilers, contribute to total deceleration. The system provides braking to a complete stop or until it is disarmed.

Autobrake - Disarm

The system disarms immediately if any of the following occur:

- pedal braking applied
- any Thrust lever advanced after landing
- Speedbrake lever moved to DOWN detent after speedbrakes have deployed on the ground
- DISARM or OFF position selected on Autobrakes selector
- autobrake fault
- normal antiskid system fault
- loss of normal brake hydraulic pressure

When the autobrake system disarms after landing, the Autobrakes selector moves to DISARM position. Rotating the Autobrakes selector to OFF removes power from the autobrake system.

When the autobrake system disarms during takeoff, the Autobrakes selector remains in RTO position, but moves to OFF after takeoff.

Parking Brake

The parking brake can be set with the normal brake hydraulic system pressurized. If the normal brake system is not pressurized, parking brake pressure is maintained by the brake accumulator. The brake accumulator is pressurized by hydraulic system 4. Accumulator pressure is shown on the brake accumulator pressure indicator.

Sufficient pressure is stored in the accumulator to set and hold the parking brake, but the accumulator is not designed to stop the aircraft.

The parking brake is set by fully depressing both brake pedals, pulling the Parking Brake lever up, then releasing the pedals. This mechanically latches the pedals in the depressed position and commands the parking brake valve to close.

When the parking brake is set, the first hydraulic system pressurized may supply a small amount of fluid to the brake lines. When brakes are released, that small amount of fluid returns to system 4. Pressurizing system 4 before pressurizing the other systems precludes the transfer of hydraulic fluid from system 1 or 2 into system 4.

The parking brake is released by depressing the pedals until the Parking Brake lever releases.

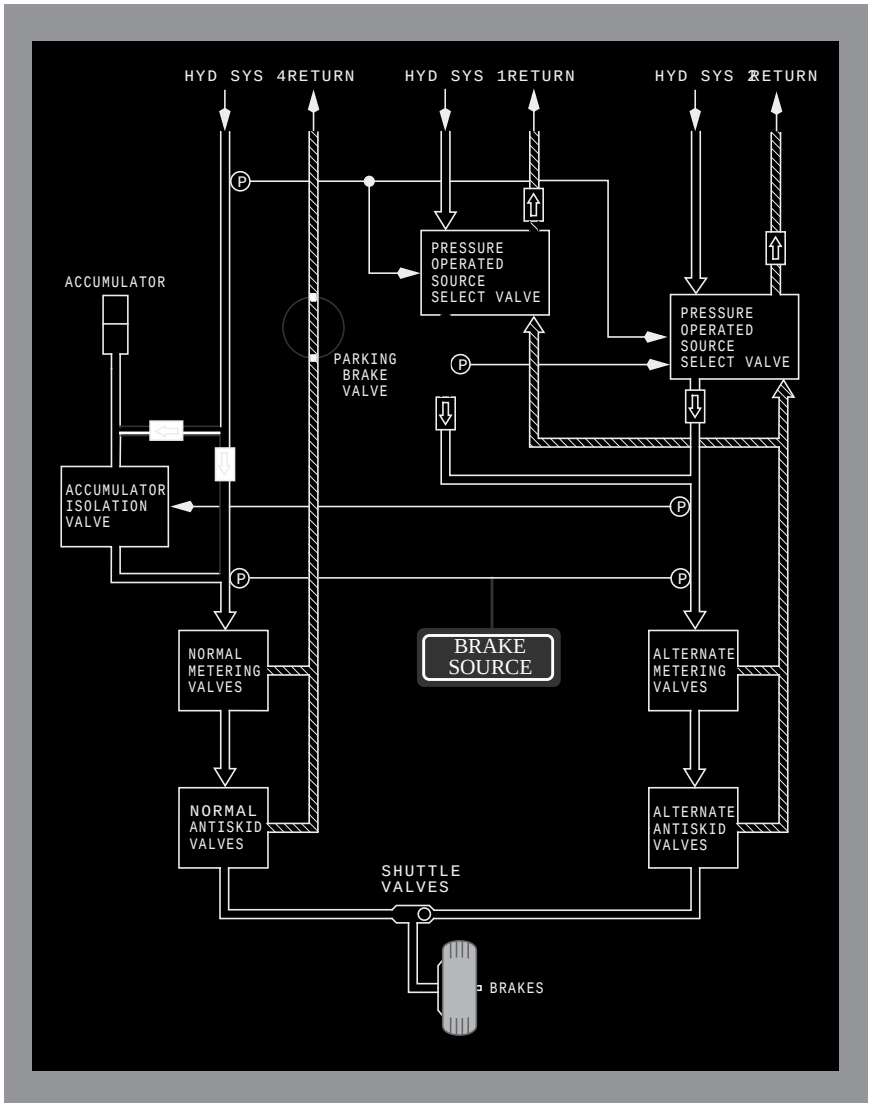
Brake Temperature Indication

Wheel brake temperatures display on the GEAR synoptic display. Numerical values related to wheel brake temperature display inside each wheel/brake symbol.

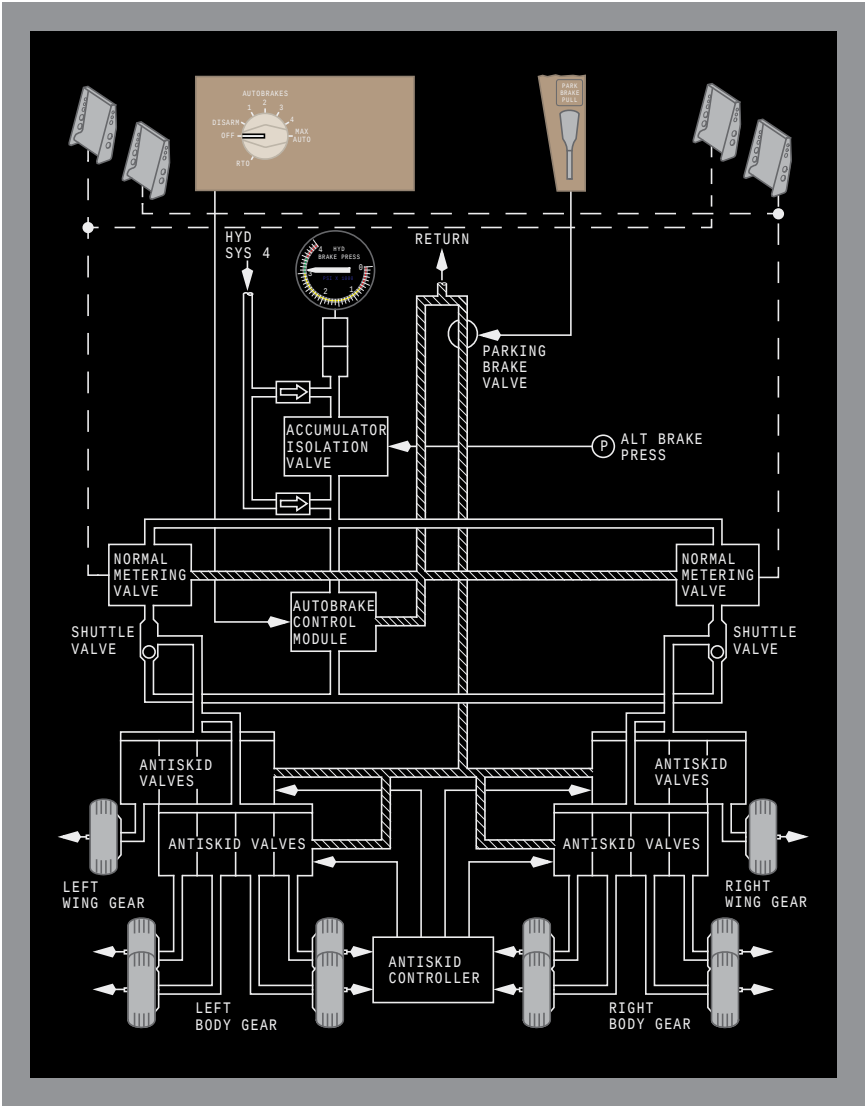
Tire Pressure Indication

Tire pressures, from 0 to 400 PSI, display beside the individual wheel symbols on the GEAR synoptic display.

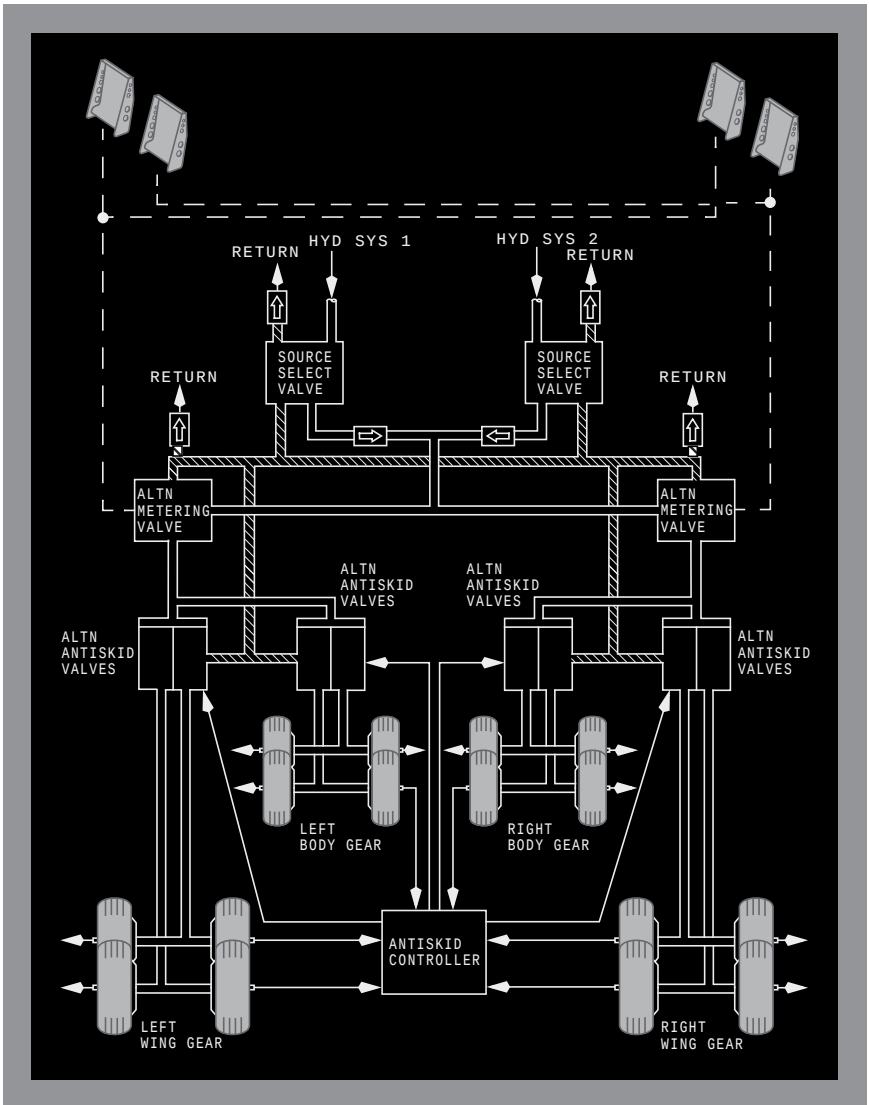
Brake Source Selection Diagram



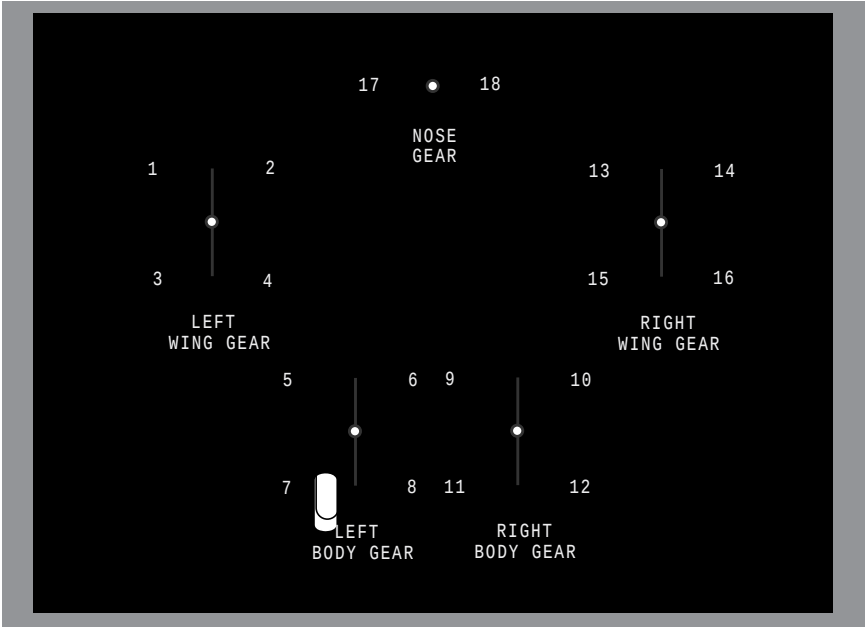
Normal Brake System Diagram



Alternate Brake System Diagram



Wheel Position Numbering Diagram



Landing Gear EICAS Messages

Chapter 14 Section 30

Landing Gear EICAS Messages

The following EICAS messages can be displayed.

Note: Configuration warning messages are covered in Chapter 15, Warning Systems.

EICAS Alert Messages

Message	Level	Aural	Message Logic
AIR/GND SYSTEM	Advisory		Air/ground sensing system failed to air position.
ANTISKID	Advisory		Fault detected in antiskid system. Fault in active antiskid system, either normal or alternate, results in loss of antiskid protection to one or more wheels.
ANTISKID OFF	Advisory		Antiskid power off on all wheels, or parking brake lever released and parking brake valve not fully open, or brake system control unit power loss occurs.
AUTOBRAKES	Advisory		Autobrake disarmed or inoperative, or autobrake armed with Autobrakes selector OFF, or RTO initiated above 85 knots and autobrake has not been applied.
>BODY GEAR STRG	Advisory		Body gear steering unlocked when commanded locked, or pressurized when not commanded.
BRAKE LIMITER	Advisory		Brake torque limiter failure on more than one wheel per truck, or parking brake lever released and parking brake valve not fully open, or brake unit control system power loss.
>BRAKE SOURCE	Caution	Beeper	Brake system pressures from hydraulic systems 1, 2, and 4 are low.
BRAKE TEMP	Advisory		Temperature of one or more brakes excessive. Brake temperature equal to or greater than 5 units.

Message	Level	Aural	Message Logic
GEAR DISAGREE	Caution	Beeper	Gear position disagrees with Landing Gear lever position after normal transit time.
GEAR DOOR	Advisory		One or more gear doors not closed after normal gear transit time. Inhibited if alternate gear extension selected.
GEAR TILT	Caution	Beeper	Main gear trucks not in full tilt position.
>TIRE PRESSURE	Advisory		One or more tire pressures out of limits.

EICAS Memo Messages

Message	Level	Aural	Message Logic
AUTOBRAKES 1, 2, 3, 4	Memo		Autobrake level selected.
AUTOBRAKES MAX	Memo		Autobrake MAX selected.
AUTOBRAKES RTO	Memo		Autobrake RTO selected.
PARK BRAKE SET	Memo		Parking brake valve closed.

Warning Systems

Chapter 15

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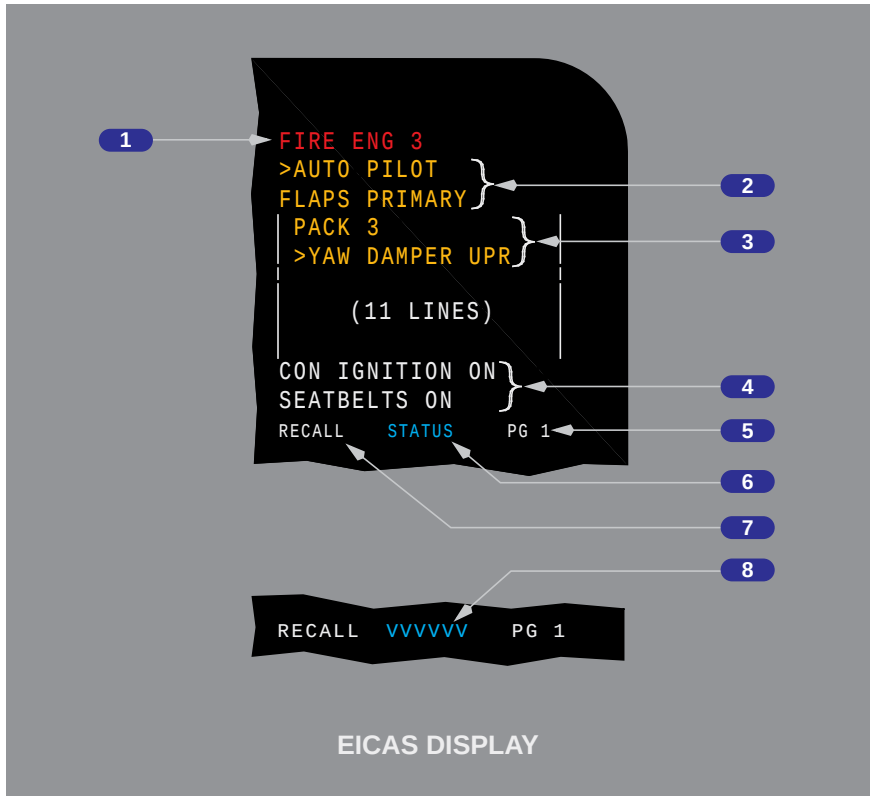
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Intentionally
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Engine Indication and Crew Alerting System (EICAS)

EICAS Messages



1 Warning Messages

Displayed (red) -

- highest priority alert messages
- red alert messages remain displayed and cannot be canceled by pushing the Cancel switch.

2 Caution Messages

Displayed (amber) -

- next highest priority alert messages after warning messages
- amber alert messages can be canceled by pushing the Cancel switch or recalled by pushing the Recall switch

3 Advisory Messages

Displayed (amber) -

- lowest priority alert message
- indented one space
- amber alert messages can be canceled by pushing the Cancel switch or recalled by pushing the Recall switch

4 Memo Messages

Displayed (white) -

- reminder of selected state of controls or systems
- cannot be canceled by pushing the Cancel switch
- EICAS alert messages have display priority over memo messages; some or all memo messages not displayed on current EICAS message page if insufficient message lines are available below alert messages

5 Page (PG) Number

Displayed (white) -

- more than one page of alert or memo messages exists
- indicates the number of page selected

6 STATUS Cue

Displayed (cyan) -

- new status message exists and the status synoptic is not displayed
- no longer displayed when status display selected
- inhibited from after engine start until 30 minutes after lift-off
- inhibited if Secondary Engine Exceedance cue is displayed

7 RECALL Indication

Displayed (white) -

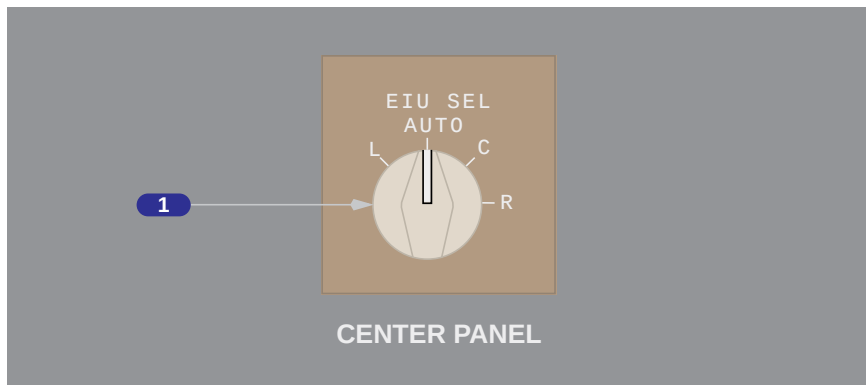
- when Recall switch pushed
- remains displayed for one second after switch released

8 Secondary Engine Exceedance Cue

Displayed (cyan) -

- engine parameter on secondary engine display have been exceeded
- displayed until displayed parameter exceeded returns to normal operating range
- inhibits display of Status cue

EFIS/EICAS Interface Unit (EIU) Selector



1 EIU Selector

L -

- left EIU provides data to EFIS and EICAS
- if left EIU fails, automatic switching to an operable EIU is inhibited; if airplane is on standby power and left EIU fails, all CRT displays fail

AUTO -

- selects an operable EIU to provide data to EFIS and EICAS
- Selects left, then center, then right

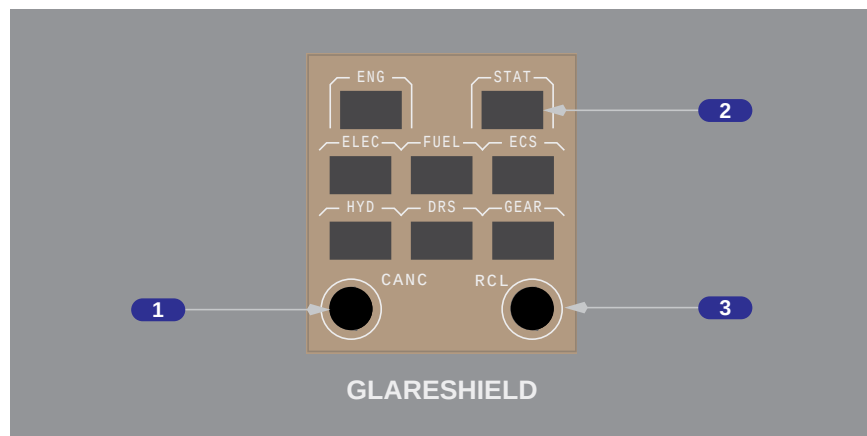
C -

- center EIU provides data to EFIS and EICAS
- if center EIU fails, automatic switching to an operable EIU is inhibited

R -

- right EIU provides data to EFIS and EICAS
- if right EIU fails, automatic switching to an operable EIU is inhibited

Display Select Panel



1 Cancel (CANC) Switch

Push -

- displays next page of caution and advisory messages when additional pages exist
- cancels caution and advisory messages when last page displayed; warning and memo messages remain displayed
- cancels red box for any engine parameter previously exceeded when displayed parameter no longer exceeds the limit

2 Status (STAT) Display Switch

Push - displays status display on secondary EICAS.

Subsequent pushes -

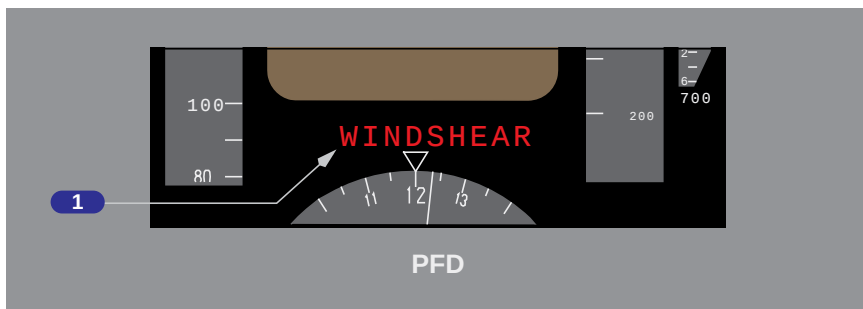
- display next page of status messages when additional pages exist
- secondary EICAS blanks when last status message page displayed

3 Recall (RCL) Switch

Push -

- redisplay all caution and advisory EICAS messages, when respective non-normal condition exists
- displays first page of messages when multiple pages exist
- redisplay red box for parameters previously exceeded
- displays RECALL indication for one second after switch released

GPWS Alerts on PFD



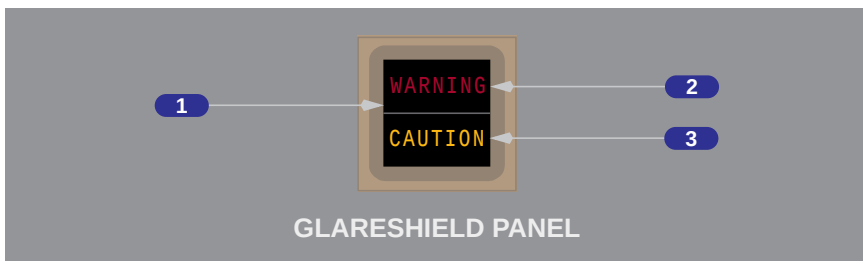
1 Alert on PFD

PULL UP (red) - GPWS PULL UP alert is occurring.

WINDSHEAR (red) -

- WINDSHEAR alert is occurring
- all other GPWS alerts inhibited

Master WARNING/CAUTION Reset Switches and Lights



1 Master WARNING/CAUTION Reset Switch

Push -

- extinguishes master WARNING lights
- extinguishes master CAUTION lights
- silences the aural alert that accompany the EICAS warning messages:
 - CABIN ALTITUDE
 - CONFIG GEAR, if displayed because landing gear not down and locked, any thrust lever at idle, and radio altitude less than 800 feet
 - FIRE
 - OVERSPEED

2 Master WARNING Light

Illuminated (red) -

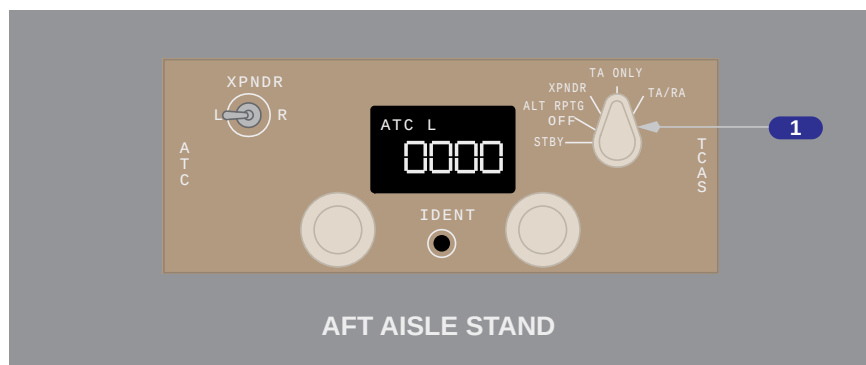
- new EICAS warning message displayed, or
- PULL UP or WINDSHEAR alert displayed on PFD

3 Master CAUTION Light

Illuminated (amber) - new EICAS caution message displayed

Traffic Alert and Collision Avoidance System (TCAS)

TCAS Controls (Transponder Panel)



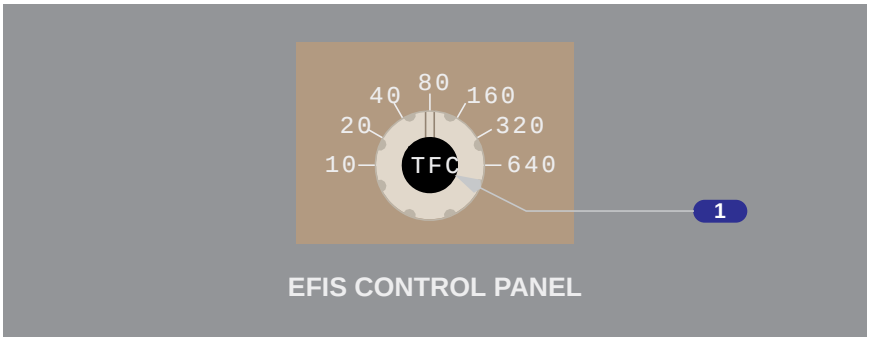
1 Transponder Mode Selector

TA ONLY (traffic advisory) -

- transponder and TCAS TA modes enabled
- all aircraft that would have been predicted as a RA are predicted as a TA

TA/RA (traffic advisory/resolution advisory) - transponder and TCAS TA and RA modes enabled.

TCAS Controls (EFIS Control Panel)

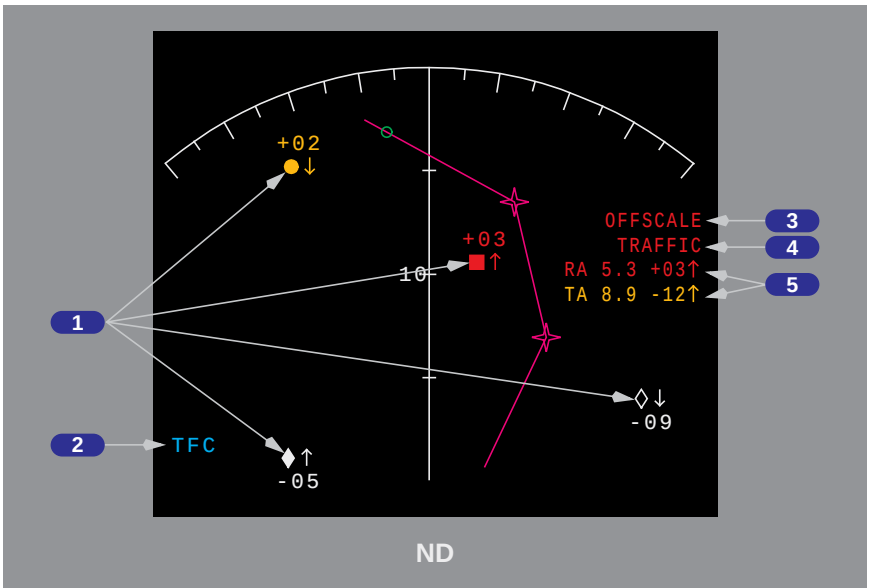


1 ND Traffic (TFC) Switch (inner)

Push – in VOR, APP, MAP, and MAP CTR modes:

- TCAS traffic displayed on ND
- range information displayed when in the expanded APP or VOR modes
- with TCAS FAIL displayed on ND, cancels TCAS FAIL message

TCAS Traffic Displays



1 Traffic Display

Indicates relative position of traffic.

- filled red square indicates a resolution advisory (RA)
- filled amber circle indicates a traffic advisory (TA)
- filled white diamond indicates proximate traffic
- unfilled white diamond indicates other traffic
- number is relative altitude of traffic in hundreds of feet; not displayed when altitude unknown
- vertical motion arrow indicates traffic climbing or descending at 500 feet per minute or greater; not displayed for vertical motion less than 500 feet per minute

Displayed automatically when:

- a RA or TA occurs, and
- TFC is not displayed on either ND, and
- respective ND is in MAP, MAP CTR, VOR, or APP mode

Displayed automatically when:

- EFIS control panel fails, and
- respective ND is in MAP, MAP CTR, VOR, or APP mode

2 TCAS Mode Annunciations

TFC (cyan) -

- TCAS traffic display enabled
- TCAS traffic displayed in MAP, MAP CTR, APP, and VOR modes

TA ONLY (cyan) -

- TCAS cannot provide RAs
- all traffic that would have been RAs are predicted as TAs

3 OFFSCALE Message

Displayed (red) -

- RA is beyond selected map range
- only when TCAS enabled

Displayed (amber) -

- TA is beyond selected map range
- only when TCAS enabled

4 TRAFFIC Alert Message

Displayed: (red) - RA is occurring.

Displayed: (amber) - TA is occurring, and RA is not occurring.

Displayed whether TCAS traffic is displayed or not.

Displayed in all ND modes and ranges.

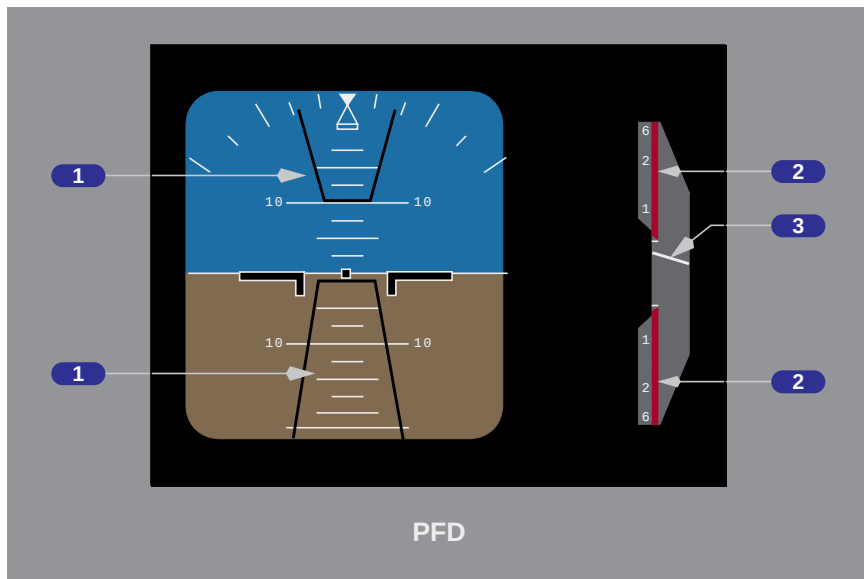
5 TCAS No-Bearing Messages

RA (red) - data tag displayed for no-bearing RA.

TA (amber) - data tag displayed for no-bearing TA.

Data tag contains distance, altitude, and vertical motion arrow.

TCAS PFD Vertical Guidance



1 RA Pitch Region To Avoid Traffic (red outlined)

Note: For a single RA, only one red outlined RA pitch region, either above or below, is displayed at a time. For two or more RAs, two red outlined RA pitch regions may be displayed.

To ensure vertical separation, the center of the airplane symbol must be outside the red outlined RA pitch regions to avoid traffic.

2 RA Vertical Speed Region to Avoid Traffic (red)

To ensure vertical separation, vertical speed must be outside the red RA vertical speed region to avoid.

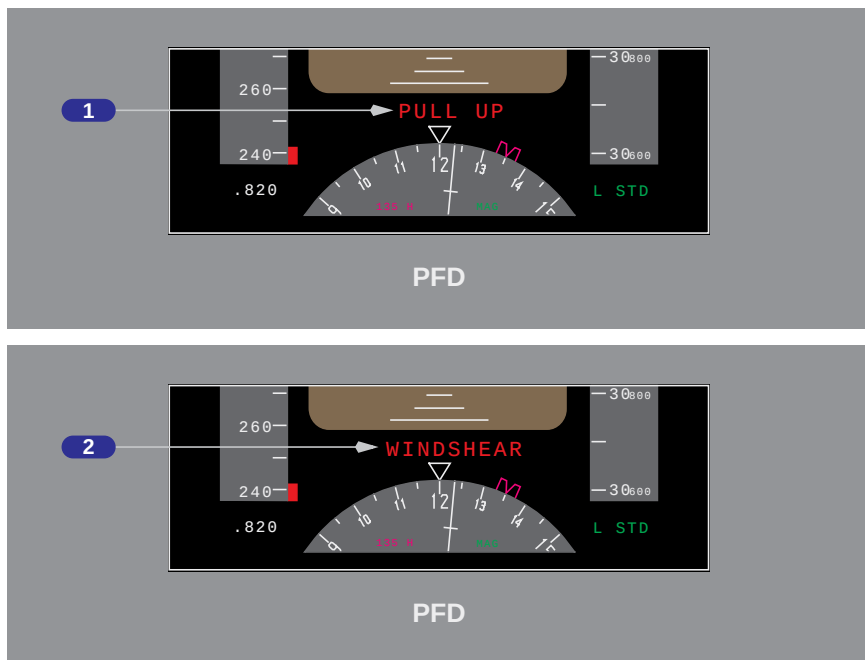
3 Vertical Speed Pointer

Red - present vertical speed does not ensure traffic is avoided.

White - present vertical speed ensures traffic is avoided.

System Warnings

Time Critical Warnings



1 PULL UP Annunciation

PULL UP (red) -

- the GPWS barometric descent rate is excessive, or
- the GPWS radio altitude decrease rate is excessive
- look ahead terrain warning is active.

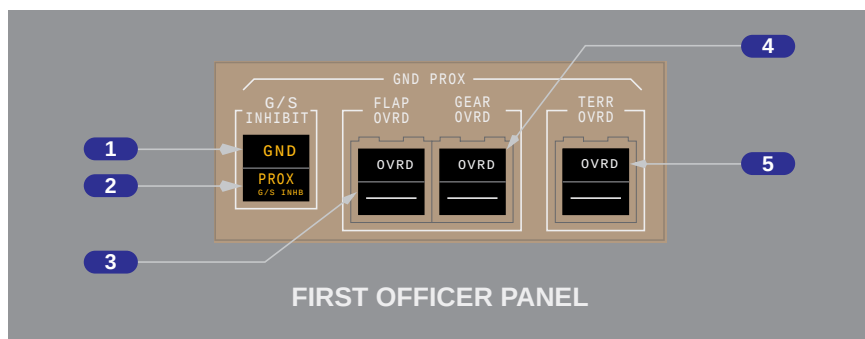
2 WINDSHEAR Annunciation

WINDSHEAR (red) -

- a windshear condition is detected
- all other GPWS modes are inhibited.

Ground Proximity Warning System (GPWS) Controls

Ground Proximity Panel



1 Ground Proximity (GND PROX) Glideslope (G/S) Inhibit Switch

Push - inhibits GLIDESLOPE alert when pushed below 1,000 feet radio altitude.

2 Ground Proximity (GND PROX) Light

Illuminated (amber) -

- GPWS GLIDE SLOPE, SINKRATE, TERRAIN, TOO LOW FLAPS, TOO LOW GEAR, or TOO LOW TERRAIN immediate alert is occurring
- Inhibited for GLIDESLOPE, or TOO LOW FLAPS, or TOO LOW GEAR alerts when respective inhibit or override switch is pushed

3 Ground Proximity (GND PROX) Flap Override (OVRD) Switch

Push (OVRD illuminated) -

- inhibits TOO LOW FLAPS alert
- EICAS advisory message GND PROX SYS will be displayed when airspeed greater than 250 knots for more than 60 seconds

4 Ground Proximity (GND PROX) Configuration (CONFIG) Gear (GEAR) Override (OVRD) Switch

Push (OVRD illuminated) -

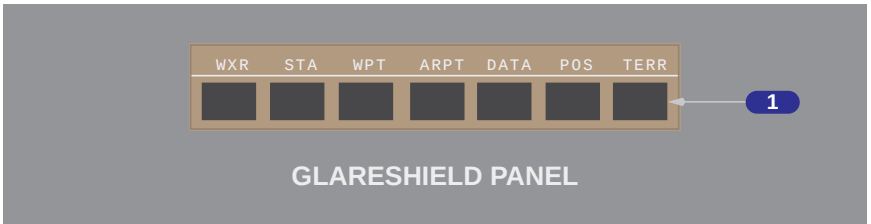
- inhibits TOO LOW GEAR alert
- inhibits the aural alert that accompanies the EICAS warning message CONFIG GEAR, if displayed because the landing gear not down and locked, any thrust lever at idle, and radio altitude less than 800 feet
- EICAS advisory message GND PROX SYS will be displayed when airspeed greater than 290 knots for more than 60 seconds

5 Ground Proximity (GND PROX) Terrain (TERR) Override (OVRD) Switch

Push (OVRD illuminated) - inhibits look-ahead terrain alerts and terrain display.

GPWS Look-Ahead Terrain Alerting Display and Annunciations

GPWS Terrain Display Select Switch



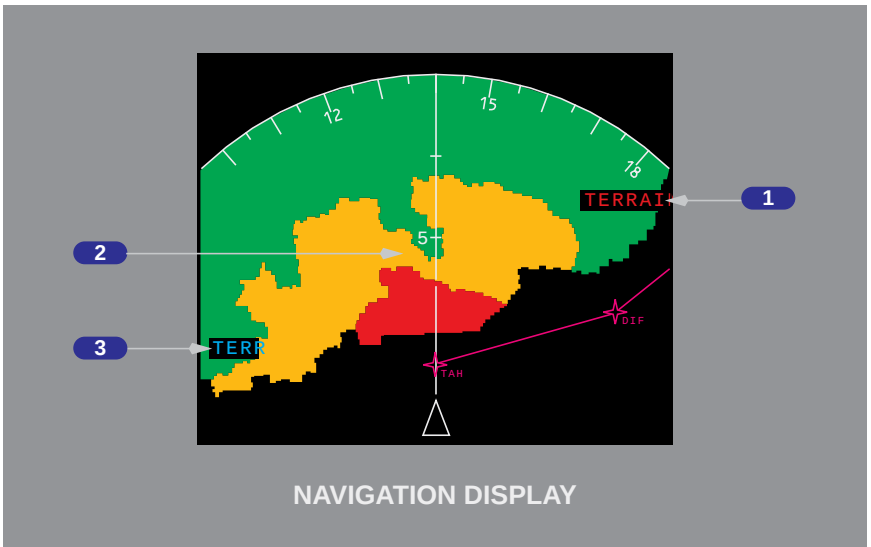
1 GPWS Terrain (TERR) Display Select Switch

Push -

- terrain data displayed is in MAP, MAP CTR, VOR, and APP modes
- weather radar data is not displayed

Second push - terrain data is not displayed.

Terrain Display



1 TERRAIN Annunciation

TERRAIN (amber) – look-ahead terrain caution alert is occurring.

TERRAIN (red) – look-ahead terrain warning alert is occurring.

Displayed in all ND display modes.

2 Terrain Display

Color and density vary based on terrain height and airplane altitude:

- dotted green: terrain from 2,000 feet below to 500 feet (250 feet with gear down) below airplane altitude
- dotted amber: terrain 500 feet (250 feet with gear down) below to 2,000 feet above airplane altitude
- dotted red: terrain more than 2,000 feet above airplane altitude
- dotted magenta: no terrain data available
- solid amber: look-ahead terrain caution alert is occurring
- solid red: look-ahead terrain warning alert is occurring

Note: In areas without terrain data, look-ahead terrain alerting and display functions not available. GPWS immediate alerts function normally.

Note: Terrain more than 2,000 feet below airplane altitude or within 400 feet of the nearest airport runway elevation is not displayed.

Displayed automatically when:

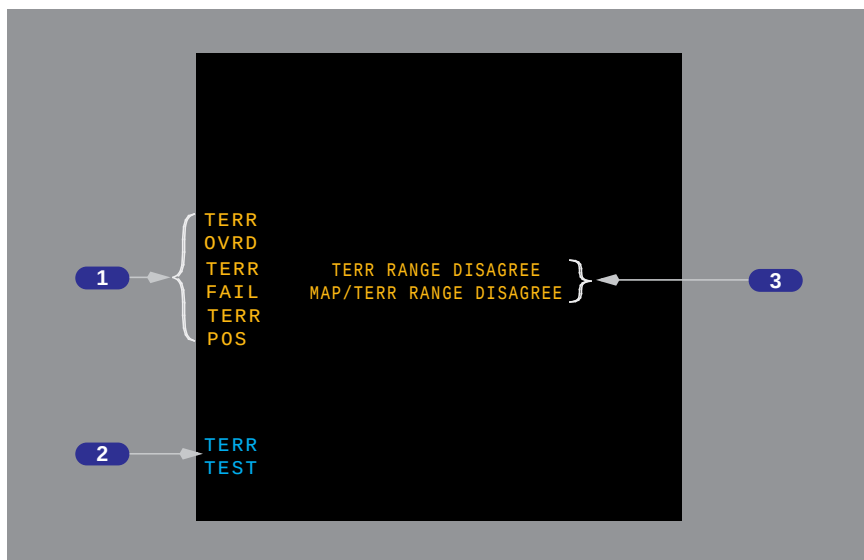
- a look-ahead terrain alert occurs, and
- TERR not selected on either ND, and
- respective ND is in MAP, MAP CTR, VOR, or APP mode

Display updates with a display sweep similar to weather radar display.

3 Terrain Mode Annunciation

TERR (cyan) – terrain display enabled.

Terrain Navigation Display Annunciations



1 Terrain Annunciations

TERR OVRD (amber) - TERR OVRD switch pushed.

TERR FAIL (amber) - look-ahead terrain alerting and display failed.

TERR POS (amber) - look-ahead terrain alerting and display unavailable due to GPS position uncertainty. During time between GPS position failure and display of TERR POS message, IRS provides position for look-ahead alerting and display.

2 Terrain Test Annunciation

TERR TEST (cyan) - GPWS operating in self-test mode.

3 Terrain Range Annunciation

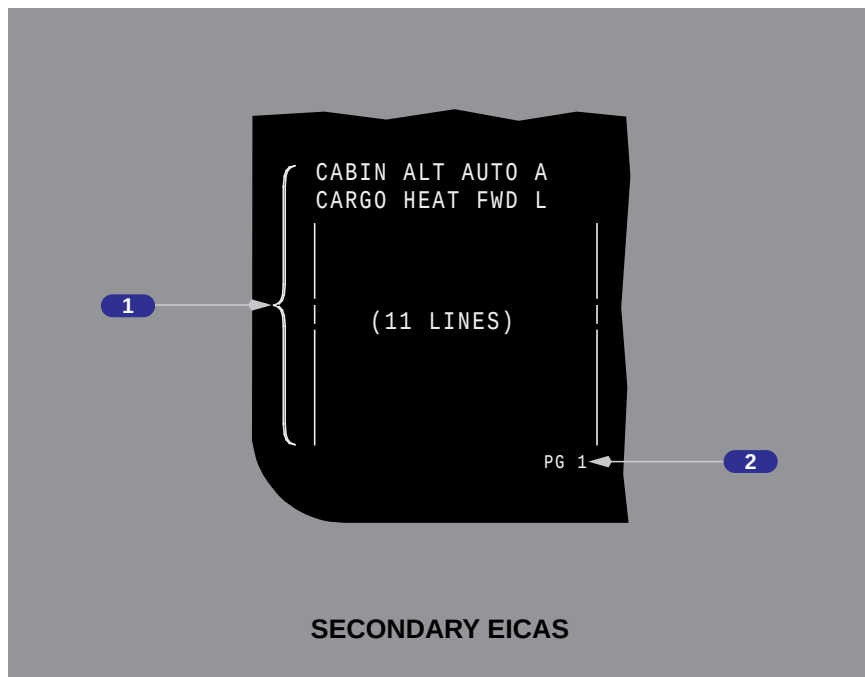
TERR RANGE DISAGREE (amber) -

- terrain display enabled, and
- terrain output range disagrees with range selected by EFIS control panel

MAP/TERR RANGE DISAGREE (amber) -

- terrain display enabled, and
- terrain output range disagrees with range selected by EFIS control panel, and
- map display output range disagrees with range selected by EFIS control panel

Status Display



1 Status Messages

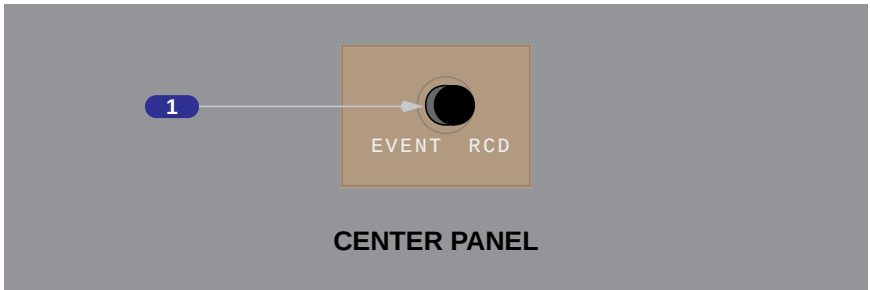
Status messages indicate equipment faults requiring MEL reference for dispatch.

2 Page (PG) Number

Displayed -

- additional pages of status messages exist
- displays number of page selected

EICAS Event Record Switch



1 EICAS Event Record (EVENT RCD) Switch

Push - records up to five EICAS events.

Intentionally
Blank

Warning Systems

System Description

Chapter 15

Section 20

Introduction

Warning systems consist of:

- engine indication and crew alerting system (EICAS)
- airspeed alerts
- takeoff and landing configuration warning system
- MCP selected altitude alerts
- traffic collision avoidance system (TCAS)
- windshear alerts
- ground proximity warning system (GPWS)
- maintenance event recording

Engine Indication and Crew Alerting System (EICAS)

EICAS consolidates engine and airplane system indications and is the primary means of displaying system indications and alerts to the flight crew. The most important indications are displayed on primary EICAS.

EFIS/EICAS Interface Unit (EIU)

The EIUs monitor all airplane systems continuously and control the information displayed on the EICAS displays. Data from airplane systems is provided to three EIUs and one of the three EIUs controls all EICAS displays. The EIU selector provides either automatic or manual selection of the controlling EIU.

EICAS Messages

Systems conditions and configuration information is provided to the crew by three types of EICAS messages:

- EICAS alert messages are the primary method to alert the crew to non-normal conditions
- EICAS memo messages are crew reminders of certain flight crew selected normal conditions
- EICAS status messages indicate equipment faults requiring MEL reference for dispatch

An EICAS alert or memo message is no longer displayed when the respective condition no longer exists.

EICAS Alert messages

From after engine start until engine shut down, EICAS alert messages are the primary means to alert the crew to non-normal conditions which may impact other operations during the flight.

There is a non-normal procedure for each EICAS alert message. The procedure for every EICAS alert message is included as a checklist in the QRH. Procedures for some EICAS alert messages have steps to reconfigure airplane systems. A caret symbol (>) prefaces an alert message that has no procedural steps.

EICAS alert messages are grouped into three priority levels: warning, caution, and advisory. Prioritization is an aid to flight crew decision making when more than one EICAS alert message is displayed.

EICAS warning messages are displayed red and EICAS caution and advisory messages are displayed amber. Red EICAS alert messages remain displayed and cannot be canceled by pushing the Cancel switch. Amber EICAS alert messages can be canceled by pushing the Cancel switch and recalled by pushing the Recall switch.

EICAS Memo Messages

EICAS memo messages are crew reminders of certain flight crew selected normal conditions. They display in white at the bottom of the last page of EICAS alert messages on the primary EICAS display.

Pushing the Cancel switch when the last page of EICAS alert messages is displayed ensures all current memo messages have been displayed.

EICAS Status Messages

Status messages indicate equipment faults which may affect aircraft dispatch capability.

All EICAS status messages are listed in the Dispatch Deviation Guide (DDG) and provide a cross reference to the Minimum Equipment List (MEL) for dispatch capability.

Display and Manipulation of EICAS Messages

If more than one EICAS alert message is displayed, the messages are displayed in a list which is grouped by priority level. EICAS warning messages are displayed in red at the top of the message list.

EICAS caution messages are displayed in amber below the lowest warning message. EICAS advisory messages are displayed in amber below the lowest caution message and are indented one character so they may be distinguished from EICAS caution messages.

The most recent EICAS alert message is displayed at the top of its priority group and all messages move down one display line. If a message is no longer displayed because the respective system non-normal condition no longer exists, all messages previously displayed move up one display line.

If there are more messages in the list than can be displayed on one page, multiple pages are created and numbered sequentially. The page number is normally displayed at the bottom of each list. Multiple pages of EICAS caution and advisory messages can be displayed one page at a time by pushing the Cancel switch. If there are more EICAS warning messages in the list than can be displayed on one page, no page number is displayed and it is not possible to display other pages. In all other cases, pushing the Cancel switch displays the next page of EICAS caution and advisory messages. EICAS warning messages are displayed at the top of each page.

Pushing the Cancel switch when the last page of the list is displayed causes all EICAS caution and advisory messages to be no longer displayed.

EICAS alert messages for new system non-normal conditions are displayed on the page being viewed.

For example, if page three is displayed and an EICAS caution message is displayed because a new system non-normal occurs, the message is displayed immediately below any EICAS warning messages. If the Recall switch is subsequently pushed to redisplay page one, the message is displayed as the first EICAS caution message on page one.

When no EICAS caution or advisory messages are displayed, pushing the Recall switch redisplay page one of the EICAS caution and advisory messages for all system non-normal conditions and the RECALL message is displayed briefly.

The most recent EICAS memo message is displayed at the bottom of the memo messages.

The Status cue is displayed on primary EICAS when a new EICAS status message is displayed. When the Status Display switch is pushed, the status display is displayed on the secondary EICAS display. The most recent status message is displayed at the top of the message list.

The Status Display switch controls the display of single and multiple pages of status messages in a manner similar to the way the Cancel and Recall switches control the display of EICAS alert messages.

Aurals, Master Warning/Caution Switches and Lights, and Ground Proximity Light

Aurals, two Master Warning/Caution lights, and the Ground Proximity light call attention to the following alerts:

- in the following table, parans () describe crew action to silence the aural alert or extinguish the light while the alert is occurring.

Aural	Light	Calls Attention To:
Bell (Silence by pushing Master Warning/Caution Reset switch.)	Master Warning lights (Extinguish by pushing Master Warning/Caution Reset switch.)	EICAS warning message: APU FIRE FIRE CARGO AFT, FWD FIRE ENG FIRE WHEEL WELL
Siren	Master WARNING lights (Extinguish by pushing Master WARNING/CAUTION Reset switch.)	EICAS warning message: AUTOPILOT DISC CONFIG FLAPS CONFIG GEAR CONFIG PARK BRK CONFIG SPOILERS CONFIG STAB
Siren (Silence by pushing Master WARNING/CAUTION Reset switch.)	Master WARNING lights (Extinguish by pushing Master WARNING/CAUTION Reset switch.)	EICAS warning message: CABIN ALTITUDE OVERSPEED
Beeper	Master CAUTION lights (Extinguish by pushing Master WARNING/CAUTION Reset switch.)	New EICAS caution message, except: ENG SHUTDOWN
Voice annunciation: DON'T SINK, DON'T SINK TOO LOW, TERRAIN	GND PROX light	GPWS immediate alert.

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Aural	Light	Calls Attention To:
Voice annunciation: CLIMB, CLIMB, CLIMB CLIMB, CLIMB NOW, CLIMB, CLIMB NOW CLIMB, CROSSING CLIMB, CLIMB, CROSSING CLIMB DESCEND, DESCEND, DESCEND DESCEND, DESCEND NOW, DESCEND, DESCEND NOW DESCEND, CROSSING DESCEND, DESCEND, CROSSING DESCEND INCREASE CLIMB, INCREASE CLIMB INCREASE DESCENT, INCREASE DESCENT MONITOR VERTICAL SPEED, MONITOR VERTICAL SPEED REDUCE CLIMB, REDUCE CLIMB REDUCE DESCENT, REDUCE DESCENT	None	Red regions to avoid on PFD Red TRAFFIC message and TCAS RA traffic display on ND
Voice annunciation CLEAR OF CONFLICT	None	Red regions to avoid on PFD, Red TRAFFIC message, and TCAS RA traffic display on ND are no longer displayed.
Voice annunciation TRAFFIC, TRAFFIC	None	Amber TRAFFIC message and TCAS TA traffic display on ND

Aural	Light	Calls Attention To:
Voice annunciation TERRAIN, TERRAIN, PULL UP	Master WARNING lights (Extinguish by pushing Master WARNING/CAUTION switch.)	Red PULL UP on both PFDs Red TERRAIN message and terrain display on ND
Voice annunciation CAUTION TERRAIN	GND PROX light	Amber TERRAIN message and terrain display on ND
Siren, followed by voice annunciation WINDSHEAR, WINDSHEAR, WINDSHEAR	Master WARNING lights (Extinguish by pushing Master WARNING/CAUTION switch)	Red WINDSHEAR on both PFDs
Voice annunciation PULL UP	Master WARNING lights (Extinguish by pushing Master WARNING/CAUTION switch)	Red PULL UP on both PFDs
Siren (If caused by Thrust lever at idle, silence by pushing Master WARNING/CAUTION switch.)	Master WARNING lights (If caused by Thrust lever at idle, extinguish by pushing Master WARNING/CAUTION switch.)	EICAS warning message CONFIG GEAR for: • Thrust lever at idle, and • radio altitude less than 800 feet, and • gear not down and locked.
Voice annunciation: GLIDE SLOPE SINK RATE TERRAIN TOO LOW, FLAPS TOO LOW, GEAR TOO LOW, TERRAIN	GND PROX light	GPWS immediate alert

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Aural	Light	Calls Attention To:
Voice annunciation: ADJUST VERTICAL SPEED, ADJUST CLIMB, CLIMB CLIMB, CLIMB NOW, CLIMB, CLIMB NOW CLIMB, CROSSING CLIMB, CLIMB, CROSSING CLIMB DESCEND, DESCEND DESCEND, DESCEND NOW, DESCEND, DESCEND NOW DESCEND, CROSSING DESCEND, DESCEND, CROSSING DESCEND INCREASE CLIMB, INCREASE CLIMB INCREASE DESCENT, INCREASE DESCENT MAINTAIN VERTICAL SPEED, MAINTAIN MAINTAIN VERTICAL SPEED CROSSING, MAINTAIN MONITOR VERTICAL SPEED	None	Red regions to avoid on PFD Red TRAFFIC message and TCAS RA traffic display on ND
Voice annunciation CLEAR OF CONFLICT	None	Red regions to avoid on PFD, Red TRAFFIC message, and TCAS RA traffic display on ND are no longer displayed.
Voice annunciation TRAFFIC, TRAFFIC	None	Amber TRAFFIC message and TCAS TA traffic display on ND

Aural	Light	Calls Attention To:

Pre FANS/CPDLC Equipped Aircraft

Altitude tones	None	Altitude tones during approach

Post FANS/CPDLC Equipped Aircraft

Altitude voice annunciations	None	Altitude voice annunciations during approach

Flight Deck Panel Annunciator Lights

Flight deck panel annunciator lights are used with EICAS messages to:

- help locate and identify affected systems and controls
- reduce potential for error

Airspeed Alerts

Stall Warning

Warning of an impending stall is provided by left and right stick shakers, which independently vibrate the left and right control columns.

Airspeed Low

The EICAS caution message AIRSPEED LOW is displayed and the box around the current airspeed indication on the PFD is highlighted amber when airspeed is below minimum maneuvering speed.

Overspeed Warning

The EICAS alert message OVERSPEED is displayed if VMO/MMO is exceeded. The message remains displayed until airspeed is reduced below VMO/MMO.

The EICAS memo message VMO GEAR DOWN is displayed when gear down dispatch has been selected in the electronics bay. When gear down dispatch is selected, the VMO/MMO calculated by the ADC are based on maximum gear extended speed.

Takeoff And Landing Configuration Warning System

The takeoff and landing configuration warning system alerts the crew that the airplane is not configured for a normal takeoff or a normal landing.

Takeoff Configuration Warnings

The respective EICAS alert message >CONFIG xxxxx is displayed if:

- airplane is on the ground, and
- FUEL CONTROL switches are in RUN position, and
- engine two or three thrust is in takeoff range, and
- airspeed is less than V1, and
- any of the following configurations exist;
 - flaps not in a takeoff position (Flaps 10 or 20), or
 - body gear not centered, or
 - parking brake set, or
 - Speedbrake lever not in DN detent, or
 - stabilizer trim not in takeoff range

The CONFIG message remains displayed until the airplane is configured for a normal takeoff or until engine 2 and 3 thrust is decreased below takeoff range and airspeed is less than V1.

Landing Configuration Warning

The landing configuration warning system alerts the crew the landing gear is not extended for landing. The EICAS warning message CONFIG GEAR is displayed if:

- the airplane is in flight, and
- any landing gear is not down and locked, and
- any of the following configurations exist;
 - any Thrust lever is closed and radio altitude is less than 800 ft., or
 - flaps in a landing position (flaps 25 or more)

If the message is displayed because a Thrust lever is closed at low radio altitudes, the message remains displayed until the Thrust levers are advanced or landing gear is down and locked.

If the message is displayed because the flaps are in a landing position, the message remains displayed until the landing gear is down and locked or the Ground Proximity Gear Override switch is pushed.

Configuration Warning System Non-normal Operation

If the takeoff warning system fails or if the takeoff warning system input to the EIU fails, the EICAS alert message CONFIG WARN SY will be displayed. If the takeoff and landing configuration system fails, CONFIG messages may or may not be displayed. If the messages are displayed with the CONFIG WARN SY message, the CONFIG messages may not be correct.

MCP Selected Altitude

Altitude alerting is provided when departing the altitude selected in the MCP altitude window.

Approaching MCP Selected Altitude

At 900 feet prior to reaching the selected altitude a c-chord sounds and a highlighted white box is displayed around the selected altitude and the current altitude on the PFD. The highlights are no longer displayed when within 300 feet of the selected altitude.

Departing MCP Selected Altitude

When departing the selected altitude by 300 feet, the EICAS alert message >ALTITUDE ALERT is displayed, and a highlighted amber box is displayed around the current altitude. The message and amber highlights are no longer displayed when:

- subsequently reapproaching to within 300 feet of the selected altitude, or
- a new MCP altitude is selected, or
- departing more than 900 feet from the selected altitude

MCP Selected Altitude Alert Inhibits

Alerts when departing MCP selected altitude are inhibited when:

- glideslope captured, or
- landing flaps selected and landing gear down and locked

Traffic Alert and Collision Avoidance System (TCAS)

TCAS alerts the crew to possible conflicting traffic. TCAS interrogates operating transponders in other aircraft, tracks the other aircraft by analyzing the transponder replies, and predicts the flight paths and positions. TCAS provides advisory, flight path guidance, and traffic displays of the other aircraft to the flight crew. Neither ND messages, voice annunciations, PFD vertical guidance, nor traffic display is provided for other airplanes that do not have operating transponders. TCAS operation is independent of ground-based air traffic control.

To provide advisories, TCAS identifies a three-dimensional airspace around the airplane where a high likelihood of traffic conflict exists. The dimensions of this airspace are contingent upon the closure rate with conflicting traffic.

TCAS provides advisories and traffic displays:

- resolution advisory (RA) and display
- proximate traffic display
- traffic advisory (TA) and display
- other traffic display

TCAS messages and TCAS traffic symbols can be displayed on the ND in the map, map centered, VOR, and approach modes. TCAS messages and TCAS traffic symbols cannot be displayed on the ND in the VOR-centered, approach-centered, or plan modes.

TCAS messages TRAFFIC, TA ONLY, and TCAS TEST may be displayed in all ND modes.

TCAS processing priorities may reduce display of certain air traffic on the ND. Reduced display of air traffic does not affect system collision avoidance alerting capability.

Resolution Advisories (RA) and Display

A RA is a prediction another aircraft will enter TCAS conflict airspace within approximately 20 to 30 seconds. If altitude data from the other aircraft is not available, no RA can be provided.

When TCAS predicts an RA:

- a TCAS voice annunciation sounds
- TCAS PFD vertical guidance is displayed
- the TCAS red message TRAFFIC is displayed on the ND

When the TCAS cyan message TFC is displayed on the ND, and the RA is within the display range of the ND, the TCAS RA Traffic aircraft symbol and its accompanying data tag are displayed on the ND.

The TCAS RA Traffic aircraft symbol is a filled red square. The RA data tag contains the altitude and the vertical motion arrow.

For no-bearing RAs, the red RA label is displayed below the red message, TRAFFIC, and the RA data tag information is displayed to the right of the label. The RA data tag contains the distance, altitude, and the vertical motion arrow.

When the RA is further from the airplane than the ND range currently displayed, the TCAS red message OFFSCALE is displayed on the ND.

Traffic Advisories (TA) and Display

A TA is a prediction another aircraft will enter the conflict airspace in 25 to 45 seconds. TAs assist the flight crew in establishing visual contact with the other aircraft.

When TCAS predicts a TA:

- the TCAS voice annunciation TRAFFIC, TRAFFIC sounds once
- the TCAS amber message TRAFFIC is displayed on the ND

When the TCAS cyan message TFC is displayed on the ND and the TA is within the display range of the ND, the TCAS TA Traffic aircraft symbol and its accompanying data tag are displayed on the ND.

The TA Traffic aircraft symbol is a filled amber circle. The TA data tag contains the altitude and vertical motion arrow.

For no-bearing TAs, the amber TA label is displayed below the TRAFFIC message, and the TA data tag information is displayed to the right of the label. The TA labels are displayed below the RA labels. The TA data tag contains the distance, altitude, and vertical motion arrow.

When the TA is further from the airplane than the ND range currently displayed, the TCAS amber message OFFSCALE is displayed on the ND.

Proximate Traffic Display

Proximate traffic is another aircraft that is neither an RA or a TA but is within:

- six miles
- 1,200 feet vertically

When the TCAS cyan message TFC is displayed on the ND, and the Proximate Traffic aircraft is within the ND display range, the TCAS Proximate Traffic aircraft symbol is displayed on the ND.

The TCAS Proximate Traffic aircraft symbol is a filled white diamond. When TCAS is receiving and processing altitude data from the Proximate Traffic aircraft, the proximate traffic data tag is displayed on the ND. The proximate traffic data tag contains the altitude and vertical motion arrow.

Other Traffic Display

Other Traffic aircraft is an aircraft that is within the ND display limits but is neither a RA, a TA, or proximate traffic aircraft. When TCAS is not receiving and processing altitude data from the Other Traffic aircraft, the Other Traffic aircraft becomes Proximate Traffic aircraft automatically when within six miles.

When the TCAS cyan message TFC is displayed on the ND and the Other Traffic aircraft is within the ND display range, the TCAS Other Traffic symbol is displayed on the ND.

The TCAS Other Traffic symbol is a hollow white diamond. When TCAS is receiving and processing altitude data from the Other Traffic aircraft, a data tag like that described in Proximate Traffic Display is displayed.

TCAS PFD Vertical Guidance

When TCAS predicts an RA, TCAS PFD vertical guidance is displayed for a traffic avoidance maneuver to ensure vertical separation. Traffic avoidance is ensured by adjusting or maintaining a pitch attitude and vertical speed outside the red RA regions.

If the traffic aircraft also has TCAS and a mode S transponder, TCAS vertical guidance is coordinated with the traffic aircraft TCAS.

TCAS ND Messages

ND Message	Color	Description
TFC	Cyan	TCAS traffic display enabled. Inhibited if following TCAS messages are displayed: TCAS FAIL, TCAS OFF, TCAS TEST
TRAFFIC	Amber	TA is occurring.
OFFSCALE	Amber	TA is occurring at range greater than current ND range. Replaced by red OFFSCALE when RA is also occurring at range greater than current ND range.
TRAFFIC	Red	RA is occurring.
OFFSCALE	Red	RA is occurring at range greater than current ND range.
TA ONLY	Cyan	TCAS can not provide RAs. All traffic that would have been RAs are predicted as TAs.
TCAS FAIL	Amber	TCAS failed, or TCAS information cannot be displayed on ND.
TCAS OFF	Amber	ND Traffic switch pushed to display traffic but TCAS not selected on transponder panel.
TCAS TEST	Cyan	TCAS in test mode. Message is displayed on all ND modes and ranges.

TCAS Voice Annunciations

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Voice Annunciation	Condition	Response
TRAFFIC, TRAFFIC	New TA, initial voice annunciation.	Attempt to visually locate the traffic.
MONITOR VERTICAL SPEED, MONITOR VERTICAL SPEED	New RA, initial voice annunciation. Present pitch attitude and vertical speed are outside the red RA regions.	Continue to keep pitch attitude and vertical speed outside the red RA regions.
CLIMB, CLIMB, CLIMB	New RA, initial voice annunciation. Present pitch attitude and vertical speed are within the red RA regions.	Increase pitch attitude and vertical speed to remain outside the red RA regions.
CLIMB, CROSSING CLIMB, CLIMB, CROSSING CLIMB	New RA, initial voice annunciation. Present pitch attitude and vertical speed are within the red RA regions. Airplane will climb through the altitude of the traffic.	
DESCEND, DESCEND, DESCEND	New RA, initial voice annunciation. Present pitch attitude and vertical speed are within the red RA regions.	Decrease pitch attitude and vertical speed to remain outside the red RA regions.
DESCEND, CROSSING DESCEND DESCEND, CROSSING DESCEND	New RA, initial voice annunciation. Present pitch attitude and vertical speed are within the red RA regions. Airplane will descend through the altitude of the traffic.	

Voice Annunciation	Condition	Response
INCREASE CLIMB, INCREASE CLIMB	Existing RA, TCAS requires change in vertical rate.	Adjust pitch attitude and vertical speed to remain outside the red RA regions.
REDUCE CLIMB, REDUCE CLIMB	Present pitch attitude and vertical speed are within the red RA regions.	
INCREASE DESCENT, INCREASE DESCENT		
REDUCE DESCENT, REDUCE DESCENT		
DESCEND, DESCEND NOW, DESCEND, DESCEND NOW	Existing RA, previous TCAS vertical guidance was to climb. Present pitch attitude and vertical speed are within the red RA regions.	Decrease pitch attitude and vertical speed to remain outside the red RA regions.
CLIMB, CLIMB NOW, CLIMB, CLIMB NOW	Existing RA, previous TCAS vertical guidance was to descend. Present pitch attitude and vertical speed are within the red RA regions.	Increase pitch attitude and vertical speed to remain outside the red RA regions.
CLEAR OF CONFLICT	TCAS PFD vertical guidance is no longer displayed and traffic changes to a TA symbol. Separation is increasing and the RA will not occur. However, the voice annunciation will not sound if TCAS can no longer predict the track of the RA aircraft.	Attempt to visually locate the traffic.

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Voice Annunciation	Condition	Response
TRAFFIC, TRAFFIC	New TA, initial voice annunciation.	Attempt to visually locate the traffic.
MONITOR VERTICAL SPEED	New RA, initial voice annunciation. Present pitch attitude and vertical speed are outside the red RA regions.	Continue to keep pitch attitude and vertical speed outside the red RA regions.
MAINTAIN VERTICAL SPEED, MAINTAIN	New RA, initial voice annunciation. Present pitch attitude and vertical speed are outside the red RA regions.	
MAINTAIN VERTICAL SPEED CROSSING, MAINTAIN	New RA, initial voice annunciation. Present pitch attitude and vertical speed are outside the red RA regions. Airplane will pass through the altitude of the traffic.	
CLIMB, CLIMB	New RA, initial voice annunciation. Present pitch attitude and vertical speed are within the red RA regions.	Increase pitch attitude and vertical speed to remain outside the red RA regions.
CLIMB, CROSSING CLIMB, CLIMB, CROSSING CLIMB	New RA, initial voice annunciation. Present pitch attitude and vertical speed are within the red RA regions. Airplane will climb through the altitude of the traffic.	

Voice Annunciation	Condition	Response
DESCEND, DESCEND	New RA, initial voice annunciation. Present pitch attitude and vertical speed are within the red RA regions.	Decrease pitch attitude and vertical speed to remain outside the red RA regions.
DESCEND, CROSSING DESCEND DESCEND, CROSSING DESCEND	New RA, initial voice annunciation. Present pitch attitude and vertical speed are within the red RA regions. Airplane will descend through the altitude of the traffic.	
INCREASE CLIMB, INCREASE CLIMB	Existing RA, TCAS requires change in vertical rate.	Adjust pitch attitude and vertical speed to remain outside the red RA regions.
INCREASE DESCENT, INCREASE DESCENT	Present pitch attitude and vertical speed are within the red RA regions.	
ADJUST VERTICAL SPEED, ADJUST	Existing RA, minimum vertical speed required to ensure separation has decreased, present pitch attitude and vertical speed are outside the red RA regions, or, new RA, initial voice annunciation. Present pitch attitude and vertical speed are within the red RA regions.	Continue to keep pitch attitude and vertical speed outside the red RA regions. Vertical speed may be decreased, or, change pitch attitude and vertical speed to remain outside the red RA regions.
DESCEND, DESCEND NOW, DESCEND, DESCEND NOW	Existing RA, previous TCAS vertical guidance was to climb. Present pitch attitude and vertical speed are within the red RA regions.	Decrease pitch attitude and vertical speed to remain outside the red RA regions.

Voice Annunciation	Condition	Response
CLIMB, CLIMB NOW, CLIMB, CLIMB NOW	Existing RA, previous TCAS vertical guidance was to descend. Present pitch attitude and vertical speed are within the red RA regions.	Increase pitch attitude and vertical speed to remain outside the red RA regions.
CLEAR OF CONFLICT	TCAS PFD vertical guidance is no longer displayed and traffic changes to a TA symbol. Separation is increasing and the RA will not occur. However, the voice annunciation will not sound if TCAS can no longer predict the track of the RA aircraft.	Attempt to visually locate the traffic.

TCAS Normal Operation

The TCAS operating mode is controlled from the transponder panel. TA/RA is normally selected, however, it is sometimes necessary to select TA ONLY to prevent nuisance RAs.

TA ONLY is selected during engine out operations to prevent RAs when adequate thrust is not available to follow the RA commands. Also, TA ONLY can be selected when intentionally operating near other traffic that may cause RAs, such as during parallel approaches and VFR operations.

TCAS Non-Normal Operation

The EICAS alert message TCAS OFF is displayed if TCAS is not operating. No TCAS RA guidance is displayed on the PFDs, no TCAS traffic symbols are displayed on the NDs, and no TCAS voice alerts sound. An amber TCAS OFF message is displayed on both NDs.

The EICAS alert message TCAS RA is displayed if TCAS cannot display RA guidance on the respective Captain or First Officer PFD. The ND traffic displays and voice alerts are unaffected.

The EICAS alert message TCAS SYSTEM is displayed if TCAS cannot display TCAS RA guidance on either PFD, and cannot display TCAS traffic symbols on either ND. An amber TCAS FAIL message is displayed on both NDs, and TCAS voice alerts will not occur.

Ground Proximity Warning System (GPWS)

Introduction

GPWS provides:

- look-ahead terrain alerts for potentially hazardous flight conditions involving impact with the ground
- immediate windshear alerts
- immediate alerts for potentially hazardous flight conditions involving impact with the obstacles and the ground
- altitude voice annunciations during approach

Look-ahead Terrain Alerting System

Look-ahead terrain alerts are provided by monitoring terrain proximity using a world-wide terrain data base. The data base contains detailed terrain data near major airports, and data in lesser detail for areas between airports. Terrain within 2,000 feet of airplane altitude is displayed on the navigation display. Terrain data is not designed to be an independent navigation aid. [AFM]

Proximate terrain data may be displayed on the ND. If there is a potential terrain hazard, GPWS look-ahead alerts are provided based on estimated time to impact.

Estimated time to impact is based on airplane position, altitude, present track, vertical path, and ground speed. FMC VNAV and LNAV is not considered in the estimated time to impact.

Non-GPS Equipped Aircraft

Altitudes used for look-ahead terrain mode alerts are a weighted combination of radio altitude, barometric altitude, and previous flight path. Weighting is reduced for an altitude source which becomes less reliable.

GPS Equipped Aircraft

Altitudes used for look-ahead terrain mode alerts are a weighted combination of radio altitude, barometric altitude, GPS, and previous flight path. Weighting is reduced for an altitude source which becomes less reliable.

Note: Terrain ahead of the airplane may exceed available climb performance. A GPWS caution or warning alert does not guarantee terrain clearance.

When the GPWS Terrain switch is pushed on, the TERR symbol is displayed on the ND and terrain contours may be displayed.

When the airplane is higher than 2,000 feet above the terrain, terrain more than 2,000 feet below airplane altitude is not displayed.

When the airplane is lower than 2,000 feet above the terrain, all obstacles and terrain within 2,000 feet of airplane altitude is displayed on the navigation display.

Note: The GPWS terrain database, GPWS look-ahead terrain alerts, and terrain display do not account for man-made obstructions.

Note: FMC position error may compromise terrain display and alerting.

The terrain display is correlated to GPS position, or to IRU position if GPS position is intermittently unavailable.

Terrain and weather radar cannot be simultaneously displayed on an ND. When one pilot selects terrain and the other pilot selects weather radar, each display updates on alternating sweeps.

GPWS Look-Ahead Terrain Alerts

Voice Annunciation	PFD and ND Display and Light	Description
TERRAIN TERRAIN PULL UP	Red PULL UP on both PFDs Master WARNING lights Red TERRAIN message on both NDs Solid red terrain on ND	20 to 30 seconds from projected impact with terrain. Pushing the GND PROX TERR OVRD switch to OVRD inhibits the alert.
CAUTION TERRAIN	Amber TERRAIN message on both NDs Solid amber terrain on ND GND PROX light	40 to 60 seconds from projected impact with terrain. Pushing the GND PROX TERR OVRD switch to OVRD inhibits the alert.
TOO LOW, TERRAIN	GND PROX light	Descent below unsafe altitude while too far from any airport in the terrain database. Pushing the GND PROX TERR OVRD switch to OVRD inhibits the alert.

Immediate Windshear Alerting System

Immediate windshear alerts are provided when an excessive downdraft or tailwind is occurring during takeoff, approach, and landing.

Voice Annunciation	PFD Display and Light	Description
(Siren) WINDSHEAR, WINDSHEAR, WINDSHEAR	Red WINDSHEAR on both PFDs Master WARNING lights	Excessive windshear detected by GPWS. Enabled below 1,500 feet radio altitude. GPWS windshear detection begins at rotation.

Immediate Alerting System

Voice Annunciation	PFD and ND Display and Light	Description
DON'T SINK	Ground Proximity light	Altitude loss with flaps and/or gear up after takeoff or go-around.
GLIDE SLOPE	Ground Proximity light	Excessive deviation below glide slope. Volume and repetition rate increase as deviation increases. Pushing the Ground Proximity Glideslope Inhibit switch inhibits the alert when pushed below 1,000 feet radio altitude.
PULL UP	Red PULL UP on both PFDs Master Warning lights	Follows SINK RATE alert when descent rate becomes severe, or follows TERRAIN alert with flaps and/or gear not in landing configuration when excessive terrain closing rate continues.
SINK RATE	Ground Proximity light	Excessive descent rate.
TERRAIN	Ground Proximity light	Excessive terrain closing rate.
TOO LOW, FLAPS	Ground Proximity light	Unsafe terrain clearance with flaps not in landing configuration at low altitude and airspeed. Pushing the Ground Proximity Flap Override switch to OVRD inhibits the alert.

Voice Annunciation	PFD and ND Display and Light	Description
TOO LOW, GEAR	Ground Proximity light	Unsafe terrain clearance with gear not in landing configuration at low altitude and airspeed with gear not down. Pushing the Ground Proximity Gear Override switch to OVRD inhibits the alert.
TOO LOW, TERRAIN	Ground Proximity light	Follows DON'T SINK alert with gear and/or flaps up after takeoff or go-around for altitude loss at low altitude, or unsafe terrain clearance with gear and/or flaps not in landing configuration at low altitude and airspeed. Pushing the Ground Proximity Flap Override switch to OVRD inhibits the alert, when the alert is because flaps not in landing position. Pushing the Ground Proximity Gear Override switch to OVRD inhibits the alert, when the alert is because gear is not down.

Altitude Tones During Approach

GPWS provides the following altitude voice annunciations during approach:

- 2,500 feet - TWENTY-FIVE HUNDRED
- 1,000 feet - ONE THOUSAND
- 500 feet - FIVE HUNDRED, when glideslope or localizer not received, or glideslope or localizer deviation greater than two dots
- 100 feet - ONE HUNDRED
- 50 feet - FIFTY
- 40 feet - FORTY
- 30 feet - THIRTY
- 20 feet - TWENTY
- 10 feet - TEN

GPWS Non-Normal Operation

Altitude Voice Annunciations During Approach Non-Normal Operation

If there is a fault in the Altitude Voice Annunciations During Approach system, the EICAS advisory message ALT CALLOUTS is displayed and Altitude Voice Annunciations During Approach are inhibited.

Look-Ahead Alert Non-Normal Operation

If there is a fault in look- ahead terrain alert, the respective terrain status annunciation TERR is displayed.

Windshear Alert Non-Normal Operation

If there is a fault in the immediate windshear system of in the PWS system, the EICAS advisory message WINDSHEAR SYS is displayed and the voice alert WINDSHEAR and the PFD alert WINDSHEAR are inhibited.

Immediate Alert Non-Normal Operation

If there is a fault in any immediate alert, the respective alert is inhibited. If a fault occurs in any immediate alert other than windshear, there is no indication to the flight crew of which alerts are inhibited. GPWS will continue to provide immediate alerts for which no fault has occurred.

Alert Inhibits

Alerts are inhibited when they are operationally unnecessary or inappropriate. Alerts are inhibited during normal system operation, and during part of the takeoff to prevent distracting the crew.

GPWS immediate windshear alert inhibits all TCAS and other GPWS alerts.

When TA/RA is selected on the transponder panel and a GPWS warning alert occurs, TCAS automatically inhibits RA mode and operates in TA ONLY mode. All aircraft that would have been predicted as a RA are predicted as a TA. When a subsequent GPWS warning alert occurs while a RA is occurring, the RA is discontinued and becomes a TA. When GPWS warning alerts are no longer occurring, TCAS returns to TA/RA mode and provides RAs for all appropriate TAs.

Alert Messages Inhibited By Other Alert Messages

Some EICAS alert messages are inhibited if another related alert message is displayed. For example, individual fuel or hydraulic pump pressure messages are inhibited if a hydraulic system pressure message is displayed.

Alert Messages Inhibited During Normal System Operation

Certain alert messages are time delayed, even though related flight deck panel annunciation lights are illuminated. Time delay inhibits prevent normal in-transit indications from being displayed as EICAS system alert messages. For example, valves are generally only sensed open and/or closed, not in-transit. When a valve is in-transit, the alert message indicating the valve has failed to open or close is inhibited to allow the valve time to move to the commanded position. If the valve is not in the commanded position at the end of the inhibit period, the respective EICAS alert message is displayed.

Voice Annunciation Inhibits

Voice annunciations for warning alerts inhibit new voice annunciations for caution alerts.

All voice annunciations are prioritized to aid flight crew decision making when more than one alert occurs.

ND Display Alert Inhibits and Automatic Display

Alert displays on the NDs are prioritized to aid flight crew decision making when more than one alert occurs. The displays are also prioritized when neither ND is in MAP, MAP CTR, VOR, or APP mode.

Immediate windshear alert inhibits the automatic display of new TCAS or look-ahead terrain alerts.

TCAS traffic can be displayed concurrently with either TERR and WXR display.

New TCAS alerts:

- When TFC is displayed on the first officer ND and both NDs are in MAP, MAP CTR, VOR, or APP mode and a new TCAS TA or RA alert occurs, TCAS traffic continue to be selected on the first officer ND while TCAS traffic display and TFC are inhibited on the captain ND. When the captain TFC switch is subsequently pushed, TCAS traffic and TFC are selected automatically on the captain ND.
- When TFC is displayed on the captain ND and both NDs are in MAP, MAP CTR, VOR, or APP mode and a new TCAS TA or RA alert occurs, TCAS traffic continues to be selected on the captain ND while TCAS traffic display and TFC are inhibited on the first officer ND. When the first officer TFC switch is subsequently pushed, TCAS traffic and TFC are selected automatically on the first officer ND.
- When TFC is displayed on neither ND and both NDs are in MAP, MAP CTR, VOR, or APP mode and a new TCAS TA or RA alert occurs, TCAS traffic and TFC are selected automatically on both NDs.
- When only one ND is in MAP, MAP CTR, VOR, or APP mode and a new TCAS TA or RA alert occurs, TCAS traffic and TFC are selected automatically on that ND. The ND not in MAP, MAP CTR, VOR, or APP mode is armed for TCAS display, and TCAS traffic and TFC will be selected automatically when MAP, MAP CTR, VOR, or APP mode is selected.
- When neither ND is in MAP, MAP CTR, VOR, or APP mode and a new TCAS TA or RA alert occurs, both NDs are armed for TCAS display. TCAS traffic and TFC will be selected automatically when the respective MAP, MAP CTR, VOR, or APP mode is selected.
- When TCAS traffic and TFC are selected automatically because a TCAS TA or RA had occurred, but TAs and RAs are no longer occurring, TCAS traffic and TFC continue to be selected until the respective TFC switch is pushed; TCAS traffic and TFC are not automatically de-selected.

New look-ahead terrain alerts:

- When both NDs are in MAP, MAP CTR, VOR, or APP mode and a new look-ahead terrain alert occurs, TERR is selected automatically for both NDs.
- When only one ND is in MAP, MAP CTR, VOR, or APP mode and a new look-ahead terrain alert occurs, TERR is selected automatically for that ND. The ND not in MAP, MAP CTR, VOR, or APP mode is armed for TERR display and TERR will be selected automatically when MAP, MAP CTR, VOR, or APP mode is selected. TERR is disarmed by selecting WXR prior to selecting MAP, MAP CTR, VOR, or APP mode.
- When neither ND is in MAP, MAP CTR, VOR, or APP mode and a new look-ahead terrain alert occurs, both NDs are armed for TERR display and TERR will be selected automatically when MAP, MAP CTR, VOR, or APP mode is selected. TERR is disarmed for either ND by selecting WXR prior to selecting MAP, MAP CTR, VOR, or APP mode on the respective ND.

Alerts Inhibited Before Engine Start and After Shutdown

Alert Inhibited	For Message	Inhibit Occurs
Master CAUTION lights Beeper	For all EICAS caution messages	On the ground, and all Fuel Control switches in CUTOFF.
Respective EICAS messages: ELEC GEN OFF ENG CONTROL ENG EEC MODE ENG FAIL ENG OIL PRESS HYD PRESS ENG NAI VALVE	For EICAS caution messages: ENG SHUTDOWN	On the ground, and respective Fuel Control switch in CUTOFF or Engine Fire switch out.

Alerts Inhibited During Engine Start

Alert Inhibited	Inhibit Begins	Inhibit Ends
All new EICAS caution and advisory messages, except: BLEED ENG FUEL VALVE ENG SHUTDOWN ENG START VLV STARTER CUTOUT	Engine START switch pulled.	Engine reaches idle RPM, or start is aborted, or five minutes elapse.

Alerts Inhibited During Takeoff

Alert Inhibited	For Message	Inhibit Begins	Inhibit Ends
EICAS caution message ENG FAIL	Message is inhibited	On ground	Lift-off
EICAS advisory message TCAS OFF	Message is inhibited		400 feet radio altitude
TCAS TA voice alerts	TCAS TAs		Approximately 500 feet radio altitude
All TCAS RAs	TCAS RAs are inhibited When RA selected on panel, TCAS switches to TA only mode and TCAS message TA ONLY is displayed on ND		Approximately 1,000 feet radio altitude
TCAS DESCEND RAs	Alerts are inhibited		Approximately 1,100 feet radio altitude
STATUS cue	All EICAS new status messages	Engine start	30 minutes after lift-off
Hi Chime	Attendant call	Any engine in takeoff thrust range	400 feet radio altitude

Alert Inhibited	For Message	Inhibit Begins	Inhibit Ends
Master Caution lights Beeper If the Master Caution lights illuminate before reaching 80 knots airspeed, they continue to be illuminated when 80 knots airspeed is exceeded and cannot be extinguished until the inhibit ends. If new EICAS caution messages are displayed during the inhibit, the beeper will sound when the inhibit ends.	New EICAS caution messages	80 knots airspeed	800 feet radio altitude or 30 seconds after rotation, whichever occurs first. If rejected takeoff initiated above 80 knots, inhibit continues until airspeed is less than 75 knots.

Alert Inhibited	For Message	Inhibit Begins	Inhibit Ends
Master Warning lights Bell If the Master Warning lights illuminate and fire bell sounds before reaching V1, they continue to be illuminated and sound when V1 is exceeded. If new FIRE messages are displayed during the inhibit, the bell will sound when the inhibit ends.	New EICAS warning messages FIRE	V1	400 feet radio altitude or 25 seconds after V1, whichever occurs first.
Master Warning lights Siren If the Master Warning lights illuminate and siren sounds before reaching V1, they continue to be illuminated and sound when V1 is exceeded If new EICAS warning messages are displayed during the inhibit, the siren will sound when the inhibit ends.	New EICAS warning messages except: CONFIG GEAR FIRE EICAS warning message CONFIG GEAR	Lift-off	800 feet radio altitude or 140 seconds after nose gear strut lift-off, whichever occurs first
EICAS advisory message FUEL TANK/ENG if tank to engine condition occurs after lift-off.	Message is inhibited		Ten minutes after lift-off

Alerts Inhibited During Landing

Alert Inhibited	For Message	Inhibit Begins	Inhibit Ends
TCAS INCREASE DESCENT RAs	Alerts are inhibited	Approximately 1,500 feet radio altitude	Go-around at approximately 1,500 feet radio altitude
TCAS DESCEND RAs		Approximately 1,100 feet radio altitude	Go-around at approximately 1,100 feet radio altitude
All TCAS RAs	Alerts are inhibited When TA/RA selected on panel, TCAS switches to TA only mode and TCAS message TA ONLY is displayed on ND	Approximately 1,000 feet radio altitude	Go-around at approximately 1,000 feet radio altitude
TCAS voice alerts	TCAS TAs	Approximately 500 feet radio altitude	Go-around at approximately 500 feet radio altitude
EICAS alert message WINDSHEAR SYS	Message is inhibited	400 feet radio altitude	80 knots airspeed
EICAS advisory message TCAS OFF			Go-around at 400 feet radio altitude

Alert Inhibited	For Message	Inhibit Begins	Inhibit Ends
Master Caution lights Beeper	All EICAS caution messages, except: AUTOPILOT AUTOTHROTTLE DISC NO AUTOLAND SPEEDBRAKES EXT	LAND 2 or LAND 3 displayed on PFD, and 200 feet radio altitude	75 knots airspeed, or 40 seconds elapse, or 800 feet radio altitude

EICAS Event Record

Pushing the EICAS EVENT RCD switch records currently displayed engine indications and additional EICAS maintenance information. Up to five events may be recorded by the first five pushes. Manual event recording is available to the crew during all phases of flight. The system also records out of limit parameters and related conditions automatically when a system parameter is exceeded. A maximum of five out of limit parameters may be automatically recorded.

Warning Systems

EICAS Messages

Chapter 15

Section 30

EICAS Alert Messages

Message	Level	Aural	Message Logic
>AIRSPEED LOW	Caution	Beeper	Airspeed less than minimum maneuvering speed.
>ALT CALLOUTS	Advisory		Altitude voice annunciations during approach no longer provided.
>ALTITUDE ALERT	Caution	Beeper	Airplane has deviated more than 300 feet from MCP selected altitude.
>CONFIG FLAPS	Warning	Siren	Flaps not in takeoff position when airplane on the ground, airspeed less than V1, three or more Fuel Control switches in RUN, and engine 2 or 3 thrust in takeoff range.
>CONFIG GEAR	Warning	Siren	Any landing gear not down and locked when any Thrust lever closed below 800 feet radio altitude or when flaps are in a landing position.
>CONFIG GEAR CTR	Warning	Siren	Body gear steering unlocked (not centered) when airplane on the ground, airspeed less than V1, three or more Fuel Control switches in RUN, and engine 2 or 3 thrust in takeoff range.
>CONFIG PARK BRK	Warning	Siren	Parking brake set when airplane on the ground, airspeed less than V1, three or more Fuel Control switches in RUN, and engine 2 or 3 thrust in takeoff range.
>CONFIG SPOILERS	Warning	Siren	Speedbrake lever not DOWN when airplane on the ground, airspeed less than V1, three or more Fuel Control switches in RUN, and engine 2 or 3 thrust in takeoff range.

Message	Level	Aural	Message Logic
>CONFIG STAB	Warning	Siren	Stabilizer not within the green band when airplane on the ground, airspeed less than V1, three or more Fuel Control switches in RUN, and engine 2 or 3 thrust in takeoff range.
>CONFIG WARN SY	Advisory		Fault detected in configuration warning system.
GND PROX SYS	Advisory		GPWS alerts may not be provided.
>OVERSPEED	Warning	Siren	Airspeed exceeds Vmo/Mmo.
>TCAS OFF	Advisory		TCAS mode TA ONLY or TA/RA not selected.
>TCAS RA CAPTAIN, F/O	Advisory		TCAS cannot display RA guidance on respective PFD.
>TCAS SYSTEM	Advisory		TCAS has failed.
>TERR OVRD	Advisory		Ground Proximity Override switch in OVRD. Look-ahead terrain alerts will not be provided.
TERR POS	Advisory		Terrain position data has been lost. Look-ahead terrain alerting and display unavailable because GPS has failed. During time between GPS failure and display of TERR POS message, IRS provides position for look-ahead alerting and display.
WINDSHEAR SYS	Advisory		Windshear alerts may not be provided.

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