CHAPTER

22

Autoflight

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AUTOFLIGHT

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AUTOPILOT FLIGHT DIRECTOR SYSTEM - INTRODUCTION

General

The autopilot flight director system (AFDS) has two purposes. These purposes are:

- To automatically control the airplane attitude
- To supply indications so the flight crew can manually control the airplane attitude.

The flight crew uses the mode control panel (MCP) to select the mode of operation.

Autopilot

The autopilot controls the airplane attitude through:

- Takeoff (flight director only)
- Climb
- Cruise
- Descent
- Approach
- Go-around
- Autoland.

The autopilot commands go to the primary flight computers (PFCs) to operate the flight control surfaces.

Flight Director

When the flight director switches are on, the flight director command bars show on the primary flight displays (PFDs). The flight crew uses the flight director bars as guides to control the attitude of the airplane.

Abbreviations and Acronyms

- A/P - autopilot
- ACE - actuator control electronics
- ADIRU - air data inertial reference unit
- AFDC - autopilot flight director computer
- AFDS - autopilot flight director system
- AGS - air/ground system
- AIMS - airplane information management system
- alt - altitude
- ASCPC - air supply cabin pressure controller
- BAP - bank angle protect
- BDA - backdrive actuator
- bkdrv - backdrive
- CDU - control display unit
- clb - climb
- CMCF - central maintenance computing function
- DLGF - data load gateway function
- EICAS - engine indication and crew alerting system
- F/D - flight director
- FMCF - flight management computing function
- FMCS - flight management computing system
- FPA - flight path angle
- FPM - feet per minute
- FSEU - flap/slat electronics unit
- G/A - go-around
- G/S - glideslope
- GCU - generator control unit
- hdg - heading
- HYDIM - hydraulic interface module
- LCD - liquid crystal display
- LED - light emitting diode
- LNAV - lateral navigation
- loc - localizer
- MCP - mode control panel

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- MFD - multi-function display
- ND - navigation display
- OPAS - overhead panel ARINC 629 system
- PCU - power control unit
- PFC - primary flight computer
- PFD - primary flight display
- PSEU - proximity sensor electronics unit
- pth - path
- SAARU - secondary attitude air data reference unit
- spd - speed
- TMCF - thrust management computing function
- TO/GA - takeoff/go-around
- trk - track
- V2 - takeoff safety speed
- V/S - vertical speed
- VNAV - vertical navigation
- WOW - weight-on-wheels
- X-CH - cross channel

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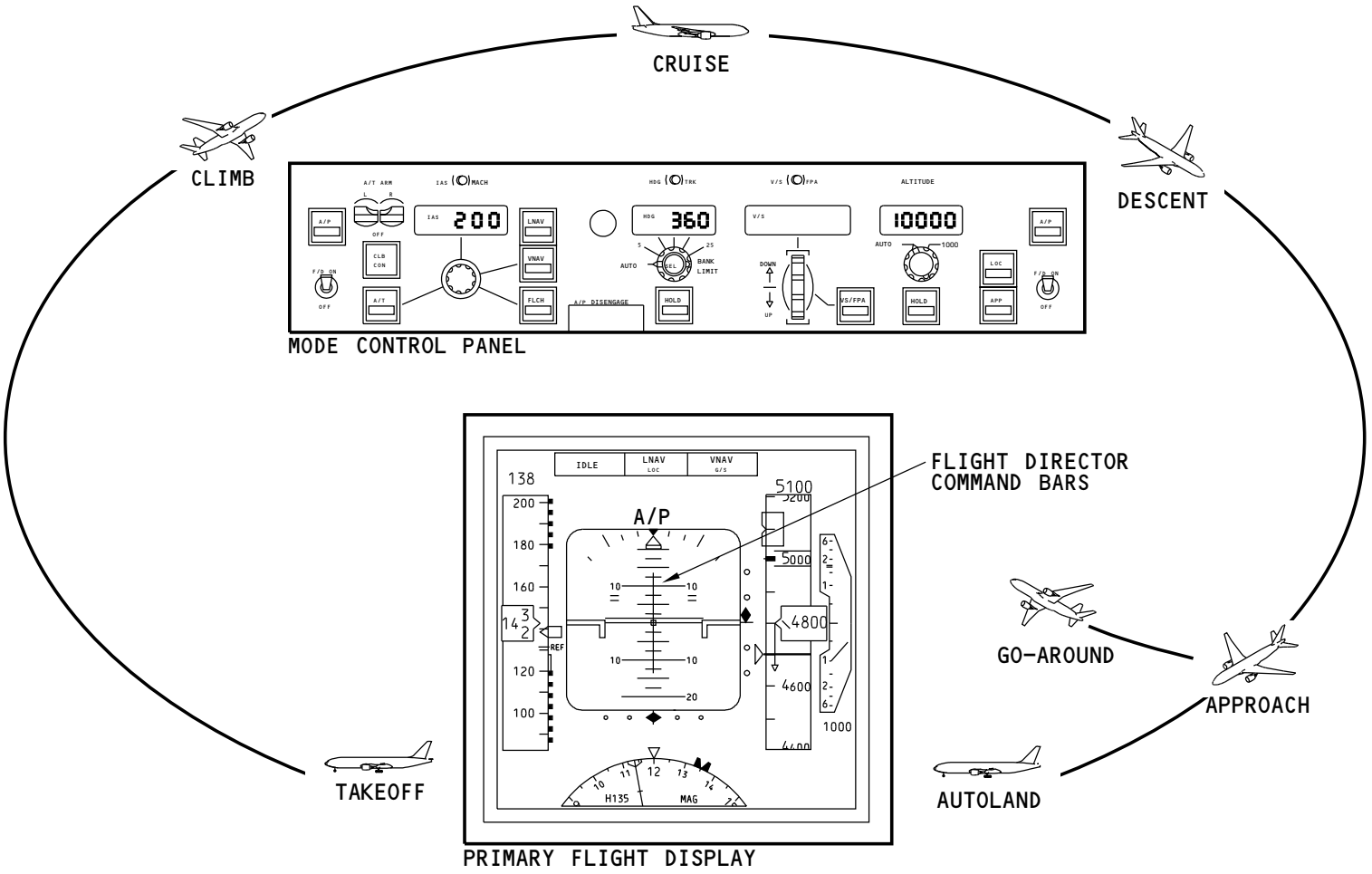

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AUTOPILOT FLIGHT DIRECTOR SYSTEM - INTRODUCTION

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AFDS - GENERAL DESCRIPTION

Pilot Interface

The mode control panel (MCP) is the primary interface between the pilot and the autopilot flight director computers (AFDCs).

Other pilot inputs to the AFDCs are the disconnect switches and the go-around (GA) switches.

Sensors

Sensors supply the AFDCs with this information:

- Transducer positions
- Inertial data
- Atmospheric data
- Ground reference data
- Airplane accelerations
- Velocities
- Attitudes.

These are the types of sensors:

- Airplane sensors
- Navigation sensors
- Air data sensors (ADIRU and SAARU).

Airplane Information Management System (AIMS) Interface

The flight management computer function (FMCF) sends LNAV and VNAV data to the AFDCs.

The thrust management computer function (TMCF) sends autothrottle data to the AFDCs.

The primary display function receives AFDS display data.

Primary Flight Control System (PFCS)

The primary flight computers (PFCs) receive commands from the AFDCs. The PFCs calculate and send surface position commands to the actuator control electronics (ACE).

The ACEs receive surface position commands from the PFCs. The ACEs send commands to the surface power control units (PCU). The PCUs move the surface.

The PFCs also calculate and send backdrive commands to the AFDCs.

Backdrive Actuators

The AFDCs receive backdrive actuator commands from the PFCs. The AFDCs send backdrive commands to the backdrive actuators. The actuators cause the control wheels, control columns, and rudder pedals to move.

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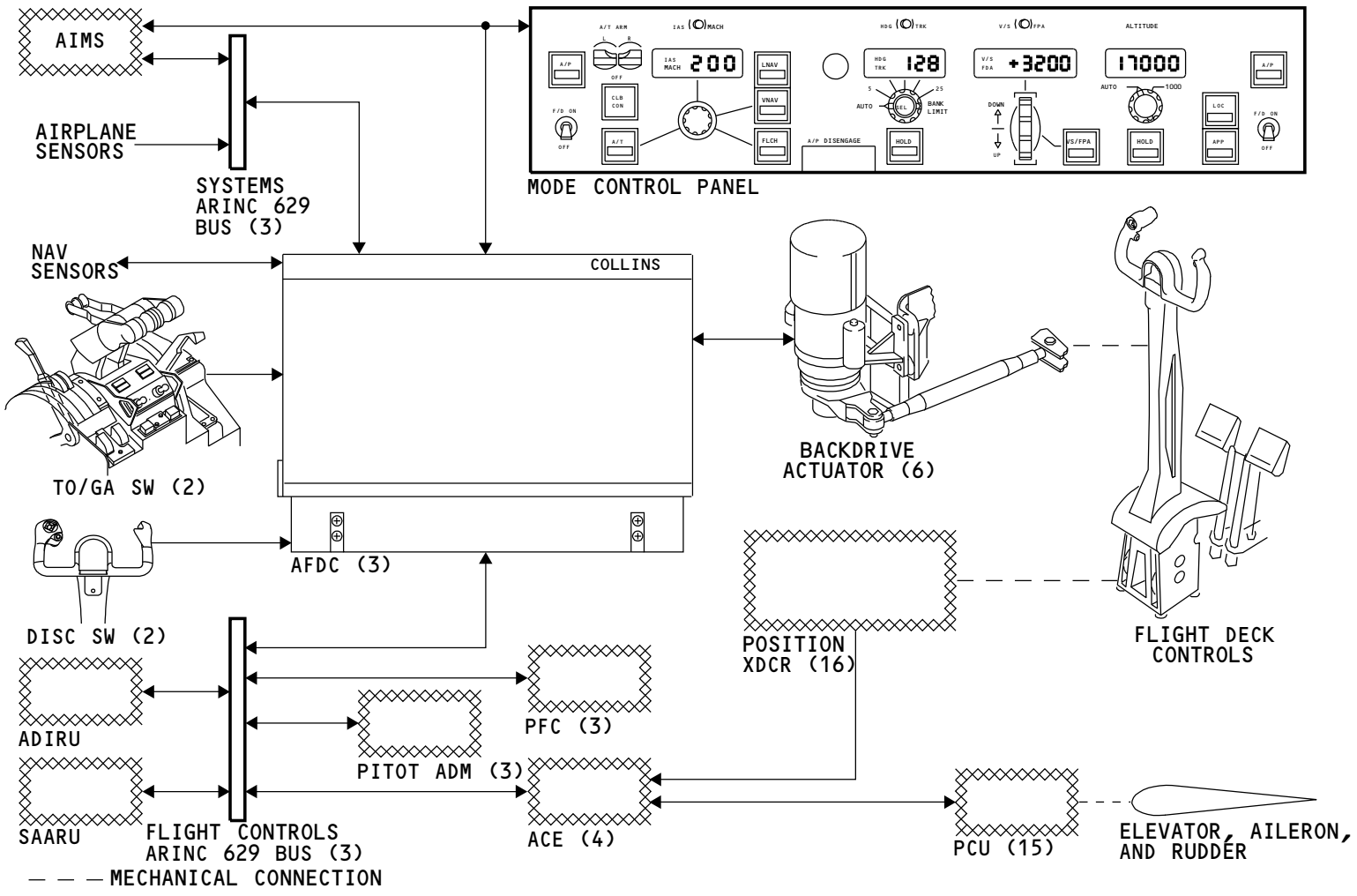

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AFDS - GENERAL DESCRIPTION

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AFDS - FLIGHT DECK COMPONENT LOCATIONS

AFDS Component Location In The Flight Deck

These are the AFDS components in the flight deck:

- Mode control panel (MCP)
- Takeoff/go-around (TO/GA) switches
- Autopilot disconnect switches.

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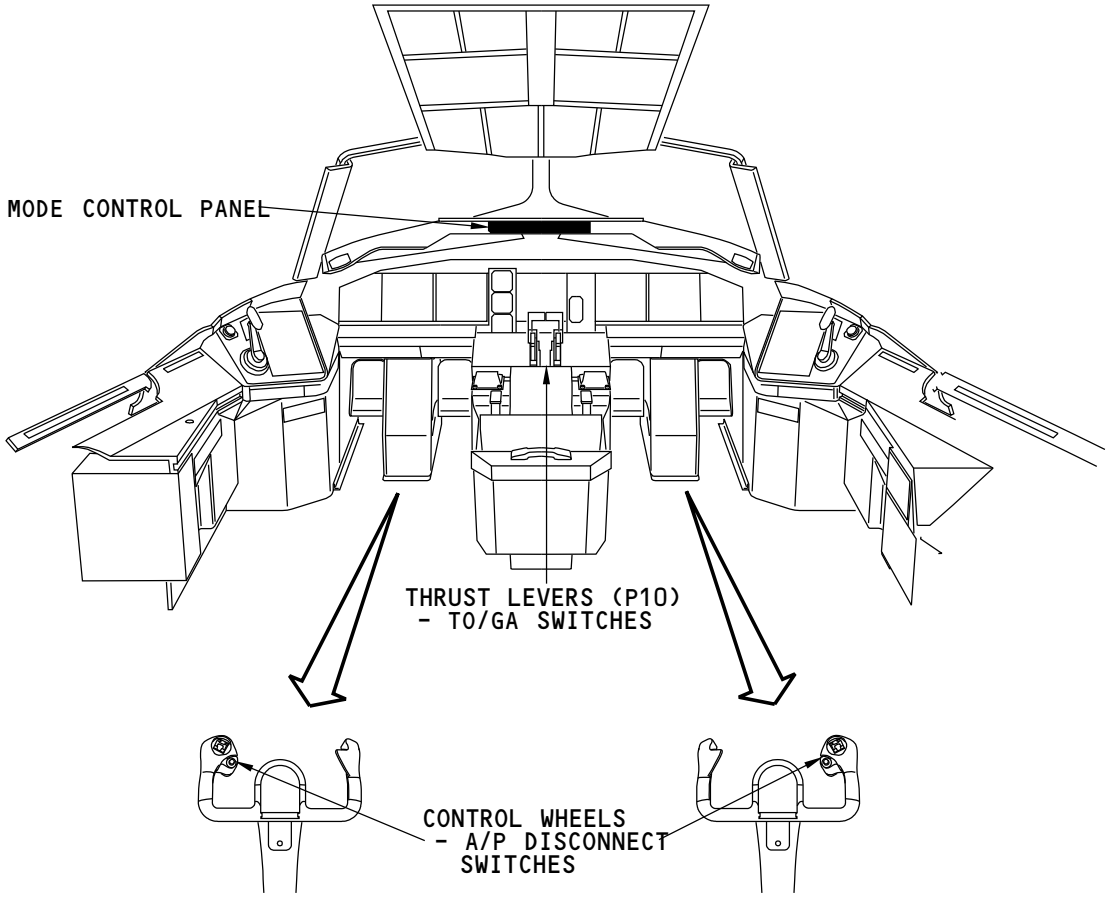

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AFDS - FLIGHT DECK COMPONENT LOCATIONS

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AFDS - MAIN EQUIPMENT CENTER COMPONENT LOCATION

AFDS Component Location

The AFDCs are on the E1, E2, and E4 racks in the main equipment center.

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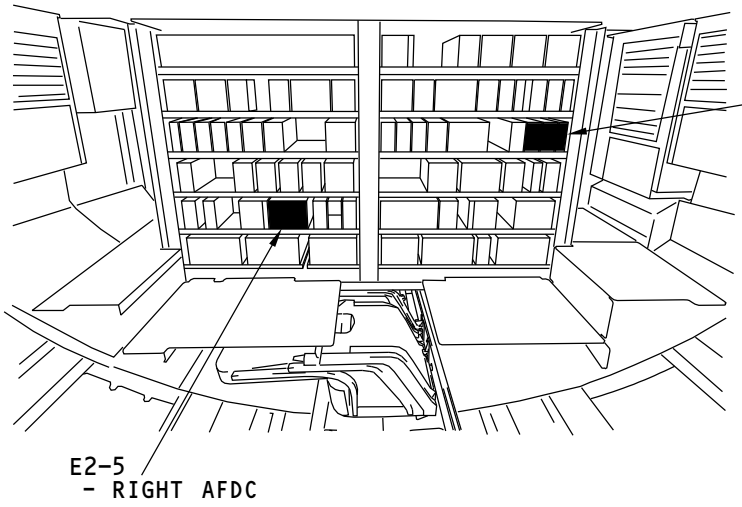
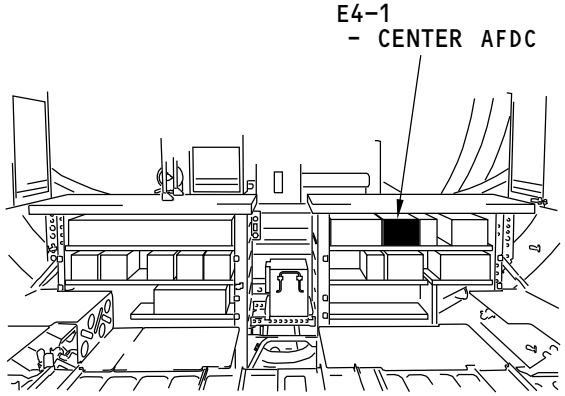


MAIN EQUIPMENT CENTER
(LOOKING AFT)



MAIN EQUIPMENT CENTER
(LOOKING FWD)

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AFDS - MAIN EQUIPMENT CENTER COMPONENT LOCATION

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AFDS - BELOW FLIGHT DECK COMPONENT LOCATIONS

AFDS Component Locations

The backdrive actuators and their mechanical connections are under the flight deck floor.

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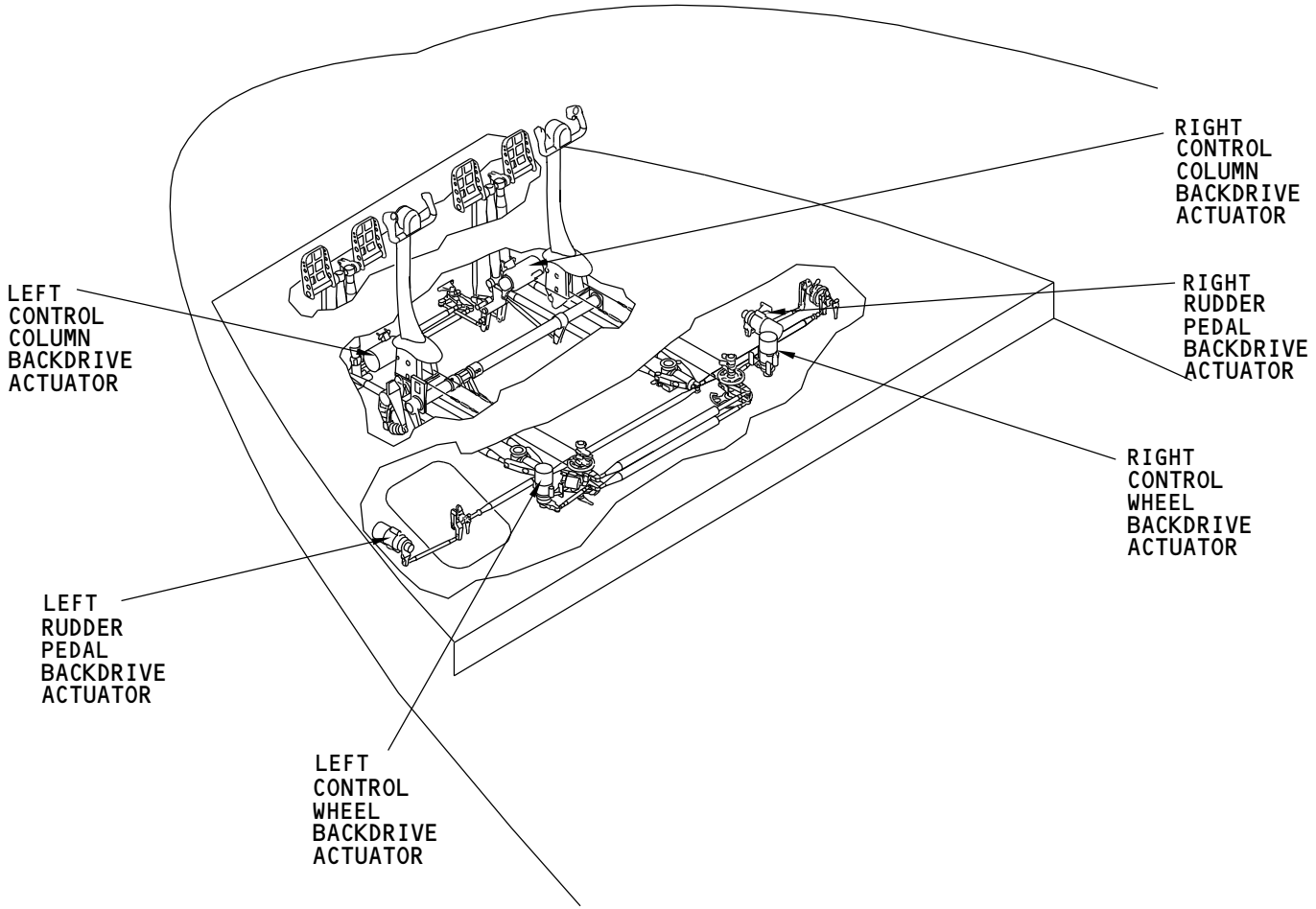

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AFDS - BELOW FLIGHT DECK COMPONENT LOCATIONS

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AFDS - POWER INTERFACE

AFDS - Power Distribution

The left and right 28v dc buses supply AFDC and backdrive power to their onside AFDCs and the MCP. The 28v dc battery bus supplies AFDC power to the center AFDC. The hot battery bus supplies a second source of power to the warning function of each AFDC.

The MCP lights receive 5v ac panel light power. Signals from the master dim and test system control the brightness of the panel lights.

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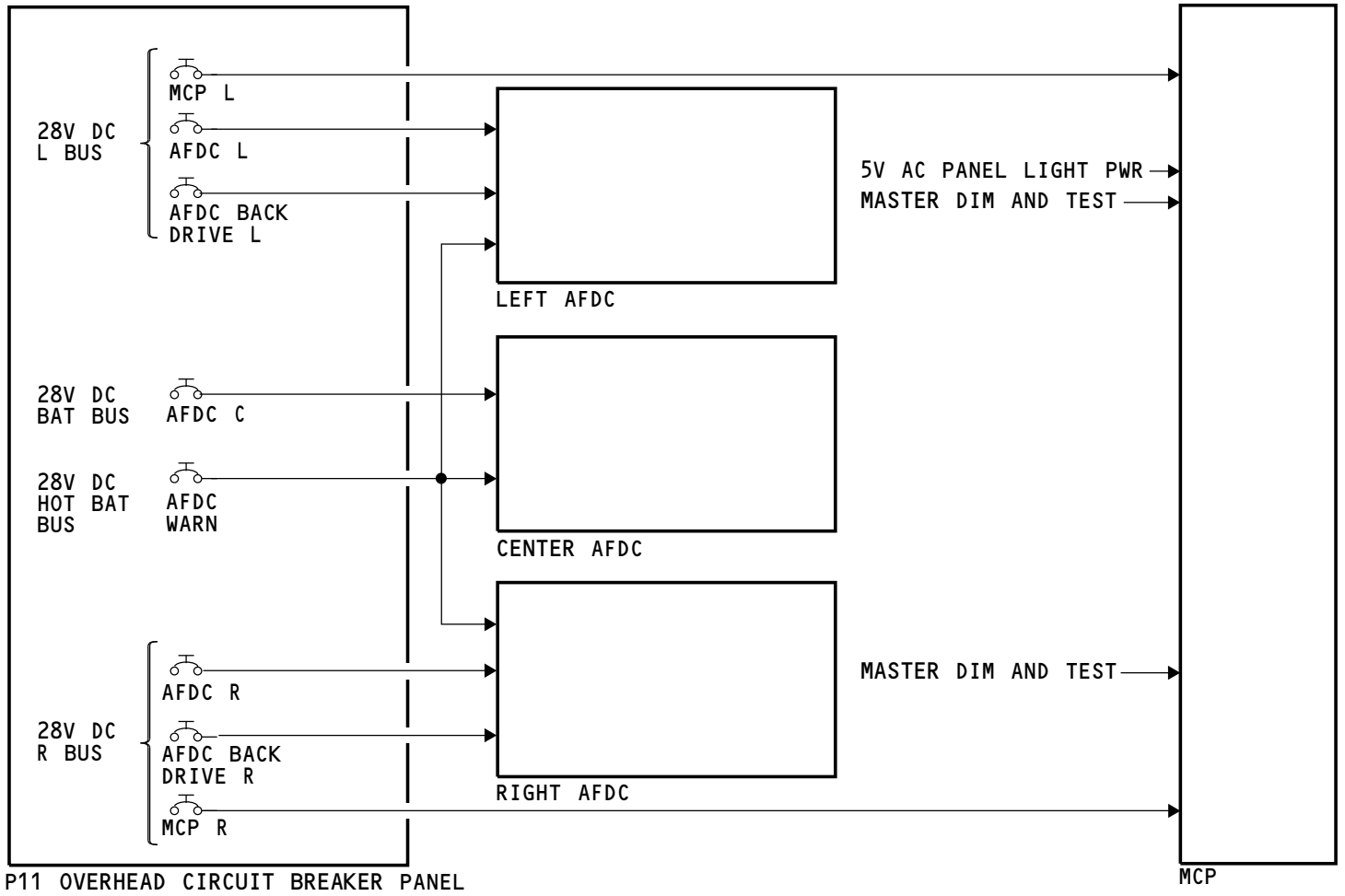

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AFDS - POWER INTERFACE

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AFDS - SYSTEMS ARINC 629 BUS INTERFACE

General

Each AFDC uses the onside systems bus to transmit and receive data.

AIMS Information

Each AIMS cabinet transmits vertical navigation (VNAV) and lateral navigation (LNAV) data to all three buses.

Control Display Unit (CDU)

Each control display unit (CDU) transmits and receives LNAV data from the left and right buses.

Flap Slat Electronics Unit (FSEU)

The left FSEU transmits flap position and slat position data to the left and center buses. The right FSEU transmits to the center and right buses.

Proximity Sensor Electronics Unit (PSEU)

The left PSEU transmits nose gear and nose gear door position to the left and center buses. The right PSEU transmits to the center and right buses.

Weight-on-Wheels (WOW) Cards

The WOW cards are part of the air/ground system (AGS). They transmit WOW data to the left and right buses. The center AFDC receives WOW data from the AFDC cross channel data buses.

Overhead Panel ARINC 629 System (OPAS)

The left OPAS controller transmits heading reference switch data on the left and right buses. The right OPAS controller transmits on the left and right buses.

Electrical Power System

The electrical load management system (ELMS), backup generator converter, and generator control units (GCU) send electrical system status to the left and right AFDCs. They transmit the data to the left and right buses. The center AFDC receives electrical system status from the cross channel data buses. Each AFDC sends bus isolation request to its on-side bus.

Air Supply and Cabin Pressurization Controllers (ASCPCs)

Each ASCPC receives AFDC mode status data from the left and right buses.

Hydraulic Interface Modules (HYDIMs)

The HYDIMs send hydraulic system status to the left and right AFDCs. All four HYDIMs transmit to left and right buses. The left and right AFDCs receive the four HYDIMs data on their on-side bus. The center AFDC receives hydraulic status data from the cross channel data buses.

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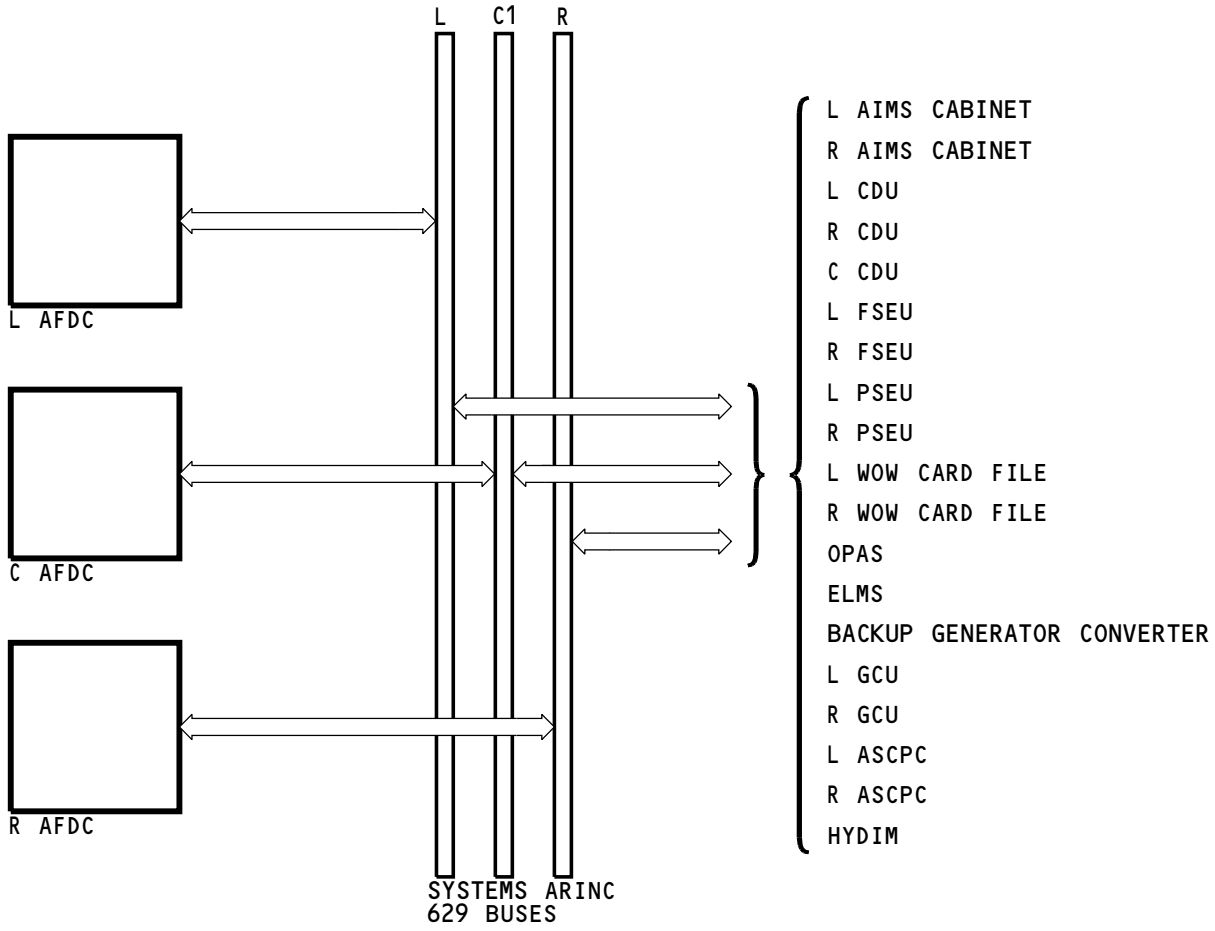

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AFDS - SYSTEMS ARINC 629 BUS INTERFACE

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AFDC

Each AFDC uses the on-side flight controls bus to transmit data. Each AFDC receives data from all three buses.

Primary Flight Control Computers

Each PFC uses the on-side flight controls bus to transmit data. Each PFC receives data from all three buses. Each AFDC receives data from all three PFCs.

The AFDCs send engage requests and autopilot commands to the PFCs. The AFDCs receive backdrive commands, flight deck control input positions, and engagement status.

Air Data Modules (ADMs)

Each ADM receives air/ground and engine running status from their on-side AFDCs.

Air Data Inertial Reference Unit (ADIRU)

Each AFDC receives attitude and air data from ADIRU on the left and right buses.

Secondary Attitude Air Data Reference Unit (SAARU)

Each AFDC receives attitude and air data from the secondary attitude air data reference unit (SAARU) on the center bus.

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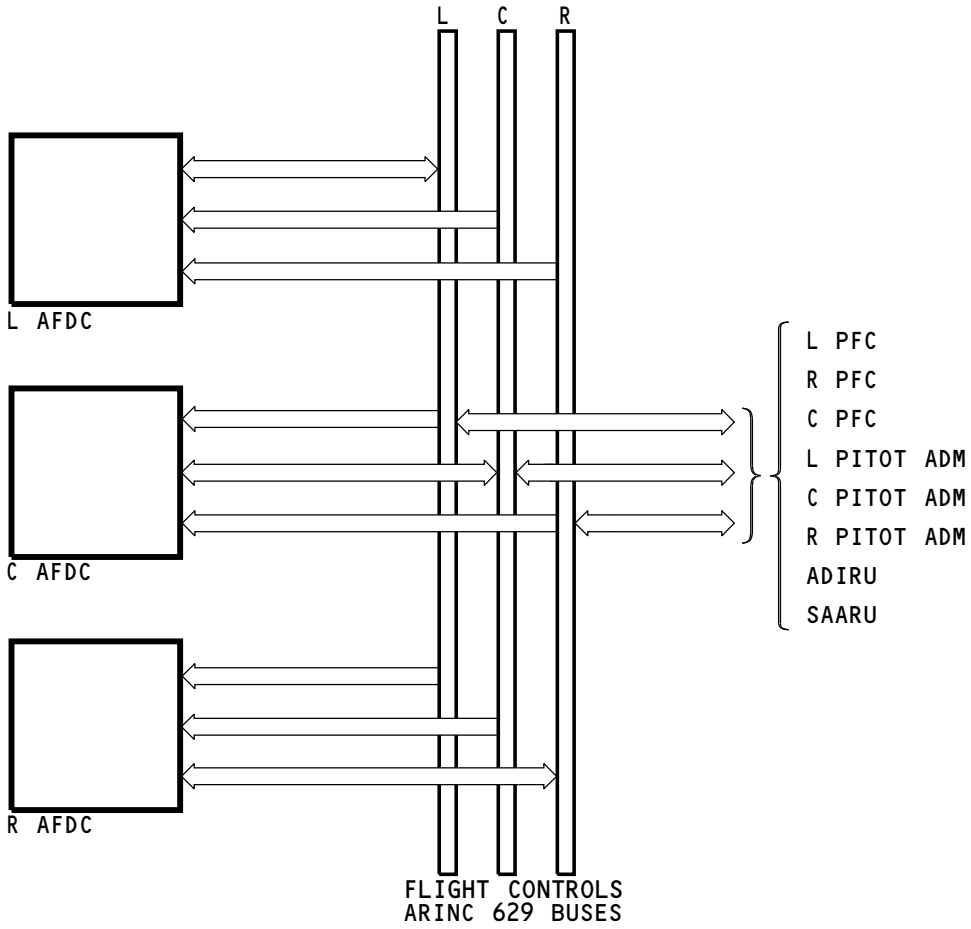

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AFDC - FLIGHT CONTROLS ARINC 629 BUSES INTERFACE

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Mode Control Panel

The mode control panel (MCP) has three 429 input data buses and two 429 output data buses.

The MCP receives mode requests and target values from the three AFDCs on separate data buses.

The MCP sends this information to the three AFDCs:

- Autopilot engage requests
- Mode requests
- Target values
- Maintenance data.

The MCP sends LNAV and VNAV mode requests and maintenance data to the AIMS cabinets.

The MCP sends selected altitude data to the ATC transponders.

Instrument Landing System (ILS)

Each multi-mode receiver (MMR) sends runway course and ILS deviation data to the on-side AFDC.

Radio Altimeter (RA) Transceiver

Each radio altimeter transceiver sends radio altitude data to the on-side AFDC.

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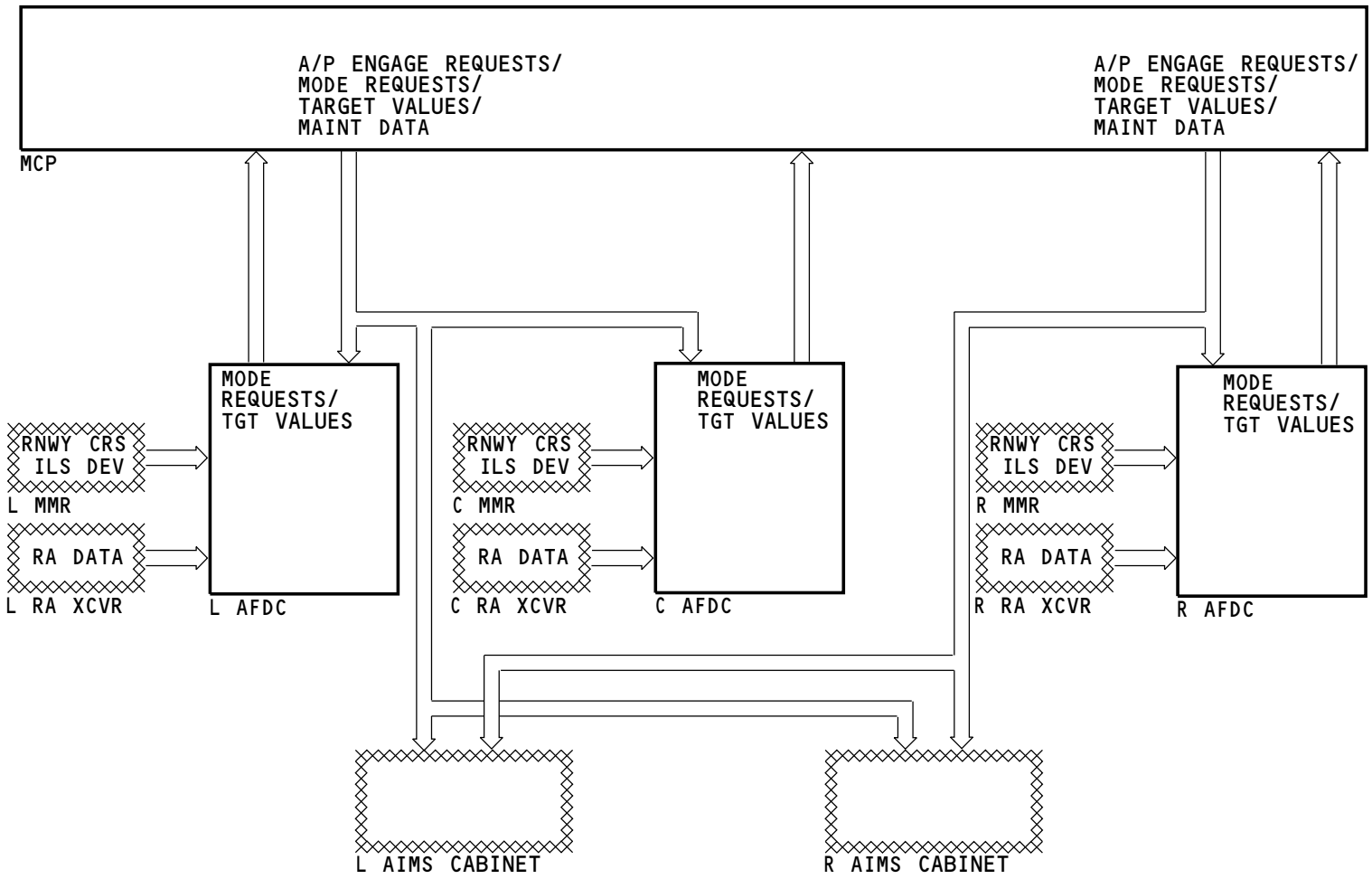

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AFDS - ARINC 429 DATA BUS INTERFACE

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Cross Channel Bus and Discrete Information

Each AFDC receives digital data on cross-channel (X-CH) buses for monitor, signal selection, and synchronization functions.

Each AFDC continuously sends an AFDC ALIVE discrete to the other AFDCs if it does not detect any internal faults.

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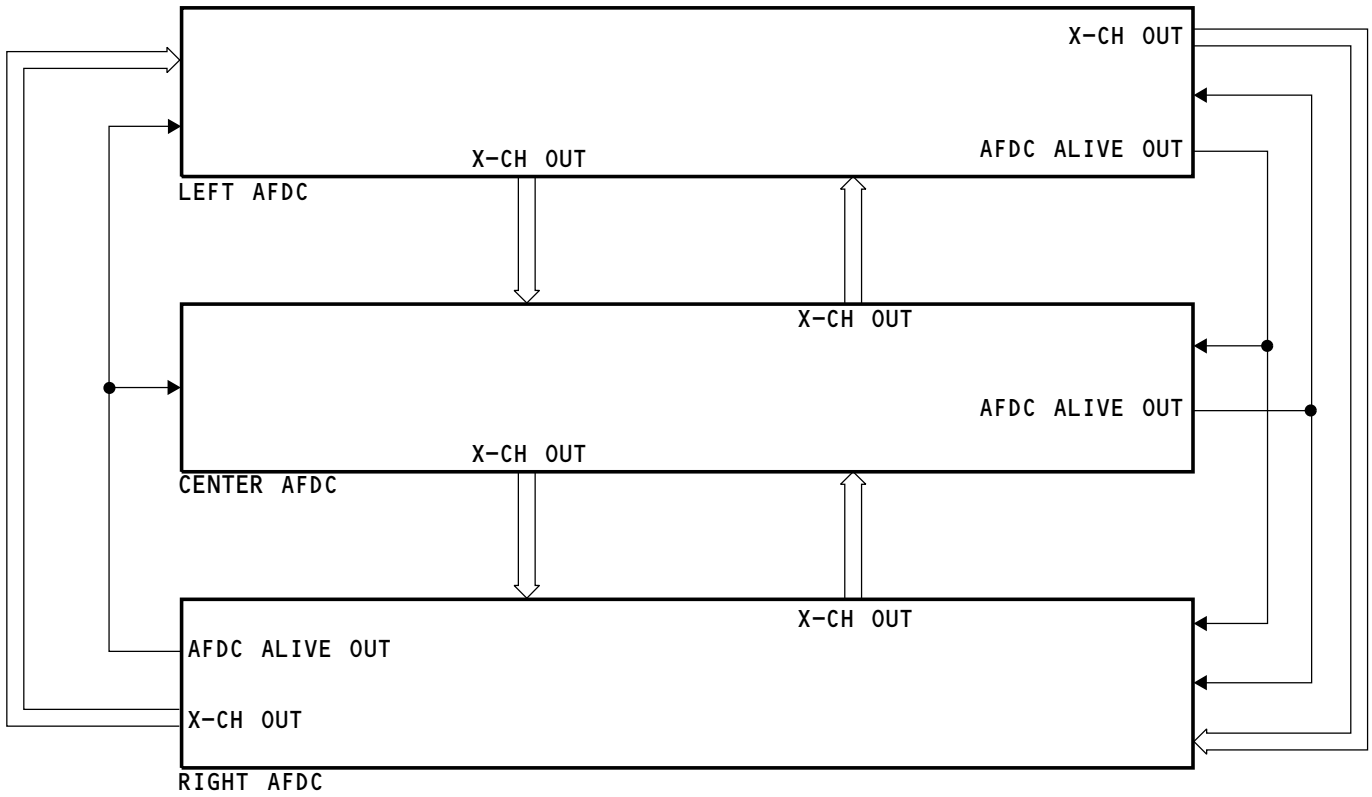

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AFDS - CROSS-CHANNEL DATA INTERFACE

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AFDS - MISCELLANEOUS ANALOG DISCRETES INTERFACE

General

Th discrete inputs to the AFDC are from these switches:

- Autopilot disconnect switches
- Takeoff/go-around (TO/GA) switches
- Autopilot disengage bar.

Interface

Each control wheel has an autopilot disconnect switch. These switches supply the A/P disengage and A/P warning reset discretes to each AFDC.

Two takeoff go-around (TO/GA) switches on the left and right thrust levers supply a discrete to each AFDC. The left discrete goes to both AIMS cabinets.

The disengage bar on the MCP supplies a secondary method to disengage the AFDCs. When the bar is in the up position, the disengage switches supply power to the engage relay in the AFDCs. When the bar is in the down position, the disengage switches supply a ground to this relay.

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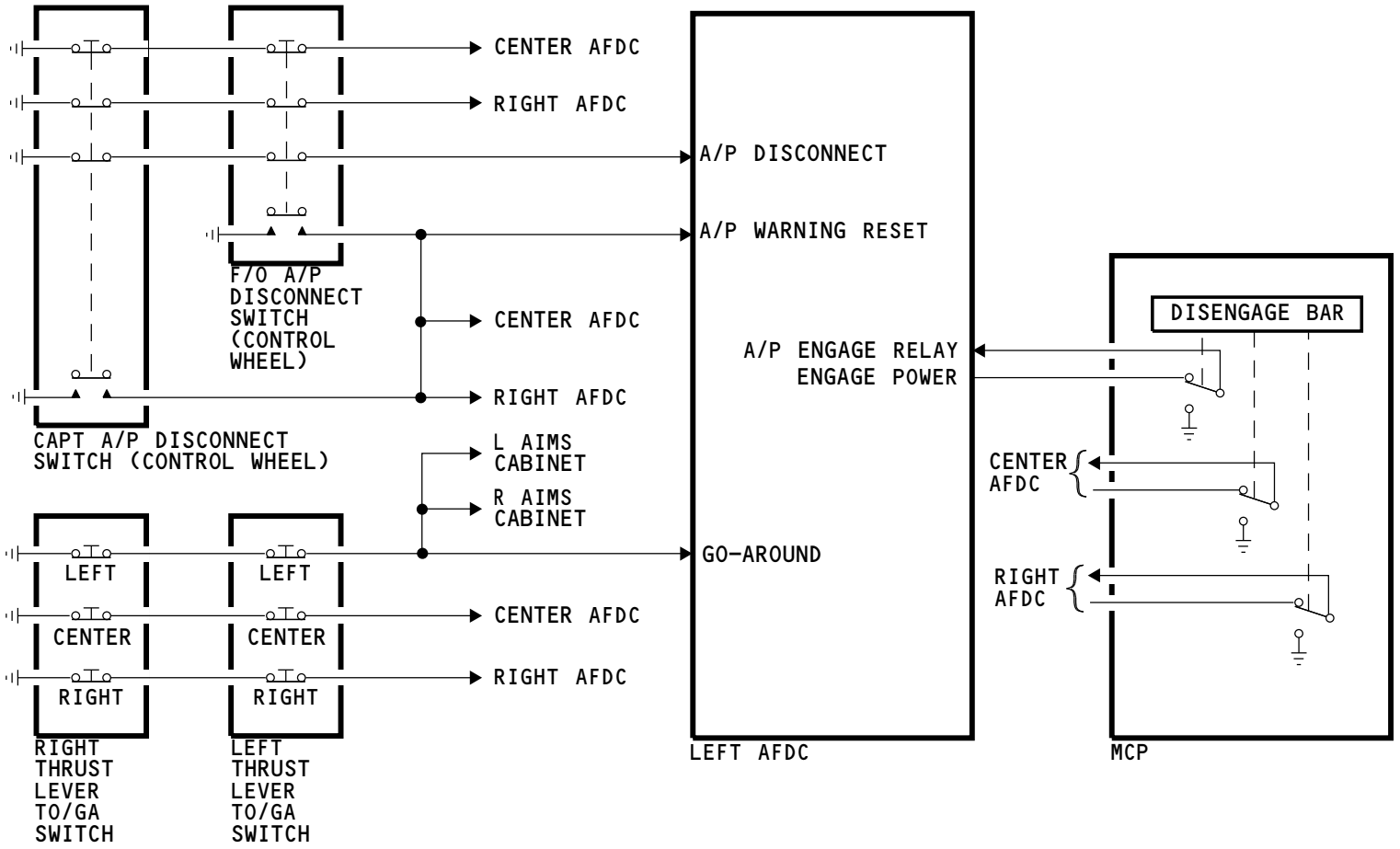

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AFDS - MISCELLANEOUS ANALOG DISCRETES INTERFACE

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Warning Electronic System

These signals go to the warning electronic units (WEUs) when there is an autopilot disconnect:

- Autopilot disconnect warning normal (A/P DISC WARN NORM)
- Autopilot disconnect warning battery 1 (A/P DISC WARN BAT 1)
- Autopilot disconnect warning battery 2 (A/P DISC WARN BAT 2).

When the WEUs receive at least two of the three warning signals, they make the master warning lights show and the wailer sounds.

AIMS

The A/P DISCONNECT WARN BAT 2 discretes are connected together outside of the AFDCs and go to the two AIMS cabinets. The primary display function of AIMS shows a warning message on EICAS.

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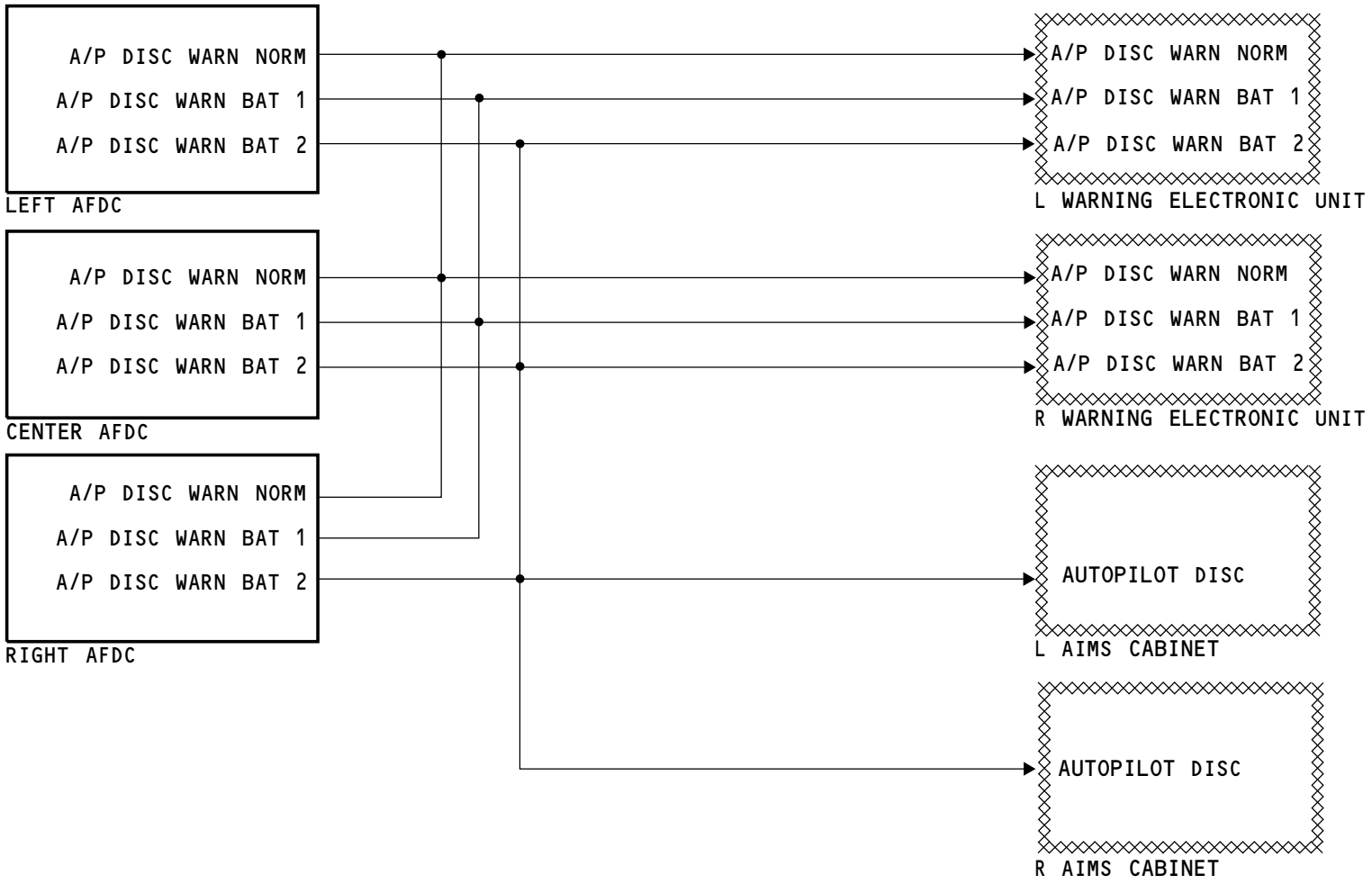

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AFDS - WARNING ANALOG DISCRETES INTERFACE

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Tune Inhibit Discrete

During an approach with the flight director or autopilot engaged, the AFDCs send a tune inhibit discrete to the multi-mode receivers (MMRs). The tune inhibit discrete inhibits flight crew from tuning the MMRs.

Antenna Switch Interface

Each AFDC controls its antenna switches for the LOC and G/S antennas.

The LOC antenna request discrete signal controls a localizer antenna switch that connects the LOC antenna to the MMR. One set of switch contacts sends feedback to the AFDC to show the position of the relay.

The G/S capture antenna request discrete signal controls a glideslope antenna switch that connects the G/S track antenna to the MMR. One set of switch contacts sends feedback to the AFDC to show the position of the relay.

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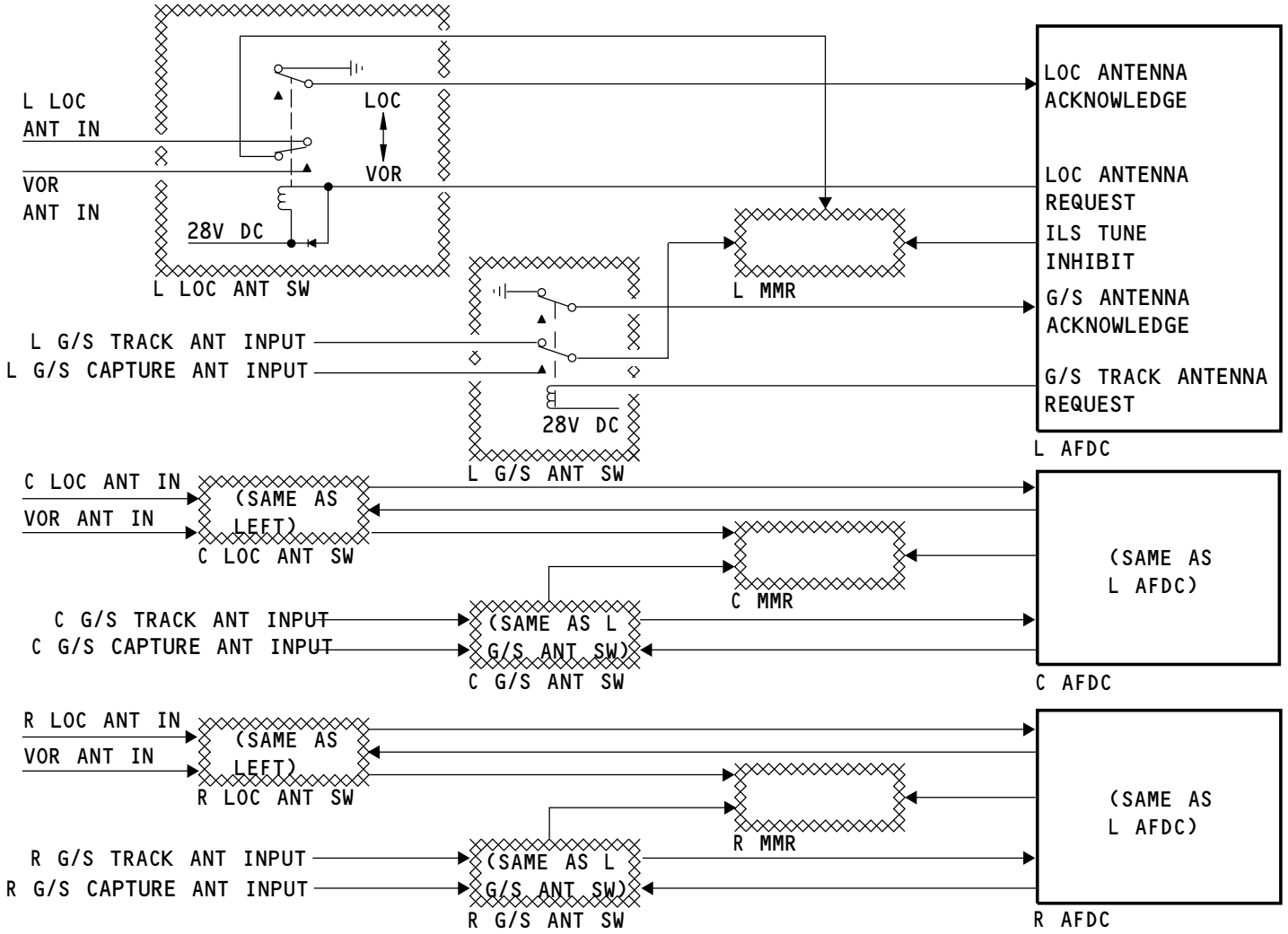

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AFDS - ILS ANALOG DISCRETES INTERFACE

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AFDS - BACKDRIVE INTERFACE

AFDC Backdrive

The left and right autopilot flight director computers (AFDCs) each connect to three backdrive actuators. These are the actuators:

- Column backdrive actuator
- Wheel backdrive actuator
- Rudder backdrive actuator.

Each actuator has these components:

- Two tachometers
- One motor
- One clutch.

The AFDCs send the control signals to the motor and clutch and receive actuator rate from the tachometers.

The center AFDC does not connect to any backdrive actuators.

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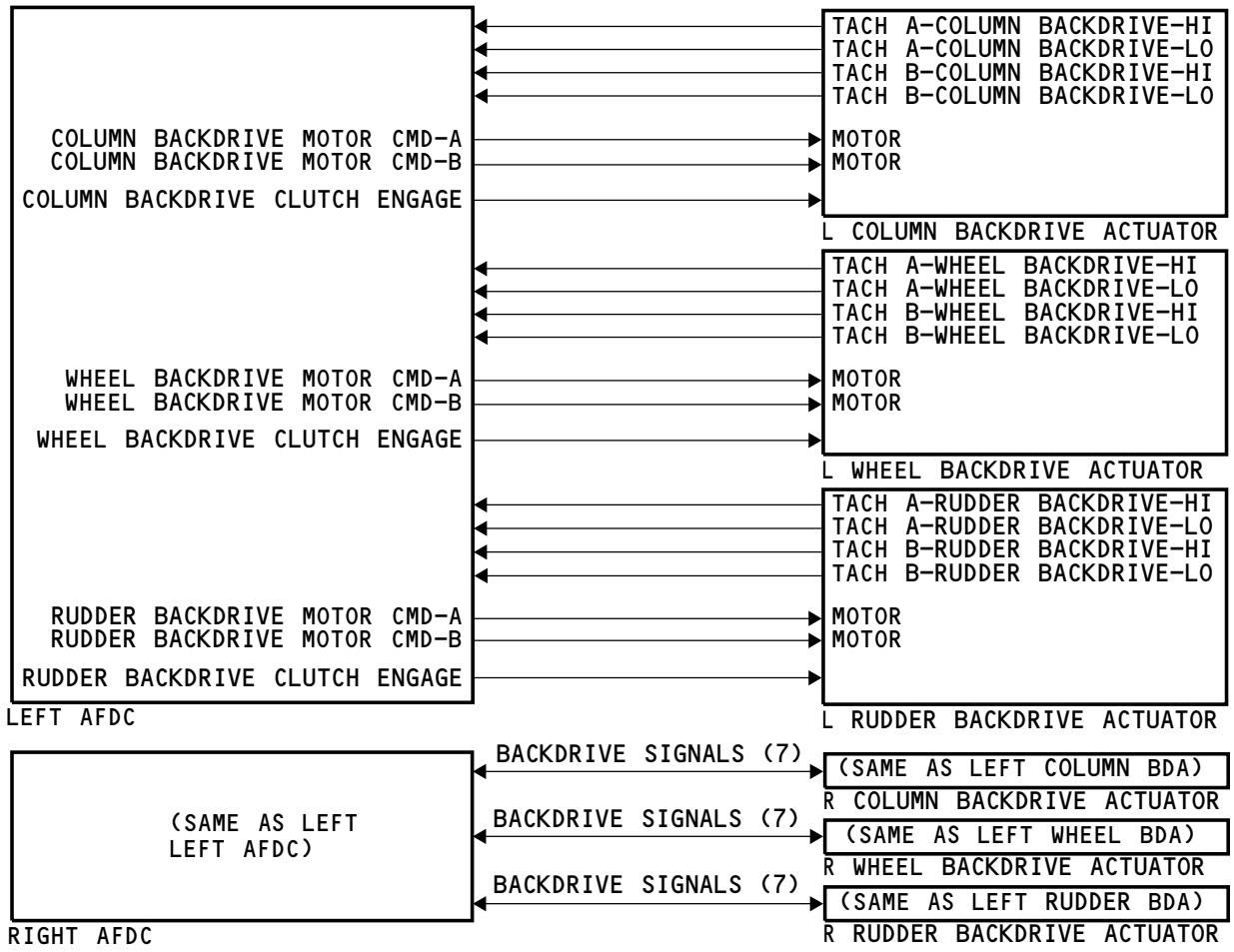

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AFDS - BACKDRIVE INTERFACE

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AFDS - MODE CONTROL PANEL - PHYSICAL DESCRIPTION

Purpose

The mode control panel (MCP) supplies the interface between the pilot and the autopilot flight director system (AFDS).

The displays on the MCP show the selected values of airplane speed, heading, and altitude.

The MCP lets the flight crew engage and operate the AFDS and the AIMS thrust management computer function (TMCF).

Physical Description

The MCP weighs approximately 16 lb. Four screws hold the MCP to the glareshield structure. They connect to floating locknuts in the bottom of the MCP. The screws are captive in the mounting rails.

Three quick-disconnect connectors on the rear of the MCP supply 28v dc power and 5v ac panel lighting. They also connect ARINC data buses and discrete inputs and outputs.

Forced air from the equipment cooling system goes in the rear of the MCP and goes out through exhaust holes at the top. The MCP automatically connects with the cooling system when you install the MCP.

Each switch assembly has two incandescent bulbs. The bulbs are in the back of the switch assembly. The bulbs use 5v ac power from the master dim and test circuits. To replace the incandescent bulbs, remove the switch assembly from the MCP.

Each mode select switch, except the CLB/CON switch, also has a 28v dc light emitting diode (LED). The LEDs show a bar at the bottom of the switch. The LEDs are not line replaceable.

There are four liquid crystal displays (LCD) to show these reference values:

- Indicated airspeed (IAS) or MACH
- Heading (HDG) or track (TRK)
- Vertical speed (V/S) or flight path angle (FPA)
- Altitude.

The LCDs are not line replaceable.

The light source for the four LCDs is a fluorescent tube. The tube is inside the MCP and is behind the LCDs. The tube is not line replaceable.

Training Information Point

As the fluorescent tube gets old, the current to the tube increases to maintain the brightness. A current monitor detects the current to the tube. If the current reaches a threshold limit, the MCP sends a request to the CMCF to make a maintenance memo. The maintenance memo is mode control panel fluorescent light is degraded. You select the maintenance memos with the maintenance planning menu on the MAT.

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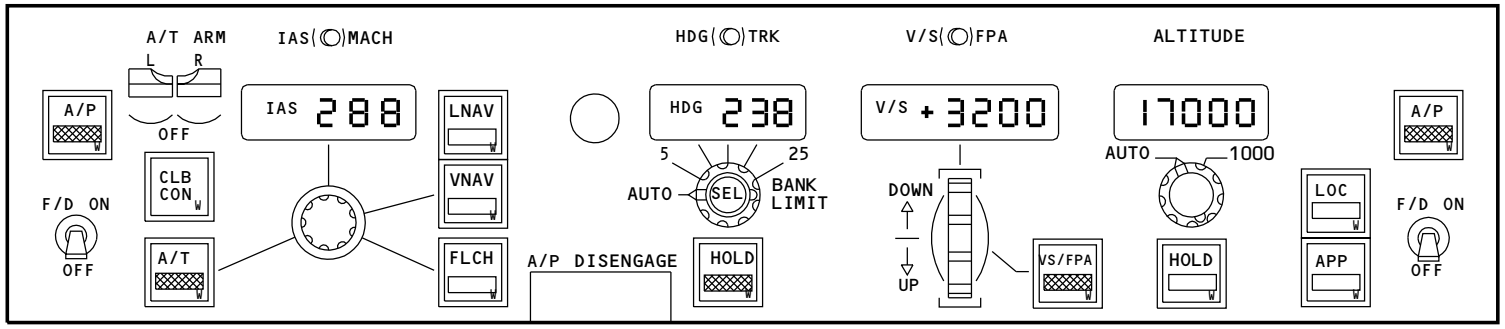
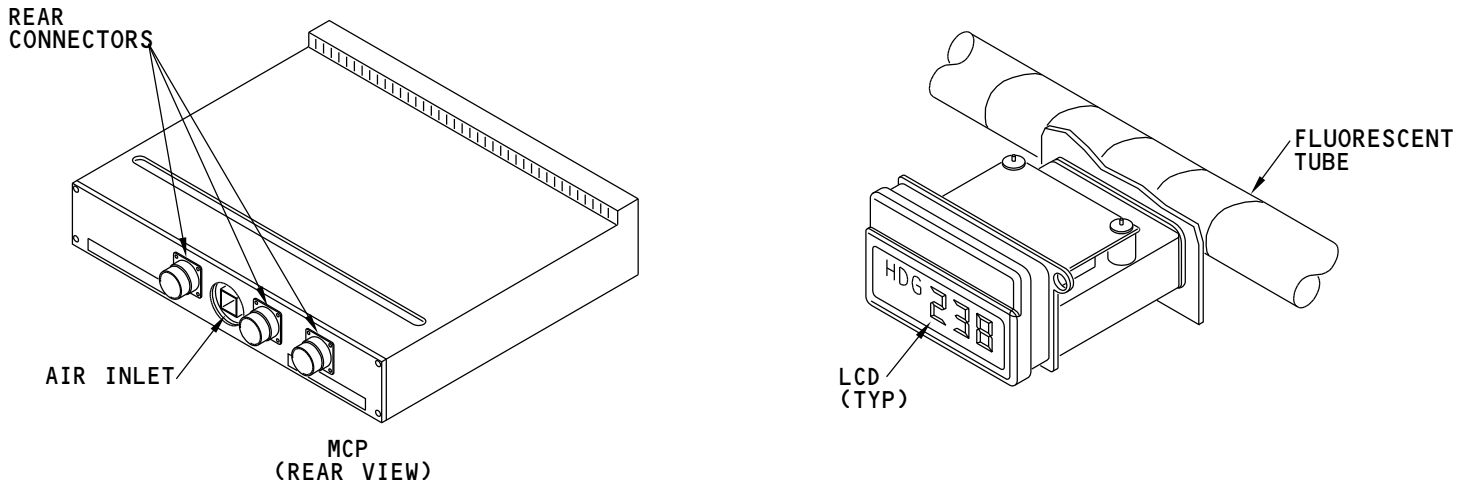


MCP



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AFDS - MODE CONTROL PANEL - PHYSICAL DESCRIPTION

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AFDS - MODE CONTROL PANEL - FUNCTIONAL DESCRIPTION

General

The major components of the MCP are:

- Power supplies, A and B
- Microprocessors, A and B
- Fluorescent tube control
- LCDs and encoders
- Push-button and toggle switches.

Power Supplies A and B

Power supplies A and B receive 28v dc from the left and right 28v dc buses. The MCP functions with either source of 28v dc.

Power supplies A and B supply +12v dc, -12v dc and +5v dc to their microprocessors and logic circuits. Power supplies A and B also supply +14v dc to power supply C which is part of the fluorescent tube control.

Microprocessor A and B

The MCP contains two separate microprocessor channels.

Microprocessor A receives data from the Left and center AFDC. Microprocessor B receives data from the right and center AFDC.

Microprocessor A sends data to the left and center AFDCs. Microprocessor B sends data to the right AFDC.

To make sure all three AFDCs use data from one MCP processor, all AFDCs use the microprocessor data sent to the master AFDC.

When the left AFDC is master, microprocessor A writes to the LCD displays. The right and center AFDCs receive microprocessor A data through the AFDC cross-channel buses.

When the right AFDC is master, microprocessor B writes to the LCD displays. The left and center AFDCs receive microprocessor B data through the AFDC cross-channel buses.

Training Information Point

If a microprocessor fails or if its interface to the AFDC fails, the MCP sends a request to the CMCF to make an EICAS status message show. The status message is MCP CTRL PANEL LANE.

Fluorescent Tube Control

The fluorescent tube control circuit supplies current to drive the tube and the tube heater.

There is a heater coil around the fluorescent tube. A temperature sensor adjacent to the tube operates the heater when the temperature is less than 40F.

Liquid Crystal Displays (LCDs) And Control Knob Encoders

There are four LCDs. They show mode reference values. The values change when you turn the selector or when the AFDCs command a new reference value.

Microprocessor A and B drive each LCD. Each selector connects to two encoders. Each encoder sends data to the on-side microprocessor.

Push-Button And Toggle Switches

Each push-button and toggle switch has two sets of contacts. One set connects to microprocessor A and one set connects to microprocessor B. The LED annunciators in the push-button switches also connect to each microprocessor.

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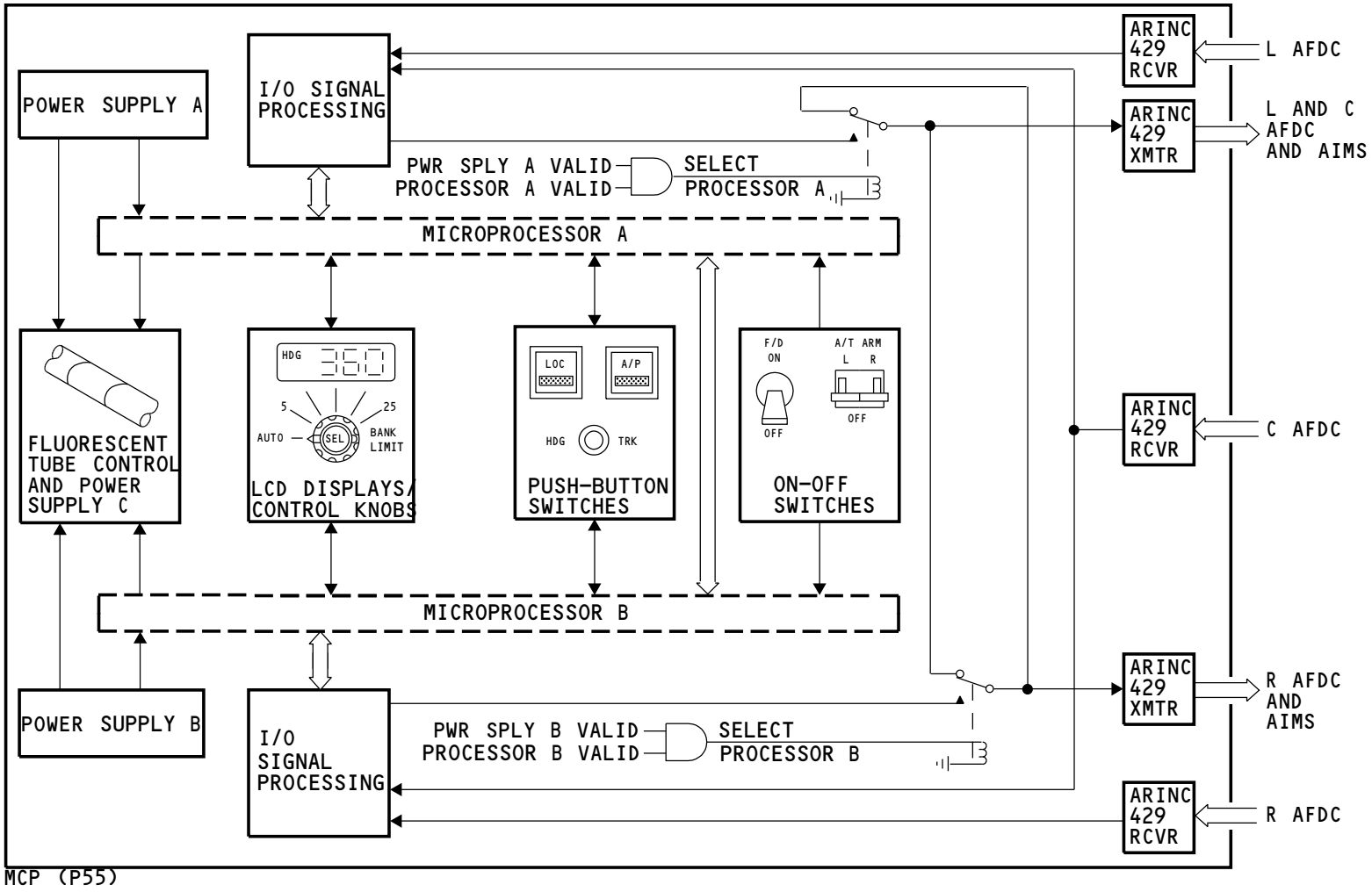

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AFDS - MODE CONTROL PANEL - FUNCTIONAL DESCRIPTION

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AFDS - MODE CONTROL PANEL - CONTROLS AND DISPLAYS

Autopilot (A/P) Engage Switches

Push either switch to engage all available A/P channels. The LEDs in both switches come on.

Autothrottle (A/T) Arm Switches

The switches arm the A/T and digital trimmer control for each engine. Both switches are normally left in the ARM position. When you set the switches to the OFF position, the A/T disconnects.

IAS/MACH Reference Switch

This switch controls the reference the IAS/MACH window shows.

IAS/MACH Window

The window shows indicated airspeed (IAS) or MACH number. IAS shows from 100 to 399 knots in one knot increments. Mach number shows from 0.400 to 0.900 MACH in increments of 0.001 MACH.

At AFDC power up, the window shows 200 knots. The window is normally blank when VNAV is active. If VNAV is not active, the window shows the current target airspeed/mach.

Mode Switches (8)

These switches request A/P, F/D, and A/T modes.

Light Sensor

A photo diode light sensor on the MCP front panel monitors ambient lighting. It controls the brightness of the LCDs.

Heading/Track (HDG/TRK) Reference Switch

This switch controls the reference for the Heading/Track window.

Heading/Track Window

The window shows heading or track angle in increments of one degree. The window range is from 001 to 360 degrees.

At AFDC power-up, the window shows 360 degrees. Runway heading shows at localizer capture.

Vertical Speed/Flight Path Angle (V/S/FPA) Reference Switch

This switch controls the reference for the vertical speed/flight path angle window.

Vertical Speed/Flight Path Angle Window

The vertical speed range is +6000 FPM to -8000 FPM. The flight path angle range is +9.9 degrees to -9.9 degrees.

The window shows four dashes when vertical speed and flight path angle modes are not active.

Altitude Window

The altitude range is from 0 to 50000 feet. The increment is variable.

The altitude in the window is also the altitude alert value for the caution and warning system. At AFDC power-up the display shows 10000 feet.

Flight Director (F/D) Switches

The F/D switches make the F/D displays show on the primary flight displays (PFDs). When the airplane is on the ground and you move a switch to the ON position, the F/D takeoff (TO) mode indications show on the associated PFD.

Altitude Increment Selector (Outer) and Altitude Selector (Inner)

The control has two concentric selectors.

The inner selector changes the reference altitude in the window. If you push the selector while in VNAV, you activate altitude intervention.

The outer selector changes the window increment. With the outer selector in the 1000 position, the inner selector changes the window at 1000 feet/detent.

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With the outer selector in the AUTO position, the window change rate is 100 feet/detent. The altitude window also shows the barometric minimums you selected on both EFIS control panels.

For example, you select barometric minimum values of 290 feet on the left EFIS control panel, and 330 feet on the right EFIS control panel. When outer selector is in auto, as you rotate the inner selector, the altitude on the window changes as follows:

- 100
- 200
- 290
- 300
- 330
- 400
- 500, etc.

If you select the same barometric minimums value on both EFIS control panels, the MCP shows the value only once.

Once the values from the EFIS control panels show on the MCP, they stay on the MCP even if you change the EFIS control panel barometric minimums.

The MCP rounds up to the next 10 feet. So if you select a barometric minimums value of 181 feet, the MCP shows 190 feet.

Vertical Speed/Flight Path Angle Selector

Rotate the selector up to decrease the value. Rotate the selector down to increase the value.

Bank Limit Selector (Outer), Heading/Track Selector (Middle), and Heading/Track Select Switch (Inner)

The control has two concentric selectors and one push-button.

The bank limit selector (outer) selects the bank angle limit used in the heading/track select mode.

The heading/track selector (middle) changes the value the window shows.

The heading/track select switch (inner) is a push-button switch. Push this switch to request the heading select or track select mode.

Autopilot Disengage Bar

The bar connects to three toggle switches. The bar is normally in the up position. Push the bar down to disengage all AFDCs.

IAS/MACH Selector

When not in VNAV, the IAS/MACH window shows the current target airspeed. Turn the IAS/MACH selector to change the target airspeed.

In VNAV, the IAS/MACH window is normally blank. If you push the selector, the window unblanks to show the current FMCF target airspeed. You can then turn the IAS/MACH selector to change the target airspeed. This is speed intervention.

Autothrottle (A/T) Engage Switch

This switch engages the autothrottle.

Climb/Continuous (CLB/CON) Thrust Switch

When two engines are in operation, this switch changes the autothrottle thrust reference to climb (CLB). When only one engine is in operation, it changes the thrust reference to maximum continuous (CON).

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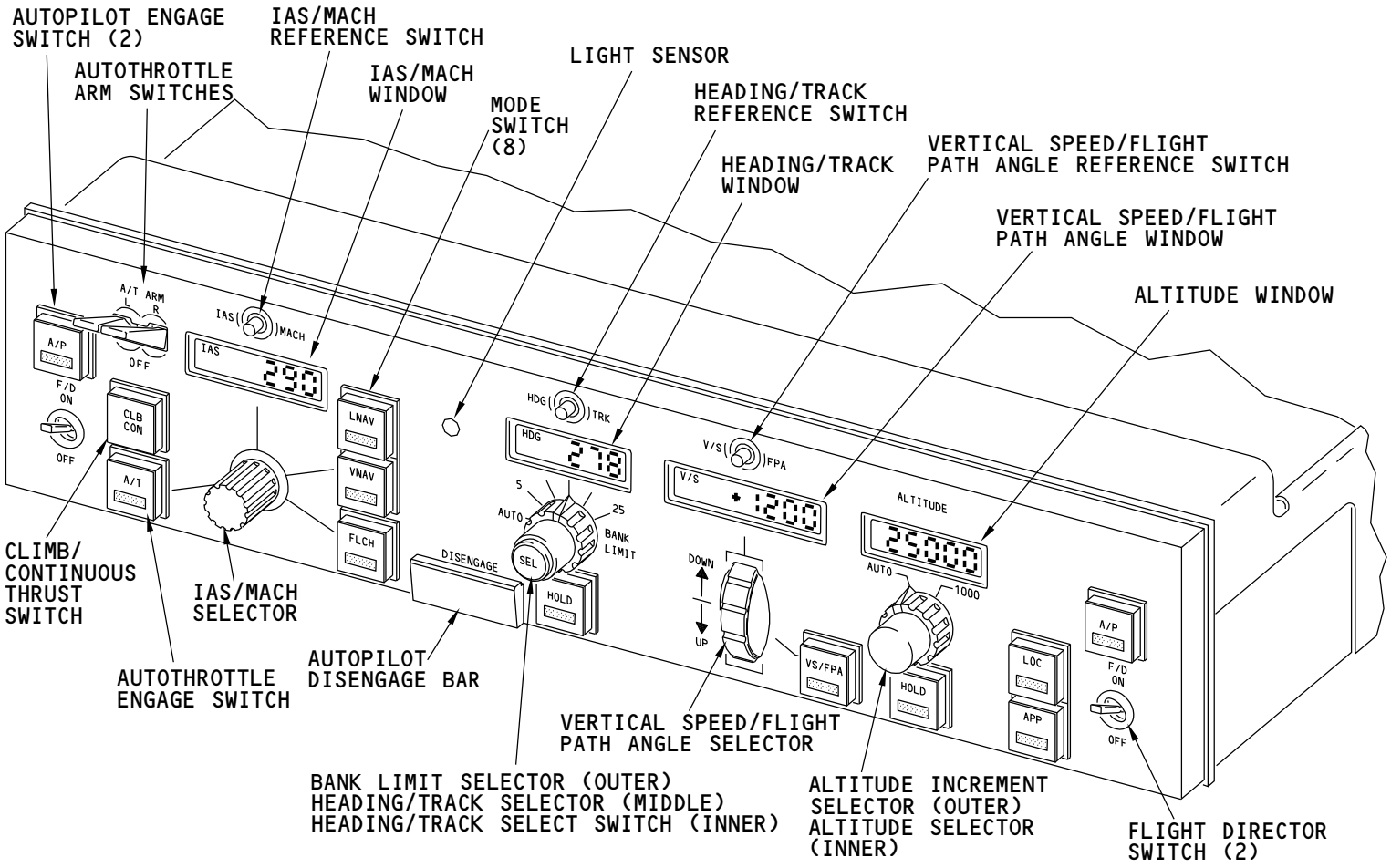

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AFDS - MODE CONTROL PANEL - CONTROLS AND DISPLAYS

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AFDS - AUTOPILOT FLIGHT DIRECTOR COMPUTER

Purpose

The autopilot flight director computer (AFDC) calculates:

- Flight director (F/D) commands
- Autopilot commands
- Backdrive actuator commands.

Physical Description

The AFDC has modules, sub-assemblies, and a chassis assembly in an ARINC 600, 8 MCU box. The top and bottom covers let cooling air flow from the bottom to the top. The AFDC is a line replaceable unit (LRU). AFDC internal components are not LRUs.

Software Loading

The AFDCs must have operational software loaded in them. Shop personnel can load the software, or you can use the MAT to do a software load.

System Configuration

Use the MAT to monitor the AFDS configuration. You can monitor these things:

- A/P hardware part number
- A/P software number
- A/P serial number
- A/P configuration pins
- A/P compatibility pins
- A/P interlock pins
- A/P options list.

This information shows for each AFDC.

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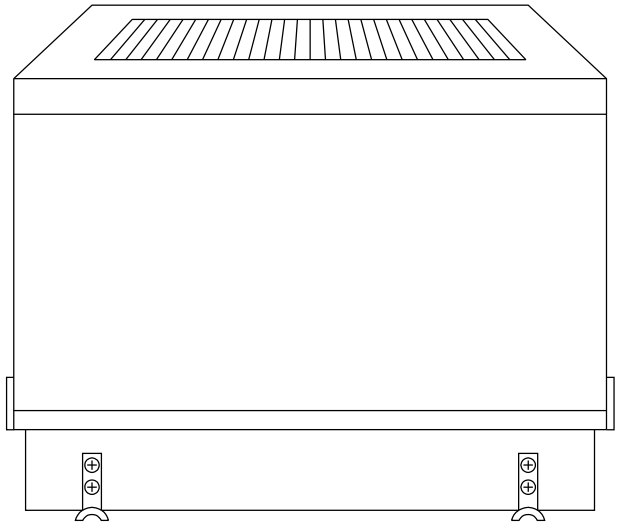

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AFDS - AUTOPILOT FLIGHT DIRECTOR COMPUTER

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AFDS - AUTOPILOT FLIGHT DIRECTOR COMPUTER - FUNCTIONAL BLOCK DIAGRAM

General

This is a block diagram of the autopilot flight director computer (AFDC).

Input Signal Selection

Each ARINC and discrete input/output (I/O) section monitors and selects input signals. Each I/O section monitors the signal validity first. If the validity check is good, the I/O section selects the signal by one of these methods:

- Mid-value selection which uses the middle value of the three signals. Radio altitude (RA) and instrument landing system (ILS) are examples of signals selected by mid-value.
- Priority selection for signals with two sources (left, right). For example, the air data inertial reference unit (ADIRU) is the normal source of air and inertial reference data. If the ADIRU fails, the AFDC selects the secondary attitude air data reference unit (SAARU).
- Forced selection for airplane information management system (AIMS) data. AIMS tells the AFDC which signal to use.

AFDC Processors

The AFDC has three processors. Processors A and B receive digital backdrive commands from the primary flight computers (PFCs). They convert the digital backdrive commands into analog. Processor C calculates the autopilot and flight director control laws. Processor C also does these functions:

- Test and data load.
- Engage/disengage logic
- Failure detection/fault response monitor

Power Supplies

The logic power supply sends +5v dc, +15v dc, -15v dc, and +28v dc to internal components of the AFDC. It also sends +28v dc disengage power to the mode control panel (MCP).

The backdrive clutch power supply sends +28v dc to the backdrive clutch engage logic and relays.

Three backdrive power supplies send drive signals to the wheel, column, and rudder pedal backdrive actuators. Each power supply is a variable voltage push-pull power supply that sends +/-50v dc to each backdrive actuator. Commands from the A and B processors control the variable output of the power supplies.

The center AFDC does not connect to backdrive actuators and does not use its backdrive power supplies.

The battery warning power supply sends +28v dc to the battery warning logic.

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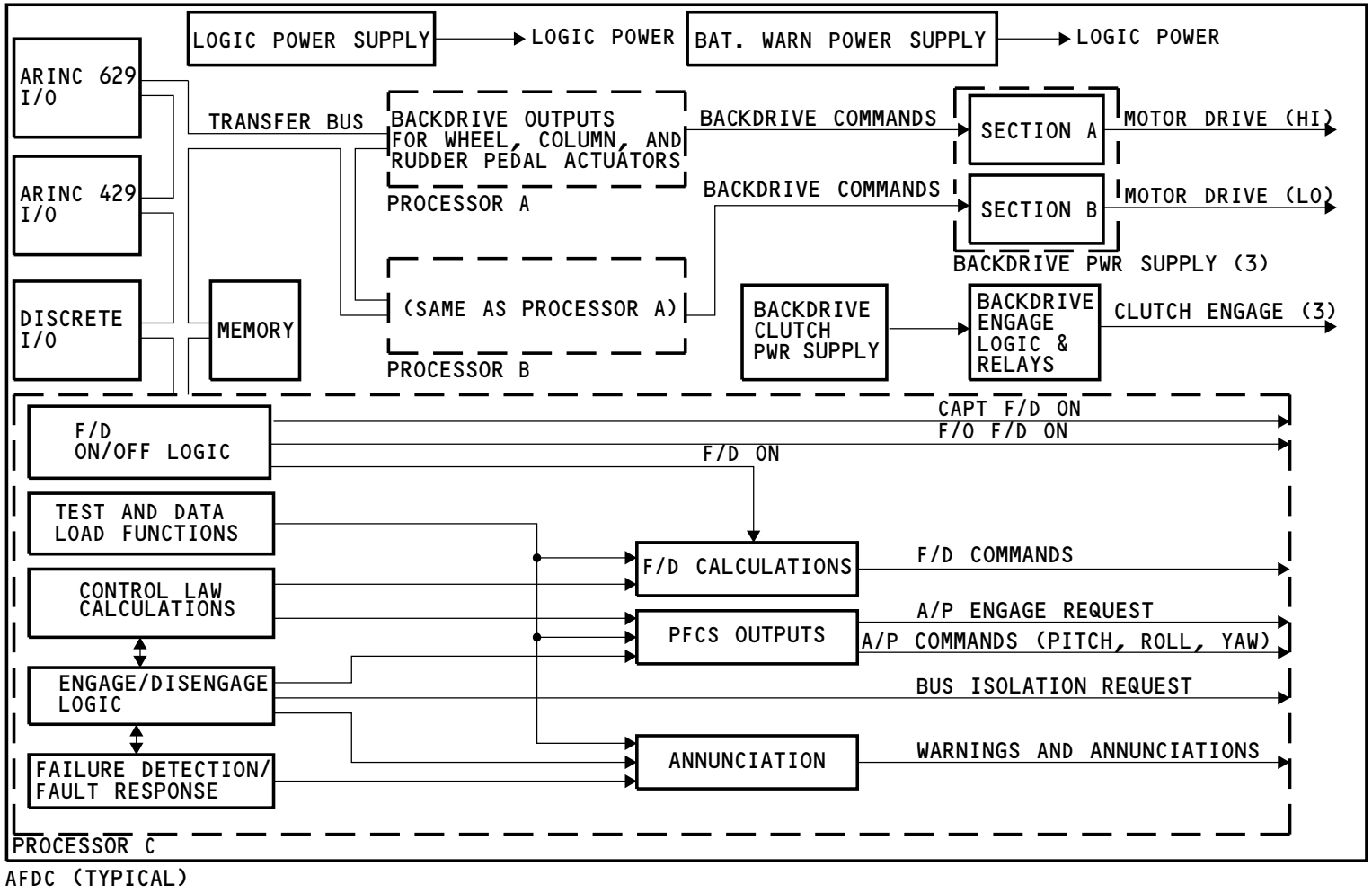

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AFDS - AUTOPILOT FLIGHT DIRECTOR COMPUTER - FUNCTIONAL BLOCK DIAGRAM

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AFDS - AUTOPILOT DISCONNECT SWITCH

Purpose

The autopilot disconnect switches are on the outboard side of each control wheel. The example shows the captain's control wheel. The first officer has the switch on the right side of the wheel. Each switch has a push-button and multiple contacts. These switches manually disconnect all AFDCs.

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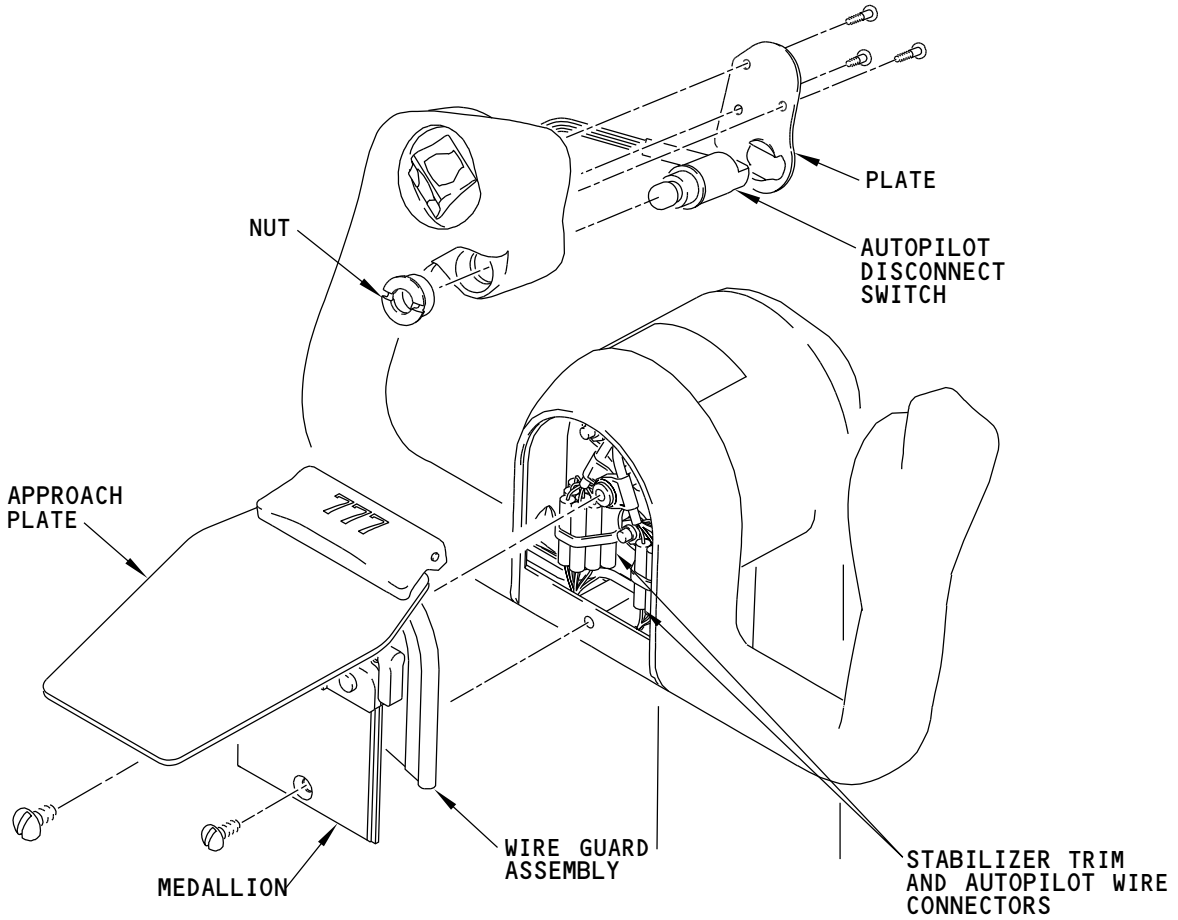

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AFDS - AUTOPILOT DISCONNECT SWITCH

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AFDS - BACKDRIVE ACTUATOR INSTALLATION - 1

Purpose

The backdrive actuators are variable torque motors. They move the control columns, control wheels, and rudder pedals during autopilot operation. This movement gives the flight crew an indication of the autopilot commands that go to the primary flight computers (PFCs).

A control wheel backdrive actuator also operates when the bank angle protection (BAP) function operates. The actuator supplies a variable torque to the roll control system if the airplane bank angle exceeds 35 degrees. BAP is available with the autopilot engaged or disengaged.

There are two backdrive actuators for each of the control columns, control wheels, and rudder pedals. The backdrive actuators are interchangeable.

Location

The six backdrive actuators are below the floor in the 41 section. Access to the control wheel and rudder pedal backdrive actuators is by the main equipment center access door. Access to the control column backdrive actuators is through the forward equipment center access door.

Physical Description

Each actuator weighs about 8 lbs (3.6 kg) and attaches to the airplane structure with four bolts.

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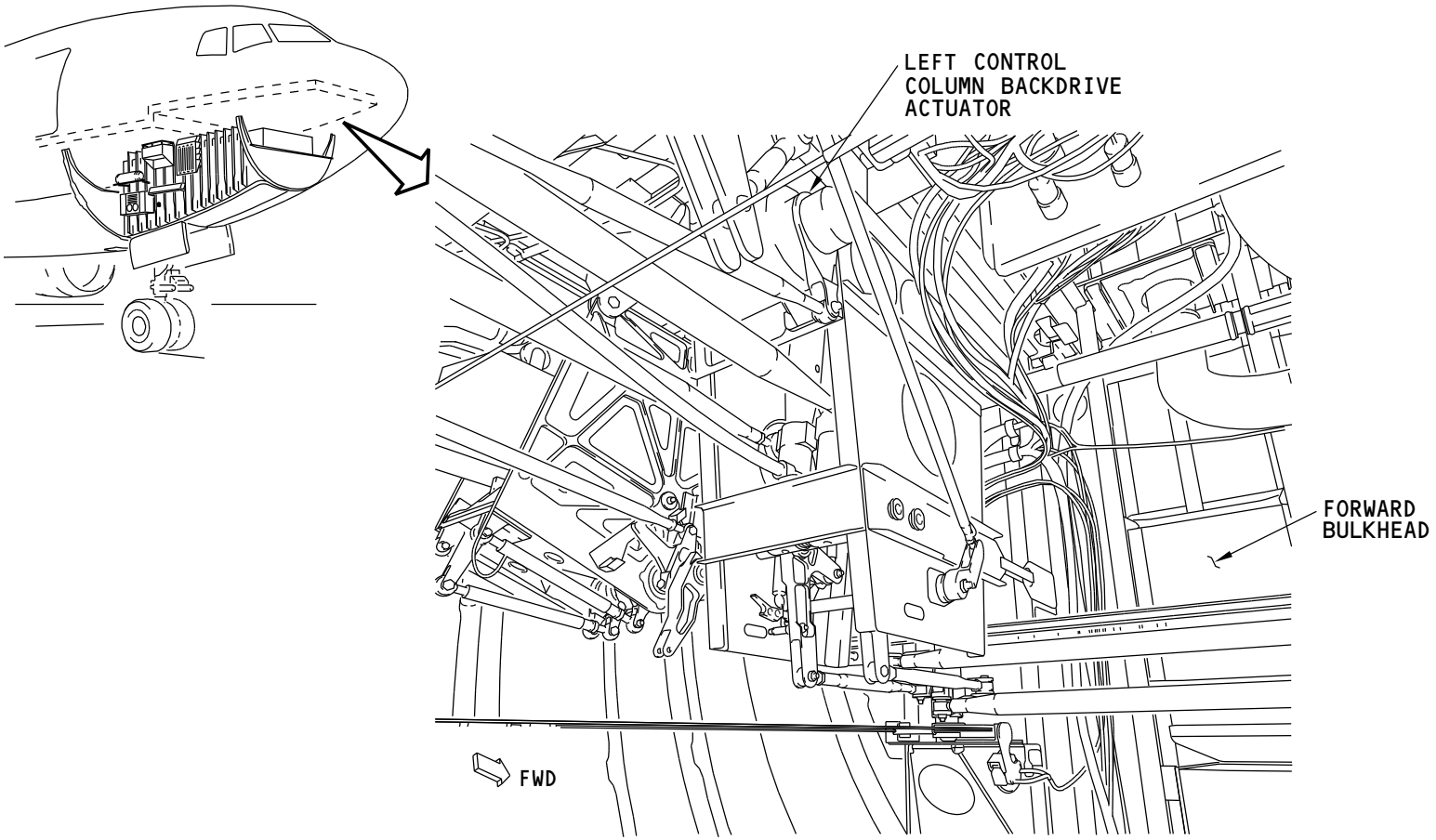

FORWARD EQUIPMENT CENTER BELOW FLIGHT DECK FLOOR

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AFDS - BACKDRIVE ACTUATOR INSTALLATION - 1

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AFDS - BACKDRIVE ACTUATOR INSTALLATION - 2

General

The right control column backdrive actuator is below the flight deck floor. Access is through the forward equipment center.

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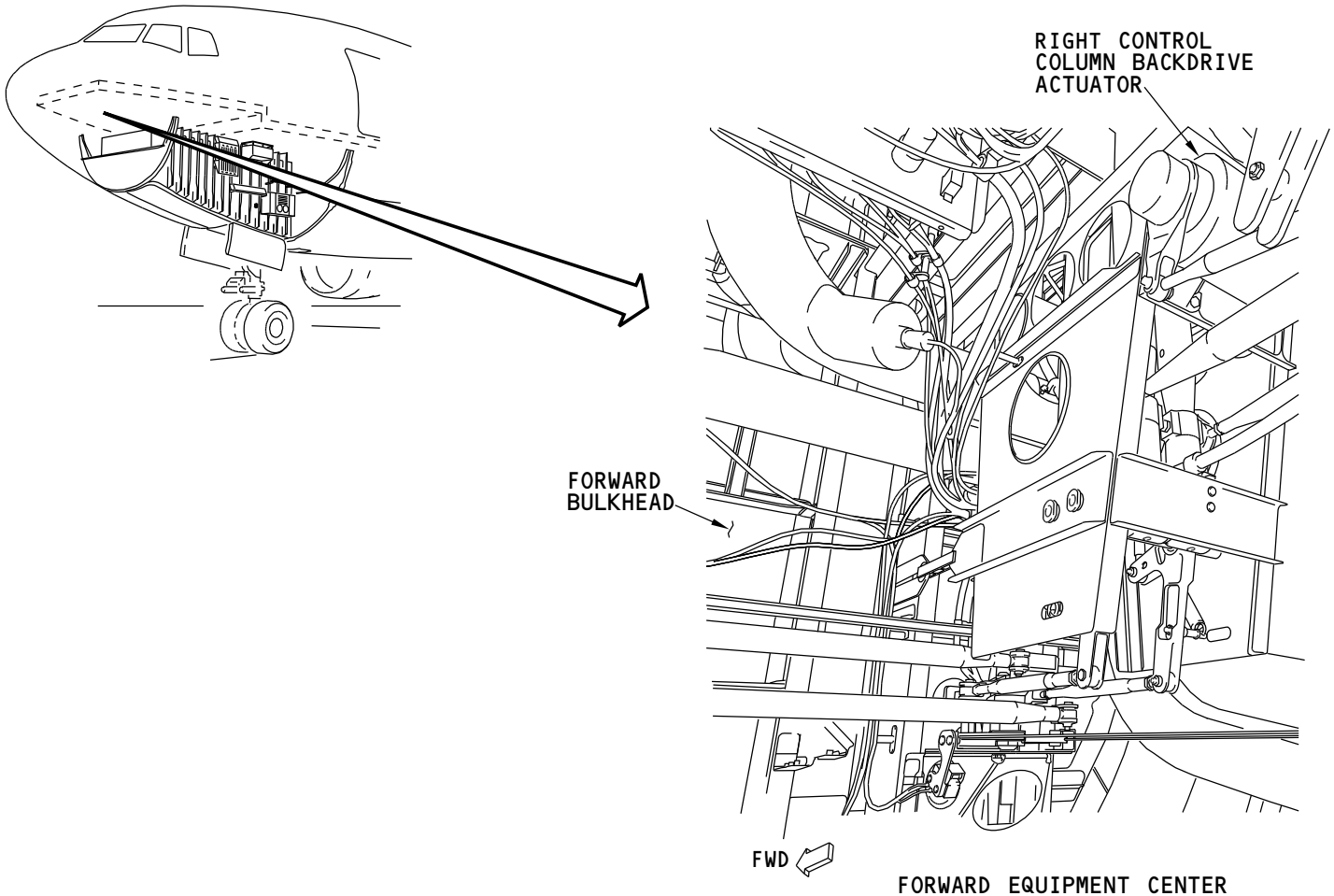

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AFDS - BACKDRIVE ACTUATOR INSTALLATION - 2

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AFDS - BACKDRIVE ACTUATOR INSTALLATION - 3

General

The left control wheel backdrive actuator and the left rudder pedal backdrive actuator are below the flight deck floor.

Access is through the left side of the main equipment center.

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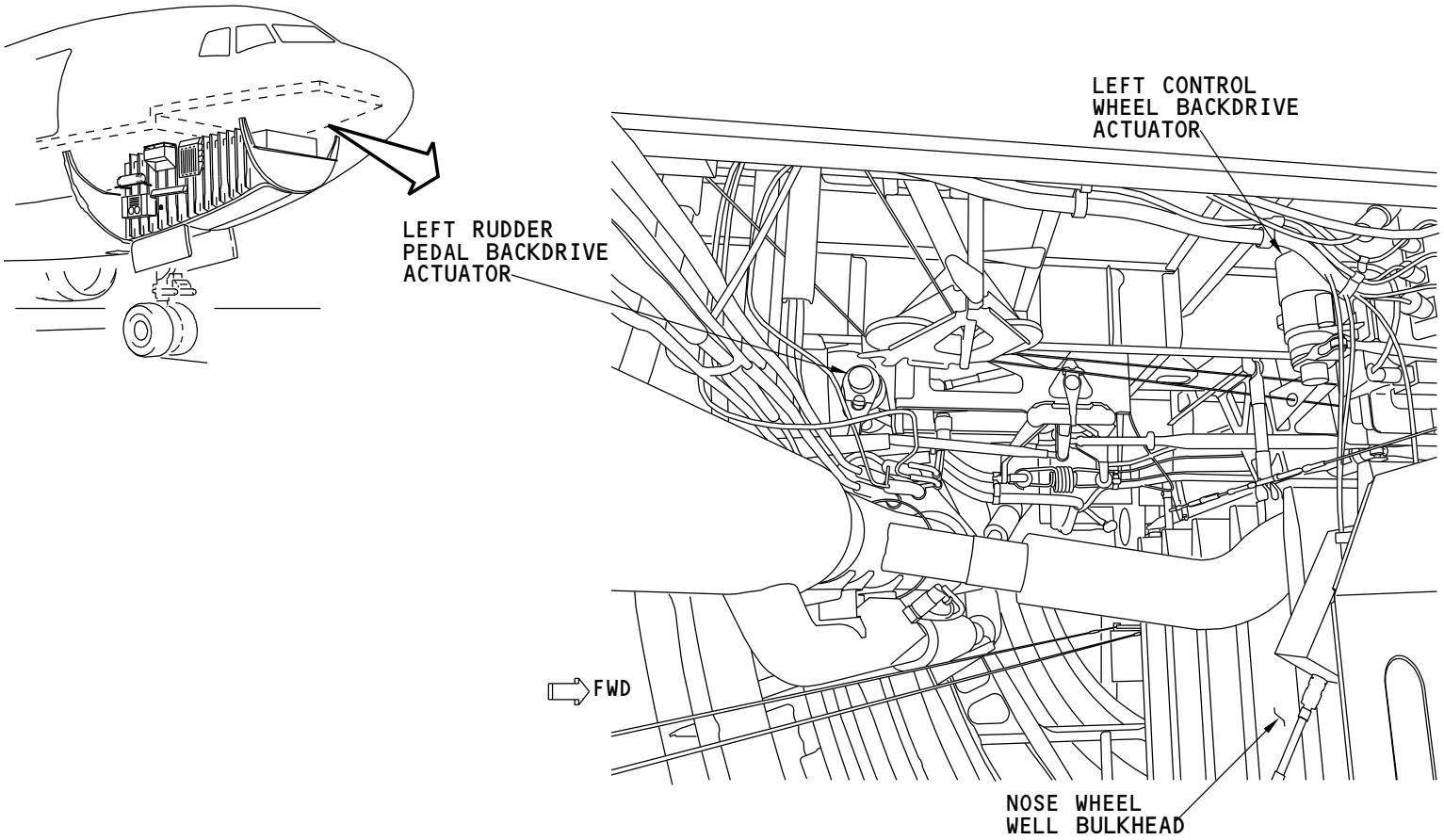

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AFDS - BACKDRIVE ACTUATOR INSTALLATION - 3

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AFDS - BACKDRIVE ACTUATOR INSTALLATION - 4

General

The right control wheel backdrive actuator and the right rudder pedal backdrive actuator are below the flight deck floor.

Access is through the right side of the main equipment center.

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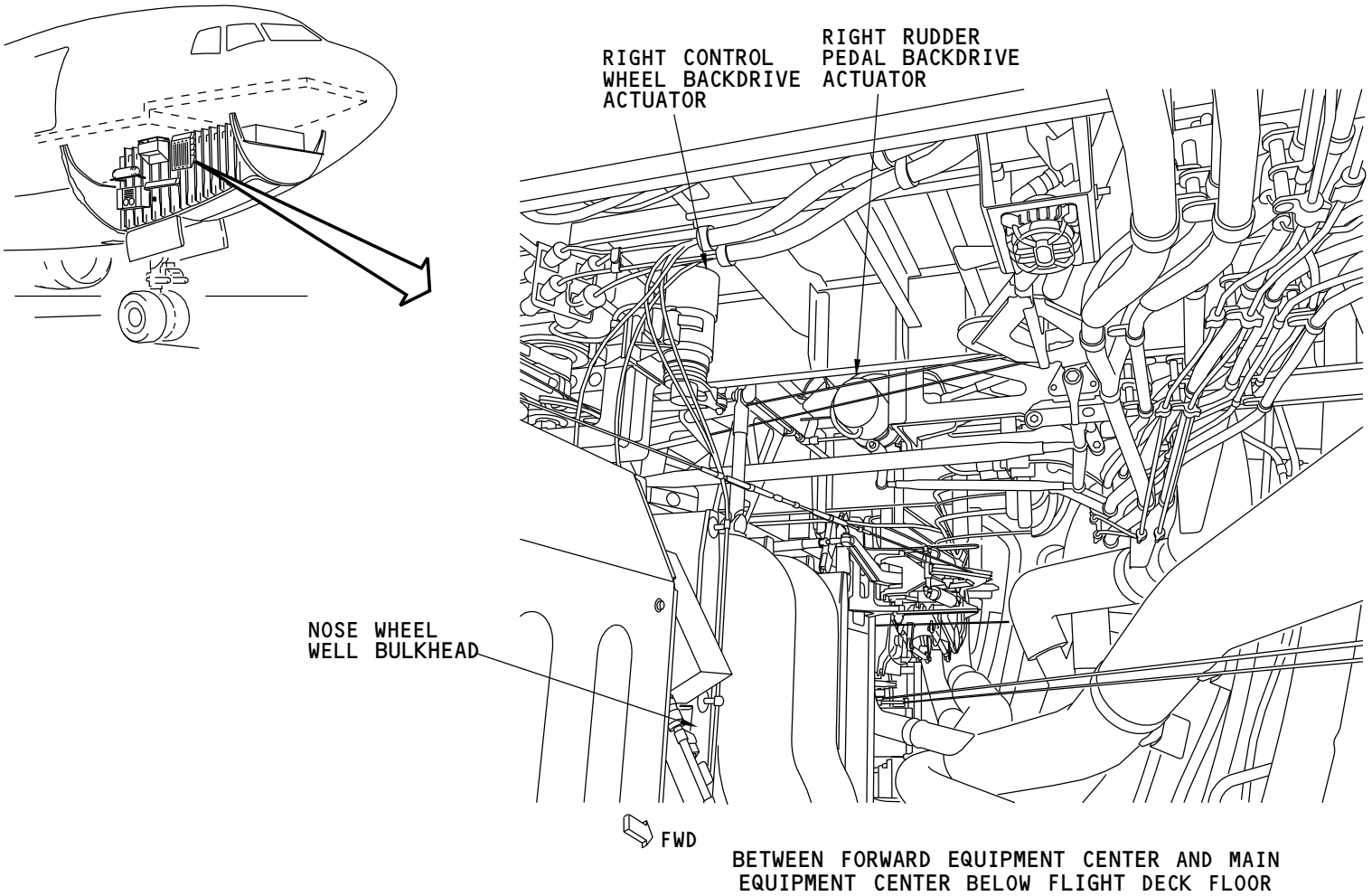

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AFDS - BACKDRIVE ACTUATOR INSTALLATION - 4

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AFDS - BACKDRIVE ACTUATOR - FUNCTIONAL DESCRIPTION

General

Each backdrive actuator contains:

- Two tachometers
- A DC motor
- An engage clutch
- An override slip clutch.

Tachometers

The two tachometers supply motor rate feedback to the AFDC processors. Tachometer A feedback goes to processor A. Tachometer B feedback goes to processor B.

DC Motor

The AFDC supplies a variable dc current to the motor. The current to the motor limits the motor torque.

Engage Clutch

The AFDC supplies 28v dc to operate the engage clutch. The clutch connects the output crank to the motor and gear train. With the clutch not engaged, the output crank is free to move with the flight controls.

Override Slip Clutch

The override slip clutch lets the pilot override the backdrive actuator if it jams.

Actuator Authority

The AFDC controls the motor current to each backdrive actuator. This limits the force that a backdrive actuator applies to the control columns, control wheels, and rudder pedals. This force is sufficient for the actuator to overcome the feel and friction forces in the control system. The force is limited so that the pilot can override the backdrive, feel, and centering forces. The autopilot disengages if the pilot overrides the backdrive, feel, and centering forces.

The AFDS engages one control column and one control wheel backdrive actuator in cruise. The override forces necessary to make the autopilot disengage are approximately:

- 50 pounds for the control column
- 27 pounds for the control wheel.

The override forces that show are the sum of the backdrive force and the feel and centering forces from the flight controls system.

The AFDS engages all six backdrive actuators in autoland. The backdrive forces for this condition are approximately two times the force for a single actuator. The override forces are approximately:

- 81 pounds for the control column
- 49 pounds for the control wheel
- 186 pounds for the rudder pedals.

If one control column actuator fails during autoland, the force limit of the remaining column actuator is two times as high. This makes sure there is enough force to prevent accidental column movement by the pilot during autoland.

If a control wheel or rudder pedal actuator fails during autoland, the force limit of the remaining actuator does not increase.

The force to cause the override slip clutch to slip is always more than the backdrive actuator motor torque.

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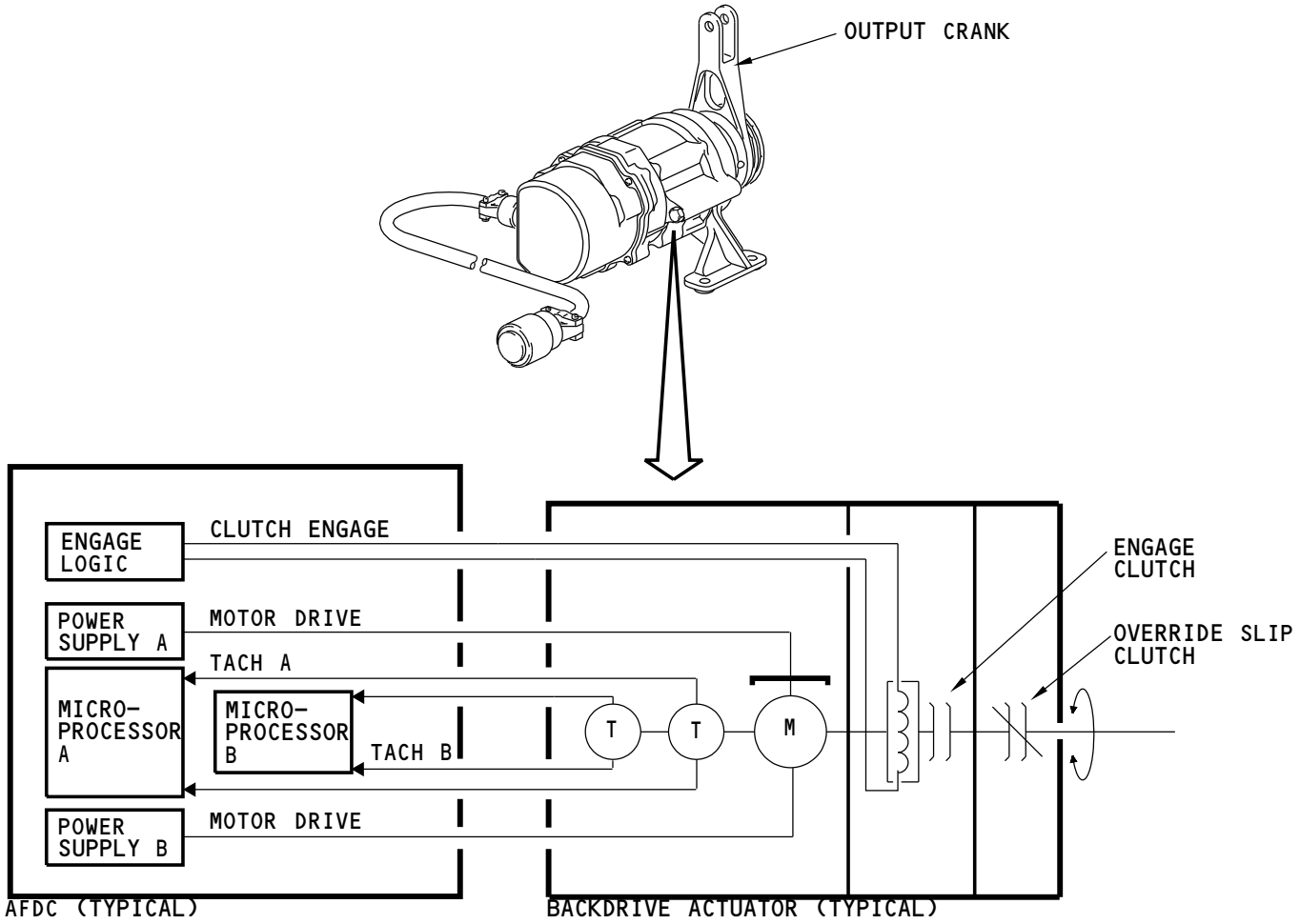

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AFDS - BACKDRIVE ACTUATOR - FUNCTIONAL DESCRIPTION

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AFDS - OPERATION - OVERVIEW

General

The autopilot flight director system (AFDS) operates on the ground and in flight.

The AFDS calculates commands for these flight sequences:

- Takeoff
- Climb
- Cruise
- Descent
- Approach
- Autoland
- Rollout
- Go-around.

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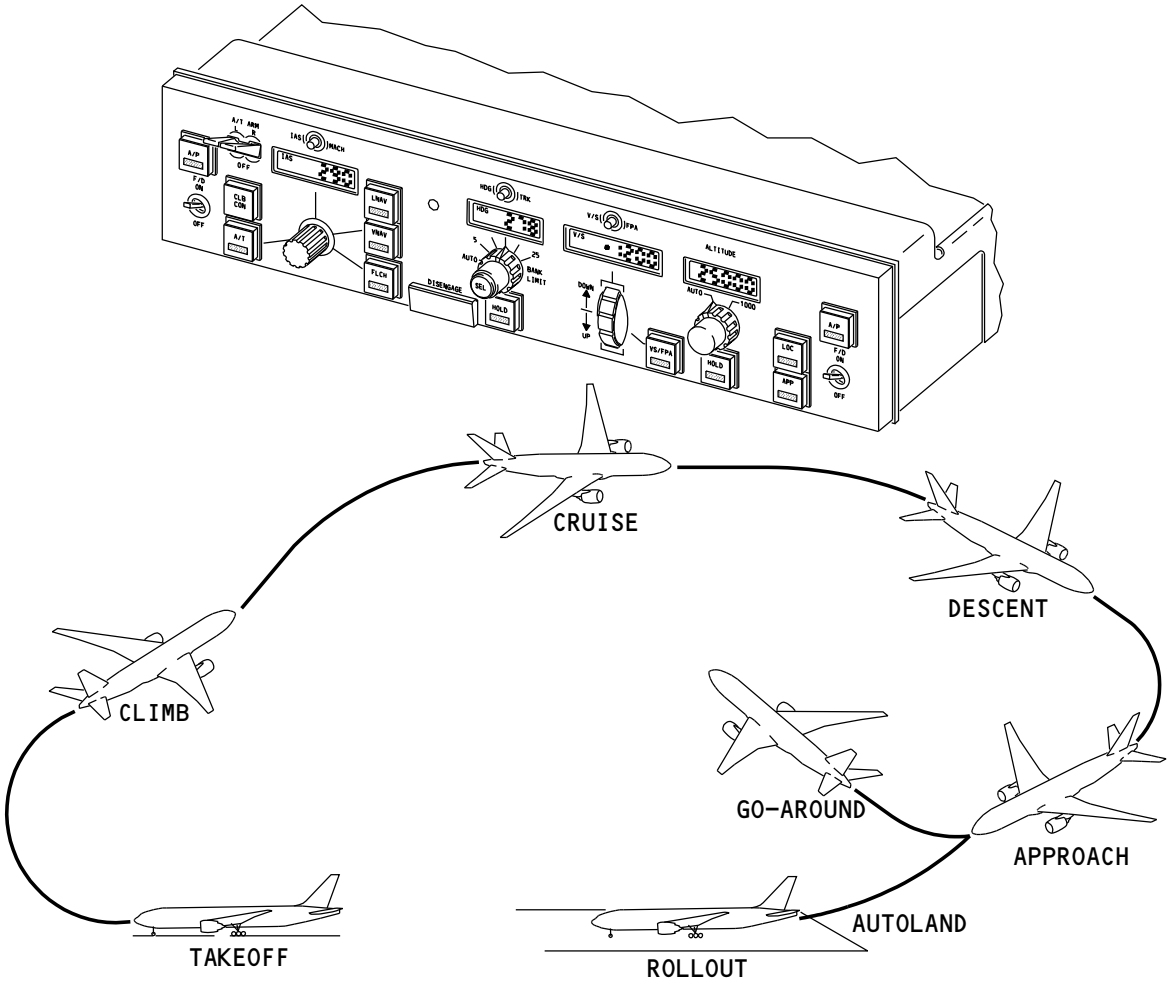

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AFDS - OPERATION - OVERVIEW

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AFDS - OPERATION - TAKEOFF

General

The F/D display supplies the pilot with roll and pitch commands during takeoff. After the airplane is off the ground, the pilot can stay in the F/D takeoff mode, or when the airplane is above 50 feet radio altitude, the pilot can engage the autopilot to the takeoff mode.

Both F/D switches must be set to the OFF position to remove the takeoff mode.

The takeoff mode has this sequence:

- Before takeoff
- Takeoff start
- Lift-off/in air
- Climbout.

Before Takeoff

All of these conditions must be true to put the F/D in the takeoff mode (TO/GA):

- The captain and/or the first officer F/D switches are in the ON position
- The autopilot is not engaged
- The airplane is on the ground.

The PFD shows:

- FLT DIR as the AFDS status
- TO/GA as the pitch and roll mode
- The F/D pitch bar shows eight degrees
- The F/D roll bar shows wings level.

The pilot sets an engine-out climb speed (V2) and a clearance altitude on the MCP. The autothrottle (A/T) arm switches are on.

Takeoff Start

The pilot pushes a TO/GA switch on the thrust levers. The autothrottle engages in the takeoff thrust mode and the throttles move forward until the engines reach takeoff thrust. THR REF shows on the PFDs as the active autothrottle mode.

In takeoff, the flight director shows on the PFDs automatically even if the flight director switches are in the OFF position. This is called AUTO POP UP. It occurs when all these conditions are true:

- A flight director switch is in the OFF position
- The pilot pushes a TO/GA switch
- The trailing edge flaps are not up.
- The airspeed is greater than 80 knots.

The TMCF removes power from the autothrottle servo motors at 80 knots. Throttle hold (HOLD) shows on the PFDs.

Lift-Off/In Air

For a normal lift-off, the pitch command holds:

- Target airspeed
- Combination of airspeed and pitch attitude
- Pitch attitude.

If the climb rate is less than 600 feet per minute, the pitch command is to hold attitude. For a climb rate between 600 feet per minute and 1200 feet per minute, the pitch command holds a mix of airspeed and attitude. For a climb rate more than 1200 feet per minute, the pitch command holds a target airspeed.

If an engine fails during takeoff, the pitch axis command is a mix of airspeed and attitude for a climb rate less than 1200 feet per minute. For a climb rate more than 1200 feet per minute, the pitch axis holds a target airspeed.

The target airspeed for a normal takeoff is the larger of these two:

- V2 plus 15 knots

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- The airspeed at lift-off plus 15 knots.

If the airspeed is more than the target for five seconds, the target airspeed becomes the smaller of the current airspeed or V2 plus 25 knots.

This mix of speed and attitude commands gives wind shear protection during takeoff and go-around. The F/D pitch command also keeps the airplane in these limits:

- Flap placard speeds
- Maximum operating velocity and Mach (VMO/MMO)
- Minimum speed.

At five feet radio altitude, the roll command changes to track hold.

The autothrottle stays in HOLD.

FLT DIR remains the active AFDS status until the pilot engages the autopilot.

The pitch and roll modes remain in TO/GA until the pilot selects another pitch or roll mode.

Climb Out

The roll command continues to hold track. The pitch command continues to hold speed, attitude, or a mix of speed and attitude.

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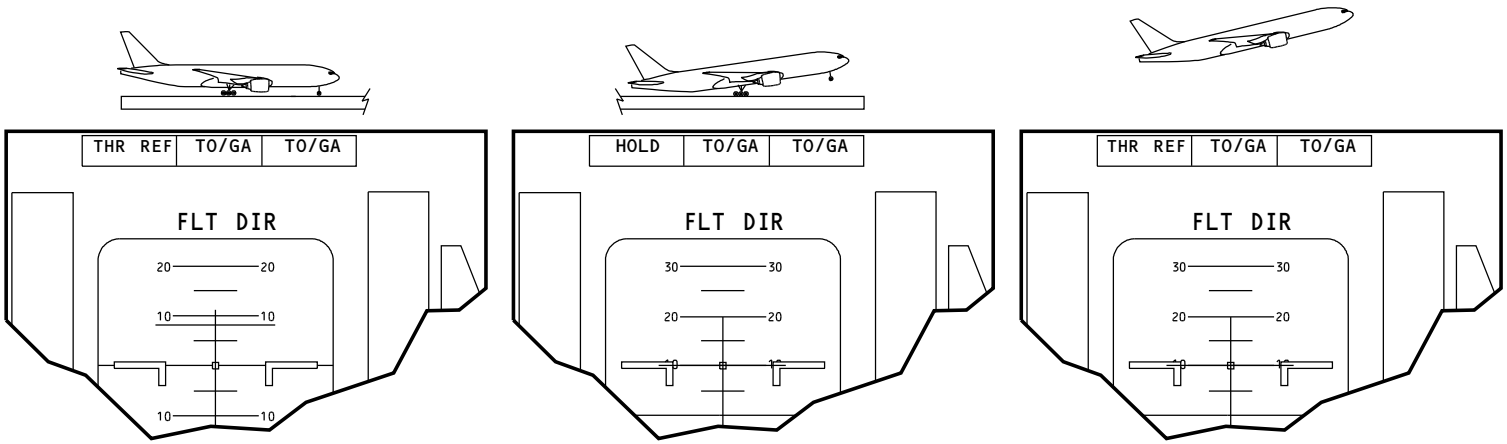

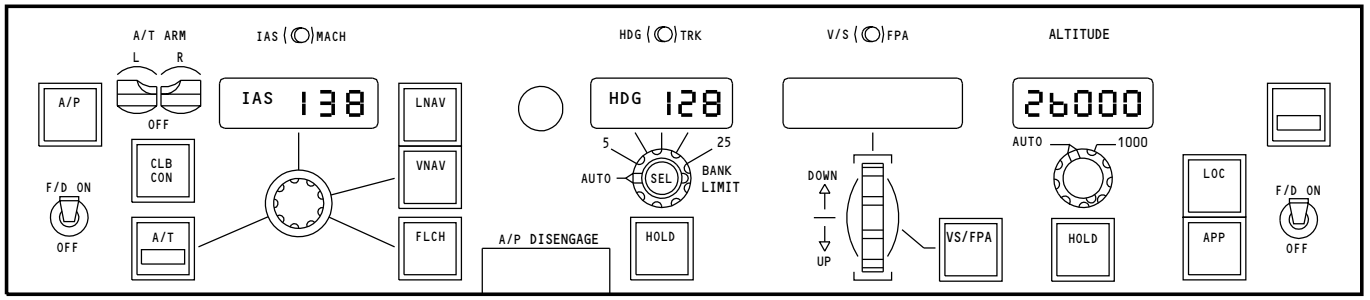

MCP

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AFDS - OPERATION - TAKEOFF

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AFDS - OPERATION - AUTOPILOT ENGAGE

General

Autopilot engagement occurs when the pilot pushes an autopilot (A/P) switch on the MCP. At that time, this happens:

- All available AFDCs and one control wheel and one column backdrive actuator engage
- A/P status shows on the PFDs.

F/D status (on or off) sets the roll and pitch mode selection.

Engage Autopilot With Flight Director On

The AFDS roll and pitch modes stay the same except in these conditions:

- With the LOC mode active, LOC changes to arm and localizer must capture again. The active roll mode is HDG or TRK hold until LOC is captured
- With the G/S mode active, G/S changes to arm and glideslope must capture again. The active pitch mode is V/S or FPA until G/S is captured.

The autopilot will engage in the takeoff mode when all these conditions are true:

- The airplane is on the ground
- A flight director is on
- The mode selected is TO/GA.
- The flaps are retracted.

Engage Autopilot With Flight Director Off

The active pitch mode is vertical speed or flight path angle.

The active roll mode is heading or track hold. If the airplane is in a bank, the autopilot commands wings level. When the airplane bank is at three degrees, the airplane holds the heading or track that is present.

The PFDs show the applicable pitch and roll modes and A/P status. The applicable mode select switch LED on the MCP is also on.

Autopilot Engage Inhibit

The AFDCs have an inhibit that prevents the engagement of the autopilot during the takeoff roll and immediately after it. You cannot engage the autopilot when all these conditions are true:

- The ground speed is more than 80 knots
- The radio altitude is less 50 feet.

This engage inhibit function does not operate if the airplane takes off with the autopilot already engaged.

Training Information Point

The airplane is not certified for takeoff with the autopilot engaged.

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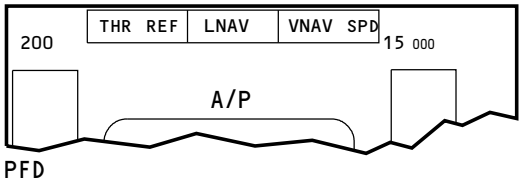
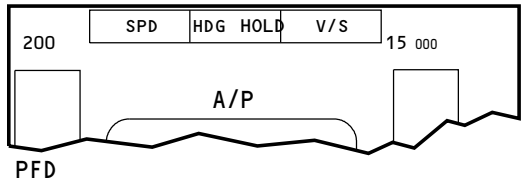


F/D ON

A/P MODE IS SAME AS
F/D MODE OR:

- HDG HOLD (OR TRK HOLD)
  IF F/D IN LOC
- V/S (OR FPA)
  IF F/D IN G/S



F/D OFF

A/P MODE IS HDG HOLD
(OR TRK HOLD) AND V/S
(OR FPA):

- A/P COMMAND IS WINGS
  LEVEL IF AIRPLANE
  IS IN A BANK
- AIRPLANE HOLDS HEADING (OR TRACK)
  WHEN THE BANK IS AT 3 DEGREES
  OR LESS

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AFDS - OPERATION - AUTOPILOT ENGAGE

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AFDS - OPERATION - ROLL INTRODUCTION

General

These AFDS roll modes are available during climb, cruise and descent:

- Lateral navigation (LNAV)
- Heading hold (HDG HOLD)
- Track hold (TRK HOLD)
- Heading select (HDG SEL)
- Track select (TRK SEL).

LNAV

The commands come from the active FMCF when there is a valid navigation data base and an active flight plan. The CDUs can send LNAV steering commands when there is no active FMCF. The AFDS use this priority to select a CDU command:

- Left, if valid
- Center, if left not valid
- Right, if left and center are not valid.

Heading/Track Hold

In this mode, the airplane holds either heading (HDG) or track (TRK).

If the HDG/TRK display on the MCP shows TRK, the airplane holds track.

If the HDG/TRK display on the MCP shows HDG, the airplane holds heading.

Heading/Track Select

In this mode, the airplane turns to the heading or track that shows in the heading/track window.

If the HDG/TRK display shows HDG, the airplane goes to and holds the heading that shows in the heading/track window.

If the HDG/TRK display shows TRK, the airplane goes to and holds the track that shows in the heading/track window.

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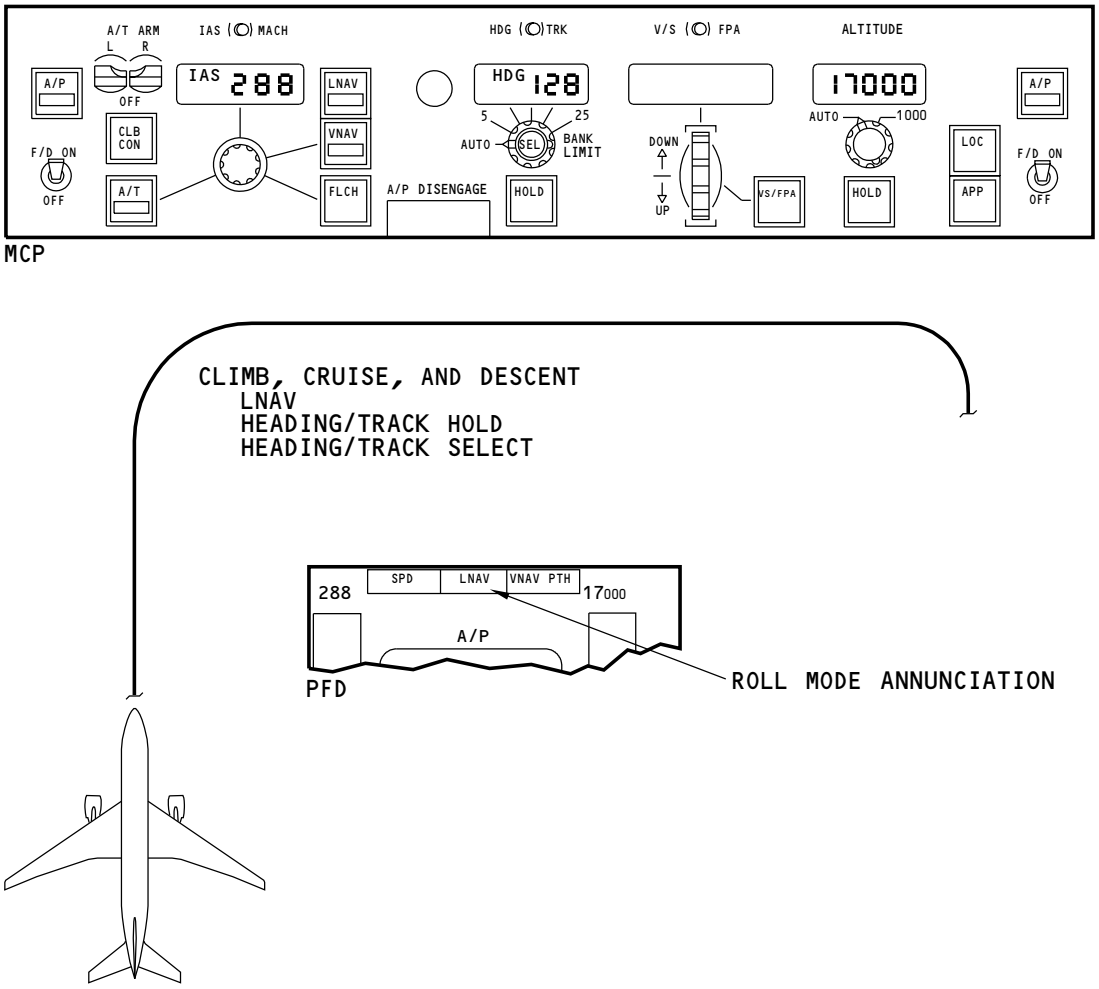

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AFDS - OPERATION - ROLL INTRODUCTION

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AFDS - OPERATION - LNAV

General

LNAV has these two sub-modes:

- LNAV arm
- LNAV active.

LNAV can also be engaged during the Takeoff Go-Around (TOGA).

- The Autopilot Flight Director System (AFDS) automatically engages the Lateral Navigation (LNAV) during the Takeoff Go-Around (TOGA) mode for a manual or coupled approach.

LNAV Arm

Push the LNAV switch on the MCP to arm LNAV. To remove the LNAV arm status, push the LNAV switch again before LNAV captures or select another roll mode.

The PFD shows LNAV in white. The LNAV light is on.

You can arm LNAV before takeoff. Also, you can arm LNAV in flight if the LOC mode is not active.

The AFDS Roll Mode will automatically engage in LNAV when the radio altitude is:

- Greater than 50 feet if the autopilot is not engaged (manual approach).
- More than 200 feet when the autopilot is engaged in a coupled approach mode (ILS, LOC, LNAV/VNAV).

The AFDS Roll Mode will automatically engage in LNAV when:

- One or both of the Flight Director switch on the Mode Control Panel (MCP) is in the 'ON' position.

The automatic engages of LNAV on the TOGA selection is inhibited when Flight Management System Visual Flight Rules is in approaches.

LNAV Active

When active, LNAV on the PFD changes to green. This occurs when all these are true:

- The lateral flight plan is active
- The airplane is greater than 50 feet above the ground
- Data to calculate the lateral guidance command is valid
- Aircraft position is satisfactory for capture.

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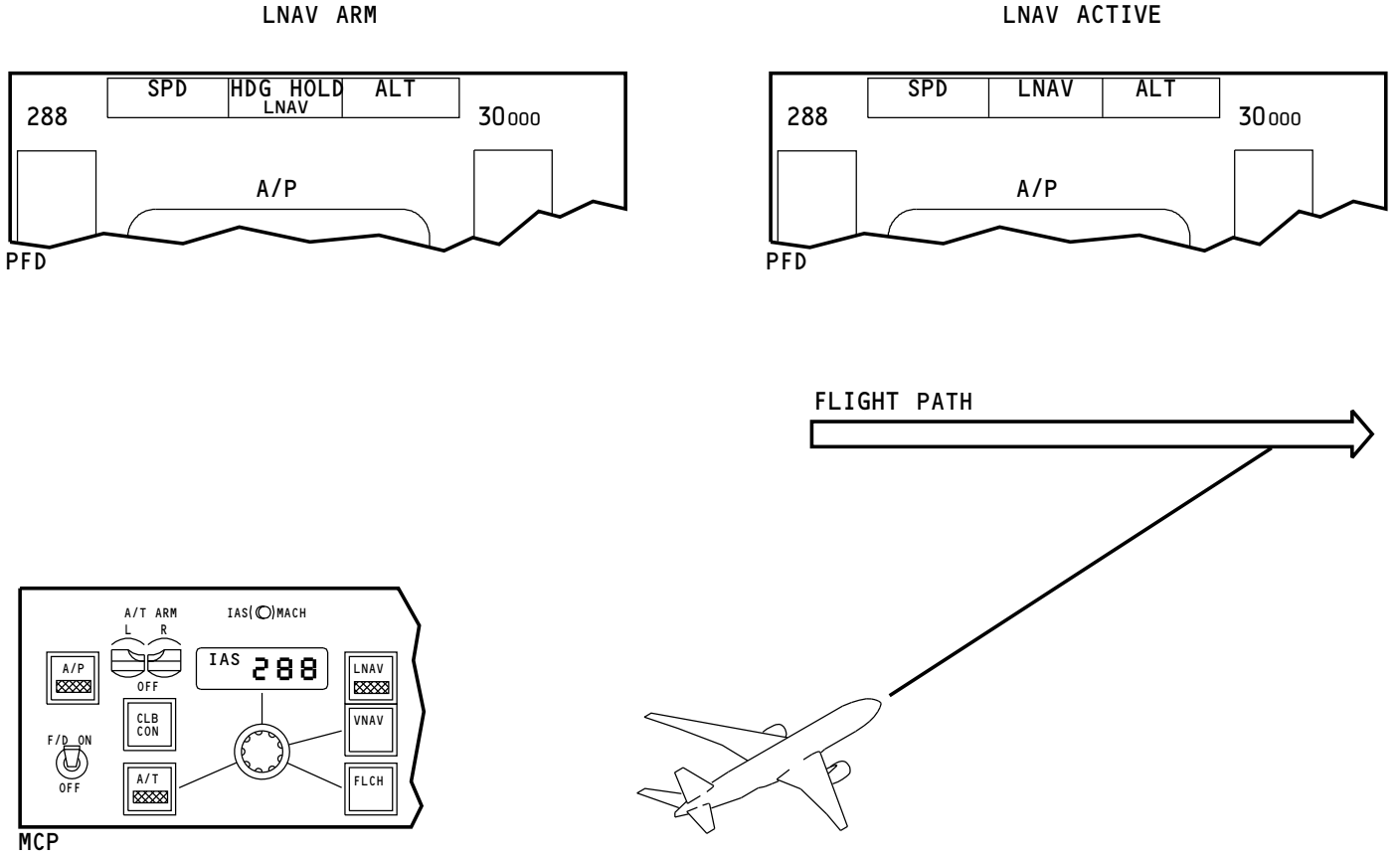

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AFDS - OPERATION - LNAV

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AFDS - OPERATION - HEADING/TRACK SELECT

General

The pilot uses the HDG/TRK select mode to change the airplane heading.

The select switch (SEL) on the MCP does not have a LED in the switch.

This example shows operation with HDG selected on the heading/track display. Operation with TRK selected is the same except for the display on the PFDs.

There are two ways to use the mode:

- Set heading before the mode is selected
- Select the mode before the heading is set.

Set Heading Before Mode

First, set a heading in the heading/track display. Then push the heading select switch. These things happen:

- HDG SEL shows on the PFD
- The airplane turns in the direction for minimum heading change
- The airplane captures and holds the heading set on the MCP.

Select Mode Before Heading

First, push the heading select switch. Then set a heading in the heading/track display. These things happen:

- HDG SEL shows on the PFD
- When the pilot turns the heading knob clockwise, the airplane banks to the right
- When the pilot turns the heading knob counterclockwise, the airplane banks to the left
- The airplane captures and holds the heading set on the MCP.

Heading/Track Select Bank Angle Limit

The pilot uses the bank limit selector on the MCP to limit the airplane bank angle. In the AUTO position, the bank angle limit changes with true airspeed.

Below 200 feet, the bank angle limit is eight degrees.

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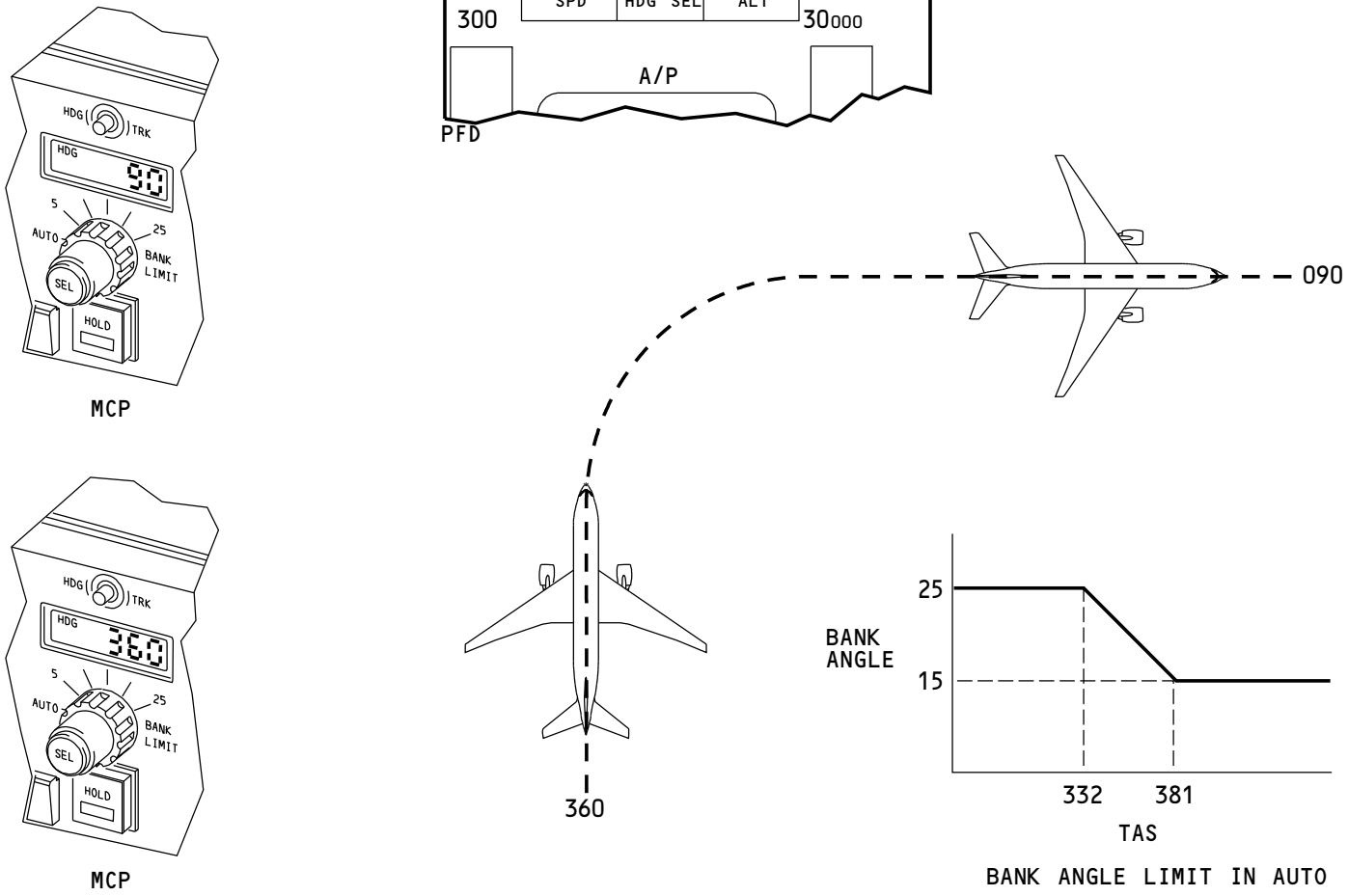

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AFDS - OPERATION - HEADING/TRACK SELECT

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AFDS - OPERATION - HEADING/TRACK HOLD

General

In this mode, the airplane holds a heading or a track angle. The pilot can set a heading or a track in the MCP displays before the mode is set.

This example shows operation with HDG selected. Operation with TRK selected is the same, except for the display on the PFDs and MCP.

Airplane In a Bank

When the pilot pushes the heading/track hold switch:

- The heading/track hold light on the MCP comes on
- The airplane rolls wings level
- HDG HOLD is shown on the PFDs
- The airplane holds the heading present when the bank angle is less than three degrees for two seconds.

Airplane Wings Level

When the pilot pushes the heading/track hold switch:

- The heading/track hold light on the MCP comes on
- HDG HOLD shows on the PFDs
- The airplane holds the present heading.

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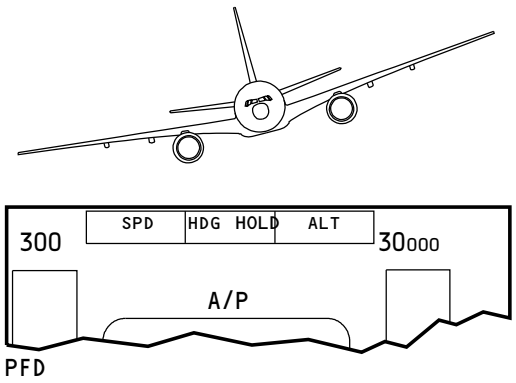
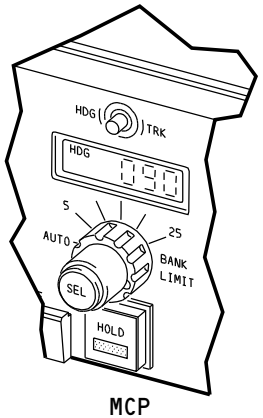
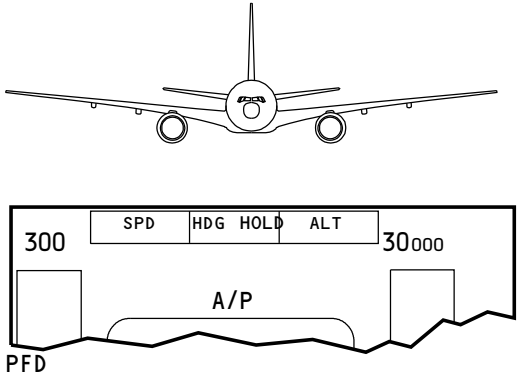


HEADING HOLD SELECTED WITH AIRPLANE IN BANK

- HEADING/TRACK HOLD LIGHT ON
- AIRPLANE ROLLS TO WINGS LEVEL
- PFD SHOWS HDG HOLD
- AIRPLANE HOLDS HEADING WHEN ROLL ATTITUDE LESS THAN 3 DEGREES FOR 2 SECONDS



MCP



HEADING HOLD SELECTED WITH WINGS LEVEL

- HEADING/TRACK HOLD LIGHT ON
- PFD SHOWS HDG HOLD
- AIRPLANE HOLDS HEADING

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AFDS - OPERATION - HEADING/TRACK HOLD

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AFDS - OPERATION - PITCH INTRODUCTION

General

These AFDS pitch modes are available during climb, cruise and descent:

- Vertical navigation (VNAV)
- Vertical speed (V/S)
- Flight path angle (FPA)
- Flight level change (FLCH)
- Altitude hold (ALT).

VNAV

The VNAV mode is a mix of throttle and elevator commands that control the vertical flight path.

The FMCF vertical steering commands come from the active FMCF based on the navigation data and the active flight plan.

Vertical Speed/Flight Path Angle

The vertical speed or flight path angle command is an elevator command. The pilot uses this mode to change flight levels. The pilot must set the engine thrust necessary to hold the vertical speed or flight path angle command.

When the V/S/FPA display shows V/S, the airplane goes to and holds the vertical speed that shows on the vertical speed/flight path angle window.

When the VS/FPA display shows FPA, the airplane goes to and holds the flight path angle that shows on the vertical speed/flight path angle window.

FLCH

The FLCH command is a mix of thrust and elevator commands to change flight levels.

When the IAS/mach display shows IAS, the elevator command holds the speed that shows on the IAS/mach window.

When the IAS/mach display shows MACH, the elevator command holds the mach that shows on the IAS/mach window.

The TMCF supplies the engine thrust commands.

Altitude Hold

In this mode, the airplane holds the barometric altitude present when the pilot pushes the altitude HOLD switch.

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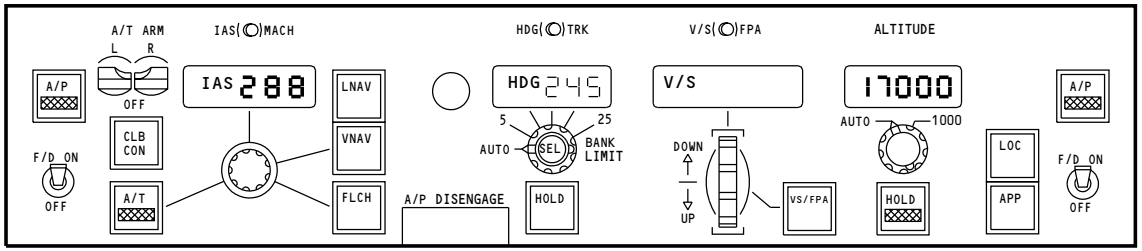
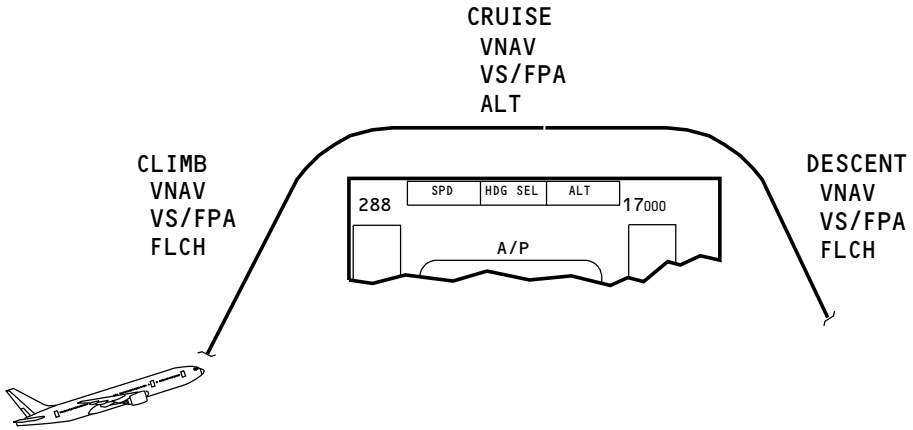


MCP



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AFDS - OPERATION - PITCH INTRODUCTION

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AFDS - OPERATION - VNAV

General

Push the VNAV mode select switch to arm VNAV. The PFD shows VNAV in white and the switch LED is on. Push the switch again to remove the arm status.

VNAV can arm before takeoff. Also VNAV can arm in flight with the glideslope mode not active.

When active, VNAV on the PFD changes to green. This occurs when all these conditions are true:

- VNAV flight plan is active
- The airplane is greater than 400 feet above the ground
- Data required to calculate the vertical guidance command is valid.

VNAV active has these three sub-modes:

- VNAV SPD (speed)
- VNAV PTH (path)
- VNAV ALT (altitude).

VNAV SPD

The VNAV SPD mode controls the elevator to hold the FMCF target speed. The mode is active in:

- Climb
- Cruise or descent when the airplane exceeds an FMCF target speed by 5 knots.

VNAV PTH

In climb, VNAV SPD changes to VNAV PTH to capture the FMCF target altitude. In the VNAV PTH mode, the airplane holds the FMCF altitude.

Before descent, the pilot sets an approach altitude on the MCP. At the top of descent, the throttle retards and the autothrottle mode is IDLE. The pitch mode stays in VNAV PTH and the airplane descends. The FMC top of descent point determines descent angle and airspeed during descent.

The VNAV PTH mode continues in descent until the airplane is near the approach altitude. The autothrottle mode returns to SPD. VNAV PTH stays active and holds the approach altitude.

VNAV ALT

The VNAV ALT (altitude) mode occurs when one of these conditions is true:

- When in VNAV SPD and the airplane captures the MCP selected altitude before the FMCF target altitude
- When in VNAV PTH (descent) and the airplane captures the MCP altitude before the FMCF altitude.

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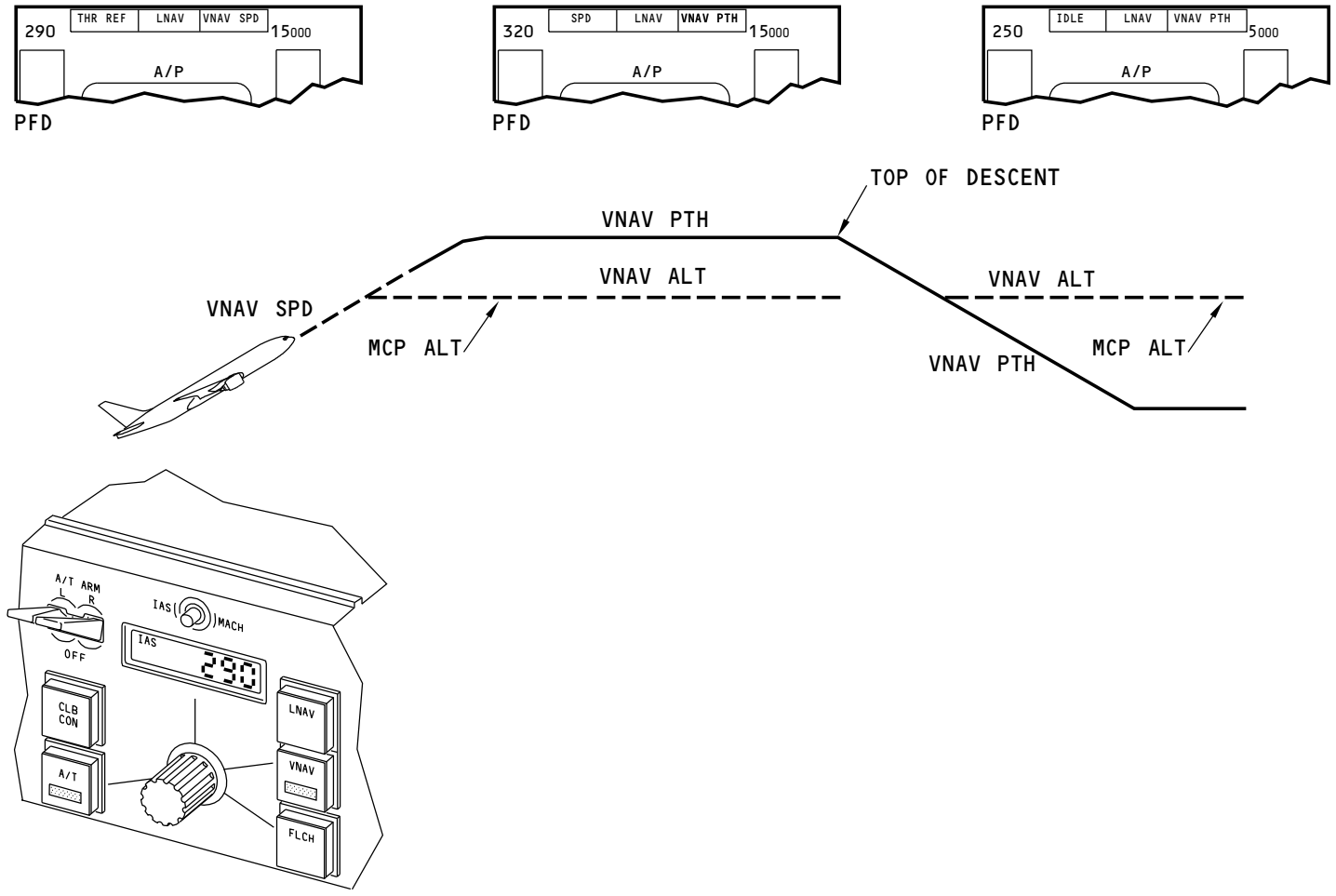

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AFDS - OPERATION - VNAV

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AFDS - OPERATION - VERTICAL SPEED/FLIGHT PATH ANGLE

General

The pilot uses the VS/FPA mode to climb or descend to the altitude set in the MCP.

This example shows FPA operation. VS mode operation is the same except for the display on the PFDs.

Climb

These occur when the pilot sets a positive FPA on the MCP and pushes the VS/FPA mode select switch:

- FPA shows on the PFD
- The switch LED is on
- The airplane holds the selected FPA.

Descend

These occur when the pilot sets a negative FPA on the MCP and pushes the VS/FPA mode select switch:

- FPA shows on the PFD
- The switch LED is on
- The airplane holds the selected FPA.

The AFDS mode changes from FPA to altitude hold (ALT) when the airplane reaches the altitude set on the MCP.

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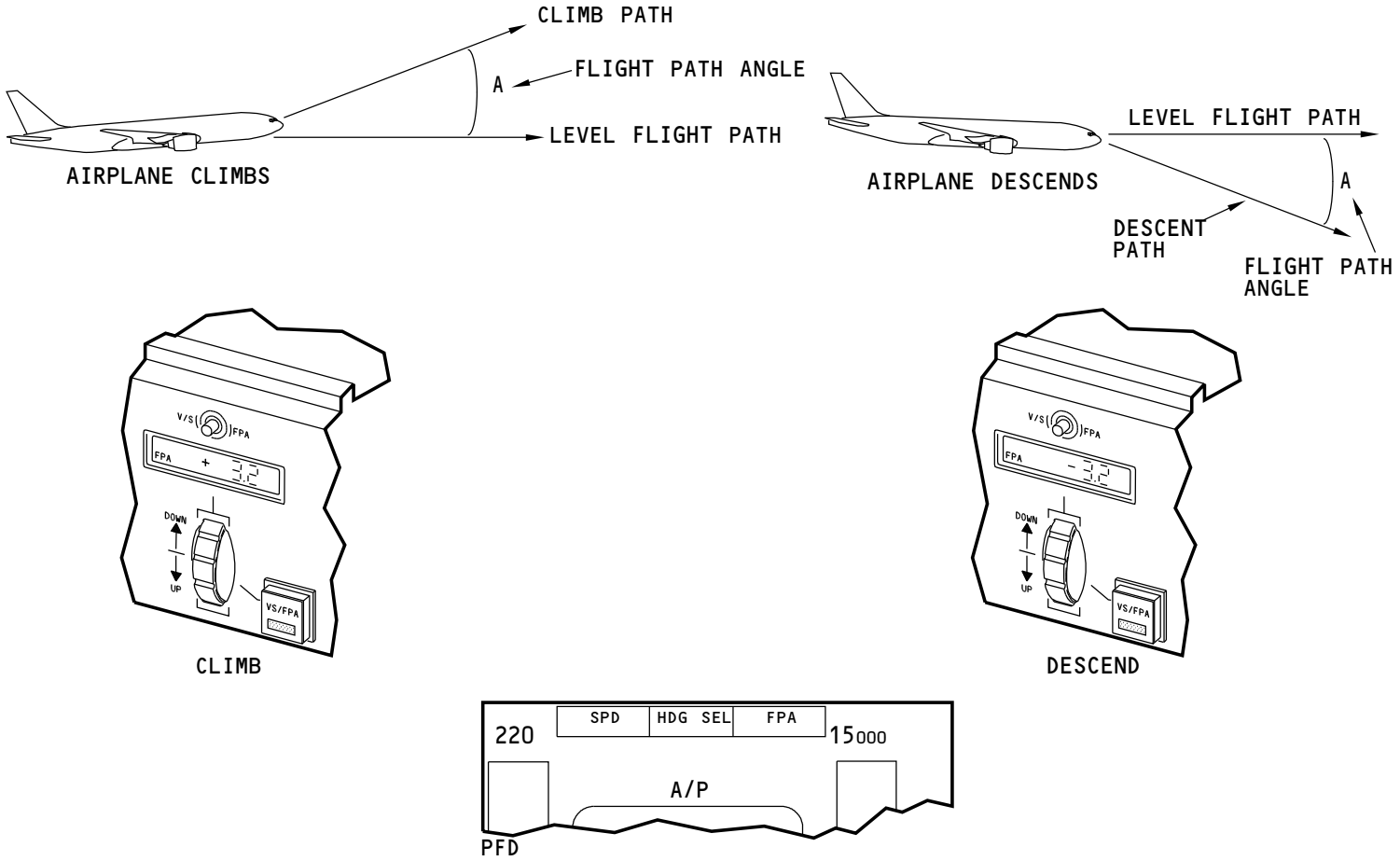

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AFDS - OPERATION - VERTICAL SPEED/FLIGHT PATH ANGLE

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AFDS - OPERATION - ALTITUDE HOLD

General

Altitude hold is active in any of these conditions:

- Push the altitude hold switch on the MCP
- Select a vertical speed (V/S) of 0000 feet per minute (FPM) in the V/S mode
- Capture and hold the altitude set on the MCP.

Altitude Hold Switch

These occur when the pilot pushes the altitude hold switch on the MCP:

- The AFDS holds the present barometric altitude
- The altitude hold light is on
- The pitch flight mode annunciator on PFD shows ALT.

Set V/S To 0000 FPM

These occur when the pilot sets a vertical speed of 0000 FPM:

- The airplane levels and holds the present barometric altitude
- The V/S mode remains active
- The pitch flight mode annunciator on PFD shows V/S.

Capture Altitude

Altitude capture starts as the airplane approaches the MCP selected altitude:

- The pitch flight mode annunciator on PFD shows ALT in green
- The airplane holds the altitude set on the MCP.

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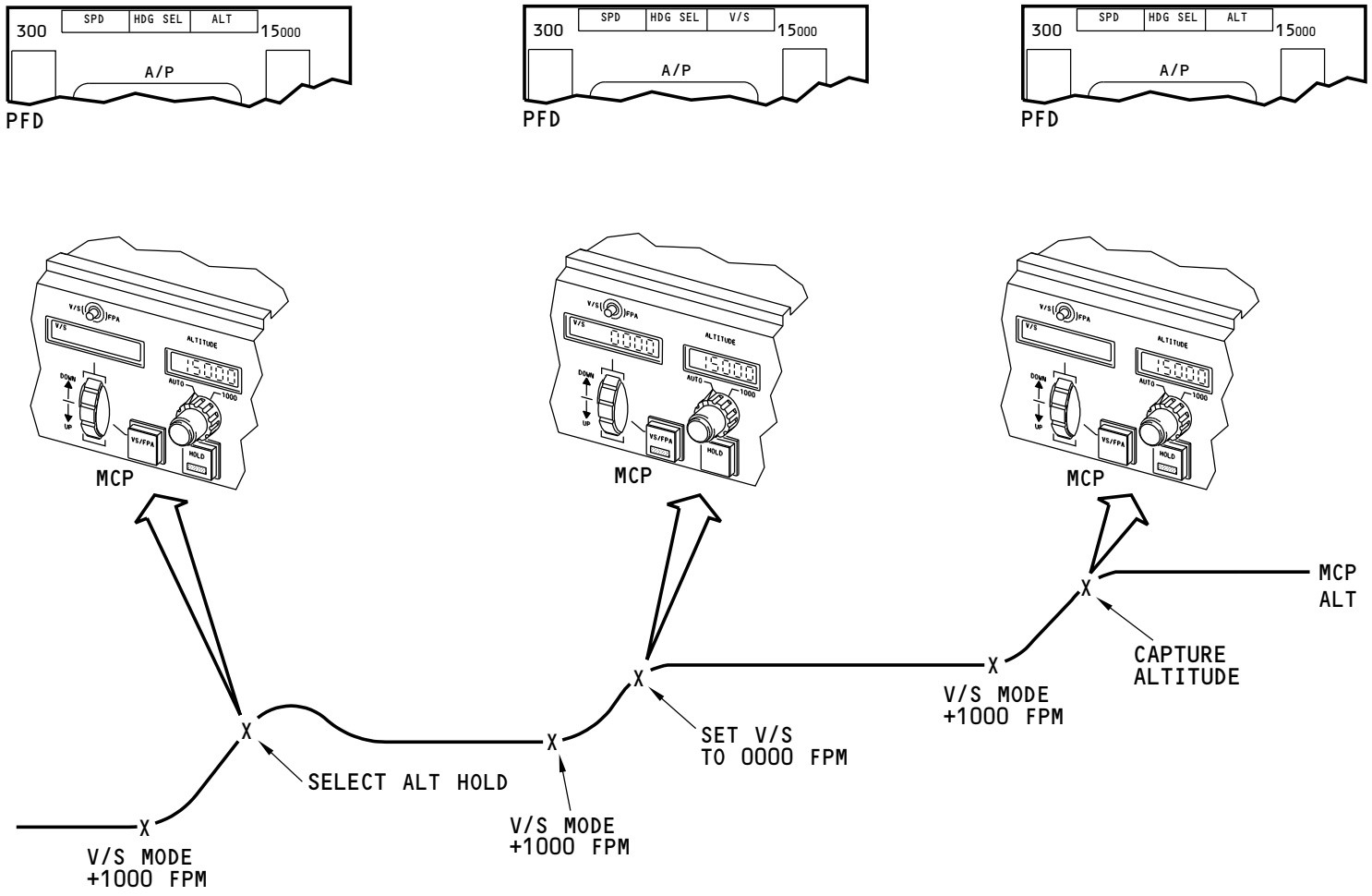

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AFDS - OPERATION - ALTITUDE HOLD

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General

The FLCH mode permits the pilot to change flight levels with the AFDS and the TMCF. The autothrottle controls thrust. The AFDS controls airspeed with the elevator.

FLCH Selection

The pilot must set a target altitude on the MCP before the FLCH mode can be set.

With the FLCH mode active, the flight level change light is on. FLCH SPD is the pitch mode and THR is the autothrottle mode on the PFDs.

If the pilot pushes the FLCH switch with VNAV as the active mode, the MCP IAS/mach window shows the FMCF target speed. The AFDS controls to this speed until the pilot sets a new speed in the window.

When TO/GA is the active pitch mode and the pilot pushes the FLCH switch, the IAS/mach window shows the higher of these:

- Present airspeed
- Speed set in the MCP.

If you push the FLCH switch when the IAS/mach window shows a speed or mach number and the active pitch mode is not TO/GA, the MCP IAS/mach window does not change.

In all cases, the AFDS controls to the speed on the MCP IAS/mach window until the pilot sets a new speed in the window.

The airplane speed stays within these limits:

- Flap placard speeds
- Maximum operating velocity and Mach (VMO/MMO)
- Minimum speed.

Altitude Capture

When the airplane is at the altitude set on the MCP, the AFDS pitch mode changes to ALT. The autothrottle mode changes to SPD.

If there is not enough engine thrust to capture the altitude and hold airspeed, the AFDS stays in the speed mode and does not go to the ALT mode.

A/T Modes

These A/T modes can show during FLCH:

- THR
- HOLD
- IDLE.

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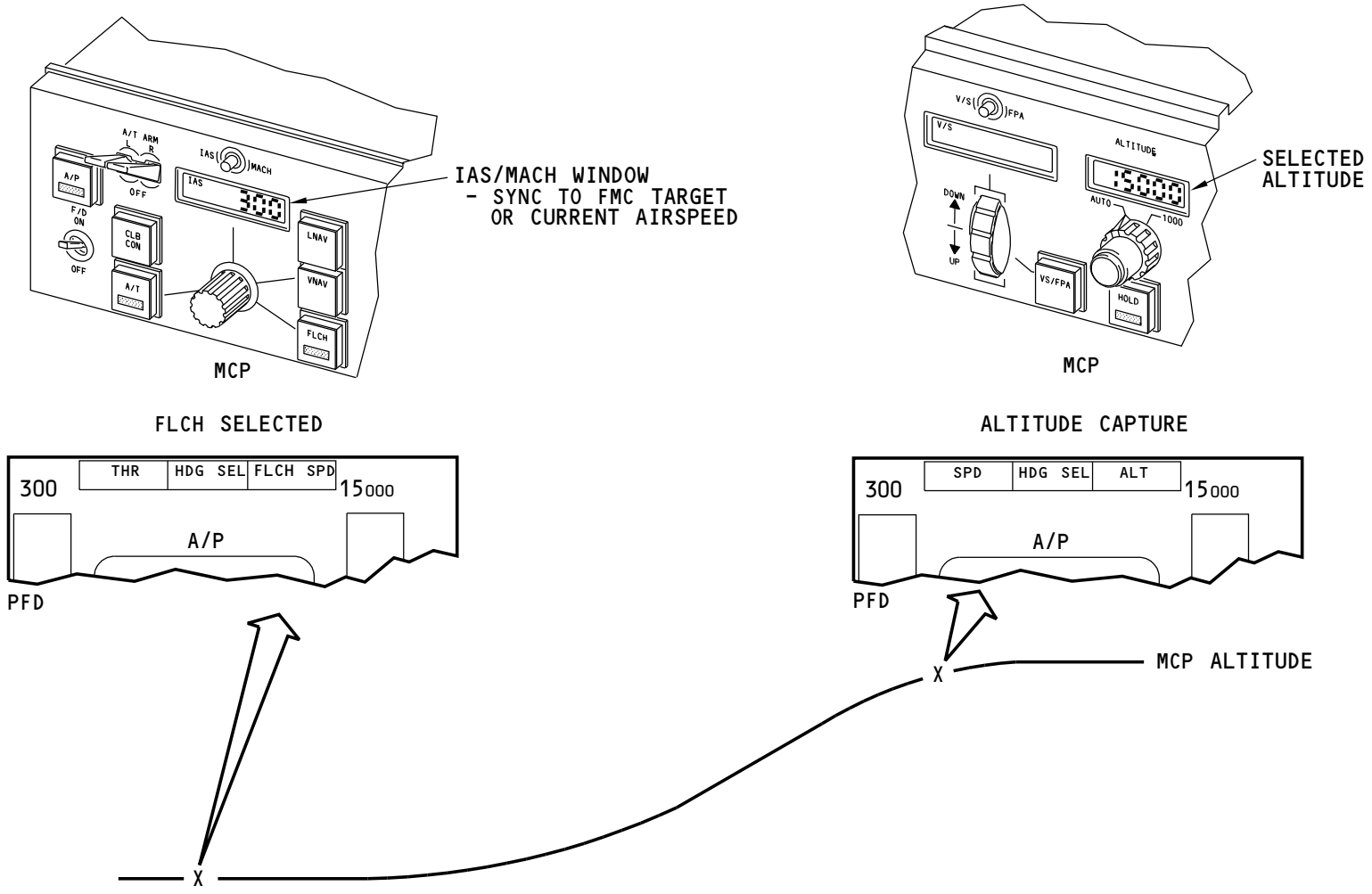

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AFDS - OPERATION - FLIGHT LEVEL CHANGE

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AFDS - OPERATION - APPROACH/AUTOLAND INTRODUCTION

General

These AFDS functions are available for landing:

- Localizer (LOC)
- Glideslope (G/S)
- Flare (FLARE)
- Runway Alignment
- Rollout (ROLLOUT)
- Go-Around (TO/GA).

The flight crew pushes the APP switch on the MCP to arm the LOC and G/S modes.

Localizer

The LOC mode captures and holds the airplane to a localizer flight path.

Glideslope

The G/S mode captures and holds the airplane to a vertical descent flight path.

Flare

The flare mode controls the airplane to a smooth touchdown at a point past the glideslope antenna. This is a computed command and is not part of the glideslope mode.

Runway Alignment

In crosswind conditions, the runway alignment mode supplies roll and yaw control to decrease the airplane crab angle for touchdown. The runway alignment mode also includes roll and yaw control for an engine failure in approach during autoland.

There is no annunciation on the PFD for this mode.

Rollout

After touchdown, the rollout mode controls the airplane to the runway center line. Airplane deviation from the localizer center line supplies rudder and nose wheel steering signals.

Go-Around

The go-around mode controls roll and pitch after an aborted approach. Also, the TMCF controls thrust during go-around.

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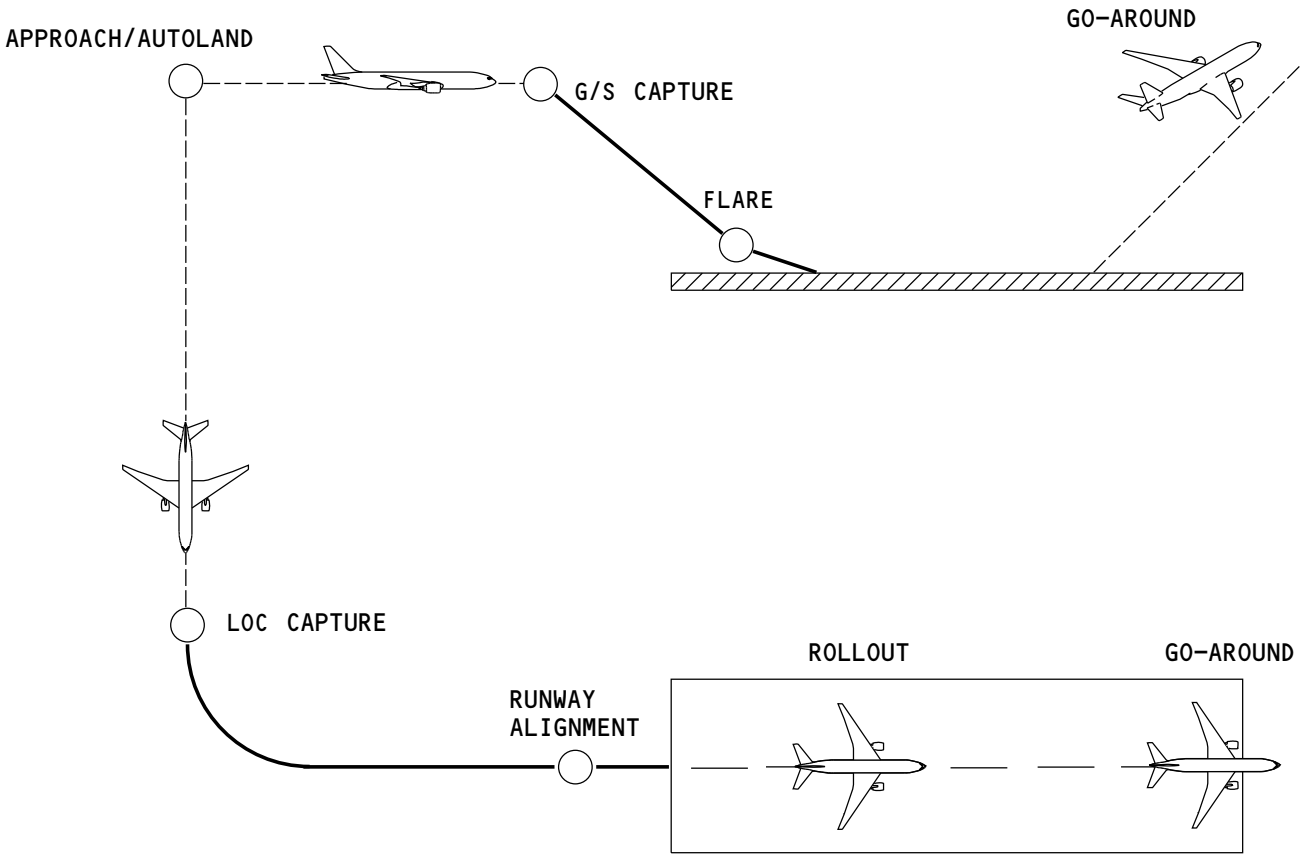

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AFDS - OPERATION - APPROACH/AUTOLAND INTRODUCTION

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AFDS - OPERATION - LOCALIZER

General

The flight crew uses the localizer switch on the MCP, to select a localizer only approach.

The flight crew uses the localizer only approach when glideslope is not available or uses a different vertical path for descent.

An ILS frequency and course must be set into the FMCF.

The flight crew can use another roll mode to fly the airplane to the localizer. In this example, the flight crew uses the heading select mode.

The LOC mode has these two sub-modes:

- Localizer arm
- Localizer active.

Localizer Arm

The LOC switch on the MCP arms only the localizer mode. The PFD shows LOC in white. The LOC switch light comes on.

To remove the arm status, push the LOC switch again before the localizer captures or select another roll mode.

Localizer Active

At LOC capture, the active roll mode changes to LOC. The MCP heading/track window changes to the ILS course.

The localizer capture point is not fixed. The AFDS calculates the localizer capture point as a function of:

- Ground speed
- Localizer deviation
- Intercept angle (must be less than 120 degrees from the selected ILS course).

The AFDS uses the previous data to put the airplane on the localizer beam without large bank angles.

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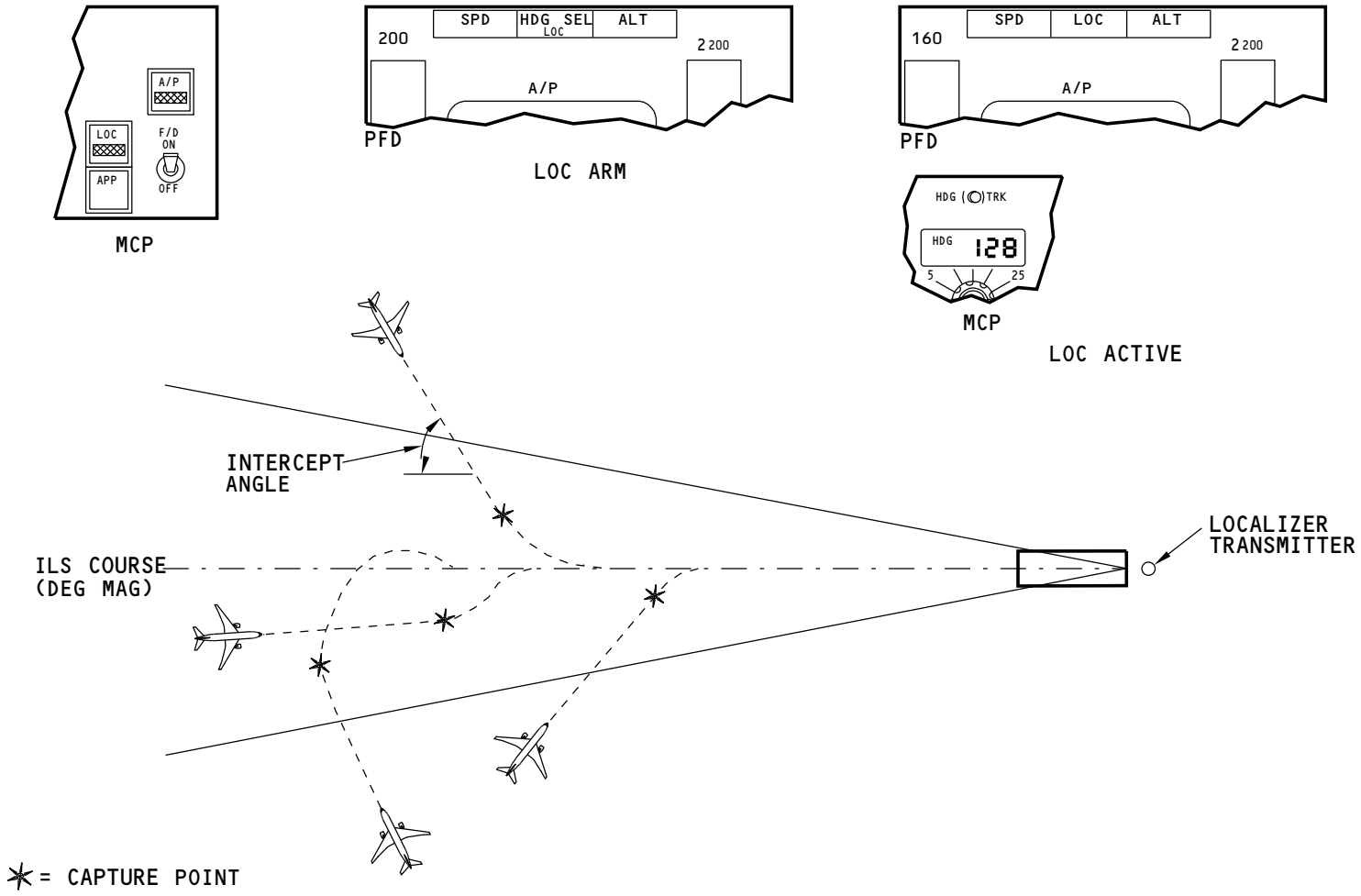

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AFDS - OPERATION - LOCALIZER

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AFDS - OPERATION - APPROACH

General

In approach (APP), the airplane automatically captures and tracks the localizer and glideslope beams. If an autopilot approach continues, the airplane lands automatically.

The flight crew or the FMCF sets the ILS frequency and the ILS course.

The two sub-modes of APP are:

- LOC and G/S arm
- LOC and G/S capture.

Autoland Status

If the autopilot is engaged in the approach mode below 1500 feet radio altitude, the autoland status shows on the PFD. The autoland status shows LAND 3, LAND 2, or NO AUTOLAND. The autoland status is the level of redundancy in the autoland system.

LAND 3 shows when there are no failures in any part of the autoland system. LAND 2 shows when any part of the autoland system is one failure away from NO AUTOLAND. NO AUTOLAND shows when the autoland system is not available.

There are more than 30 conditions that can cause a change from LAND 3 to LAND 2 or NO AUTOLAND. Refer to the airplane system schematics for a full list of the conditions that change the autoland status to LAND 2 or NO AUTOLAND.

These are some failures that cause a change from LAND 3 to LAND 2:

- Single AFDC failure
- Single backdrive actuator failure
- Single radio altimeter failure
- Single multi-mode receiver failure
- ADIRU status message.

These are some failures that cause a change from LAND 3 to NO AUTOLAND:

- Two AFDCs fail
- Approach mode not active at 600 feet
- Two radio altimeters fail
- Two multi-mode receivers fail
- ADIRU failure.

For more information on the Causes of Autopilot EICAS and MFD Annunciations, see Schematic 3 of 22-11-07 in the 777 System Schematic Manual (SSM).

Approach Arm

These occur when the flight crew pushes the approach (APP) switch on the MCP:

- The approach light on the MCP comes on
- LOC and G/S show white on the PFD
- A bus isolation request goes to the electrical power system.

Bus isolation stays active during an autoland until the autopilot disengages or the airplane climbs above 400 feet radio altitude after a go-around starts.

If bus isolation fails, the autoland status changes from LAND 3 to LAND 2.

If you push the APP switch while both LOC and G/S are armed, the approach mode will disarm.

LOC And G/S Capture

The localizer capture point is not fixed. The AFDS calculates the localizer capture point as a function of these data:

- Ground speed
- Localizer deviation
- Intercept angle (must be less than 120 degrees from the selected runway heading).

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The glideslope capture point is not fixed. Glideslope capture is a function of these data:

- The airplane distance from the center of the glideslope beam
- Glideslope deviation.

At LOC capture, the active roll mode changes to LOC. The MCP heading/track window changes to the ILS course.

At G/S capture, the active pitch mode changes to G/S.

The AFDS supplies an ILS tune inhibit signal when G/S and LOC are active with the autopilot system engaged.

The AFDS also supplies an ILS tune inhibit signal when the autopilot is not engaged and all of these conditions are true:

- A flight director is on
- G/S and LOC are active
- The airplane is below 500 feet of radio altitude.

If the autopilot is not engaged and pilot tunes the ILS when the radio altitude is 500 feet or more, the flight director displays go out of view.

With LOC and/or G/S captured, the APP mode goes away by one of these methods:

- Select another pitch mode if only G/S is active
- Select another roll mode including LOC, if only LOC is active
- Push either TO/GA switch if G/S is active, or the trailing edge flaps are not up
- Disengage the autopilot and put the F/D switches in the off position
- Push the APP switch if the airplane is above 1500 feet and both LOC and G/S are active.

The last method lets the flight crew disconnect the APP mode if air traffic control sends the airplane to another runway. The flight crew sets a new ILS frequency and ILS course and pushes the APP switch to arm LOC and G/S again.

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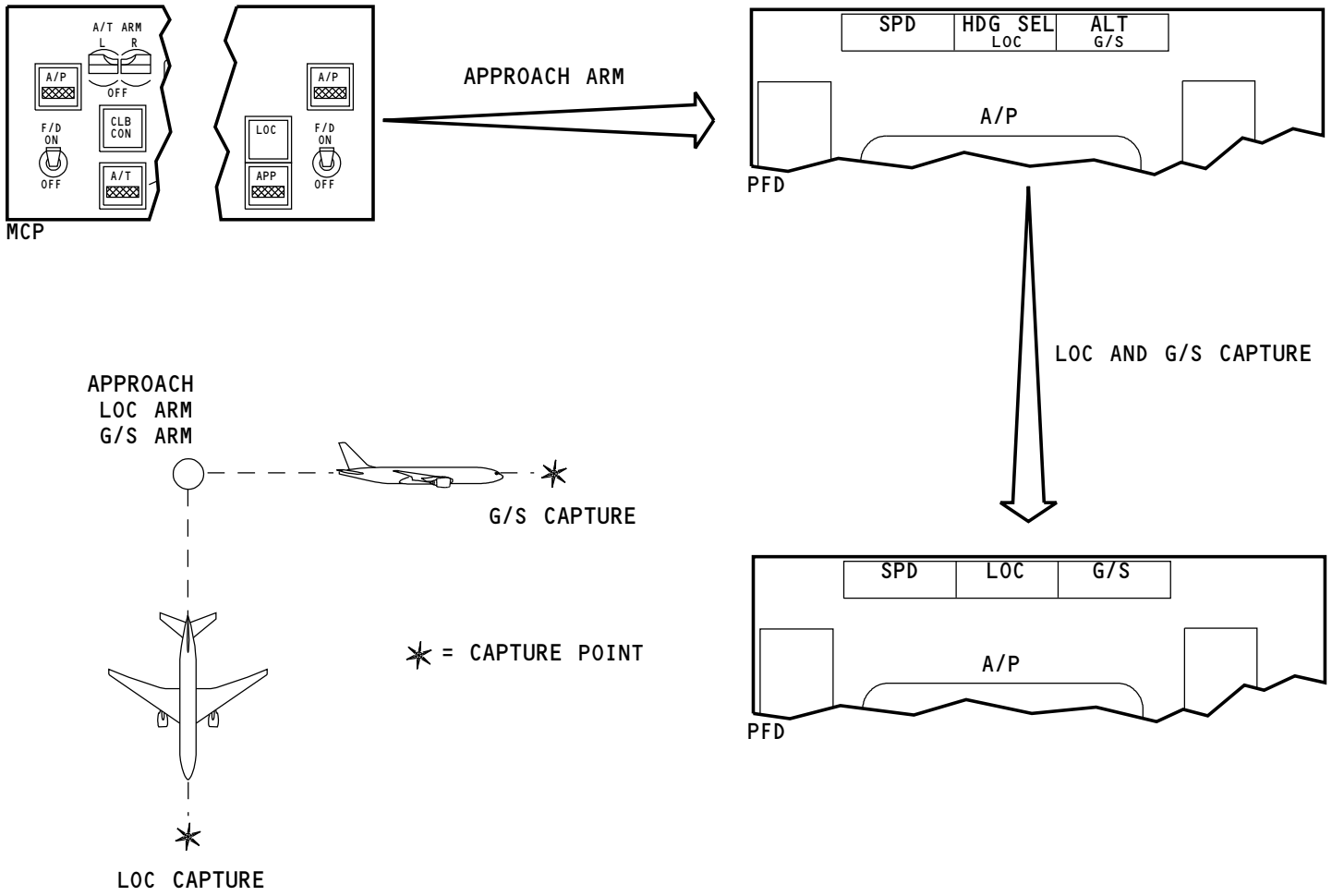

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AFDS - OPERATION - APPROACH

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AFDS - OPERATION - AUTOLAND PITCH

General

In autoland, the AFDS controls the elevator for these functions:

- Glideslope (G/S)
- Flare
- Touchdown.

The flare mode and touchdown sub-mode occur when the autopilot is engaged and at least two AFDCs operate.

Glideslope

With the G/S mode active, the AFDS keeps the airplane on the vertical descent flight path.

With the autopilot engaged and G/S and LOC modes active, these events occur as the airplane descends below 1500 feet:

- The other control column and wheel backdrive actuators and both rudder pedal actuators engage. All available backdrive actuators engage.
- LAND 3, LAND 2 or NO AUTOLAND shows on the PFD as the active autoland status
- ROLLOUT and FLARE modes arm and show on the PFD.
- The runway alignment sub-mode is active. There is no added annunciation for runway alignment on the PFD.

Flare/Touchdown

FLARE replaces G/S as the active mode on the PFD.

During flare, airplane touchdown occurs 450 feet past the glideslope transmitter at a descent rate of 1.5 feet/second.

The altitude at which the flare mode becomes active is flare height. The descent rate of the airplane sets this height. An adjustable flare height gives constant touchdown performance for a wide range of approach speeds.

The AFDS sends a throttle idle command to the TMCF at 25 feet radio altitude.

An airplane nose down command brings the nose wheel in contact with the runway. This occurs when the radio altitude is below five feet and the pitch attitude of the airplane is less than two degrees. At this time, the pitch mode goes blank on the PFD.

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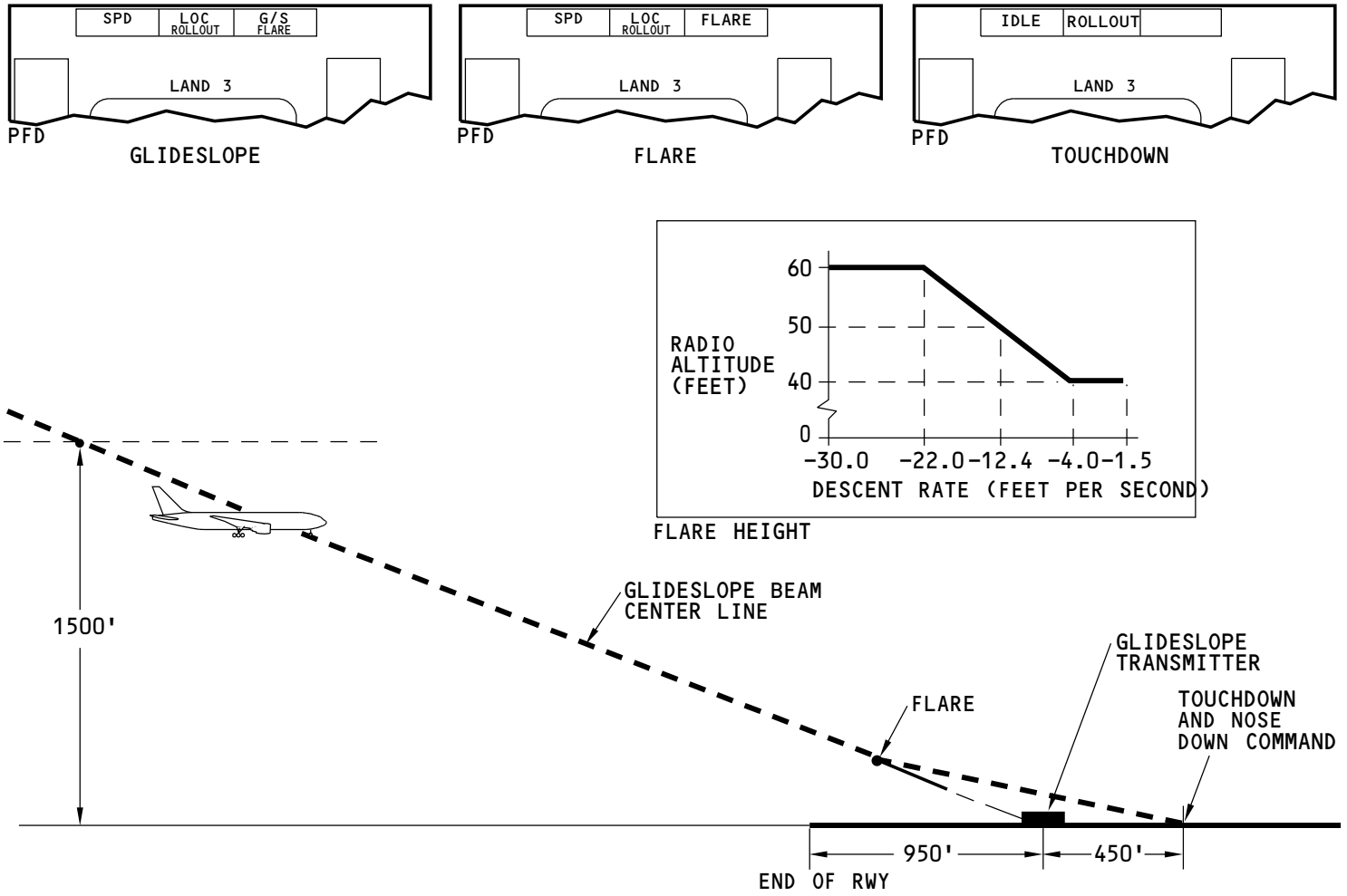

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AFDS - OPERATION - AUTOLAND PITCH

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AFDS - OPERATION - AUTOLAND ROLL AND YAW

General

The runway alignment function corrects for engine out and crosswind conditions during an autoland. This is to make sure the wings are level or the upwind wing is low for all possible wind and engine out combinations. The AFDS does this with rudder and aileron commands (sideslip).

At landing, the rollout mode controls rudder and nosewheel steering to keep the airplane on the center line of the runway.

Crosswind Runway Alignment

Crosswind control occurs at 500 feet or 200 feet.

When the crab angle is more than ten degrees (high crosswinds), the alignment occurs at 500 feet. The AFDS command decreases the crab angle by five degrees.

When the crab angle is between five and ten degrees (medium crosswinds), alignment occurs at 500 feet. Another alignment occurs at 200 feet. The total crab angle reduction for both alignments is five degrees.

When the crab angle is less than five degrees (light crosswinds), alignment occurs at 200 feet. The AFDS removes the crab angle.

Engine Out Runway Alignment

Engine out runway alignment occurs at 1300 feet. The speed and the direction of the crosswind sets the amount of sideslip.

Rollout

The rollout mode arms at 1500 feet during an autoland.

As the airplane descends below two feet of radio altitude, the mode is active and ROLLOUT replaces LOC as the active mode on the PFD.

Rollout guidance continues until the flight crew disengages the autopilot and sets the flight director switches to off.

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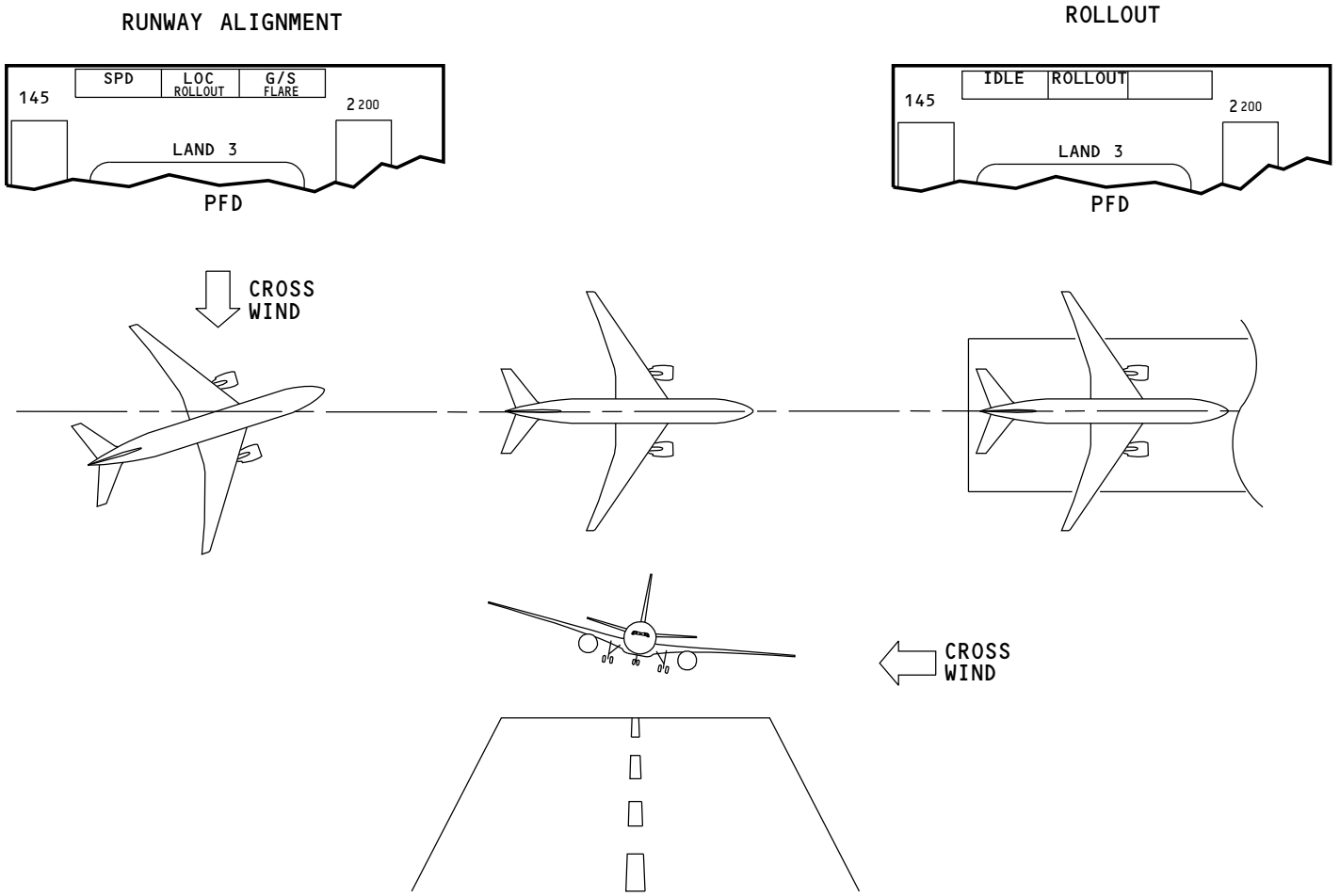

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AFDS - OPERATION - AUTOLAND ROLL AND YAW

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AFDS - OPERATION - GO-AROUND

General

Go-around is a combined AFDS and TMCF mode. The pilot uses the mode in these conditions:

- An aborted approach
- Windshear during takeoff or landing.

The pitch command keeps the airplane in these limits:

- Flap placard speeds
- Maximum operating velocity and Mach (VMO/MMO)
- Minimum speed.

The roll command holds the present track of the airplane over the ground.

In go-around, the flight director display on the PFDs automatically comes on even if the flight director switches are off. This is called AUTO POP UP. It occurs when all these conditions are true:

- A flight director switch is off
- The trailing edge flaps are not up
- The pilot pushes a TO/GA switch.

Go-Around Arm

Go-around arms when the airplane is in the air and, one of these conditions is true:

- Glideslope mode is active
- The trailing edge flaps are not up.

The PFD and MCP continue to show the approach modes.

Go-Around Active

The go-around mode starts when the pilot pushes either TO/GA switch. With one push of the TO/GA switch, the autothrottle controls to a 2000 ft/min climb. With a second push, the autothrottle controls to full go-around thrust. TO/GA shows on the PFD as the active mode for roll and pitch. The autothrottle mode is thrust (THR).

The AFDS supplies an initial pitch up command to make sure the airplane clears any obstacles. After the pitch up command, the AFDS commands one of these:

- Target airspeed
- A combination of target airspeed and pitch attitude
- Pitch attitude.

If the climb rate is less than 600 FPM, the pitch command is to hold attitude. For a climb rate between 600 FPM and 1200 FPM, the pitch axis holds a mixture of airspeed and attitude. For a climb rate more than 1200 FPM, the pitch axis holds a target airspeed.

For go-around with an engine out, the pitch axis command is a mixture of airspeed and attitude at a climb rate less than 1200 FPM. For a climb rate more 1200 FPM, the pitch axis holds a target airspeed.

This mix of speed and attitude command gives windshear protection during go-around.

Go-Around Off

Below 400 feet, the AFDS stays in go-around unless the pilot disengages the autopilot and sets the flight director switches to off.

Above 400 feet, the pilot can select another roll or pitch mode.

In this example, the AFDS captures the MCP altitude of 5000 feet. The PFDs show ALT and the airplane levels off at 5000 feet.

Go-around stays as the active roll mode until the pilot selects another roll mode.

The pitch mode change from TO/GA to ALT makes the autothrottle change to SPD mode at the speed set on the MCP.

When a go-around occurs below 1500 feet during an autoland, all six backdrive actuators stay engaged until a different roll or pitch mode, other than TO/GA, is selected.

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AFDS - OPERATION - GO-AROUND

When a go-around occurs below 1500 feet during an autoland, bus-isolation stays active until the airplane is above 400 feet.

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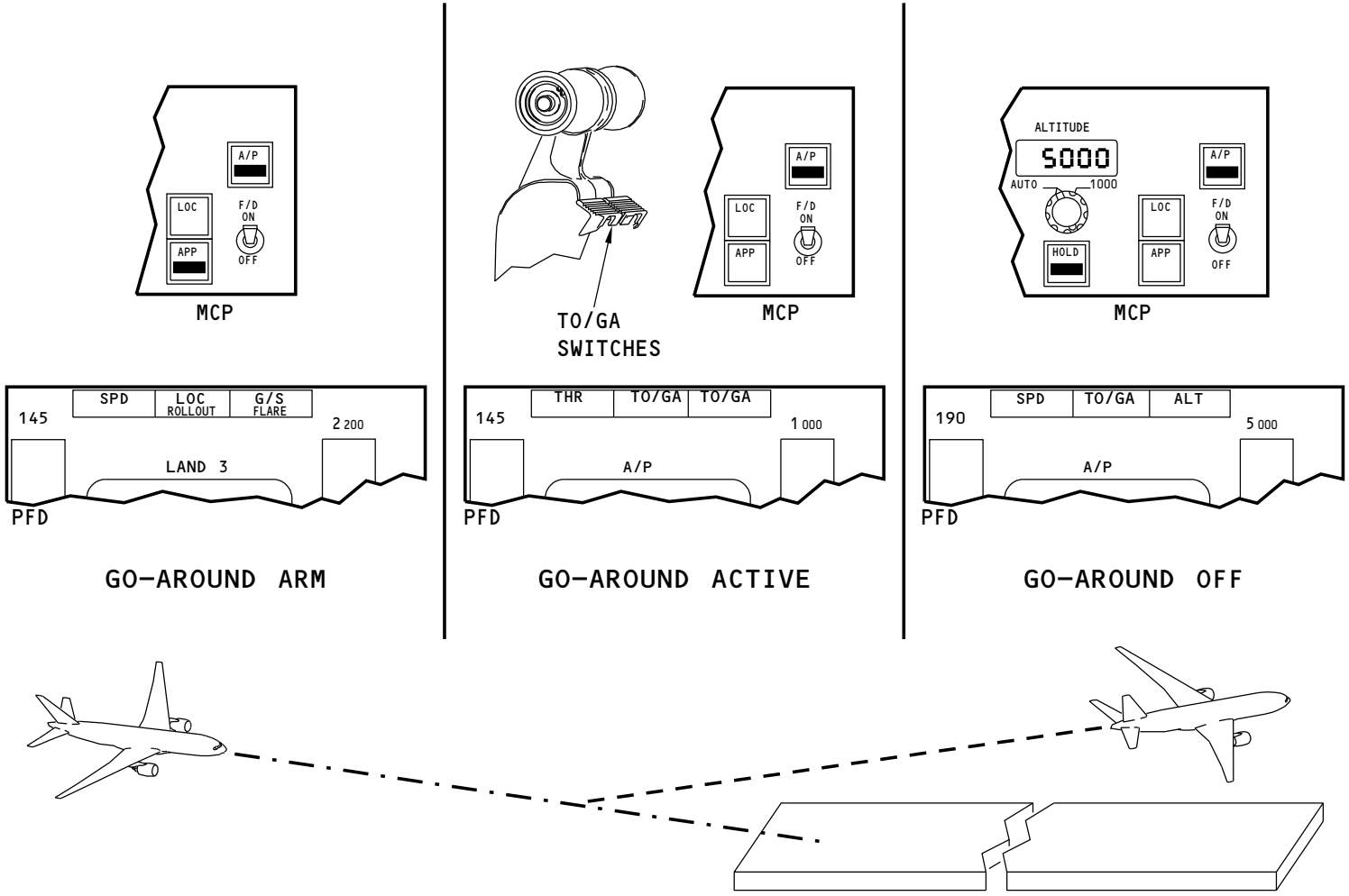

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AFDS - OPERATION - GO-AROUND

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General

The AFDC program has the:

- Pitch control laws
- Roll/Yaw control laws
- Backdrive command section.

Pitch Control Laws

The pitch control laws calculate part of the pitch command and send it to the primary flight computers (PFCs). The PFCs accept the pitch command only when the primary flight control system (PFCS) mode is NORMAL. If the PFCS mode is SECONDARY or DIRECT, the PFCs do not permit the autopilot to engage. The PFCs use this command to calculate a surface command that goes to the actuator control electronics (ACEs).

The ACEs change the PFCs surface commands to analog signals and send them to the power control units (PCUs). The PCUs move the flight control surfaces. The surface position transducers in the PCUs send surface position to the ACEs. The ACEs send the surface position to the PFCs. This position feedback completes the PFCs control loop. The AFDCs control loop closes when the AFDCs sense the airplane attitude and performance changes to match the initial AFDC pitch command.

Roll/Yaw Control Laws

The roll/yaw control laws calculate the roll and yaw commands and sends them to the PFCs. The PFCs accept the roll and yaw commands only when the PFCS mode is NORMAL. If the PFCS mode is SECONDARY or DIRECT, the PFCs do not permit the autopilot to engage. The PFCs change the roll and yaw commands to surface commands. The surface commands go to the ACEs.

The ACEs change the PFCs surface commands to analog signals and send them to the PCUs. The PCUs move the flight control surfaces. The surface position transducers in the PCUs send surface position to the ACEs. The ACEs send the surface position to the PFCs. This position feedback completes the PFCs control loop. The AFDCs control loop closes when the AFDCs sense the airplane attitude and performance changes to match the initial AFDC roll/yaw command.

Backdrive Command Section

The backdrive command section calculates the control column, control wheel, and rudder pedal backdrive actuator drive signals. The AFDCs operate the backdrive actuators during:

- Autopilot operations
- Bank angle protection (control wheel backdrive actuators only).

During autopilot operations, the PFCs use the AFDC pitch and roll/yaw control law commands to calculate backdrive commands. The backdrive commands go to the AFDCs. The AFDCs change the commands to actuator drive signals and send them to the backdrive actuators.

For bank angle protection (BAP), the PFCs monitor manual bank angle commands. If the flight crew banks the airplane more than 35 degrees, the PFCs send a control wheel engage signal to the AFDC. The PFCs also send control wheel backdrive commands that are opposite to the flight crew input. The AFDCs change the control wheel commands to actuator drive signals and send them to the control wheel backdrive actuators. The control wheel backdrive actuators move the control wheel to roll the airplane to a roll attitude less than 30 degrees. The control wheel position transducers send the control wheel position to the ACEs. The ACEs digitize the control wheel position and send it to the PFCs. The PFCs convert the control wheel position to a surface command (aileron/flaperon). The PFCs send the surface command to the ACEs. The ACEs send the surface command to the PCUs. The PCUs move the surfaces. The surface position transducers supply surface position to the ACEs. The ACEs send the surface position to the PFCs. This closes the PFCs control loop. The pilot can override the control wheel backdrive actuators with more force to the control wheel. The PFCs use signals from a control wheel force transducer to detect a pilot override.

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BAP operates with the autopilot engaged or disengaged. If the autopilot is engaged when BAP is active, the AFDCs make an autopilot caution EICAS message and a roll mode failure shows on the PFD.

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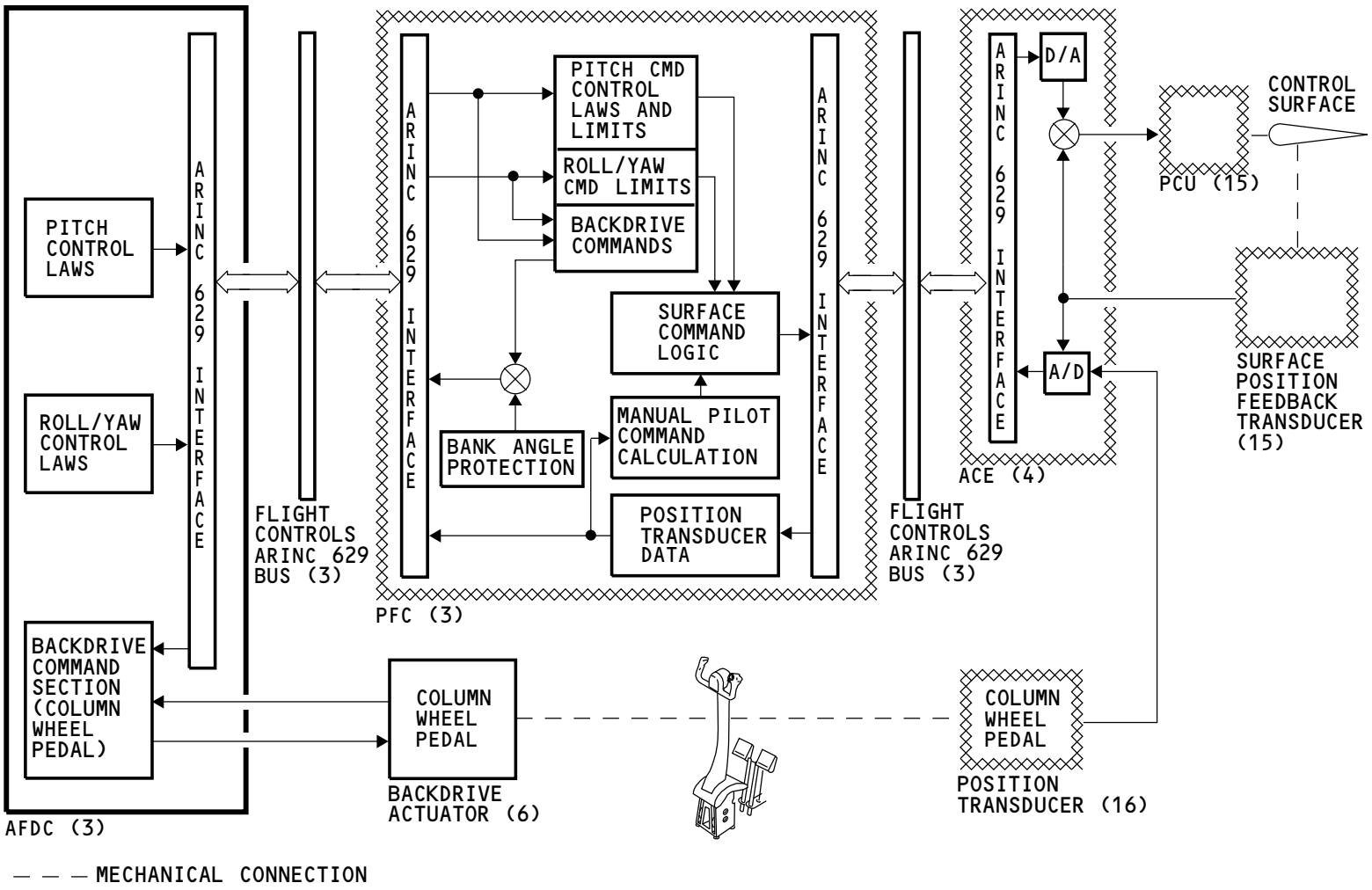

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AFDS - FUNCTIONAL DESCRIPTION - AUTOPILOT CONTROLS

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AFDS - FUNCTIONAL DESCRIPTION - FLIGHT DIRECTOR CONTROL

General

The AFDC sends pitch and roll control law data to the flight director program. The program calculates this display data:

- Pitch flight director bar
- Roll flight director bar.

The AFDC sends the display data to the AIMS cabinets.

An AFDC failure can cause the loss of one or both flight director bars.

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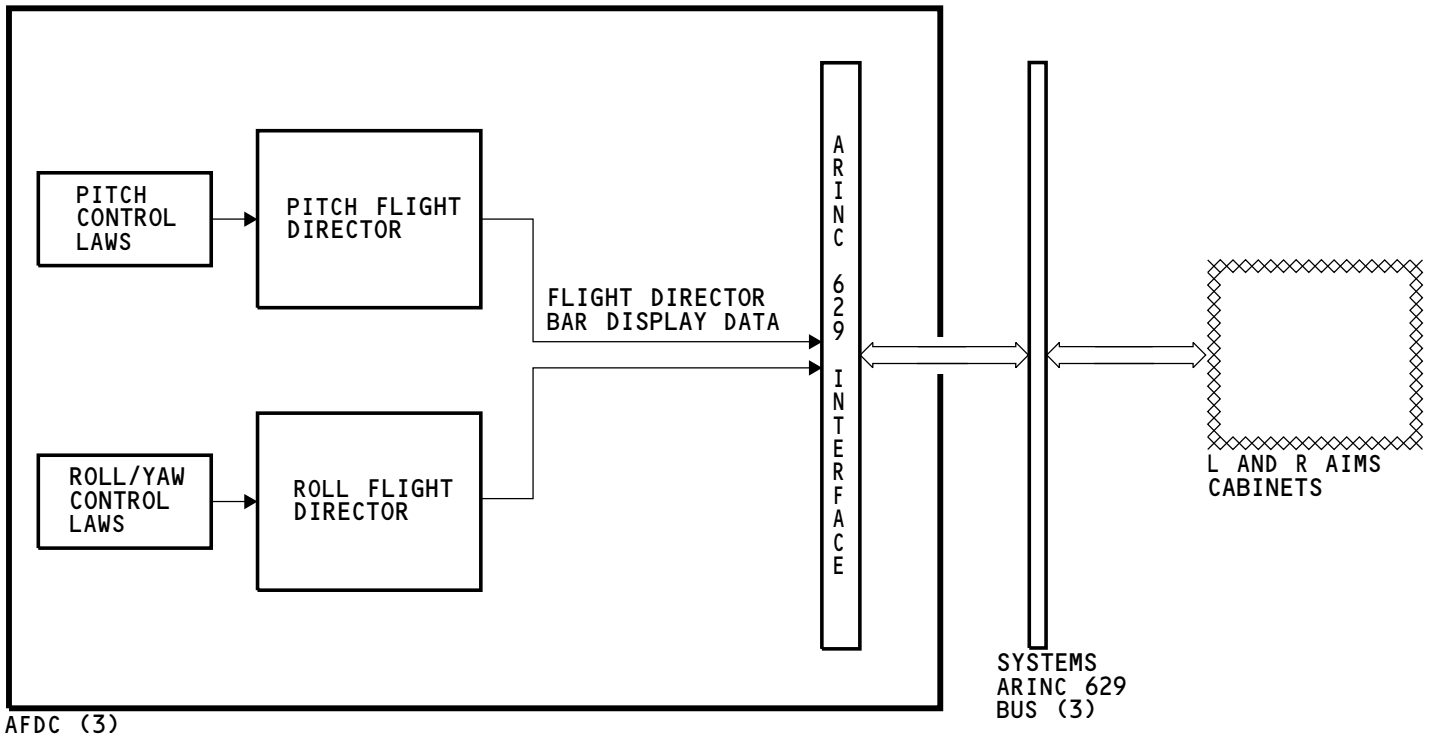

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AFDS - FUNCTIONAL DESCRIPTION - FLIGHT DIRECTOR CONTROL

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AFDS - FUNCTIONAL DESCRIPTION - PITCH CONTROL

General

The AFDC pitch control laws calculate part of the pitch command signal that goes to the PFC. They also calculate the F/D data.

The AFDC calculates a vertical speed command for these modes:

- Vertical speed (V/S)
- Flight path angle (FPA).

The AFDC calculates a speed command for these modes:

- Takeoff (TO)
- Go-around (G/A)
- Flight level change (FLCH).

The AFDC calculates a position command for these modes:

- Altitude hold
- Altitude select
- Glideslope (G/S)
- Flare.

These commands go to the flight directors (F/D) and the PFCs.

Vertical Speed/Flight Path Angle

The AFDC calculates a vertical speed command.

The AFDC uses these signals to calculate the vertical speed command:

- MCP selected vertical speed or flight path angle calculated vertical speed
- Vertical speed.

Speed-Through-Elevator

The speed-through-elevator function supplies protection for:

- Minimum speed
- Windshear
- Maximum speed.

The AFDC uses angle of attack (AOA) and pitch rate to calculate the minimum speed.

The AFDC uses altitude rate and forward gust rate to calculate the windshear.

The AFDC uses these to calculate the maximum speed:

- Maximum velocity (VMO)
- Maximum mach (MMO)
- Flap placard signals.

The AFDC uses selected mach or speed to calculate the speed signal. It also uses engine out during TO calculations.

The AFDC uses the speed signal with true airspeed to calculate the speed command. The AFDC also makes sure the speed error stays in the protection limits.

Vertical Position

The AFDC uses these to calculate the altitude hold/altitude select position command:

- MCP selected altitude
- Baro altitude
- Altitude rate.

The AFDC uses G/S deviation and G/S deviation rate to calculate the glideslope position command.

The AFDC uses gear altitude and gear altitude rate to calculate the flare position command.

Vertical Navigation (VNAV)

The AIMS cabinet sends VNAV steering commands to the AFDC.

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AFDS - FUNCTIONAL DESCRIPTION - PITCH CONTROL

Pitch Flight Director (F/D)

The AFDC uses these to calculate the pitch F/D command:

- Pitch attitude
- Turn compensation
- Pitch command.

The F/D then formats the signal and sends it to AIMS.

Pitch CMD Limit

The AFDC limits the rate and angle of the pitch command signal that goes to the PFCs.

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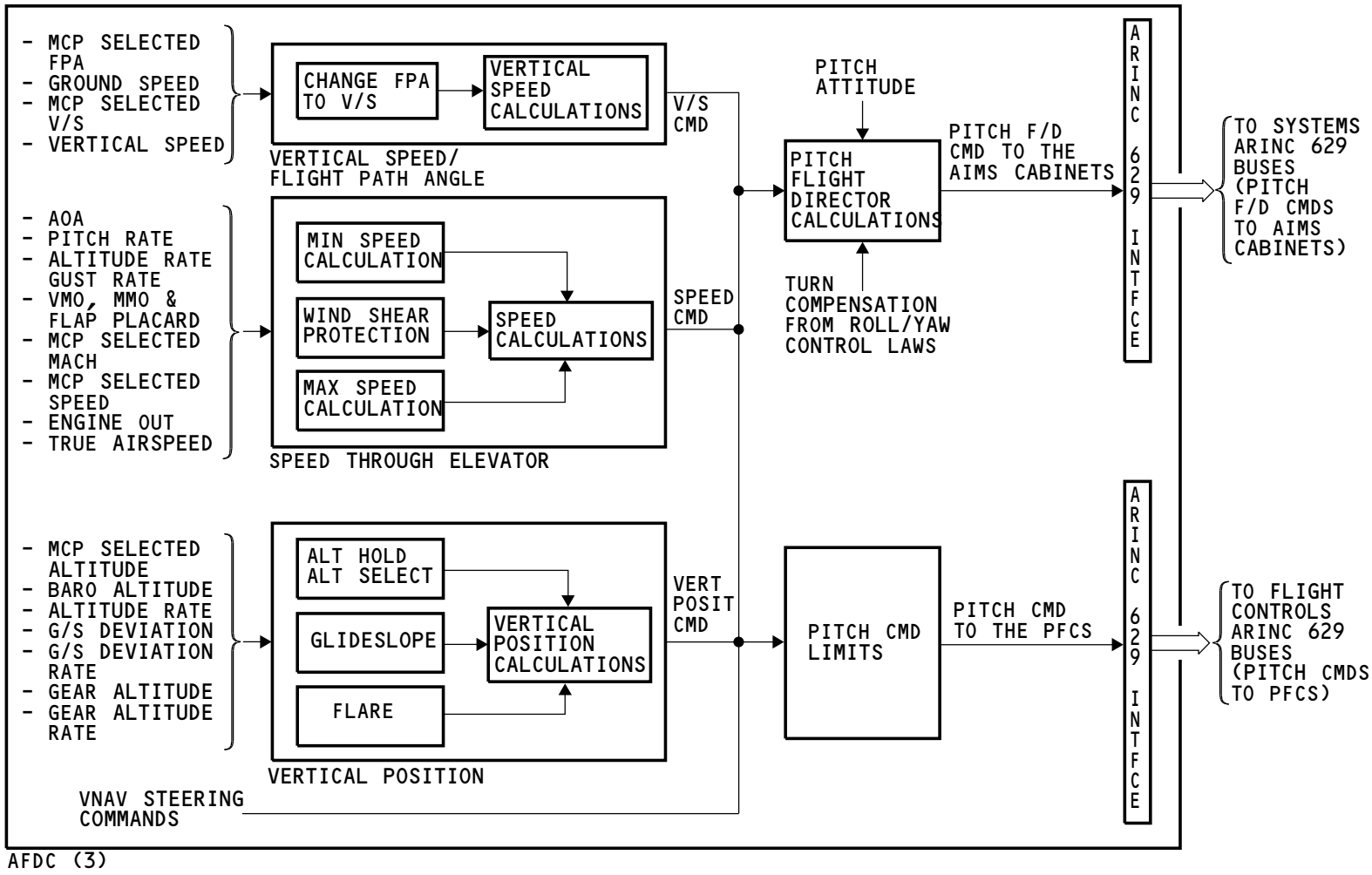

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AFDS - FUNCTIONAL DESCRIPTION - PITCH CONTROL

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AFDS - FUNCTIONAL DESCRIPTION - ROLL AND YAW CONTROL

General

The AFDC roll/yaw control laws calculate the roll and yaw signals that go to the PFC. They also calculate the F/D data.

Lateral Navigation (LNAV)

The AIMS flight management computer function or the control and display units send LNAV steering commands to the AFDC.

Heading/Track

The AFDC calculates a heading/track command for these modes:

- Heading select
- Heading hold
- Track select
- Track hold.

The AFDC uses these inputs to calculate the roll command:

- Mode control panel (MCP) bank limit
- Heading/track select
- MCP selected heading
- Airplane heading
- MCP selected track
- Ground track.

Localizer

The AFDC calculates localizer commands for approach and localizer modes.

The AFDC uses these inputs to calculate the roll command:

- Localizer deviation
- Localizer deviation rate
- ILS course.

Runway Alignment

The AFDC calculates the roll command and yaw command for the runway alignment modes.

The AFDC uses ILS course and airplane heading inputs to calculate the yaw control command and the roll command.

Rollout

The AFDC calculates the yaw command for the rollout mode.

The AFDC uses these inputs to calculate the rudder surface command for yaw control:

- Localizer deviation
- Localizer deviation rate
- Rudder position.

It also calculates a roll command for flight director (F/D) display during ground rollout. The flight crew uses the F/D rollout display to control the rudder pedals after the airplane has landed.

Roll Flight Director

The AFDC uses the roll command or LNAV steering command and roll attitude to calculate the roll F/D signal. The F/D then formats the signal and sends it to AIMS.

Roll Command Calculations and Limiting

The AFDC uses these to calculate the roll command and turn compensation signal:

- LNAV steering command
- Roll command
- Roll attitude
- Roll rate.

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The AFDC limits the bank angle during autopilot and bank angle protection (BAP) operations. The AFDC sends the roll command to the PFCs and the turn compensation signal to the yaw command and the pitch F/D calculations.

Yaw Command Calculations and Limiting

The AFDC uses these inputs to calculate the rudder command:

- Turn compensation
- Yaw command
- Yaw rate.

The AFDC limits the rudder command for the selected mode and sends it to the PFCs.

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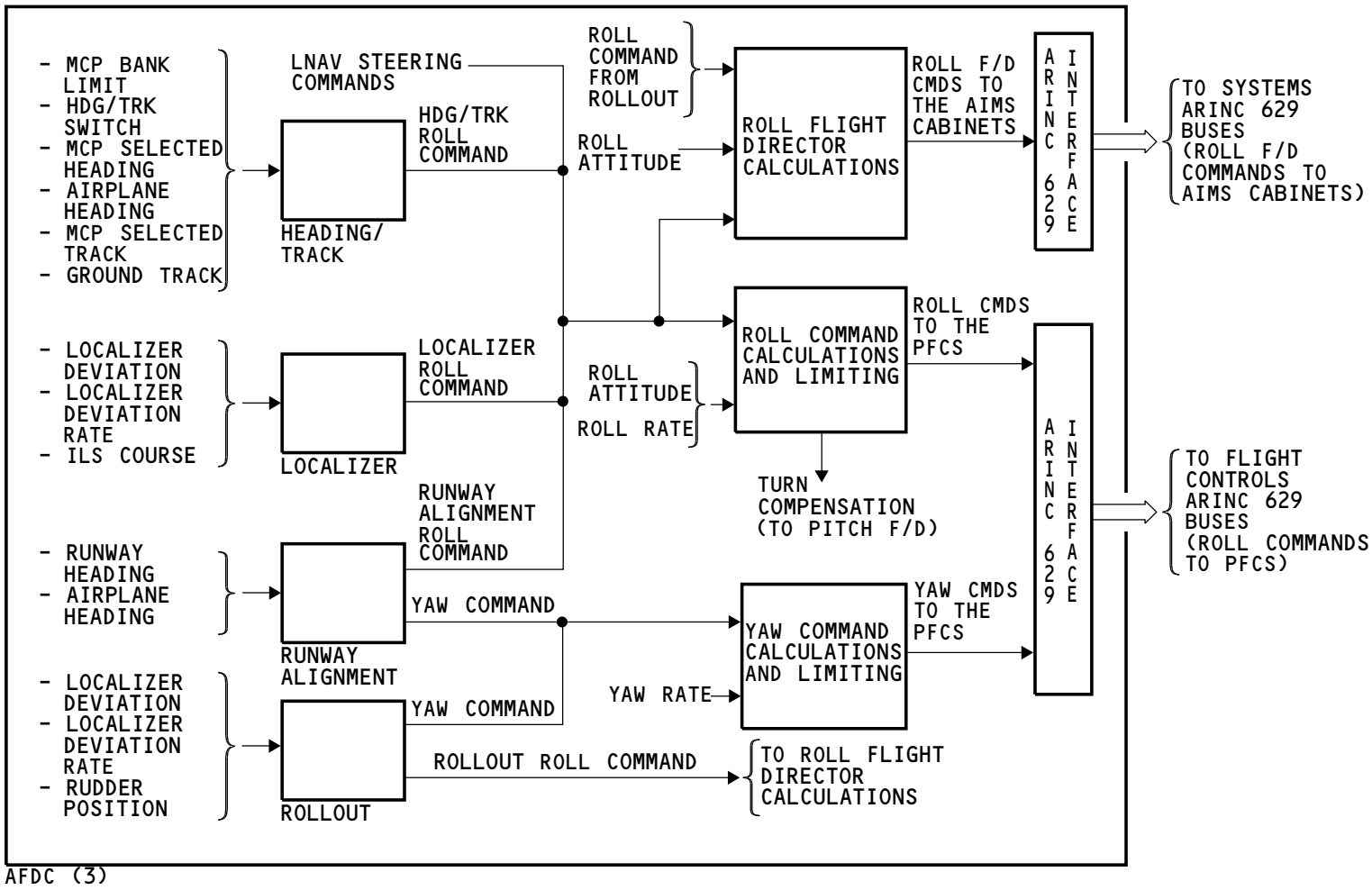

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AFDS - FUNCTIONAL DESCRIPTION - ROLL AND YAW CONTROL

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AFDS - FUNCTIONAL DESCRIPTION - BACKDRIVE CONTROLS

General

The AFDC backdrive control laws use PFC backdrive commands to supply these commands:

- Control column
- Control wheel
- Control pedal.

Control Column Backdrive

The A and B processors use these signals to supply the control column backdrive command:

- PFC autopilot engage
- PFC column backdrive command
- Column position
- Column tachometer (TACH) feedback A or B.

Control Wheel Backdrive

The A and B processors use these signals to supply the control wheel backdrive command for autopilot operation:

- PFC autopilot engage
- PFC wheel backdrive command
- Wheel position
- Wheel TACH feedback A or B.

The A and B processors use these signals to supply the control wheel backdrive command for bank angle protection (BAP) operation:

- PFC engage wheel backdrive
- PFC wheel torque command
- Wheel position
- Wheel TACH feedback A or B.

In BAP operation, the PFC sends a wheel torque limit command to the AFDC. This will let the flight crew override the backdrive actuator if necessary.

Control Pedal Backdrive

The A and B processors use these signals to supply the control pedal backdrive command:

- PFC Autopilot engage
- PFC Yaw engage
- PFC pedal backdrive command
- Pedal position
- Pedal backdrive actuator tachometer (TACH) feedback A or B.

Backdrive Power Supplies

Each processor sends a backdrive command to a backdrive power supply. Two power supplies, one A and one B, are necessary to drive the motor in each backdrive actuator. This supplies a push-pull drive signal to the actuator motor.

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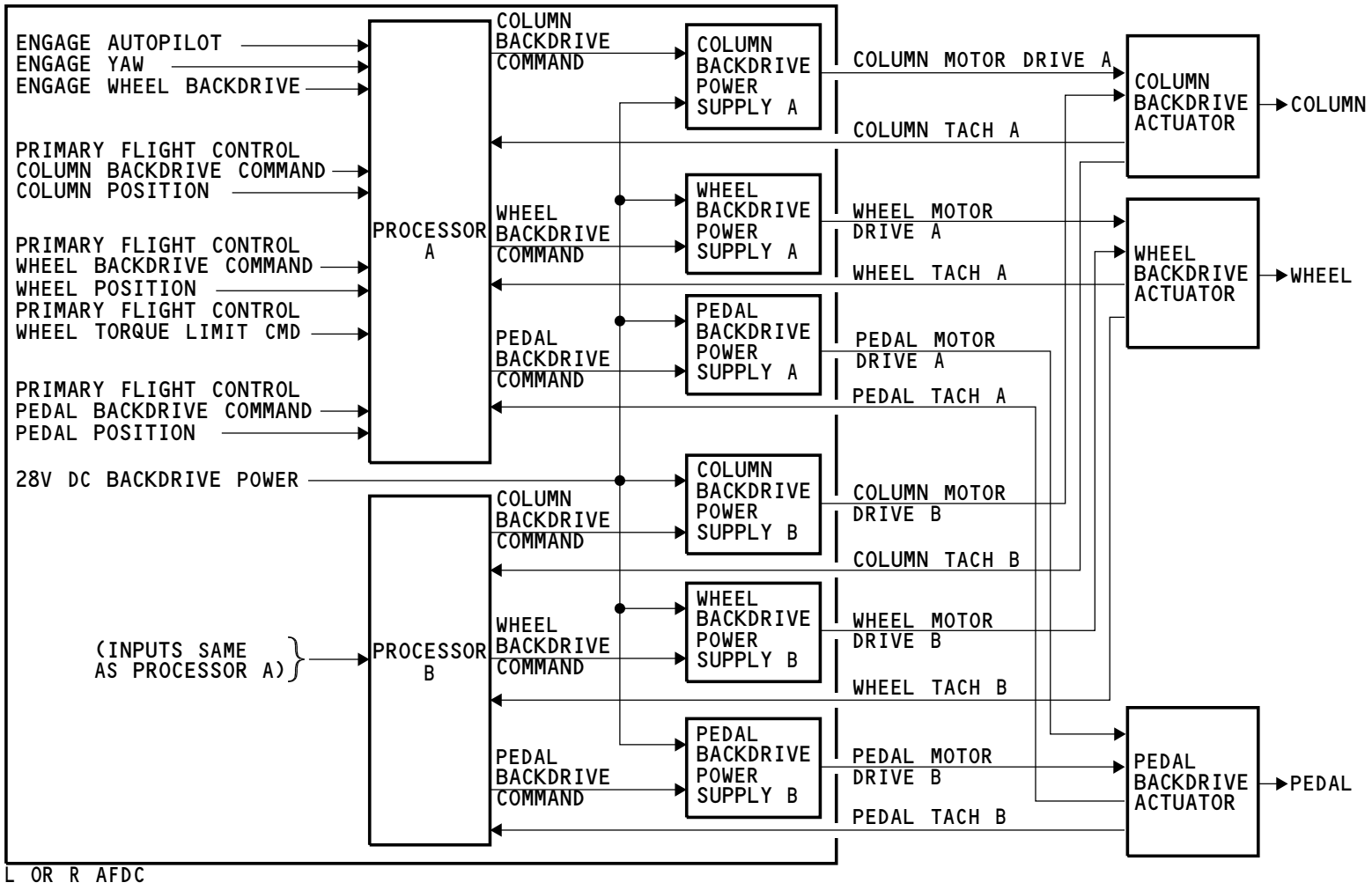

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AFDS - FUNCTIONAL DESCRIPTION - BACKDRIVE CONTROLS

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AFDS - FUNCTIONAL DESCRIPTION - ENGAGE INTERLOCKS INTRODUCTION

Purpose

The autopilot engage interlock circuits in the AFDCs and PFCs monitor the operation, power, and components of the AFDS and PFCS. With normal conditions, the circuits let the autopilot engage. If conditions are not normal, the autopilot disengages or the autopilot does not engage.

Mode Control Panel

The autopilot engage switches are on the MCP. The flight crew pushes either switch to engage the autopilot.

Usually, all three AFDCs engage when the flight crew pushes either A/P engage switch. If there are faults, it is possible to engage one or two AFDCs. Autoland requires two or three AFDCs engaged.

The disengage bar on the MCP lets the flight crew disengage the autopilot from the MCP. The autopilot cannot engage unless the bar is in the up position.

AFDC

The AFDCs process the engage request from the MCP and send it to the PFCs.

The engage logic and backdrive engage relays in the AFDCs monitor these components, systems, and sensors:

- MCP
- Autopilot disengage switches
- AFDC cross channel data
- PFCS
- ADIRU
- SAARU
- ILS
- RA
- Backdrive actuators.

PFCs

The PFCS controls the elevator, aileron, and rudder. When the PFCs receive valid engage requests from the AFDCs, the PFCs change control of these surfaces from the flight crew to the autopilot. The PFCs also command the AFDCs to engage the backdrive actuators.

Backdrive Actuators

The left and right AFDCs have rudder pedal, control wheel, and control column backdrive actuators. The center AFDC does not control backdrive. For this reason, the autopilot does not engage with only the center AFDC.

The engage relays for the backdrive actuators are in the AFDCs.

Logic in the AFDCs monitor the electrical components in the backdrive actuators.

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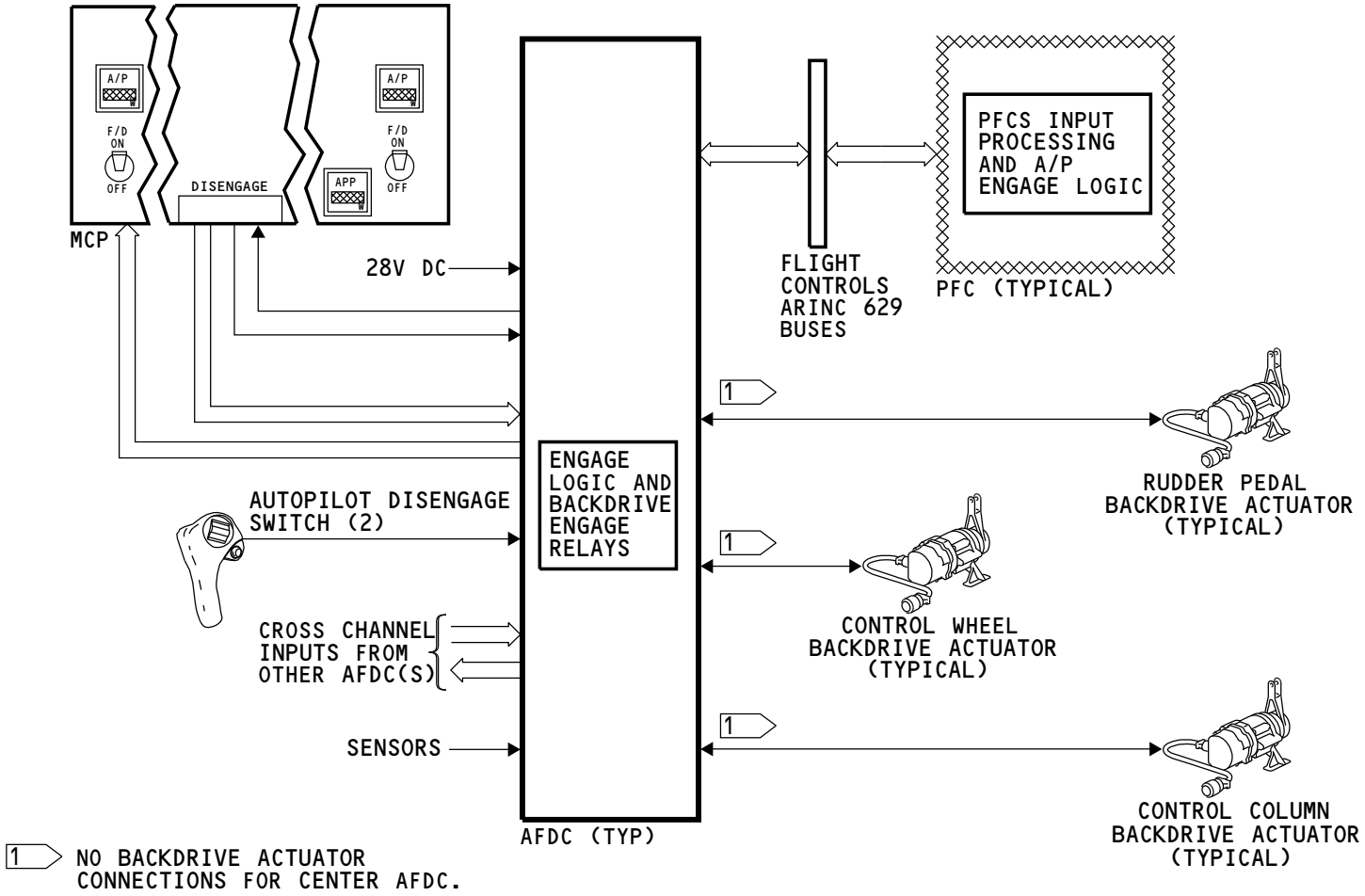

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AFDS - FUNCTIONAL DESCRIPTION - ENGAGE INTERLOCKS INTRODUCTION

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AFDS - FUNCTIONAL DESCRIPTION - ENGAGE INTERLOCKS BLOCK DIAGRAM

General

Cruise engage refers to engagement of the pitch and roll axis. Autoland engage refers to the added engagement of the yaw axis.

Cruise Engage

Pitch and roll engagement starts when the flight crew pushes either autopilot engage switch on the MCP. The LEDs in both switches come on if there is a valid AFDC.

The autopilot engage logic in the AFDCs receives the engage request from the MCP. Each valid AFDC sends a pitch and roll engage request signal to the three PFCs when these conditions are true:

- The left or right AFDC is valid with a valid column and wheel backdrive actuator (backdrive channel)
- There are no engage inhibit faults.

All PFCs receive the pitch and roll engage request from each AFDC. Signal selection and fault detection logic in each PFC checks for these conditions:

- There is a valid pitch and roll command from one of the AFDCs
- The PFCS is in the normal mode.

When both of these conditions are true, the PFCs:

- Accept and acknowledge the pitch and roll engage request
- Change from pilot control to autopilot control of the pitch and roll axis.

Each valid AFDC engages in pitch and roll. The control wheel and control column backdrive actuators connected to the master AFDC also engage.

AFDC Master Selection

The AFDC master selection changes each time the autopilot engages. This also changes which MCP processor controls the MCP displays.

Autoland Engage

The autopilot arms the yaw axis when the pilot pushes the APP switch on the MCP.

The AFDCs send a yaw engage request to the PFCs when these conditions are true:

- The autopilot is engaged in pitch and roll
- The airplane is below 1500 feet of radio altitude
- Glideslope (G/S) mode is active
- Localizer (LOC) mode is active and the airplane is on course
- There are no faults that prevent yaw engagement.

The PFCs check for these conditions:

- The autopilot is engaged in pitch and roll
- At least two AFDCs request yaw engage
- The PFCs receive at least two valid pitch, roll and yaw commands.

When the conditions are true, the PFCs do this:

- Accept and acknowledge the yaw engage request
- Change from pilot control to autopilot control of the yaw axis.

Each valid AFDC engages in yaw. Also, the pedal actuators and the other wheel and column actuators engage.

Backdrive Actuator Force Fight

The AFDCs do a test on the six backdrive actuators after the backdrive actuators engage. The test is a force fight test.

The AFDCs supply a small bias command of opposite polarity to each backdrive actuator set. The AFDCs monitor the current supplied to each actuator. A weak actuator disengages.

All six actuators must engage to get a LAND 3 status. For example, a LAND 2 status occurs if an actuator does not engage.

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AFDS - FUNCTIONAL DESCRIPTION - ENGAGE INTERLOCKS BLOCK DIAGRAM

Disengage

A power supply in each AFDC supplies 28v dc to its set of backdrive actuator engage relays. The 28v dc goes from the engage relays to backdrive actuator clutches. The 28v dc goes through toggle switches connected to the disengage bar on the MCP. There are three switches, one for each AFDC.

The autopilot disengages manually with the MCP disengage bar or a control wheel autopilot disengage switch.

An automatic disconnect occurs when one of these conditions is true:

- An engage removal fault occurs
- The flight crew overrides the autopilot command with the rudder pedal, control wheel, or control column.

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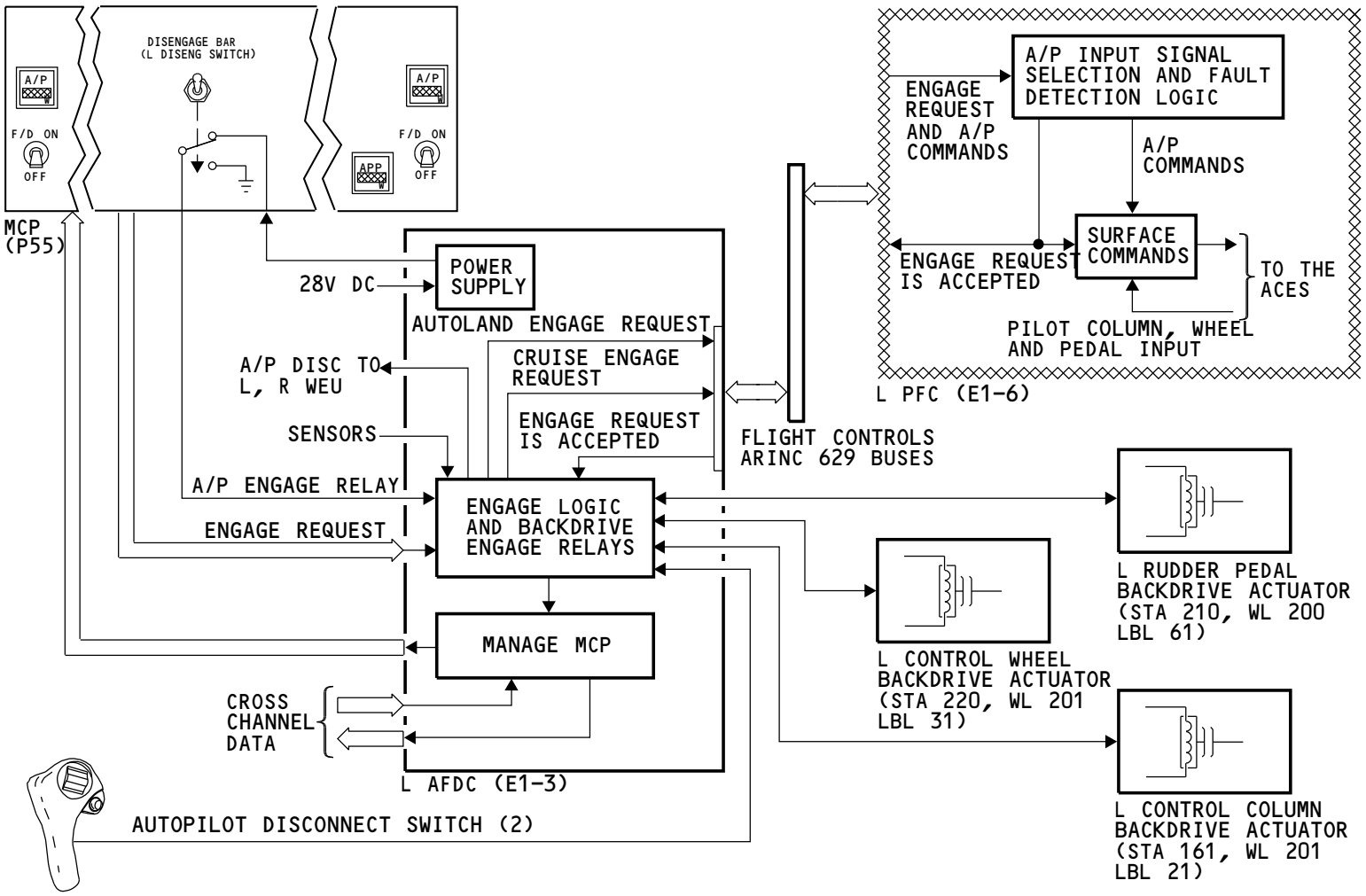

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AFDS - FUNCTIONAL DESCRIPTION - ENGAGE INTERLOCKS BLOCK DIAGRAM

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AFDS - FUNCTIONAL DESCRIPTION - CRUISE ENGAGE INTERLOCK CONDITIONS

General

The conditions shown here apply to failures in the AFDS, PFCS, and sensor components which cause the autopilot to disengage in cruise. Other failures cause one or more of these:

- Changes to the flight mode annunciator on the PFD
- Mode fail
- Caution/advisory messages.

Engage Inhibit

If the engage inhibit signal is true, the AFDCs cannot engage. If you try to engage the autopilot, the AFDS sends a disengage warning to WES and AIMS.

Engage Removal

If the engage removal signal is true, the AFDS does these three things:

- Removes the engage requests to the PFCs
- Disengages all backdrive actuators
- Sends a disengage warning to WES and AIMS.

Conditions that cause an engage removal also cause AFDS status or warning messages.

When the AFDCs remove the engage requests to the PFCS, the PFCs:

- Accept and acknowledge the engage request removal
- Change from autopilot control to flight crew control of the pitch, roll and yaw (if engaged) axis.

Training Information Point

The purpose of this graphic is to supply a basic understanding of the cruise engage interlock conditions. The conditions shown on this graphic are a partial list of all the possible cruise engage interlock conditions.

Refer to the airplane system schematics for ATA chapter/section 22-11 for a full list of all the cruise engage interlock conditions.

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CRUISE CONDITION	ENGAGE INHIBIT	ENGAGE REMOVAL
THE PFCS IS NOT IN THE NORMAL MODE	X	X
ADIRU AND SAARU FAIL	X	X
THE THREE ADMS FAIL	X	
ALL PFCS FAIL	X	X
(THERE ARE PROGRAM PIN FAULTS WITH THE LEFT AND RIGHT AFDC) OR (THE MASTER AFDC)	X	X
ALL AFDC PROGRAM PINS ARE DIFFERENT	X	X
ALL AFDC SOFTWARE IS DIFFERENT	X	X
MASTER AFDC FAIL		X
ALL MCP FUNCTIONS FAIL	X	
(THE LEFT WHEEL OR COLUMN BACKDRIVE ACTUATOR FAIL) AND (THE LEFT AFDC IS MASTER)		X
(THE RIGHT WHEEL OR COLUMN BACKDRIVE ACTUATOR FAIL) AND (THE RIGHT AFDC IS MASTER)		X
THE MCP DISENGAGE BAR IS DOWN	X	X
A CONTROL WHEEL DISENGAGE SWITCH IS PUSHED	X	X
(BOTH ANGLE OF ATTACK VANES FAIL) AND (THE PFCS STALL PROTECTION MODE IS ACTIVE)	X	X
THE AUTOPILOT PITCH OR ROLL COMMAND IS ABOVE THE PFCS LIMIT		X
(A PFC DETECTS A PILOT OVERRIDE OF THE COLUMN OR WHEEL) AND (THE A/P IS ENGAGED)		X
(BOTH WEU CHANNELS OR THEIR AOA VANE INPUT FAIL) AND (THE AFDS IS IN TAKEOFF OR GO-AROUND)	X	X
PFCS DO NOT ACKNOWLEDGE A/P ENGAGE REQUEST WITHIN 0.5 SECONDS	X	
(LEFT WHEEL AND COLUMN) OR (RIGHT WHEEL AND COLUMN) BACKDRIVE ACTUATORS DO NOT ENGAGE WITHIN 0.2 SECONDS	X	
(LEFT WHEEL OR COLUMN) AND (RIGHT WHEEL OR COLUMN) BACKDRIVE ACTUATORS FAIL	X	X

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AFDS - FUNCTIONAL DESCRIPTION - CRUISE ENGAGE INTERLOCK CONDITIONS

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AFDS - FUNCTIONAL DESCRIPTION - AUTOLAND ENGAGE INTERLOCK CONDITIONS

General

The conditions shown here apply to failures in the AFDS, PFCS, and sensor components which cause the autopilot to disengage during approach and autoland.

Engage Inhibit

If the engage inhibit signal is true, the AFDCs cannot engage. If you try to engage the autopilot, the AFDS sends a disengage warning to WES and AIMS.

Conditions that cause an engage inhibit signal also supply AFDS status and warning messages.

Engage Removal

If the engage removal signal is true, the AFDS does these three things:

- Removes the engage requests to the PFCs
- Disengages all backdrive actuators
- Sends a disengage warning to WES and AIMS.

Conditions that cause an engage removal also cause AFDS status or warning messages.

Training Information Point

The purpose of this graphic is to supply a basic understanding of the autoland engage interlock conditions. The conditions shown on this graphic are a partial list of all the possible autoland engage interlock conditions. Refer to the airplane system schematics for ATA chapter/section 22-11 for a full list of all the autoland engage interlock conditions.

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AUTOLAND CONDITION	ENGAGE INHIBIT	ENGAGE REMOVAL
THE PFCS IS NOT IN THE NORMAL MODE	X	X
ADIRU AND SAARU FAIL	X	X
THE THREE ADMS FAIL	X	
ALL PFCS FAIL	X	X
THE PFDS USE AUTOPILOT COMMANDS FROM ONLY ONE AFDC IN THE FLARE MODE AT TOUCHDOWN		X
ALL AFDC PROGRAM PINS ARE DIFFERENT	X	X
ALL AFDC SOFTWARE IS DIFFERENT	X	X
(DUAL ILS FAILURE) AND (THE A/P IS ENGAGED AND LOC MODE IS ACTIVE)		X
(DUAL ILS FAILURE) AND (THE A/P IS ENGAGED AND G/S MODE IS ACTIVE)		X
(DUAL RADIO ALTIMETER FAIL) AND (RADIO ALTITUDE IS BELOW 1500 FT)		X
LAND 3 STATUS AND (BOTH CONTROL WHEEL BACKDRIVE ACTUATORS FAIL) OR (BOTH CONTROL COLUMN BACKDRIVE ACTUATORS FAIL) OR (BOTH RUDDER PEDAL BACKDRIVE ACTUATORS FAIL)	X	X
THE MCP DISENGAGE BAR IS DOWN	X	X
A CONTROL WHEEL DISENGAGE SWITCH IS PUSHED	X	X
(BOTH ANGLE OF ATTACK VANES FAIL) AND (THE PFCS STALL PROTECTION MODE IS ACTIVE)	X	X
THE AUTOPILOT PITCH OR ROLL COMMAND IS ABOVE THE PFCS LIMIT	X	X
A PFC DETECTS A PILOT OVERRIDE OF THE COLUMN, WHEEL OR PEDAL		X
LEFT AND RIGHT AFDCS FAIL	X	X

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AFDS - FUNCTIONAL DESCRIPTION - AUTOLAND ENGAGE INTERLOCK CONDITIONS

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AFDS - FUNCTIONAL DESCRIPTION - ENGAGE INTERLOCKS MASTER/SLAVE SELECTION

General

The AFDCs operate as master or slave when the autopilot engages in cruise. Two or three AFDCs must engage before the master/slave selection occurs.

Only the left or right AFDCs can be master because they operate the backdrive actuators. Any of the three AFDCs can operate as slave.

The master selection changes between the left and right AFDC to:

- Apply equal wear between the backdrive actuators
- Automatically select a good AFDC for master after a failure disengages the autopilot.

The AFDS does not use the master/slave function in autoland.

Selection Process

The AFDCs use these methods to select the master AFDC:

- The right AFDC is the master when the AFDS gets power
- The master AFDC changes each time the autopilot disengages and re-engages.

Master AFDC Function

The master AFDC does these functions:

- Column and wheel backdrive actuator selection and control in cruise
- Wheel backdrive actuator selection during BAP
- Control of AFDS modes
- Sends AFDS mode data to the slave AFDCs
- Calculate pitch, roll and yaw commands.

If the master AFDC cannot do these functions, the autopilot disengages. You can engage the autopilot again with a different AFDC as the master.

The MCP microprocessor in control follows the master AFDC selection when:

- The left AFDC is the master, MCP microprocessor A writes to all the MCP displays
- The right AFDC is the master, MCP microprocessor B writes to all the MCP displays.

Slave AFDC Function

The slave AFDC does these functions:

- Calculate pitch, roll and yaw commands
- Receives AFDS mode data from the master AFDC
- Limits the AFDS pitch and roll commands to safe values.

If a slave AFDC cannot do its functions, the PFCs do not use autopilot commands from that AFDC.

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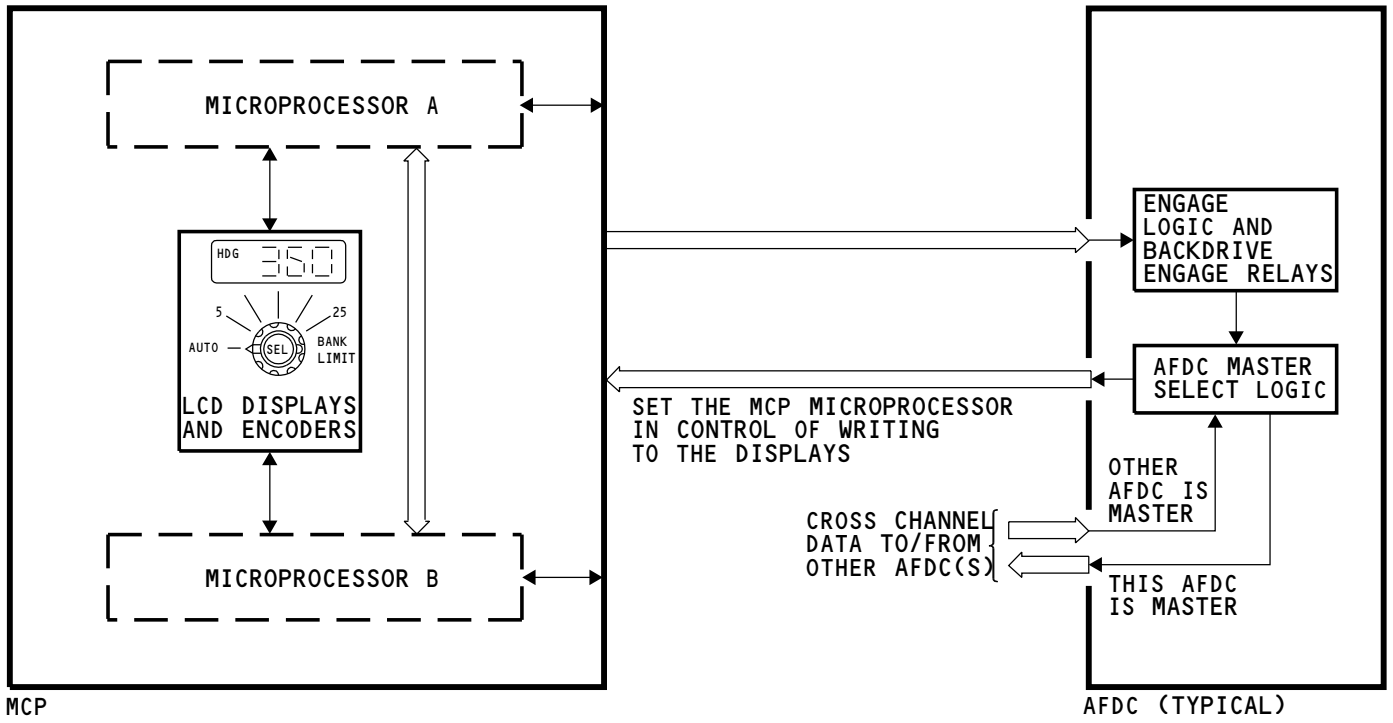

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AFDS - FUNCTIONAL DESCRIPTION - ENGAGE INTERLOCKS MASTER/SLAVE SELECTION

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AFDS - ILS ANTENNA SWITCHING LOGIC

ILS Antenna Switching

The autopilot flight director computers (AFDCs) select the position of their onside localizer and glideslope antenna switches.

ILS Tune Inhibit

The AFDCs prevent tuning of the multi-mode receivers (MMRs) when the airplane makes an autopilot engaged approach. The AFDCs also prevent tuning of the MMRs when the pilot makes a flight director only approach and the airplane is below 500 feet of radio altitude.

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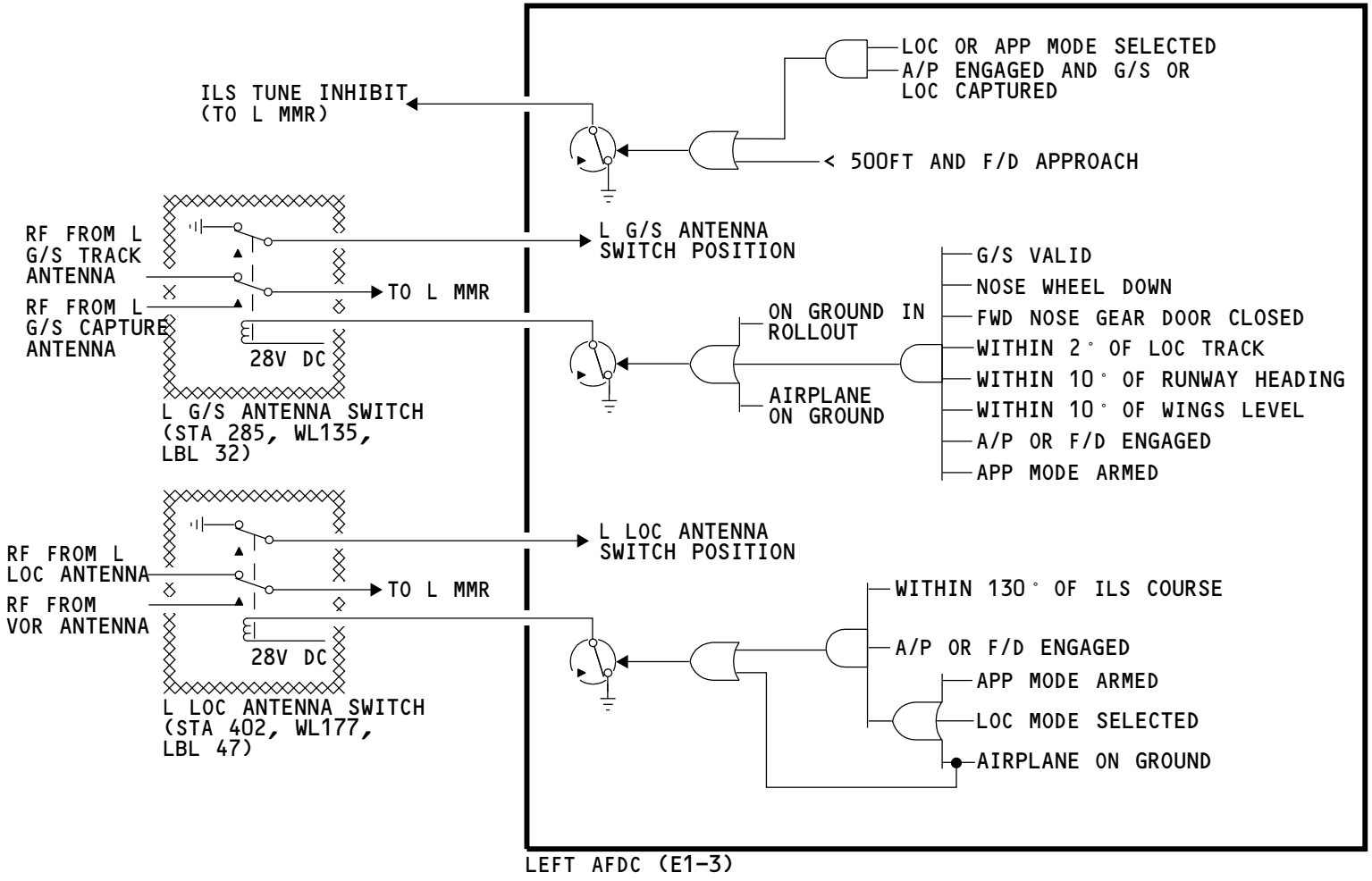

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AFDS - ILS ANTENNA SWITCHING LOGIC

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AFDS - FUNCTIONAL DESCRIPTION - WARNING AND ANNUNCIATION INTRODUCTION

General

The AFDCs warning and annunciation functions send normal and non-normal indications of AFDS performance to:

- The AIMS cabinets
- The warning electronic system (WES).

Description

Each AFDC sends this normal data to the AIMS cabinets:

- Mode
- Status
- Flight director commands
- Autoland status.

AIMS shows this data on the primary flight displays (PFDs).

Each AFDC sends this non-normal data to AIMS:

- Autopilot disconnect warning
- Autopilot caution
- Autoland status
- Mode fail
- Flight director (F/D) fail.

Each AFDC sends the disconnect warning discrete to the WES. This causes the master warning lights and the wailer to come on.

The AIMS also turns on the master caution light and causes the WES to make the caution aural.

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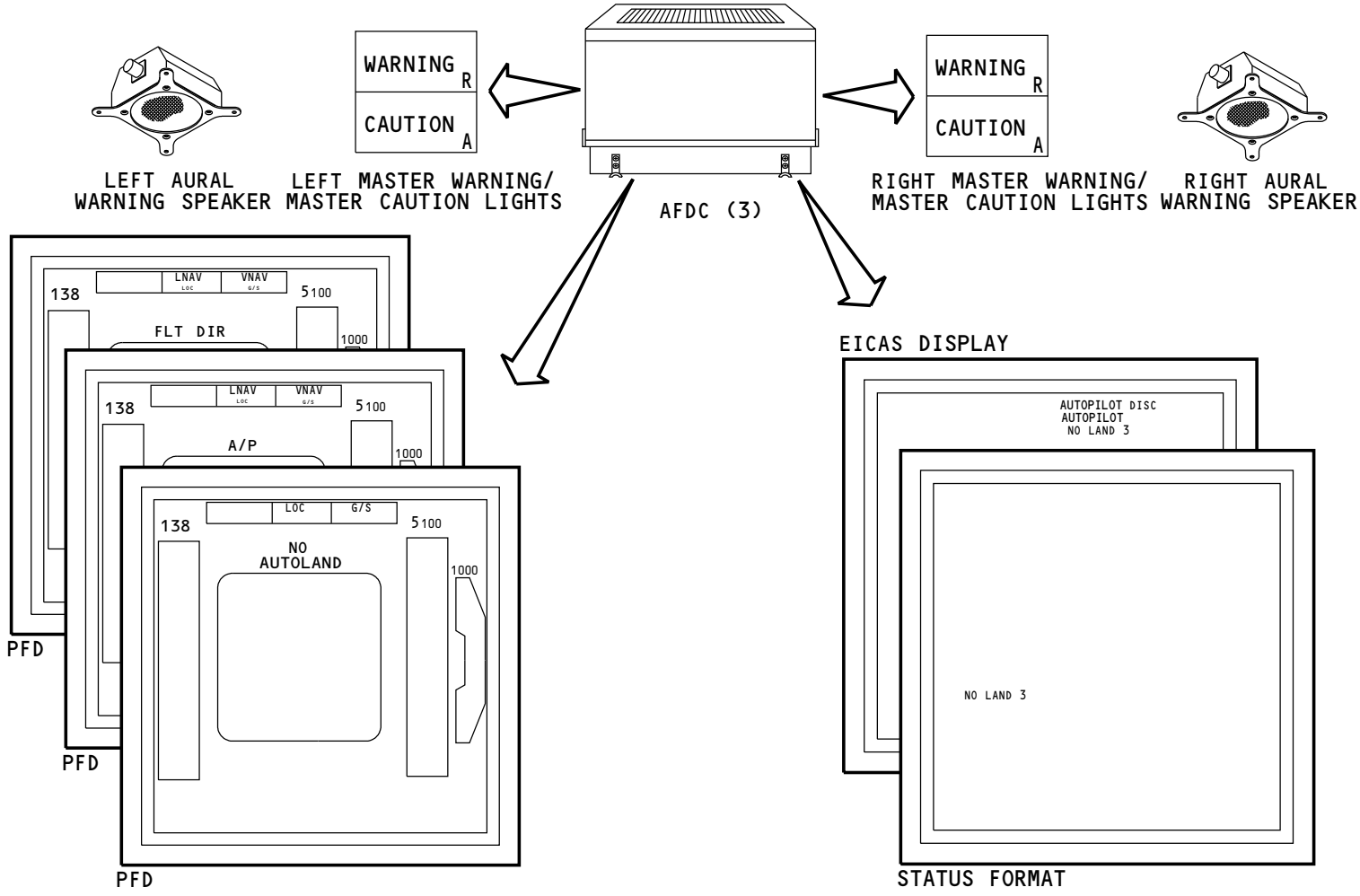

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AFDS - FUNCTIONAL DESCRIPTION - WARNING AND ANNUNCIATION INTRODUCTION

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AFDS - FUNCTIONAL DESCRIPTION - WARNING AND ANNUNCIATION - PFD AND ND DISPLAYS

General

The primary flight displays (PFDs) show AFDS modes, status messages, and flight director (F/D) information. The PFD also shows selected mode control panel (MCP) data.

Display Priority

The AIMS uses the validity of the three AFDCs and the MCP A and B processors to find the priority for the displays.

This is the AFDC priority for the captain PFD:

- left AFDC if valid
- Center AFDC if left AFDC is not valid
- Right AFDC if left and center AFDCs are not valid.

This is the AFDC priority for the first officer PFD:

- Right AFDC if valid
- Center AFDC if right AFDC is not valid
- Left AFDC if right and center AFDCs are not valid.

This is the MCP priority for both PFDs:

- The A microprocessor if valid
- The B microprocessor if the A microprocessor is not valid.

AFDS Modes

The top of the PFD shows the AFDS modes of operation. This is the flight mode annunciator (FMA). Active and arm pitch and roll modes show.

The failure of sensor data necessary for the active pitch or roll mode causes a yellow bar to show through the mode on the FMA. This bar indicates a mode failure. An arm mode will not show the mode fail bar.

Flight Director Commands

Flight director commands show on the PFD as pitch and roll F/D bars. A mode fail causes the appropriate F/D bar to go out of view.

When the AIMS does not receive any valid F/D data from the AFDCs and either of the F/D switches is on, a F/D failure flag shows on the PFD.

AFDS Engage and Autoland Status Annunciation

The AIMS shows this AFDS status:

- FLT DIR - when in flight director only operation
- A/P - when in autopilot operation
- LAND 3, LAND 2, or NO AUTOLAND - when in approach and below 1500 feet radio altitude
- Test - if any AFDC is in test.

This is the autoland status display priority:

- NO AUTOLAND
- LAND 2
- LAND 3.

MCP Selected Data

The AIMS shows this data from the MCP:

- Selected speed
- Selected mach
- Selected altitude
- Selected vertical speed
- Selected flight path angle
- Selected heading
- Selected track.

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Selected Flight Path Angle

Selected flight path angle (FPA) shows on the PFD when you select FPA on the MCP. The selected FPA is a target for the flight path vector (FPV) symbol, it is not a target for the flight director pitch bar. If you select FPA on the MCP before you select the FPV on the EFIS control panel, the FPV will show automatically on the PFD.

Navigation Display (ND)

The ND shows the selected track or heading cursors. The AIMS uses the validity of the MCP A and B processors for the priority of the display.

This is the MCP priority for both NDs:

- A processor
- B processor.

Barometric Reference Source

The barometric reference source shows which barometric (baro) correction the AFDCs use. An L shows that the AFDCs use the captain baro correction value. An R shows that the AFDCs use the first officer baro correction value. Both PFDs show the same baro reference source.

When there is no autopilot engagement and whe the flight director is selected only, the AFDCs use the captain barometric correction when the left flight director switch is on, and both PFDs show the letter L. If you select the ON position for only the right flight director switch, the AFDCs use the first officer barometric correction and both PFDs show the letter R. If both flight director switches are on, the AFDCs use the captain barometric correction, and both PFDs show the letter L

When you engage the autopilot with the left autopilot engage switch, the AFDCs use the captain baro correction value and both PFDs show the letter L. When you engage the autopilot with the right autopilot engage switch, the AFDCs use the first officer baro correction value and both PFDs show the letter R.

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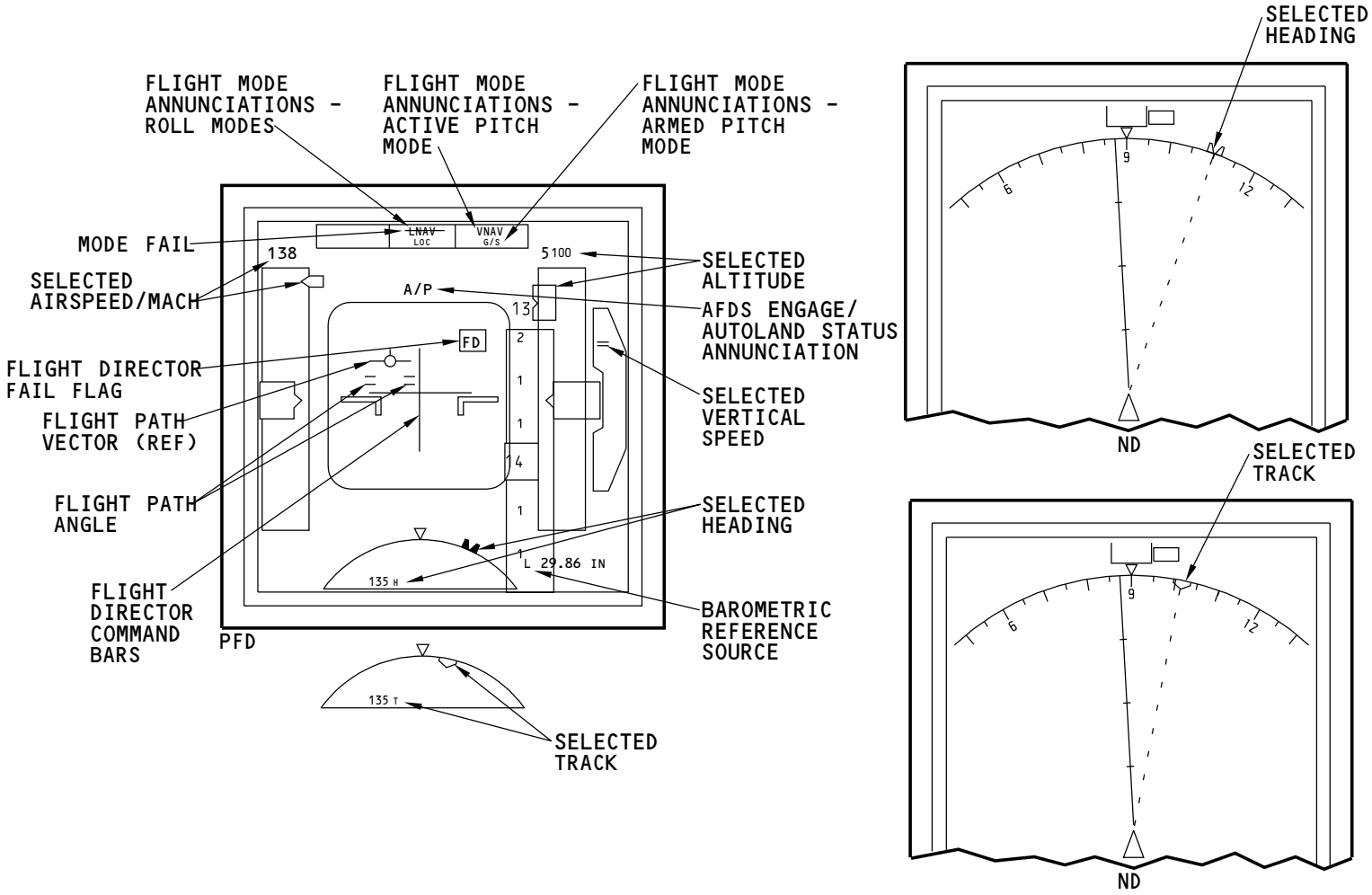

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AFDS - FUNCTIONAL DESCRIPTION - WARNING AND ANNUNCIATION - PFD AND ND DISPLAYS

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AFDS - FUNCTIONAL DESCRIPTION - WARNING AND ANNUNCIATIONS - EICAS DISPLAYS

General

The EICAS and MFD displays show messages, warnings, and autoland capability for the autopilot system. The warning electronic units (WEUs) make the master warning lights come on when a warning message shows on the EICAS display. The AIMS makes the master caution lights come on when a caution message shows on the EICAS display.

The AFDCs send data that causes these types of messages to show on the EICAS display and the MFD:

- Warning on the EICAS display
- Caution on the EICAS display
- Advisory on the EICAS display
- Status on the status display.

Warning

The AFDCs send the AUTOPILOT DISC warning message request to the AIMS when either of these happens:

- The flight crew disconnects all engaged AFDCs
- All engaged AFDCs automatically disconnect.

The wheel disconnect switch resets the AUTOPILOT DISCONNECT warning.

The wheel disconnect switch tests the AUTOPILOT DISCONNECT warning if the autopilot is not engaged. The warning resets when the flight crew releases the switch.

Caution

The AFDCs send these autopilot caution messages requests to the AIMS:

- AUTOPILOT, when an autopilot mode fail occurs
- NO LAND 3, when autoland capability degrades while in approach after LAND 3 shows. This only occurs above 200 feet radio altitude
- NO AUTOLAND, when all autoland capability is lost during approach after LAND 2 or LAND 3 has shown. This also occurs during approach if LAND 2 or LAND 3 is not active by 600 feet radio altitude.

Advisory

The AFDCs send these advisory message requests to the AIMS:

- NO LAND 3, when autoland capability degrades before the LAND 3 autoland status annunciation shows
- NO AUTOLAND, when loss of all autoland capability occurs before the LAND 3 or LAND 2 autoland status annunciation shows.

Status

The AFDCs send these autopilot status message requests to the AIMS:

- AFDC L, R, or C; when an AFDC does not operate
- AUTOPILOT BACKDRIVE L or R, when the left or right backdrive system does not operate
- MODE CTRL PANEL LANE, when one of the two lanes in the AFDS MCP or its interface to the AFDC fails
- NO AUTOLAND, when loss of all autoland capability occurs
- NO LAND 3, when the NO LAND 3 caution or advisory message shows
- NO LAND 3, autoland capability degrades during approach when the airplane is below 200 feet radio altitude. There is no caution or advisory message.

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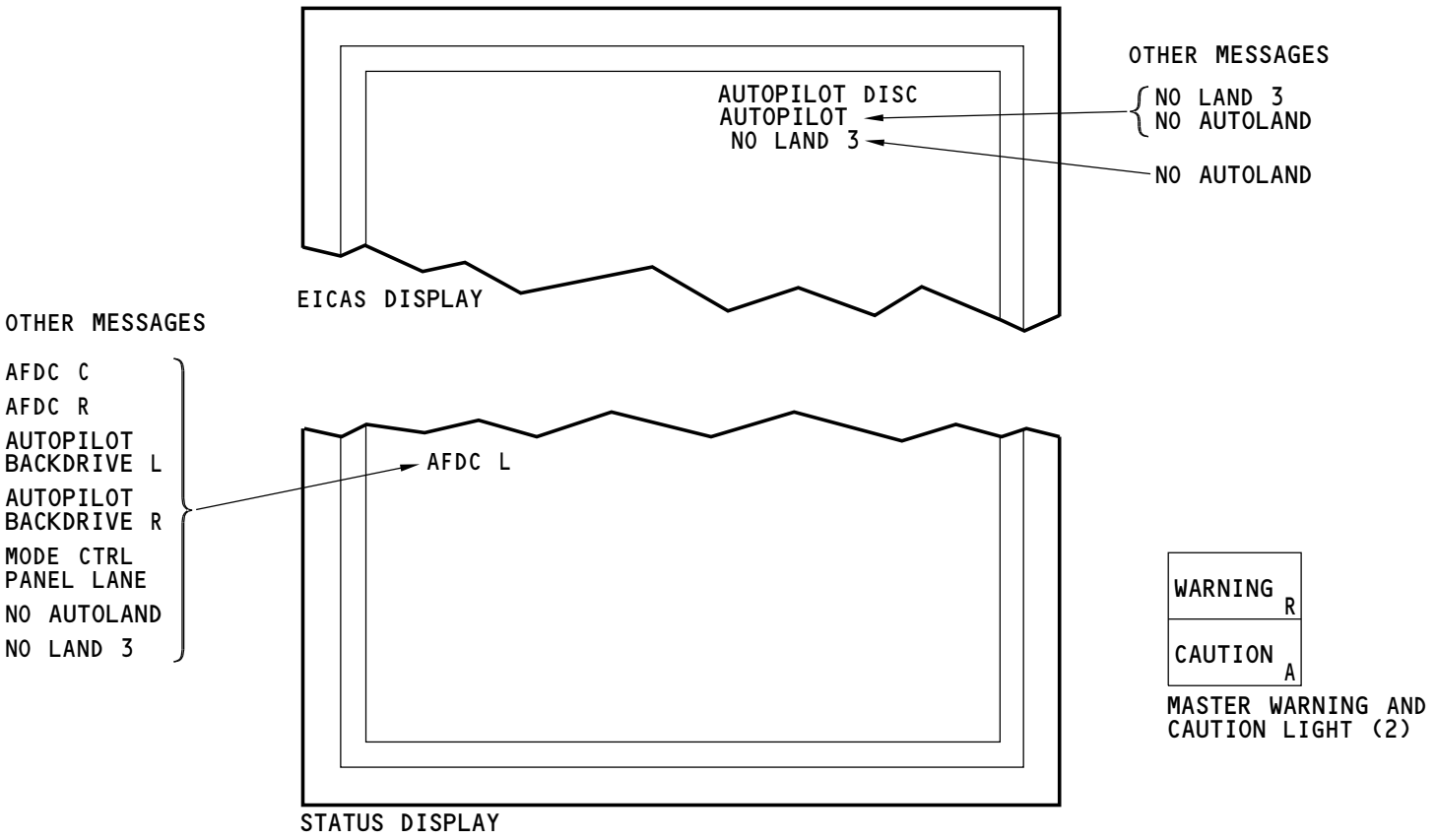

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AFDS - FUNCTIONAL DESCRIPTION - WARNING AND ANNUNCIATIONS - EICAS DISPLAYS

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AFDS - SPECIAL FUNCTIONS

General

You can select these two special functions on the MAT:

- Localizer antenna switching
- Glideslope antenna switching.

The AFDS special functions make the localizer and glideslope switches change position. You use these special functions during ILS system troubleshooting.

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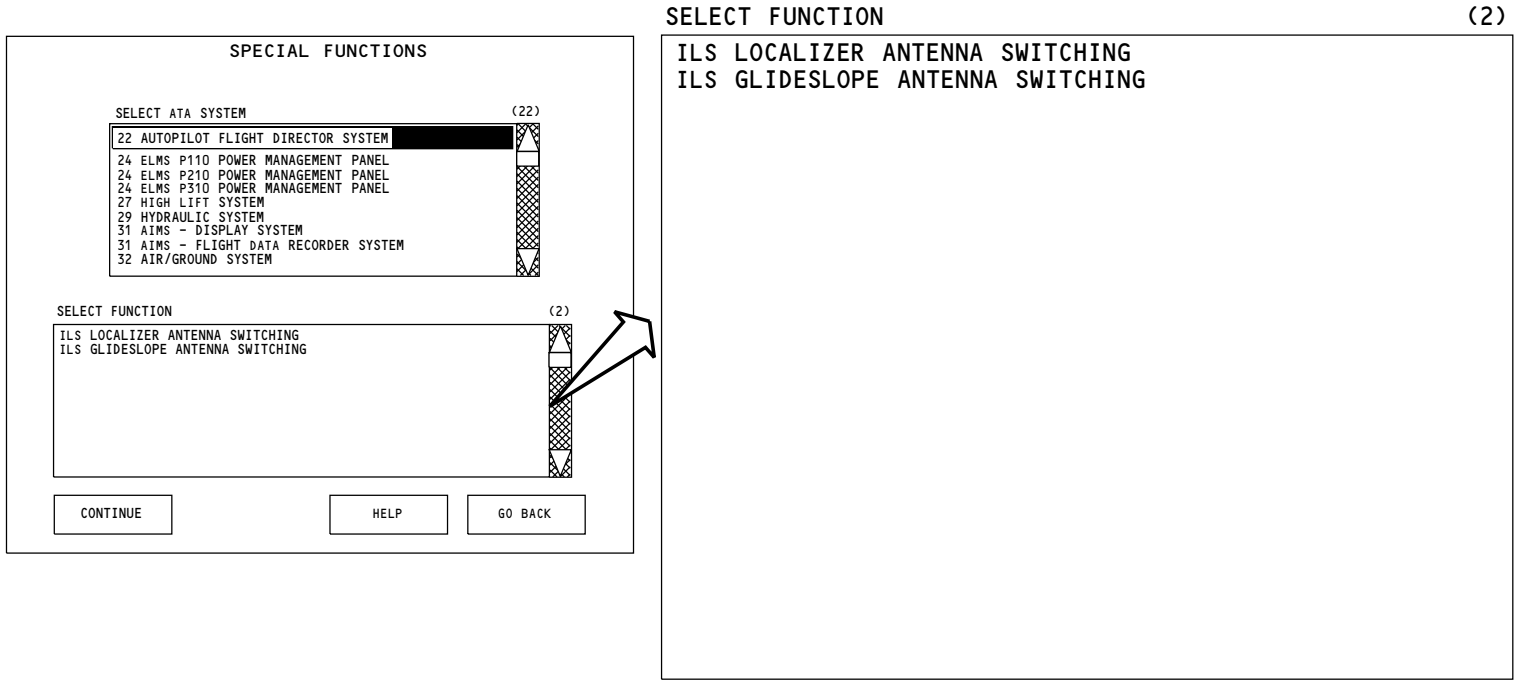

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AFDS - SPECIAL FUNCTIONS

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AFDS - LRU TESTS

General

The LRU replacement tests verify the correct installation of an LRU.

Autopilot Disconnect Switch LRU Replacement Test

The autopilot disconnect switch LRU replacement test makes sure all contacts of the captain's and first officer's disconnect switches operate correctly.

During the test, the MAT tells you to operate the captain's and first officer's disconnect switches one at a time. The test makes sure all AFDCs receive the correct results.

The autopilot disconnect switch LRU replacement test isolates faults to:

- The AFDC (left, center, or right)
- The captain's disconnect switch
- The first officer's disconnect switch.

AFDC LRU Replacement Tests

The left, right, or center AFDC LRU replacement test causes the AFDC self-test and interface test to start. At the end of the test, the MAT shows AFDC internal and interface faults.

Backdrive Actuator LRU Replacement Tests

All backdrive actuator LRU replacement tests make sure the backdrive electrical signal wires are good. They also make sure the flight deck controls move to the correct position at the correct rate. The left or right AFDC:

- Calculates the backdrive command
- Engages its backdrive actuator
- Drives its backdrive actuator.

The backdrive actuator LRU replacement tests isolate faults to:

- The AFDC (left or right)
- Tachometer A
- Tachometer B
- The engage clutch
- The motor.

Mode Control Panel LRU Replacement Test

The mode control panel LRU replacement test isolates faults to the:

- AFDC (left, center, or right)
- MCP
- MCP/AFDC interface.

TO/GA Switch LRU Replacement Test

The TO/GA switch LRU replacement test makes sure all contacts of both TO/GA switches operate correctly. The TO/GA switches interface with all AFDCs and AIMS cabinets.

During the test, the MAT tells you to operate the left and right go-around switches one at a time. The test makes sure all AFDCs and AIMS cabinets receive the correct results.

The TO/GA switch LRU replacement test isolates faults to the:

- AFDC (left, center, or right)
- TO/GA switch
- TO/GA switch analog interface with all AFDCs and AIMS cabinets.

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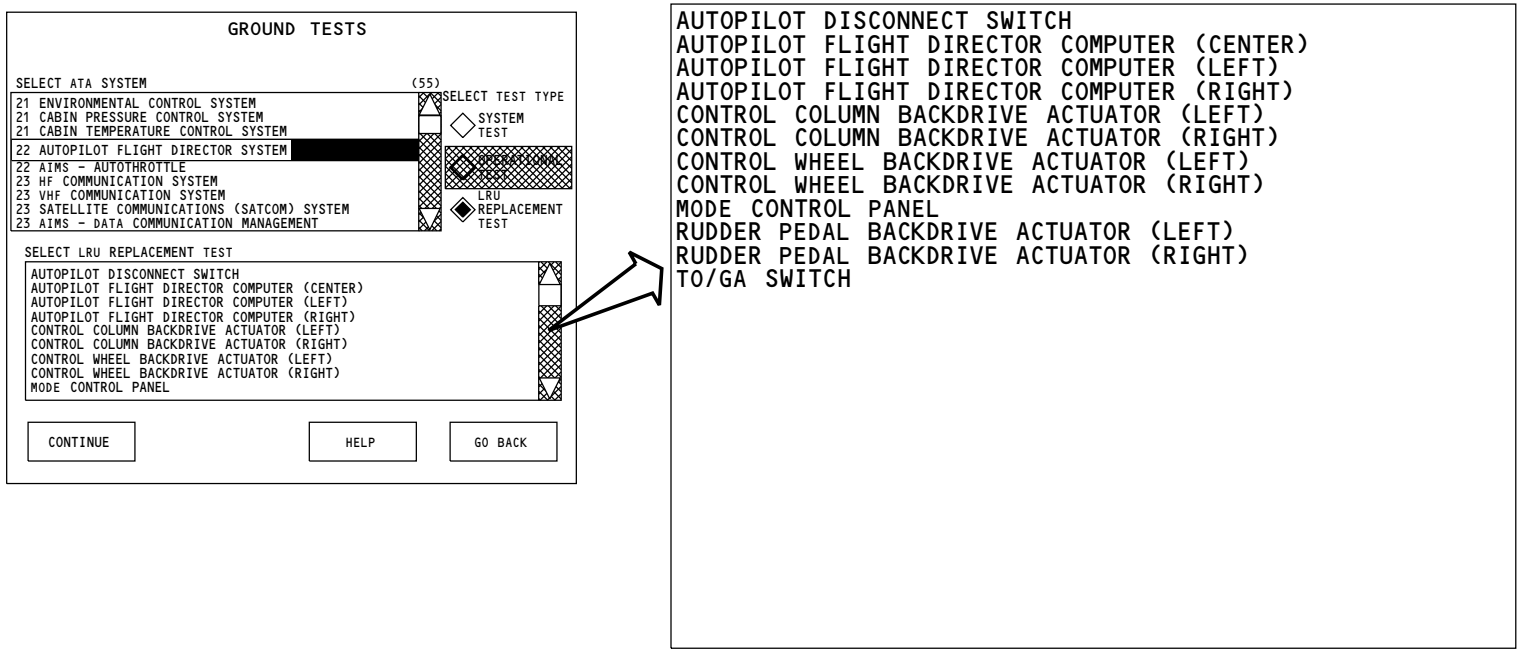

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AFDS - LRU TESTS

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AFDS - SYSTEM TESTS

General

The AFDS system tests verify the correct functionality of the AFDS.

Autopilot Disconnect Warning System Test

The autopilot disconnect warning system test makes sure these functions are correct:

- Installation and operation of the A/P disengage switches
- 28v dc battery power input to the AFDCs
- A/P analog cross-channel discretes
- AFDS-WES analog interfaces
- AFDS-AIMS cabinet analog interfaces
- AFDC disengage warning monitors.

During the test, the MAT tells you to operate the captain's and first officer's disengage switches. You then make sure these functions operate correctly:

- The aural warning
- The master warning lights
- The EICAS messages.

AFDCs System Test

The test program for the AFDCs system test causes all three AFDCs to do a self-test and interface test. This test detects these:

- AFDC internal failures
- Analog signals that are not in their normal state when the airplane is on the ground and is not moving
- ARINC 629 input bus inactivity
- ARINC 429 input bus inactivity
- Incorrect ILS or RA to AFDC connections. For example, left ILS receiver or radio altimeter transceiver not connected to the left AFDC.

Backdrive Actuator System Tests

These tests operate like the LRU replacement tests for the control column, control wheel, or rudder pedal actuators. The tests also do a check of dual backdrive functions.

This test isolates the same faults as the backdrive actuator LRU replacement tests and these:

- Actuator polarity faults
- Single actuator drive faults
- Dual actuator drive faults
- AFDC backdrive monitor faults.

ILS Interface System Test

The ILS interface system test makes sure these functions are correct for all three AFDCs:

- Localizer antenna switches
- Glideslope antenna switches
- ILS tune inhibit.

During the test, the AFDCs operate these functions to make sure all signal wires are correct:

- Tune inhibit discrete
- Localizer antenna switches
- Glideslope antenna switches.

Mode Control Panel System Test

The MCP system test makes sure these functions are correct:

- All MCP switches, selectors and displays
- MCP panel variable lighting
- MCP configuration pins
- Autothrottle switch discrete output to AIMS

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- ARINC 429 bus output to AIMS and the AFDCs
- ARINC 429 inputs from the AFDCs
- Disengage bar discrete outputs to the AFDCs
- Disengage bar discrete inputs from the AFDCs
- Input activity for all buses
- AFDC MCP flight fault monitors.

During the test, the MAT tells you to operate all switches and selectors applicable to the MCP. You also visually monitor the displays on the MCP for correct results.

This MCP system test isolates the same faults as the MCP LRU replacement test and these:

- MCP switch, selector, lights, and display faults
- MCP program pin faults
- MCP/AFDC discrete interface faults
- MCP/AIMS discrete interface faults
- ARINC 429 output bus faults
- Internal MCP monitor faults
- Internal MCP redundant and parallel data path faults.

TO/GA Switch System Test

The TO/GA switch system test is the same as the TO/GA switch LRU replacement test.

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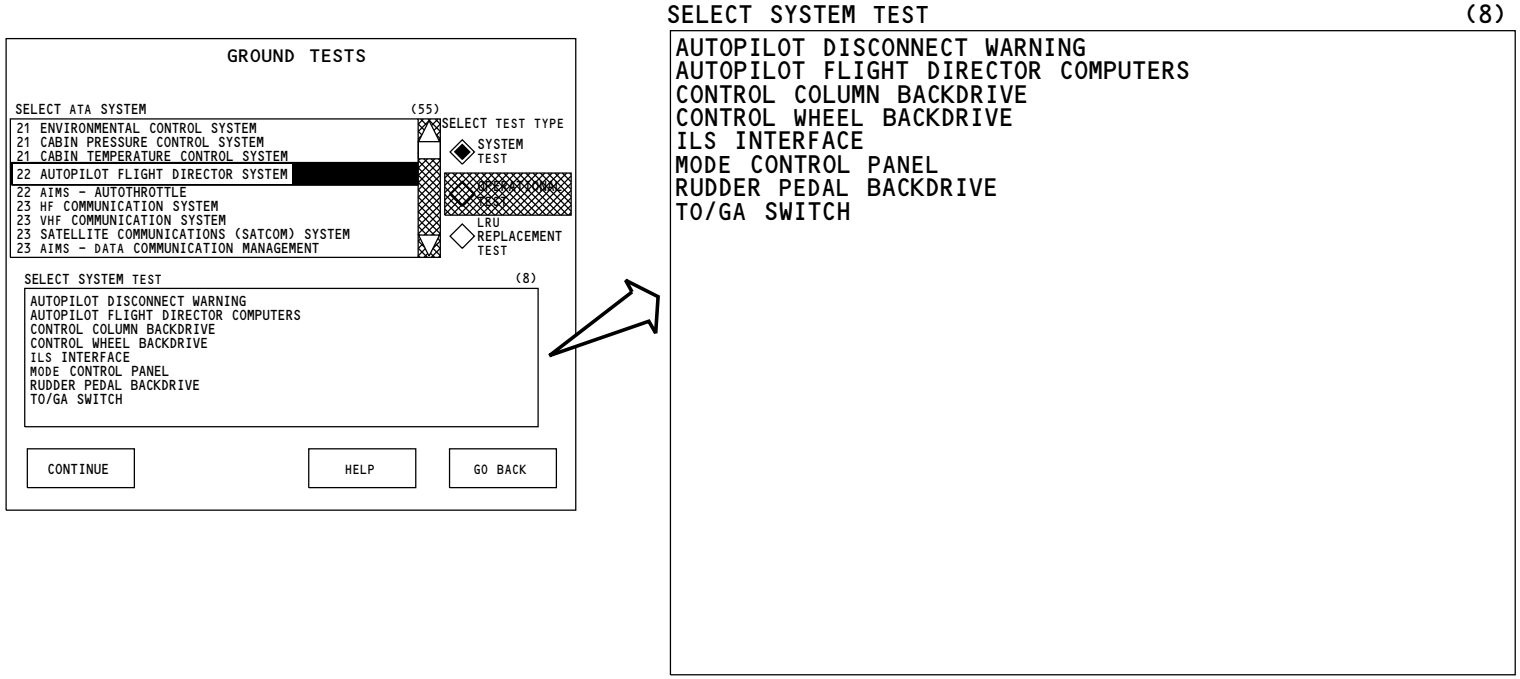

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AFDS - SYSTEM TESTS

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THRUST MANAGEMENT COMPUTING SYSTEM (TMCS) - INTRODUCTION

General

The thrust management computing system (TMCS) is part of the airplane information management system (AIMS). The TMCS controls engine thrust in response to mode requests from the:

- Mode control panel (MCP)
- Flight management computing function (FMCF)
- Flight deck switches.

The TMCS can operate in all flight phases.

Abbreviations and Acronyms

- A/P - autopilot
- A/T - autothrottle
- ACMF - airplane condition monitoring function
- ADIRU - air data inertial reference unit
- AFDC - autopilot flight director computer
- AFDS - autopilot flight director system
- AGL - above ground level
- AIMS - airplane information management system
- alt - altitude
- app - approach
- ARINC - Aeronautical Radio, Incorporated
- ASCPC - air supply cabin pressure controller
- ASG - ARINC signal gateway
- ASIC - application specific integrated circuit
- ASM - autothrottle servo motor
- BARO - barometric altitude
- clb - climb
- CMCF - central maintenance computing function
- cmd - command
- con - continuous
- CPM - core processor module
- CTC - cabin temperature controller
- D - derate
- des - descent
- DFDAF - digital flight data acquisition function
- disc - disconnect
- DCGF - data conversion gateway function
- DCMF - data communication management function
- ECM - electronic control module
- EEC - electronic engine control
- EDIU - engine data interface unit
- FD - fire detection
- FDCF - flight deck communication function
- F/D - flight director
- FLCH - flight level change
- flt - flight
- FMCF - flight management computing function
- FMCS - flight management computing system
- FPM - feet per minute
- FPS - feet per second
- FSEU - flap slat electronics unit
- G/A - go around
- GG - graphics generator
- GS - ground speed
- GW - gross weight
- IAS - indicated airspeed
- IC - intercabinet
- IOM - input/output module
- KTS - knots (nautical miles per hour)
- L - left

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THRUST MANAGEMENT COMPUTING SYSTEM (TMCS) - INTRODUCTION

- MAT - maintenance access terminal
- MCP - mode control panel
- Mmo - maximum operating mach
- N1 - low speed compressor RPM
- N2 - high speed compresor RPM
- OPAS - overhead panel ARINC system
- OPBC - overhead panel bus controller
- OPC - operational program configuration
- OPS - operational program software
- PDF - primary display function
- PFC - primary flight computer
- PTH - path
- PSEU - proximity sensor electronics unit
- PSB - power switching bridge
- PSM - power switching module
- PSU - power switching unit
- PSU - power supply unit
- pwr - power
- QARF - quick access recorder function
- ref - reference
- rqst - request
- R - right
- RA - radio altimeter
- RT - receiver-transmitter
- SAARU - secondary attitude air data reference unit
- SO - shutoff
- SPD - speed
- tach - tachometer
- TAS - true airspeed
- TAT - total air temperature
- T/D - top of descent
- TMCF - thrust management computing function
- thr - thrust
- thr ref - thrust reference
- TLC - thrust limit calculation
- TLDB - thrust limit data base
- TO - takeoff
- TO/GA - takeoff/go-around
- UTCF - universal time (coordinated) function
- Vmo - maximum operating velocity
- VNAV - vertical navigation
- WES - warning electronic system
- WEU - warning electronic unit

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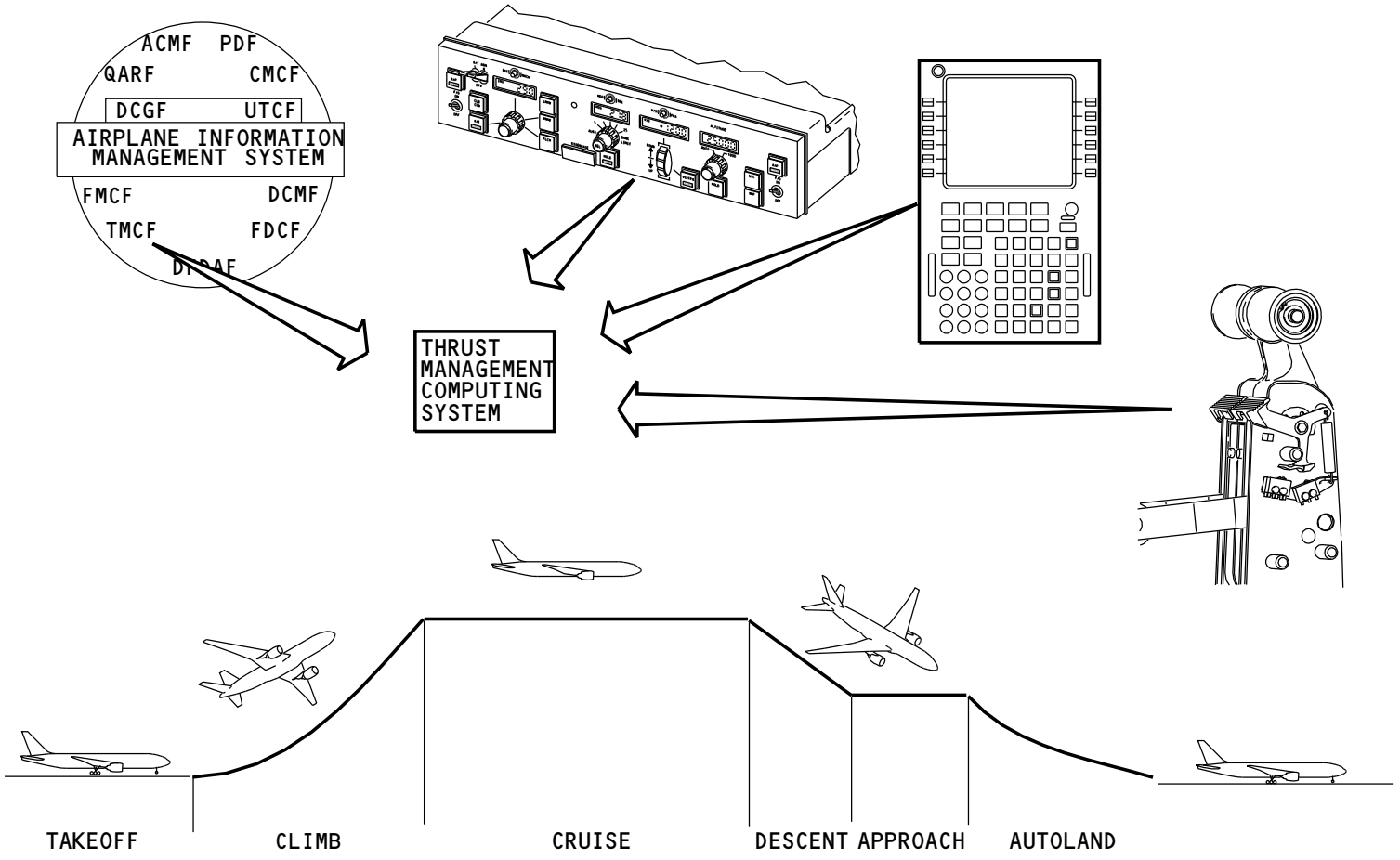

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THRUST MANAGEMENT COMPUTING SYSTEM (TMCS) - INTRODUCTION

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TMCS - GENERAL DESCRIPTION

General

The operator interface to the TMCS is through the Control Display Unit (CDU)s and the Mode Control Panel (MCP). Several airplane systems and components send and receive TMCS information. TMCS information shows on the Primary Flight Display (PFD) and the Engine Indication and Crew Alerting System (EICAS) display.

TMCS Components

The TMCS has these components:

- TMCF in Airplane Information Management System (AIMS) cabinets.
- Autothrottle servo motors (ASMs).
- A/T disconnect switches.
- Takeoff go-around (TO/GA) switches.
- A/T arm and mode switches on the MCP.

There are two TMCFs, one in each AIMS cabinet. Each TMCF gets digital and digital discrete data from airframe and engine components. The TMCF also receives flight deck commands (A/T mode requests) and switch position inputs.

The TMCS does these sub-functions:

- Autothrottle (A/T) control laws.
- Thrust limit calculation.
- Engine trim calculation.
- Built-In-Test Equipment (BITE) and fault monitoring.
- TMCS annunciations.

The ASMs receive digital commands from the TMCF and analog data from the MCP.

The A/T disconnect and TO/GA switches on the center aisle control stand supply disconnect, TO or GA inputs to the TMCF.

The MCP A/T arm and mode switches send digital control and mode data to the TMCF.

The A/T arm switches on the MCP supply analog arm or inhibit signals to the ASMs. They also supply engine trim enable logic to the electronic engine controls (EECs).

TMCS Interfaces

The TMCF receives data on the flight controls Aeronautical Radio Incorporated (ARINC) 629 data buses from these components:

- Air Data Inertial Reference Unit (ADIRU).
- Secondary Attitude Air Data Reference Unit (SAARU).
- Primary Flight Computer (PFC).

The TMCF receives data on the systems ARINC 629 data buses from these components:

- Autopilot Flight Director Computer (AFDC).
- Air Supply Cabin Pressure Controller (ASCPC)(2).
- Cabin Temperature Controller (CTC) (2).
- Proximity Switch Electronics Unit (PSEU) (2).
- Warning Electronic Unit (WEU) (2).
- Engine Data Interface Unit (EDIU) (2).
- Overhead Panel Bus Controller (OPBC) (2).
- Flap/Slat Electronics Unit (FSEU) (2).
- ARINC Signal Gateway (ASG) (2).
- CDU (3).

The TMCF receives ARINC 429 data from these:

- MCP.
- Radio Altimeter (RA) transceiver (xcvr) (3)
- Autothrottle servo motor (ASM) (2).

The TMCF receives analog inputs from these:

- Engine RPM, N1/N2
- Fuel shutoff switch (2)

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- Master warning and caution light switch.

The TMCF also receives analog inputs from these:

- Autothrottle (A/T) disconnect switch (2)
- Takeoff go-around (TO/GA) switch (2)
- Autothrottle servo motor (ASM) (2).

The TMCF sends data to these components and switches:

- WEU (2).
- EDIU (2).
- AFDC (3).
- PFC (3).
- Master warning and caution light switch (2)
- ASM (2).

The TMCF sends display and fault data to the primary display function and the central maintenance computing function in the AIMS cabinets.

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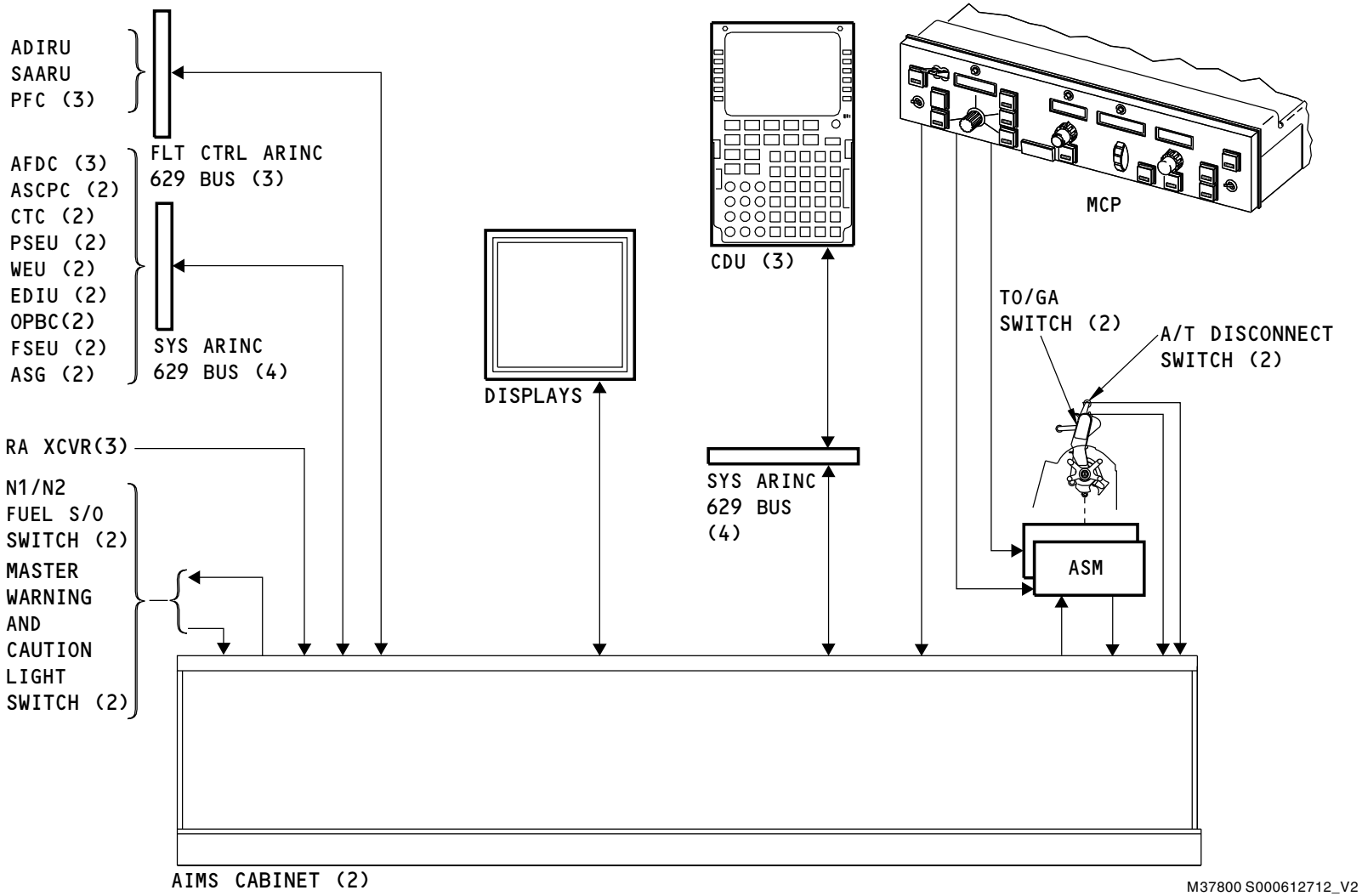

TMCS - GENERAL DESCRIPTION

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TMCS - FLIGHT DECK COMPONENT LOCATIONS

TMCS Component Locations - P55

These are the components of the TMCS on the P55 glareshield center panel:

- Autothrottle (A/T) mode switch (2) on mode control panel (MCP)
- A/T arm switch (2) on MCP.

TMCS Component Locations - P10

These are the components of the TMCS on the thrust levers and below the control stand:

- Takeoff go-around (TO/GA) switch (2)
- A/T disconnect switch (2)
- A/T servo motor (ASM) (2), one on each side below the control stand.

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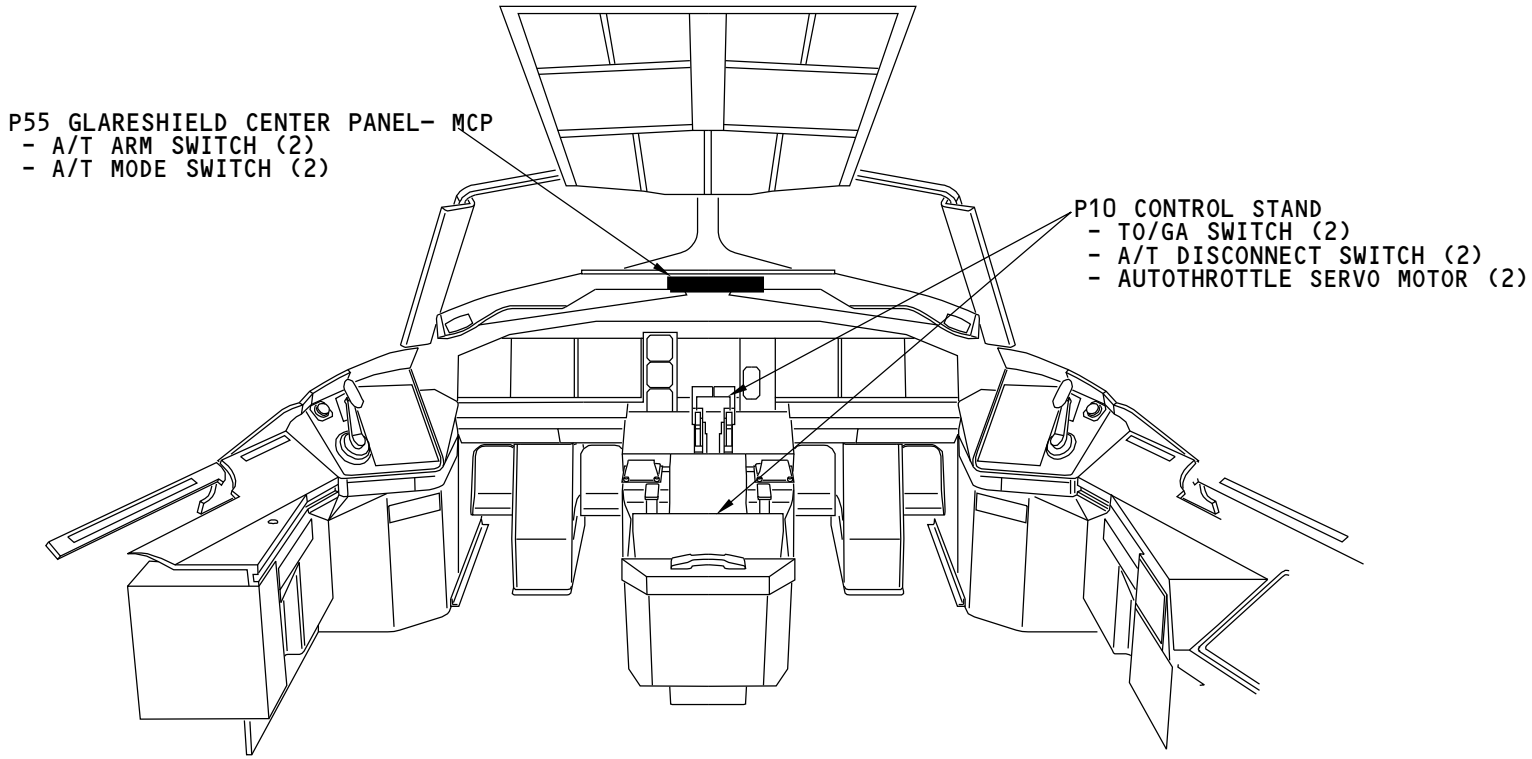

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TMCS - FLIGHT DECK COMPONENT LOCATIONS

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TMCS Component Locations - MEC

The thrust management computing function (TMCF) is part of the airplane information management system (AIMS). The left AIMS cabinet is on the E3-1 shelf. The right AIMS cabinet is on the E2-1 shelf.

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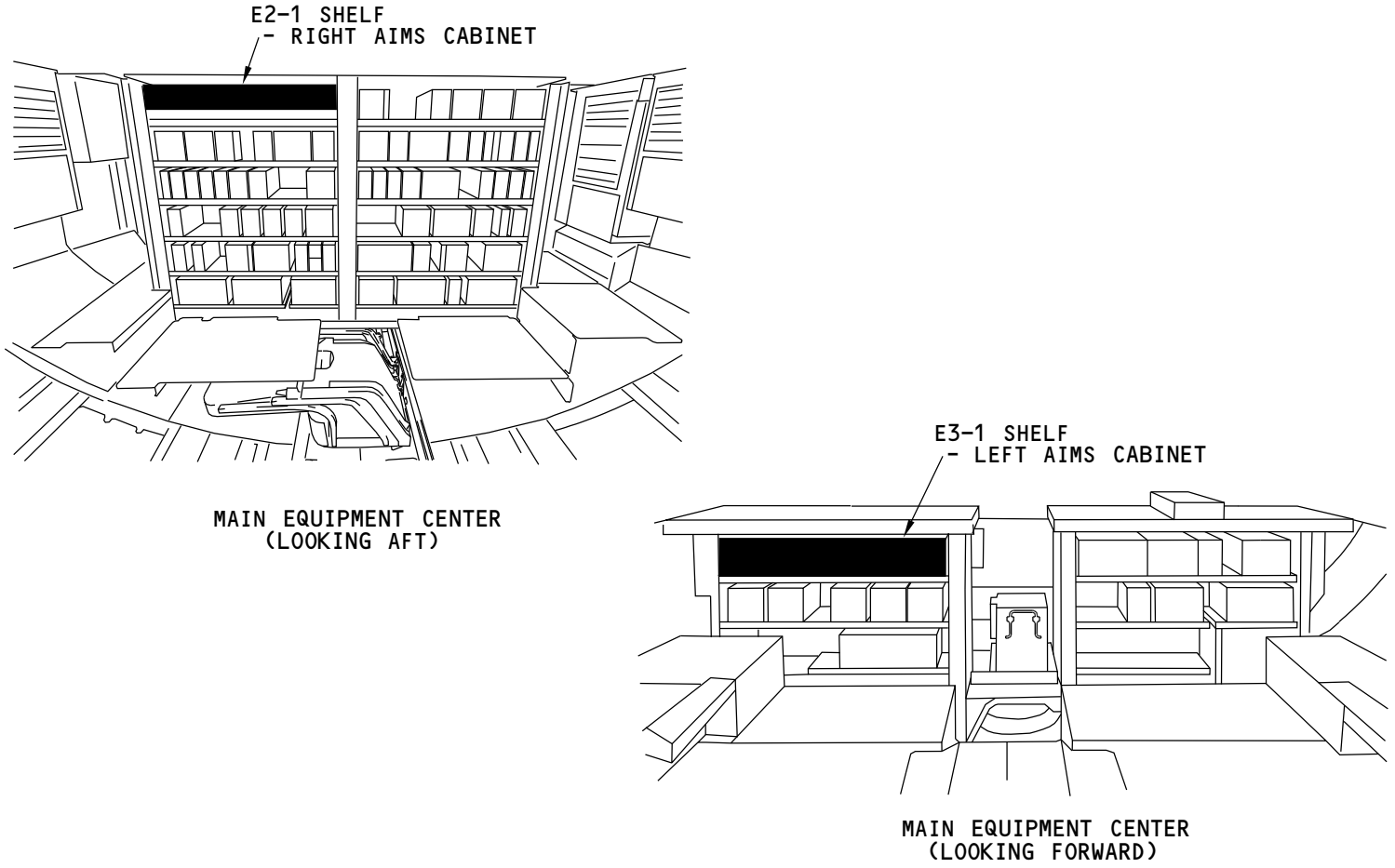

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TMCS - MAIN EQUIPMENT CENTER COMPONENT LOCATIONS

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TMCS - INTERFACES - 1

General

The left and right AIMS cabinets receive inputs from and send outputs to many components, sensors, and switches for the thrust management computing function (TMCF). These interfaces are on the flight controls ARINC 629 data buses, the systems ARINC 629 data buses, or analog discrete signals.

The IOMs show the inputs that come directly from TMCF components.

ADIRU Inputs - Flight Control Bus (L and R)

The air data inertial reference unit (ADIRU) sends these parameters and status to the TMCFs:

- Altitude
- Vertical speed
- Air speed
- Mach
- Temperature
- Ground speed (G/S).

The TMCFs use this data to calculate the A/T modes and thrust limits.

SAARU Inputs - Flight Control Bus (C)

The secondary attitude air data reference unit (SAARU) sends these backup parameters to the TMCFs:

- Altitude
- Vertical speed
- Air speed
- Mach
- Temperature
- Ground speed (G/S).

The TMCFs use this data to calculate the A/T modes and thrust limits.

PFC Outputs - Flight Control Bus (L, R, and C)

The PFCs receive this data from the TMCFs:

- Left engine idle discrete
- Right engine idle discrete
- Left engine fail
- Right engine fail
- Speed mode
- Go around mode (GA).

AFDC Inputs - Systems Bus (L, R, and C1)

The AFDCs send a flare retard command to the TMCFs when the airplane is in the final land (autoland) configuration. This causes the TMCF to command the throttles to idle at a set A/T rate. The TMCFs also receive AFDCs status.

The pitch speed command lets the AFDCs and the TMCFs coordinate in flight level change (FLCH) and takeoff/go around (TO/GA).

The AFDCs also send voted TO/GA to the TMCFs. The AFDCs receive a discrete signal from the TO/GA switch. The AFDCs send a digital voted TO/GA signal to the TMCF. The TMCF uses the voted TO/GA signal to engage take off or go-around modes.

AFDC Outputs - Systems Bus (L, R, and C1)

The TMCF sends this data to the AFDCs:

- A/T engage
- Command altitude rate
- Engine fail and operating discretes
- A/T mode discretes.

CDU Inputs - Systems Bus (L and R)

The CDU sends thrust limit mode and derated thrust limit data and status to the TMCFs.

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ASCPC Inputs - Systems Bus (L and R)

The air supply cabin pressure controllers (ASCPCs) sends engine bleed data to the TMCFs to calculate the lower thrust operating limit.

CTC Inputs - Systems Bus (L and R)

The cabin temperature controllers (CTCs) send cabin bleed data to the TMCFs to find the lower thrust operating limit.

PSEU Inputs - Systems Bus (L and R)

The proximity switch electronic units (PSEUs) send air/ground logic to the TMCFs. The in air logic enables A/T mode operation and inhibits takeoff (TO) mode engage in the air. The on ground logic enables TO mode engage and inhibits all other A/T modes of operation.

WEU Inputs - Systems Bus (L, R, and C1)

The TMCFs receive maximum and minimum speed from the warning electronic units (WEUs).

WEU Outputs - Systems Bus (L, R, and C1)

The TMCFs sends an A/T disengage discrete to the (WEUs) for an automatic or manual A/T disengage. This signal causes the WEUs to sound the caution aural, a four-beep tone in the aural warning speakers. The TMCFs also send engine fail and takeoff thrust limit data to the WEUs.

EDIU Inputs - Systems Bus (L, R, C1, and C2)

The engine data interface units (EDIUs) send engine parameters to help the TMCFs calculate the A/T servo motor commands. The TMCFs also receive status from the EDIUs.

EDIU Outputs - Systems Bus (L, R, C1, and C2)

The TMCFs send this data to the EDIUs:

- Thrust data N1 and N2
- Engine trim commands
- Bleed data (configuration codes).

OPBC Inputs - Systems Bus (L and R)

The overhead panel bus controllers (OPBCs) send this data to the TMCFs:

- FMC selector switch position
- Left and right engine fire handle position
- L/R engine anti-ice switch position
- Wing anti-ice switch position
- L/R engine alternate mode.

FSEU Inputs - Systems Bus (L, R, and C1)

The flap slat electronics units (FSEUs) send flap angle data to the TMCFs.

ASG Inputs - Systems Bus (L and R)

The ASG sends this data to the TMCFs:

- Left and right cowl anti-ice valve position
- Left and right engine anti-ice valve position
- Air/ground data from the weight on wheels (WOW) cards.

RA RT Inputs - ARINC 429

The radio altimeter (RA) receiver transmitters (RTs) send radio altitude and status to the TMCFs in the AIMS cabinets. This provides A/T flare retard engage or inhibit logic just before touchdown.

Engine RPM (N1 and N2) Analog Inputs

The left and right engine RPM sensors send low (N1) and high (N2) engine RPM to the TMCFs.

Fuel Shutoff (SO) Switches Analog Discrete Inputs

The TMCFs receive the left and right fuel SO switch position as analog discretes. This helps the TMCFs determine engine status along with other inputs.

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Master Warning and Caution Light Analog Discrete Inputs

The master warning and caution switch light supplies an analog discrete to the TMCFs to reset the caution lights. Push a master warning and caution switch light to reset the A/T disconnect function.

Master Caution Analog Discrete Outputs

The TMCFs send an analog discrete to the master warning and caution light switches. This causes the caution light to come on. This occurs when a manual or an automatic A/T disengage occurs.

A/T Disconnect Switch Analog Discrete Inputs

The autothrottle (A/T) disconnect switch supplies a manual A/T disengage analog discrete to the TMCFs to disengage both A/T servo motors. A second push causes the TMCF to reset both the A/T function and the AUTOTHROTTLE DISC caution message on the EICAS display.

TO/GA Switch Analog Discrete Inputs

The takeoff/go around (TO/GA) switch sends a TO/GA analog discrete to the TMCFs to start the A/T mode. The TO/GA switch supplies logic to the AFDS for the TO/GA mode. The TO/GA switch analog discrete input is a backup to the voted TO/GA input from the AFDCs. On the ground, the thrust limit mode is TO for the TMCS. In the air, the thrust limit mode is GA for the TMCS.

AIMS Intercabinet Bus (ICB) Interfaces

The left and right TMCFs use the ICB to share and compare data.

The left TMCF and right TMCF calculate the same A/T commands. Only one TMCF is active. They compare these items:

- Data bases
- Input data
- Sensor status
- BITE results.

The active TMCF sends synchronization data to the non-active TMCF at these times:

- When they do not agree
- During power interrupts
- At power up.

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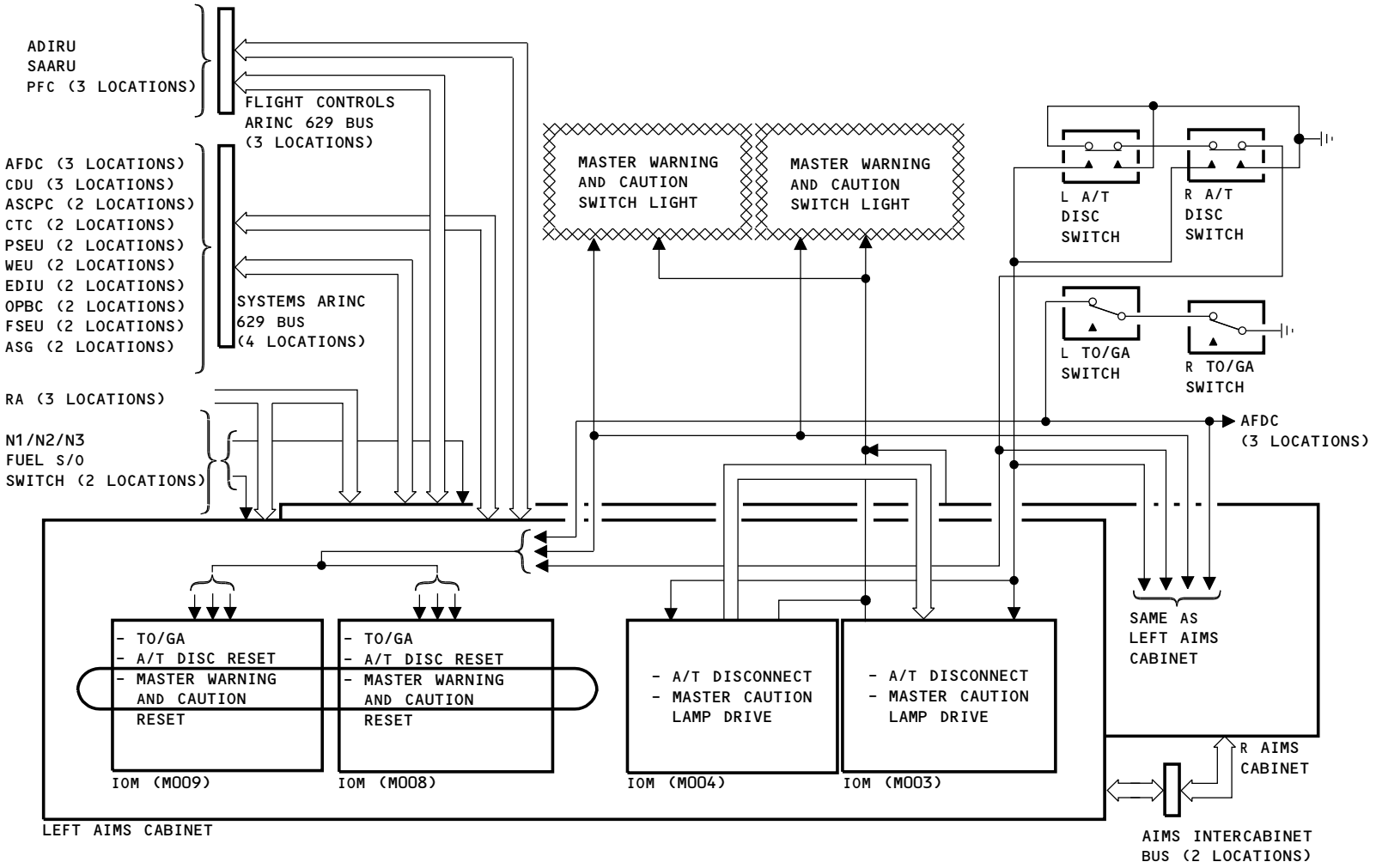

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TMCS - INTERFACES - 1

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General

The active TMCF automatically sets the throttle levers in response to crew or system inputs.

Each autothrottle servo motor (ASM) needs power inputs and control signals from the AIMS cabinets and the Mode Control Panel (MCP).

Power Interface

The P11 overhead circuit breaker panel supplies 28V dc to the left and right ASM for operation. On/off control comes from the MCP. The A/T ARM switches control 28v dc to the ASMs for servo motor operation.

MCP Digital and Analog Discrete Interfaces

The MCP sends this digital discrete data to the TMCFs:

- A/T arm (on/off) - Single (L or R) or dual (both) autothrottle operation occurs when the appropriate arm switch is in the ARM [up] position
- A/T mode
- AFDS mode
- Parameters for A/T mode logic
- MCP status.

The MCP sends this analog discrete data to the ASMs:

- A/T arm (ON) switch supplies ASM control power in the on position
- A/T arm (OFF) switch removes power (positive disengage) from its ASM in the off position.

ASM Digital Interface

The active TMCF causes the throttles to move forward or aft when it sends the ASMs digital commands. The ASM operation stops with the inhibit input. The A/T servo motors send digital throttle position (low speed tachometer) feedback data to the TMCFs when the servomotor moves. The autothrottle servo motors also send status information to the TMCFs.

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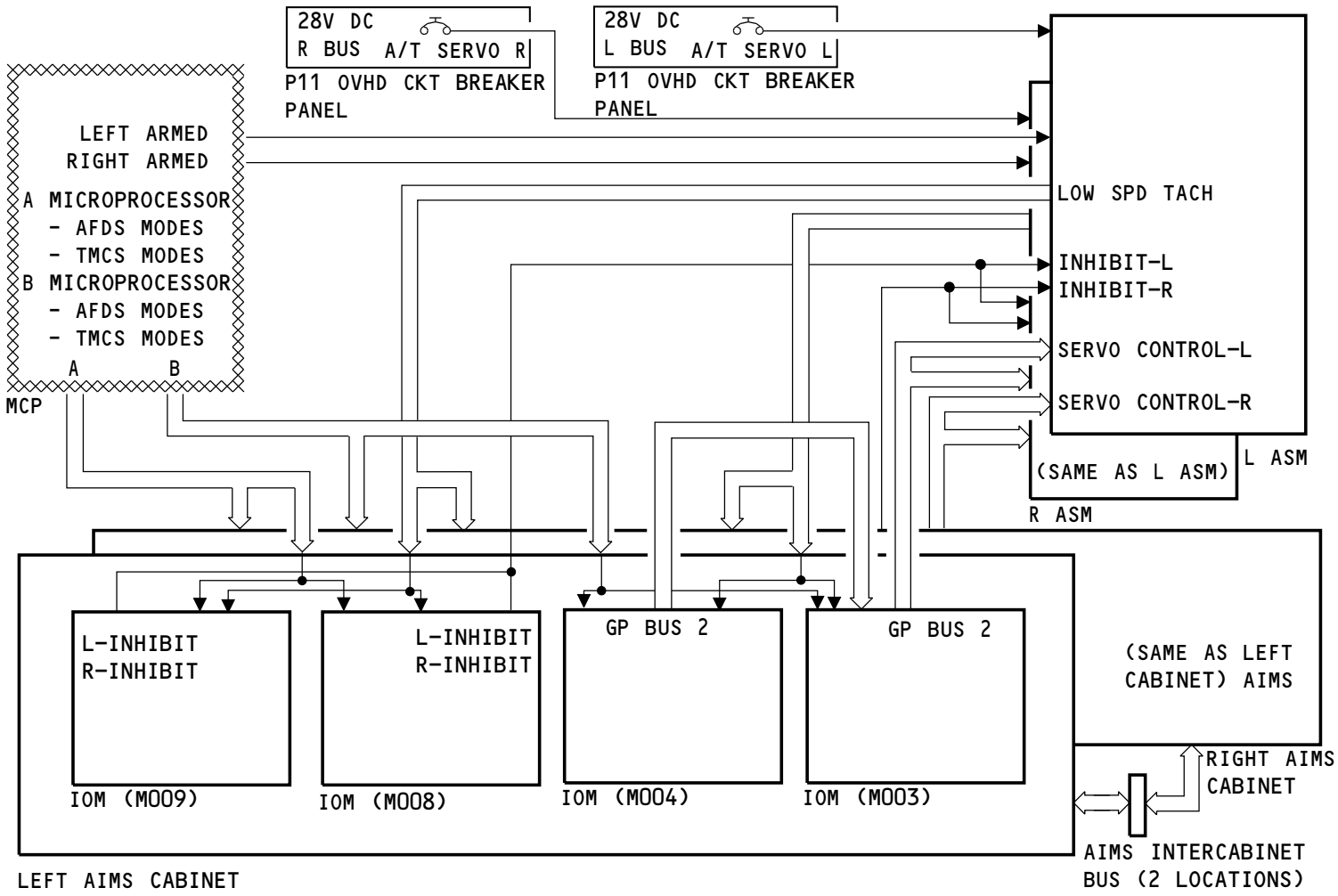

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TMCS - INTERFACES - 2

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TMCS - A/T SERVO MOTOR

General

The integrated autothrottle servo motors (ASMs) are below the throttle quadrant (P10). The active TMCF sends servo rate commands to each ASM to move its throttle forward or aft through a separate gear box assembly.

Physical Description

The ASM weighs 1.9 pounds and measures 4.5 inches by 3.26 inches by 4 inches. The electrical power interface is from the bottom of the ASM.

Operation

Each ASM consists of these:

- Electronic control module (ECM)
- Power supply unit (PSU)
- Power switching module (PSM)
- Power switching bridge (PSB)
- DC motor with magnetic sensors.

Power to the ASM is 28v dc for excitation and motor control. The ASM pulse modulates and amplifies the digital servo rate commands it receives from the TMCF.

Each ASM receives analog (A/T arm and inhibit L/R) and digital (FMC selector position) discretes to enable its operation. Each ASM sends the TMCF a digital discrete of its state and digital rate feedback.

There are three magnetic pick-off sensors in the DC motor stator that measure rate feedback. These sensors measure the rate between the rotor and stator as the motor moves the throttle forward or aft.

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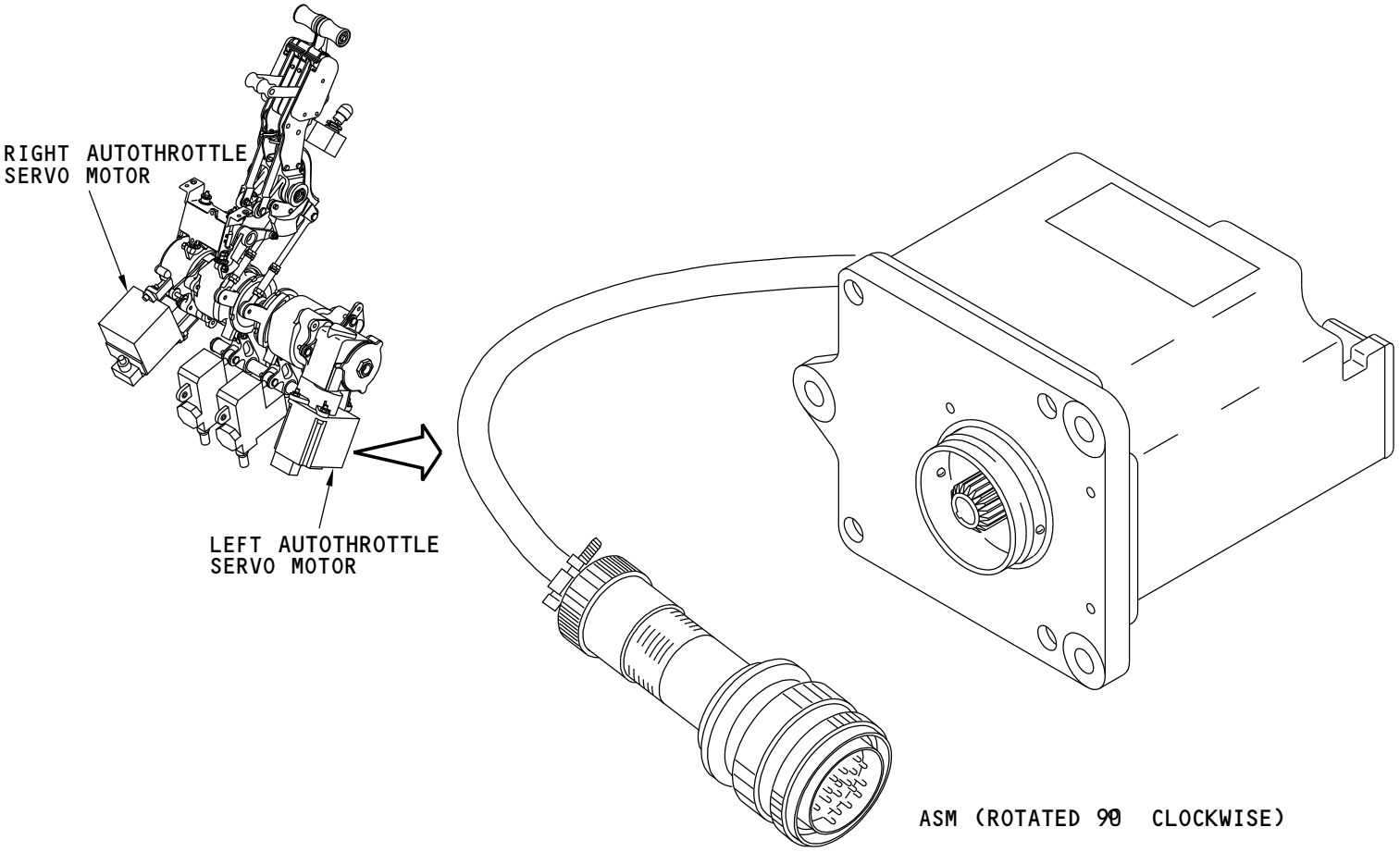

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TMCS - A/T SERVO MOTOR

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TMCS - A/T ARM, A/T MODE, AND THRUST LEVER SWITCHES

General

You use switches on the mode control panel (MCP) and on the thrust levers to arm, select, or disconnect A/T modes.

MCP A/T Arm Switch

The A/T arm switches are on the MCP. You use the A/T arm switches to enable ASM excitation power (28V dc) for operation. The on position (both) also supplies engine trim equalization control from the TMCFs. The off position removes power from that ASM and removes engine trim equalization control.

MCP A/T Mode Switches

The MCP has these A/T mode switches with these functions:

- Climb/continuous (CLB/CON), selects the CLB thrust limit mode in the air or CON thrust limit mode in the air when one engine fails
- A/T, selects the A/T speed (SPD) mode or the thrust reference (THR REF) mode when in the air
- Flight level change (FLCH), gives a thrust command that changes with a small or large altitude change
- Vertical navigation (VNAV), allows the throttles to operate with the autopilot flight director system (AFDS) to control thrust or speed.

To arm the autothrottle, move one or both of the A/T arm switches to the UP position. To engage the A/T, push the A/T switch on the MCP. The autothrottle engages automatically if any of these modes engage:

- VNAV
- FLCH
- TO/GA.

Thrust Lever Switches

These switches are on the left and right thrust levers:

- Takeoff/go-around (TO/GA), S3, S5, and S7 (left) S2, S4, and S6 (right)
- A/T disconnect.

Push a TO/GA lever to engage that TO/GA switch. This causes the selected takeoff (TO) thrust limit mode to operate on the ground. When radio altitude is more than 2 feet, a second push of a TO/GA lever removes any thrust derates. The thrust levers move to full takeoff thrust. On the ground, a second push of the TO/GA lever has no effect.

On approach, a single push of the TO/GA lever moves the thrust levers to a thrust value to climb at 2,000 fpm. A second push moves the thrust levers to full go-around thrust.

An A/T disconnect switch is on the left and right thrust lever. Push an A/T disconnect switch to disconnect the A/T and show the AUTOTHROTTLE DISC caution message on the EICAS display. To reset the AUTOTHROTTLE DISC caution message, push the A/T disconnect switch again.

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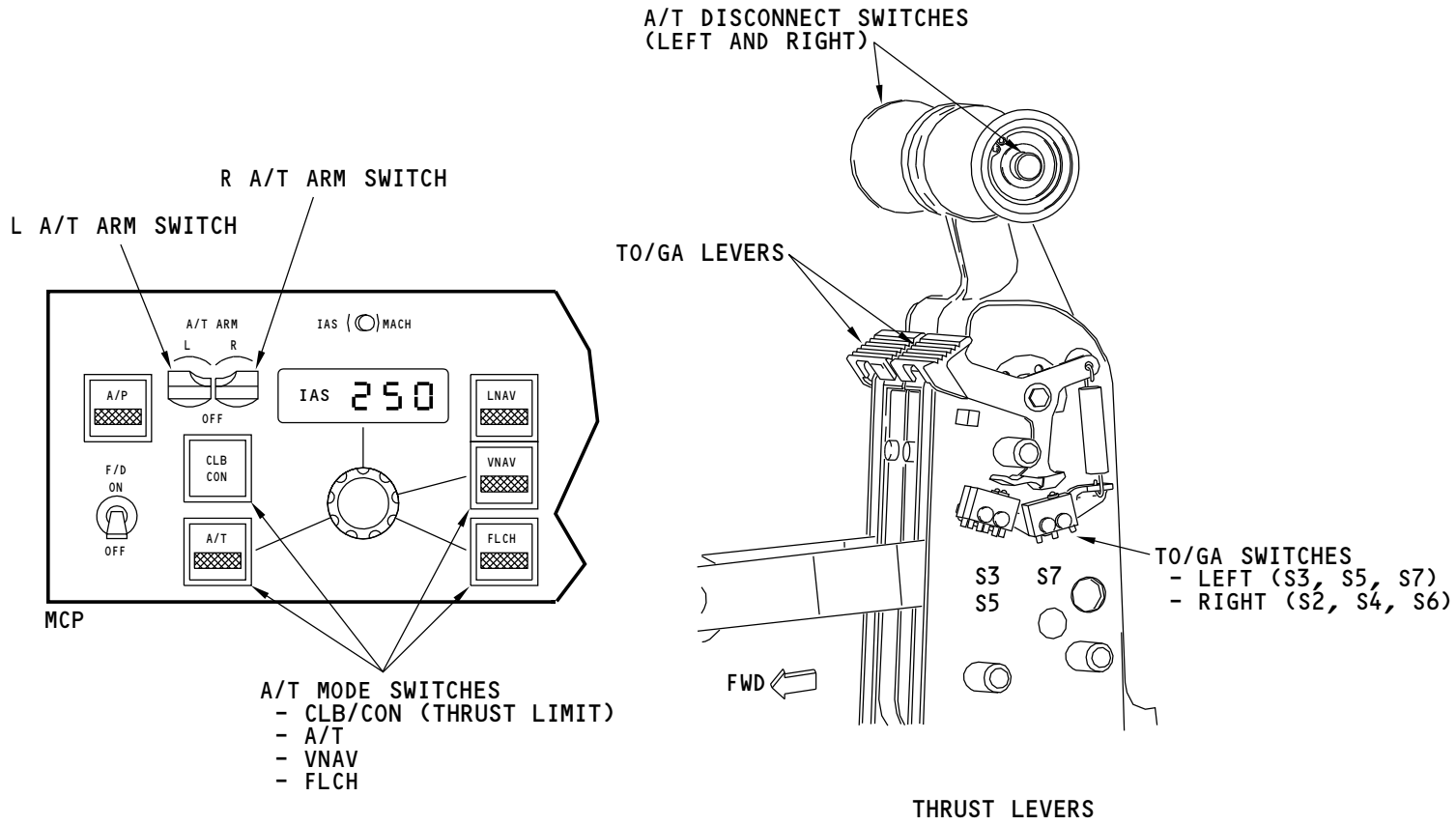

M37831 S000612720_V1

TMCS - A/T ARM, A/T MODE, AND THRUST LEVER SWITCHES

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General

The autothrottle (A/T) modes show on the primary flight display (PFD) when an A/T mode engages.

A/T Modes

Normal A/T mode annunciation and operation is with both the left and right A/T servo motors (ASM) in operation. A left (L) or right (R) precedes the A/T mode annunciation when only one ASM operates.

These are the A/T modes that show on the PFD:

- Speed (SPD/X SPD)
- Thrust (THR/X THR)
- Thrust reference (THR REF/X THR REF)
- HOLD/X HOLD
- IDLE/X IDLE
- TEST/X TEST.

SPD or X SPD shows when:

- A/T engage conditions are valid and vertical navigation (VNAV) commands the throttles to hold SPD
- VNAV or flight level change (FLCH) mode transitions to another pitch mode, such as vertical speed, altitude hold, capture, or glideslope capture
- The A/T mode on the mode control panel (MCP) is active, the airplane is in the air and the autopilot flight director system (AFDS) is not in a speed mode.

THR or X THR shows when the TMCF receives an A/T mode request and goes into one of these modes:

- VNAV descent
- FLCH
- Go-around (GA) thrust mode.

THR REF or X THR REF shows when the TMCF receives a takeoff (TO) A/T request from the left or right TO/GA switch and the TMCF commands the throttles to full TO thrust. THR REF shows for VNAV CLB or a GA thrust mode.

HOLD or X HOLD shows when the TMCF removes excitation power from the ASMs. HOLD shows in these A/T modes:

- FLCH idle descent
- FLCH with pilot override
- TO thrust mode when computed air speed (CAS) is more than 80 kts
- VNAV idle descent.

IDLE or X IDLE show for these A/T modes:

- VNAV descent
- A flare retard idle command from the AFDS.

TEST or X TEST shows when a TMCS ground test is active.

The A/T mode annunciation is blank with one of these:

- No A/T mode requests
- The left and right TMCS invalid.

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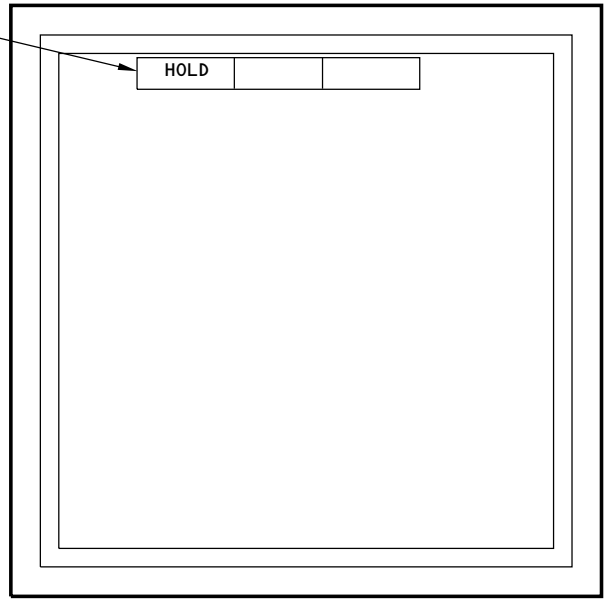
AUTOTHROTTLE MODES:
- THR REF
- HOLD
- THR
- SPD
- IDLE
- TEST
1 - X THR REF
- X HOLD
- X THR
- X SPD
- X IDLE
- X TEST
- (BLANK)



PRIMARY FLIGHT DISPLAY

1 X - LEFT OR RIGHT

M37808 S000612721_V1

TMCS - PRIMARY FLIGHT DISPLAY - OPERATION

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TMCS - EICAS DISPLAY - OPERATION

General

The EICAS display shows this TMCF data that relates to engine/thrust performance:

- Thrust limit mode
- Selected temperature
- Thrust limit
- Target N1
- Maximum thrust limit.

Thrust limit Mode

The takeoff (TO) thrust limit mode shows automatically on the ground at power up. Other thrust limit modes show automatically or with a manual selection on the CDU THRUST LIMIT page when in flight. It also shows automatically when in flight and VNAV (vertical navigation) engages.

These are the three ways to derate the engine thrust:

- Select TO 1 or TO 2
- Enter an assumed temperature
- Select CLB 1 or CLB 2.

Takeoff derates are available on the CDU THRUST LIMIT page. There are two TO derates, TO 1 and TO 2. The takeoff derate levels for TO 1 and TO 2 can change from 1% to a maximum of 30% below the full TO rating. The variable takeoff rating menu is on the AIRLINE POLICY PAGE.

A temperature derate occurs with a temperature entry on the CDU THRUST LIMIT page. The TMCF uses this value when it is more than the present temperature in use for TO thrust calculation. D shows in front of the TO thrust limit for a temperature derated thrust. A temperature derate can add derate to a fixed derate. In this case the D and TO 1 or TO 2 shows on the EICAS. The maximum temperature derate is 25% from a TO derate level.

There are two climb derates, CLB 1 and CLB 2. Climb derates are available on the CDU THRUST LIMIT page. CLB 1 derate level is 10% and CLB 2 derate level is 20% of the climb thrust.

Selected Temperature

The TMCF uses temperature (selected) inputs from the CDU THRUST LIMIT page when the input is more than the TAT. The TMCF uses the selected temperature input to calculate temperature derated thrust limits.

Thrust Limit

The TMCF calculates the thrust limit with inputs from the FMCF and other sensors and components. The digital readout shows on the EICAS display.

Maximum Thrust limit

The electronic engine control (EEC) calculates the maximum thrust limit. The TMCF is the secondary source for the maximum thrust limit display.

Target N1

The target thrust cursor shows in green when it shows the N1 limit calculated by the TMCF for the active thrust limit mode.

The target thrust cursor shows in magenta when the TMCF uses a target N1 that the FMCF calculates. The target thrust cursor shows in magenta during any of these conditions:

- VNAV is engaged and the autothrottle mode is THR REF. This occurs when VNAV is engaged during climb.
- VNAV is engaged and the autothrottle mode is THR. This occurs when VNAV is engaged during descent and anti-ice is on.
- VNAV is engaged and the autothrottle is off. The pilots can manually set the thrust levers to agree with the target N1 that shows on EICAS.

Fault Messages

TMCS fault messages show on the EICAS display for these conditions:

- AUTOTHROTTLE DISC, caution occurs when the TMCS detects an automatic or manual disengagement
- AUTOTHROTTLE L and/or AUTOTHROTTLE R, advisory occurs when the TMCS detects an ASM or arm switch failure.

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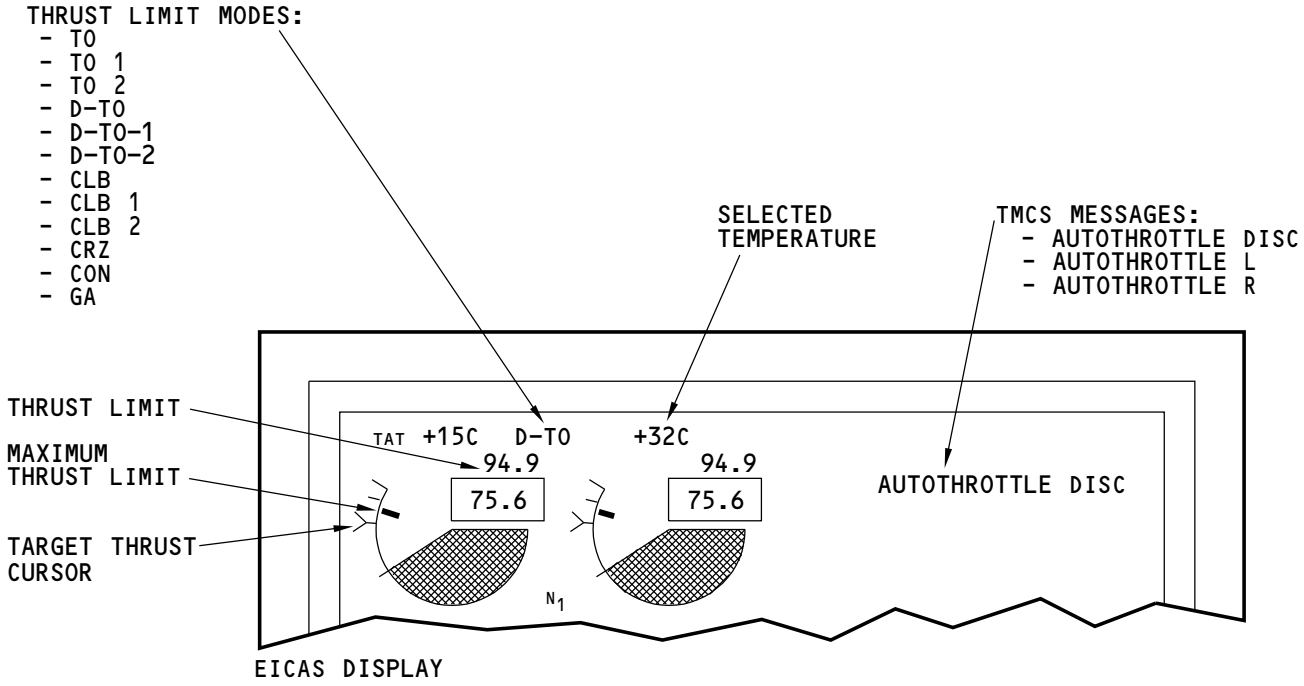

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TMCS - EICAS DISPLAY - OPERATION

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TMCS - AUTOTHROTTLE FLIGHT PROFILE

General

During normal flight operations, the flight crew uses the TMCF to perform several routine or normal operations and tasks. These operations or tasks relate to autothrottle modes.

The autothrottle (A/T) modes operate in these flight phases:

- Takeoff (TO)
- Climb (CLB)
- Cruise (CRZ)
- Descent (DES)
- Approach (APP)
- Go-around (GA).

Autothrottle functions that relate to flight phases are flare retard during autoland and autothrottle disconnect.

Autothrottle thrust mode annunciations relate to pitch mode annunciations on the PFD. Use the MCP to select these modes.

Takeoff

In TO, the autothrottle controls thrust to the takeoff thrust limit. The autothrottle mode annunciation on the PFD is thrust reference (THR REF). At 80 knots (KTS) air speed, the autothrottle mode annunciation on the PFD changes to HOLD.

Climb

These are the three autothrottle mode selections in climb:

- Vertical navigation (VNAV)
- Flight level change (FLCH)
- Autothrottle (MCP) speed mode or thrust mode.

These are the autothrottle mode annunciations for these modes:

- THR REF when VNAV engages
- THR when FLCH engages
- SPD or THR REF when autothrottle mode engages.

The autothrottle mode only (MCP) engages when VNAV, FLCH, and TO/GA are not active and the airplane is in the air.

Cruise

These are the two autothrottle modes in cruise:

- VNAV
- Autothrottle mode only.

These are the autothrottle mode annunciations in cruise:

- SPD when VNAV engages
- SPD, VNAV is not active.

Descent

These are the three autothrottle modes in descent:

- VNAV
- FLCH
- Autothrottle mode only.

These are the autothrottle mode annunciations in descent:

- IDLE, THR, or HOLD shows for VNAV
- THR, or HOLD shows for FLCH
- SPD.

Approach

SPD is normal mode in approach with glideslope active or in a manual approach.

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Go-Around

A GA mode request causes the autothrottle mode to change to THR. A second GA request causes the autothrottle mode to change to THR REF. You push a TO/GA lever to request GA.

Flare Retard

Flare retard occurs at 25 feet radio altitude during approach with a command from the autopilot flight director system (AFDS). The autothrottle mode changes to IDLE during a flare retard.

Autothrottle Disconnect

The autothrottle disconnects when there is a manual autothrottle disconnect or when there is thrust reverser application. This occurs after initial touchdown during rollout.

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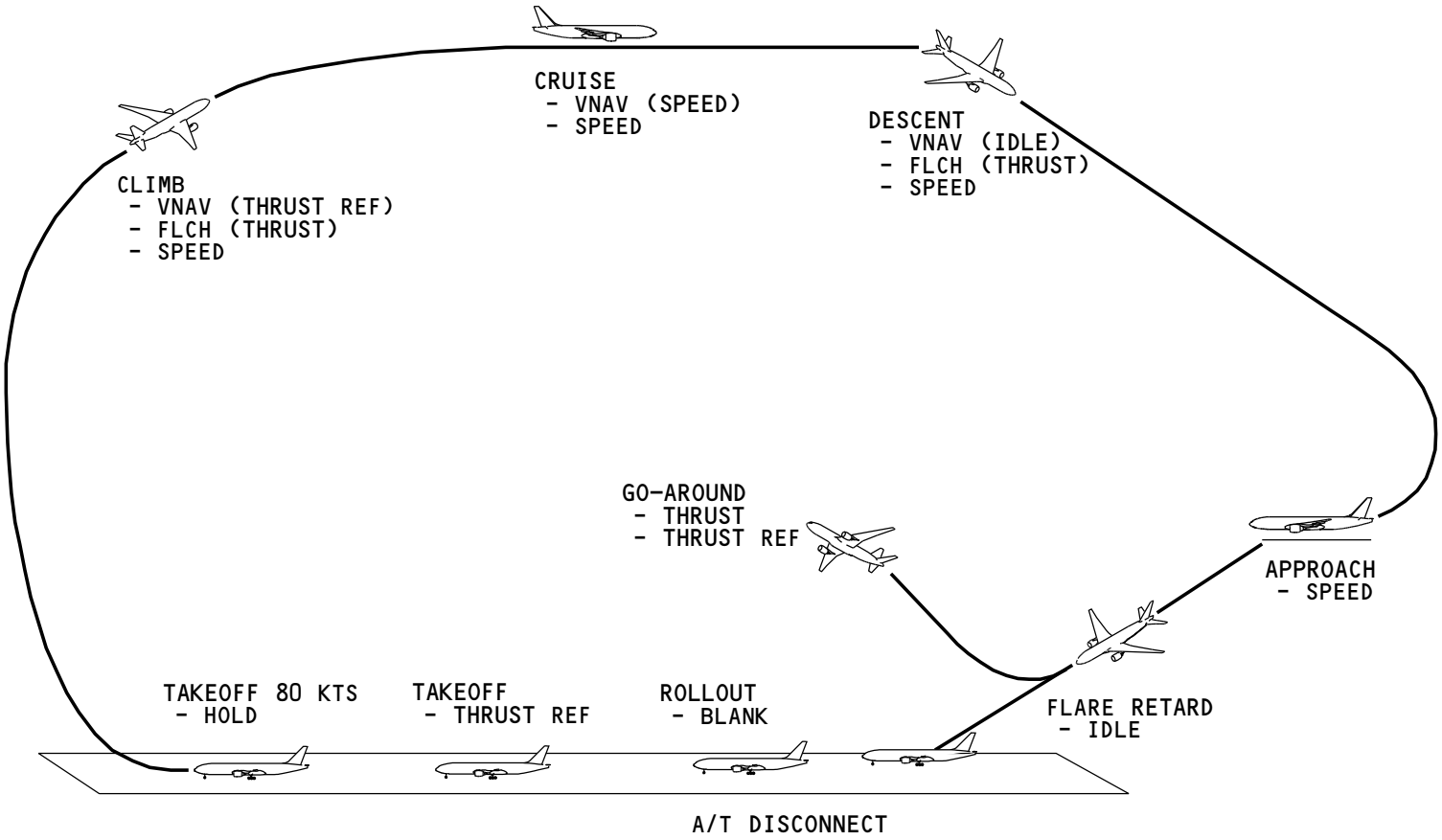

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TMCS - AUTOTHROTTLE FLIGHT PROFILE

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TMCS - A/T OPERATION - TAKEOFF

General

To prepare the AFDS and the A/T for the takeoff phase of the flight, use the mode control panel (MCP) to set the necessary parameters. Use the EICAS display and the PFD to see the modes and mode changes.

Before the A/T mode can engage, the system must pass servo motor tests to ensure proper operation.

Mode Selection

The takeoff (TO) mode engages with these conditions:

- Autothrottle (A/T) arm switches on
- Airplane on the ground
- Flap position not zero
- Thrust limit mode takeoff (TO)
- Push a TO/GA lever with less than 50 KTs air speed.

Takeoff Mode Operation

At the start of takeoff, the TMCF does the A/T stopper test. This test does a check for the ability of the TMCF to remove power from the servos.

The TMCF sends ASM commands to move the throttles to the TO thrust limit. The throttles move when the TMCF completes and passes the A/T stopper tests. The A/T mode is thrust reference (THR REF) on the PFD. At more than 80 KTs air speed, the A/T mode changes to HOLD.

During normal operation, as the airplane goes above 400 feet AGL, the A/T mode changes to THR REF.

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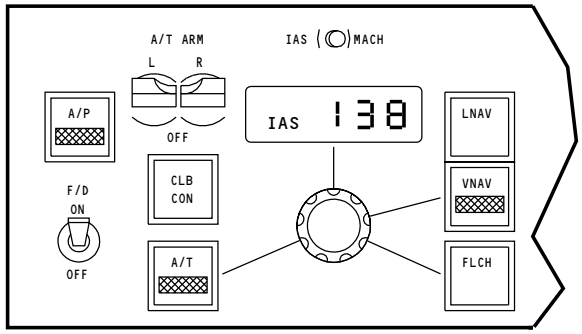
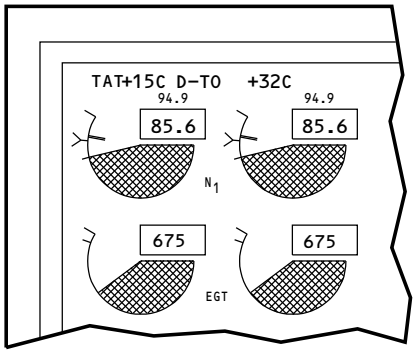
CONDITION:
- ON THE GROUND
- A/T ARMED
- VNAV ARMED
- TO/GA LEVER PUSHED
- < 50 KTS AIR SPEED (A/S)
- THROTTLES AT TO THRUST LIMIT



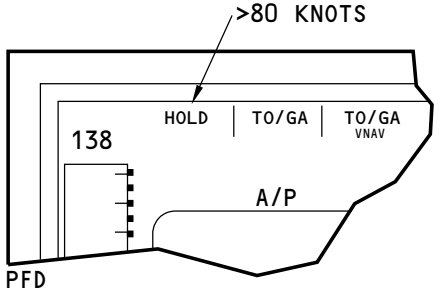
MCP

MCP:
- VNAV SWITCH LIGHT ON
- A/T SWITCH LIGHT ON
- F/D ACTIVE

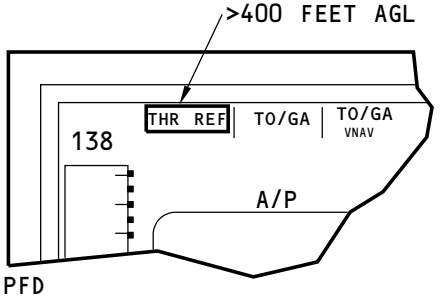


EICAS DISPLAY

EICAS DISPLAY:
- TO THRUST LIMIT
- ENGINES ADVANCE TO TAKEOFF THR LIMIT CURSOR (GREEN)



PFD



PFD

PFD:
- THE A/T MODE IS THR REF
- 80 KTS (A/S) THE MODE CHANGES TO HOLD
- FLAP SPEED PROTECTION IS AVAILABLE > 400 FEET ABOVE GROUND LEVEL (AGL)

M37839 S000612730_V1

TMCS - A/T OPERATION - TAKEOFF

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Mode Selection

The thrust limit mode engages in climb (CLB) with these conditions:

- Active route
- Performance page complete
- Vertical navigation (VNAV) armed
- VNAV engages when the airplane is 400 feet above ground level (AGL)
- A/T armed
- Flight director or A/P active.

Operation

At the thrust reduction altitude, the FMCF sends commands to the TMCF to move the throttles to the climb thrust position. This occurs at or above 400 feet for a flap or an altitude setting. The flap or altitude setting is preset in the airline modifiable information (AMI). The thrust limit mode changes from TO to CLB as the airplane goes through the preset altitude or at a preset flap position. You can change the preset altitude or flap position for a flight on the CDU TAKEOFF REF page 2.

The thrust limit cursor changes from green to magenta on the EICAS display when CLB thrust engages.

The A/T mode changes from HOLD to THR REF at 400 feet (BARO) when VNAV engages.

The FMCF also sends pitch control commands to the autopilot flight director system (AFDS) to control speed on elevator while in climb.

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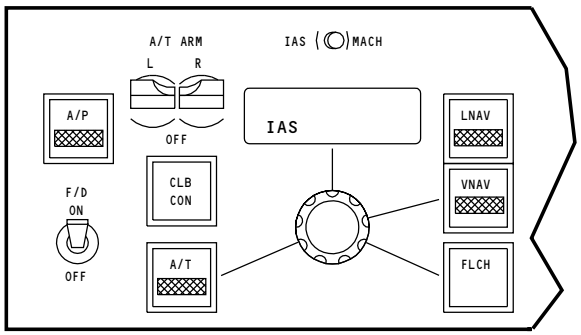
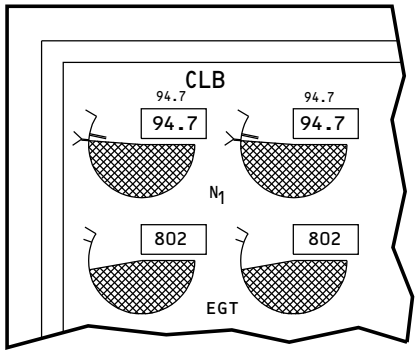
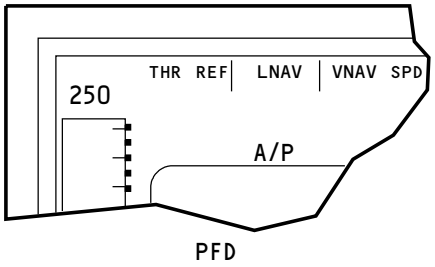
CONDITION:
- IN CLIMB
- > 400 FEET (AGL)
- VNAV ENGAGED



MCP



EICAS DISPLAY



PFD

MCP:
- VNAV ENGAGES > 400 FEET (AGL)
- SPEED WINDOW BLANKS
- F/D ACTIVE

EICAS DISPLAY:
- AT THE THRUST REDUCTION ALTITUDE
  OR
- AT FLAPS 5 OR FLAPS 1
- THE THRUST LIMIT MODE CHANGES FROM TO - CLB AND THE CURSOR CHANGES FROM GREEN TO MAGENTA

PFD:
- A/T MODE IS THR REF

M37840 S000612731_V1

TMCS - A/T OPERATION - VNAV CLIMB

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Mode Selection

In VNAV, the thrust limit mode engages in cruise (CRZ) prior to cruise altitude capture. The change from CLB to CRZ is automatic with inputs from the FMCF to the TMCF.

Operation

When the airplane gets to the flight level altitude or MCP altitude, the thrust limit mode changes to CRZ and the A/T mode changes to SPD. The TMCF commands the throttles to move to a speed command with inputs from the FMCF. The magenta thrust limit cursor changes to green on the EICAS display.

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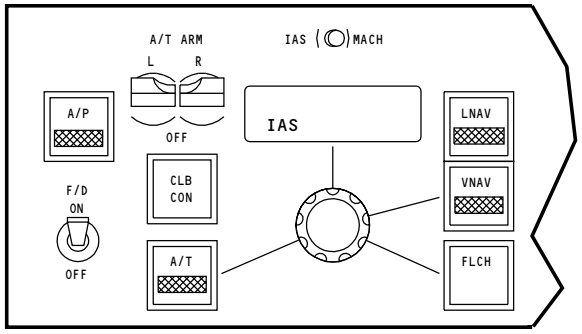
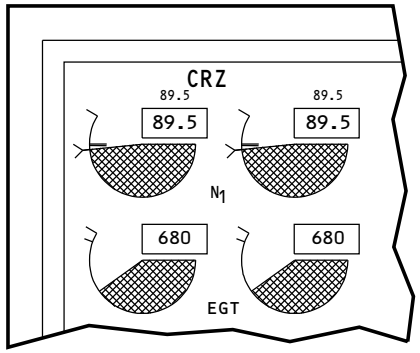
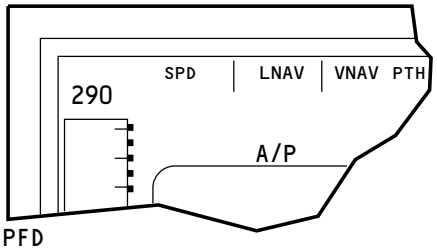
CONDITION:
- AT CRUISE ALTITUDE
- VNAV ENGAGED
- AIRPLANE LEVELS OUT



MCP



EICAS DISPLAY



PFD

MCP:
- NO CHANGES

EICAS DISPLAY:
- THRUST LIMIT MODE GOES TO CRZ
- THRUST CURSOR GOES TO GREEN (MAX CRUISE THR LIMIT)

PFD:
- A/T MODE GOES TO SPD

M37843 S000612734_V1

TMCS - A/T OPERATION - VNAV CRUISE

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TMCS - A/T OPERATION - VNAV DESCENT

Mode Selection

When the airplane nears the top of descent, the FMCF causes the A/T to go to the next flight phase, descent.

Operation

The TMCF commands the throttles to idle thrust at flight phase transition. The A/T mode is IDLE or THR in descent. The A/T mode changes to HOLD when a pilot moves the throttles opposite to the throttle command or when the throttles reach the aft mechanical stop.

The thrust limit mode stays in cruise (CRZ).

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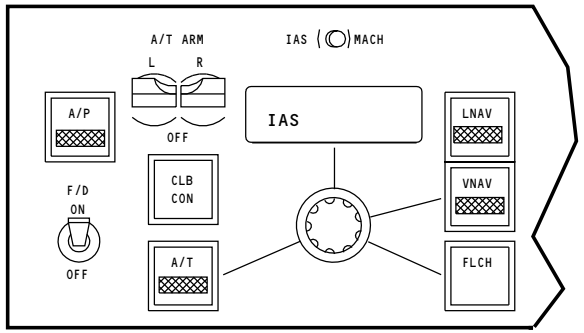
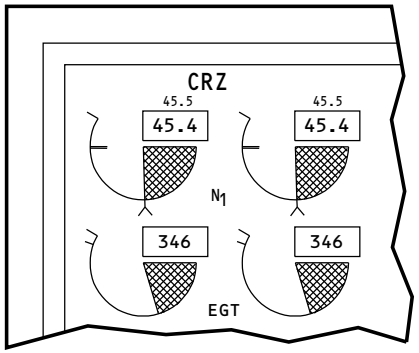
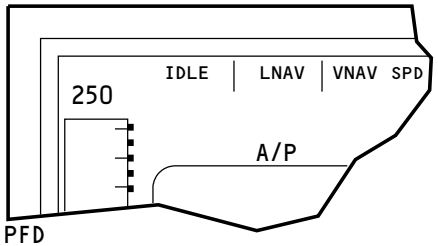
CONDITION:
- AIRPLANE IN DESCENT
- VNAV ENGAGED



MCP



EICAS DISPLAY



PFD

MCP:
- NO CHANGE

EICAS DISPLAY:
- THRUST CURSOR SHOWS CRZ THRUST LIMIT

PFD:
- AT START OF DESCENT, A/T MODE GOES TO IDLE AND THROTTLES MOVE AFT
- AT THE AFT MECHANICAL STOP, THE A/T MODE GOES FROM IDLE TO HOLD

M37844 S000612735_V1

TMCS - A/T OPERATION - VNAV DESCENT

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Mode Selection

The TMCF sends A/T servo motor (ASM) commands to control engine thrust when all these conditions are present:

- A/T arm switches are on
- An autopilot (A/P) or flight director (F/D) switch is active
- Flight level change (FLCH) switch is active
- Airplane is in the air.

Operation

When you push the FLCH mode switch on the MCP, the airspeed window unblanks to show current airspeed. The TMCF uses the difference between the present altitude and the MCP altitude to calculate a vertical speed to capture the MCP altitude. Airspeed does not change. The A/T control laws command thrust which produces a vertical speed to complete the altitude change in 125 seconds. The A/T command can not exceed the thrust limit mode.

If an override occurs while in the FLCH mode, the A/T mode goes to HOLD. HOLD shows on the PFD. The thrust limit mode changes to CLB on the engine primary format. An override occurs when throttle position and throttle command differ by more than eight degrees. This may occur when a pilot overrides the throttles. HOLD also shows when the throttle command moves the throttles to the aft mechanical stop and the ASM continues to move.

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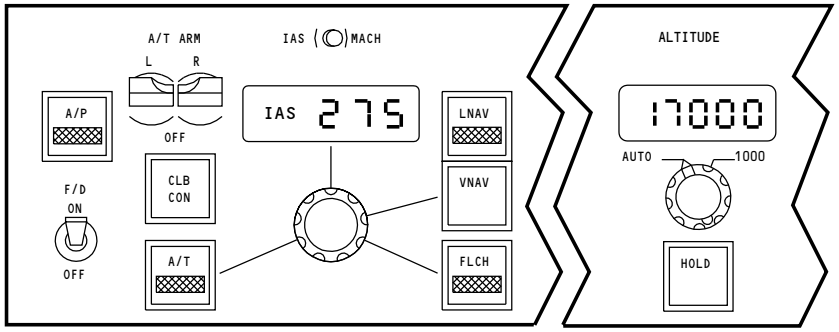
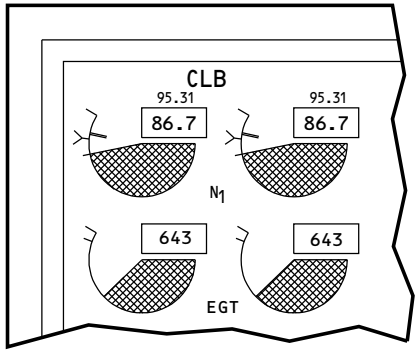
CONDITION:
- CURRENT ALTITUDE < MCP ALTITUDE
- FLCH ENGAGED



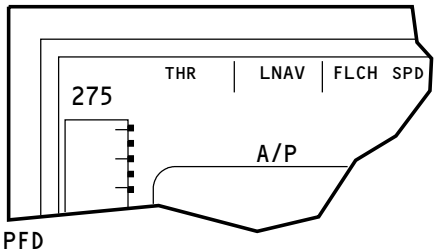
MCP

MCP:
- FLCH SWITCH LIGHT IS ON
- F/D ACTIVE



EICAS DISPLAY

EICAS DISPLAY:
- THRUST LIMIT MODE IS CLB



PFD

PFD:
- A/T MODE GOES TO THR

M37847 S000612738_V1

TMCS - A/T OPERATION - FLIGHT LEVEL CHANGE

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Mode Selection

In VNAV cruise, the speed (SPD) mode engages when all these conditions are true:

- Autothrottle arm switches on
- Airplane in the air more than 400 feet above ground level (AGL) BARO altitude
- Takeoff (TO) mode not active
- Go-around (GA) mode not active
- Flight level change (FLCH) not active
- Select the A/T switch on the mode control panel (MCP)
- Default SPD selection (mode change from FLCH or VNAV).

Operation

The TMCF sends the A/T servo motor commands to move the throttles in the SPD mode to control the airplane speed. In VNAV, the MCP speed window is normally blank. Push the IAS/Mach selector switch to unblank the speed window and show current FMCF target speed. Turn the selector to change FMCF target speed. The TMCF responds to speed window changes. Thrust limit, speed limit (Vmo/Mmo), and flap speed limit protection are active in this mode. SPD shows as the A/T mode on the primary flight display (PFD).

The A/T SPD mode can operate with or without an A/P pitch mode.

Climb/Continuous Switch

When two engines are in operation, this switch changes the autothrottle thrust reference to climb (CLB). When only one engine is in operation, it changes the thrust reference to maximum continuous (CON). The climb/continuous switch does not engage the autothrottle.

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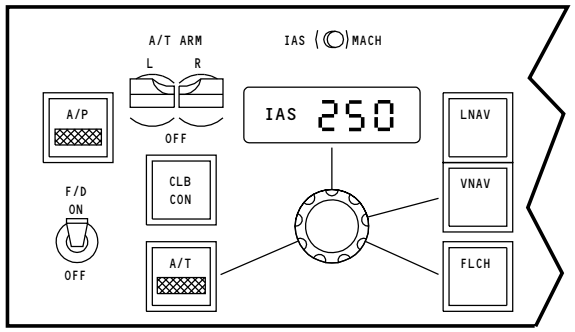
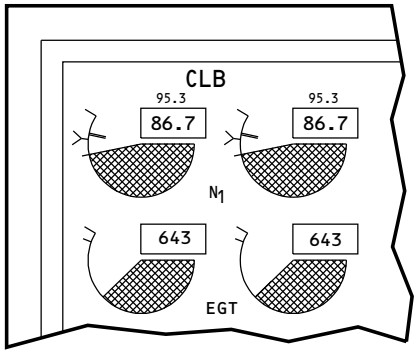
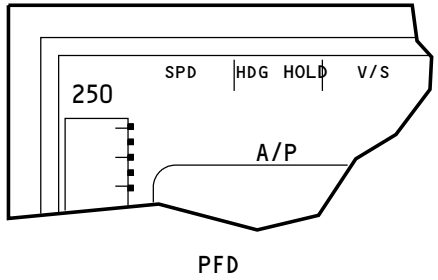
CONDITION:
- MCP A/T SWITCH ACTIVE



MCP



EICAS DISPLAY



PFD

MCP:
- AIRPLANE SPEED SHOWS IN THE IAS DISPLAY
- A/T SWITCH LIGHT ON
- F/D ACTIVE

EICAS DISPLAY:
- THE CURSOR (GREEN) SHOWS THE THRUST LIMIT
- PUSH THE CLB/CON SWITCH THRUST LIMIT MODE IS CLIMB
- PUSH THE CLB/CON SWITCH THRUST LIMIT MODE IS CON (SINGLE ENGINE OPERATION)

PFD:
- THE A/T MODE CHANGES TO SPD
- THE TMCF CONTROLS THE AIRPLANE TO THE MCP IAS SPEED DISPLAY

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TMCS - A/T OPERATION - SPEED

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Mode selection

The go-around (GA) mode engages when all these conditions are true:

- Autothrottle arm switches on
- Airplane in the air
- Glideslope active (engaged) or flaps not zero
- Thrust limit mode not takeoff (TO)
- Push either TO/GA lever.

Operation

The GA mode arms in approach when the flaps are down or glideslope is active. GA shows as the thrust limit mode on the EICAS display. Push any TO/GA lever to start the GA mode. The A/T mode annunciation goes to thrust (THR).

The TMCF commands the A/T servo motors (ASM) to move the throttles and control the airplane to 2000 feet per minute (FPM) vertical speed. Push any TO/GA lever again to start the full thrust GA mode. The A/T mode changes to thrust reference (THR REF). The TMCF commands the ASMs to move the throttles to the full GA thrust limit that shows on the EICAS display.

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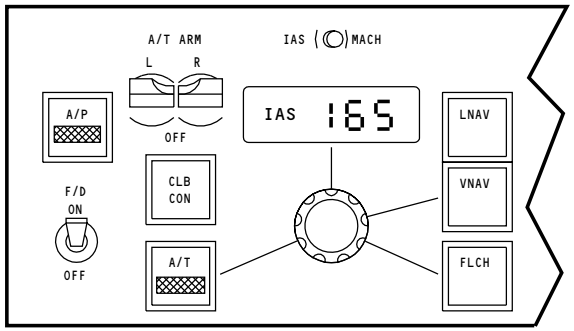
CONDITION:
- IN APPROACH
- TO/GA LEVER PUSHED



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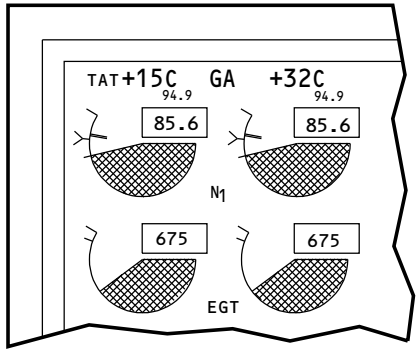
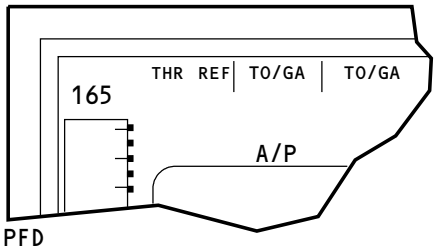
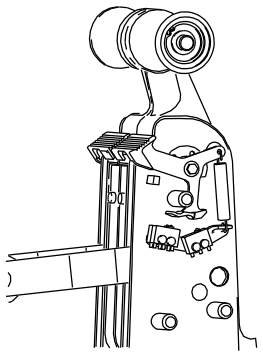


EICAS DISPLAY



PFD



THROTTLES

MCP:
- F/D SWITCH ON

EICAS DISPLAY:
- IN APPROACH (GA SHOWS-ARMED) FOR GLIDESLOPE ACTIVE OR FLAPS NOT ZERO
- THE GREEN THRUST LIMIT CURSORS IS THE GA THRUST LIMIT (COMMANDED THRUST IS LESS UNTIL GA ENGAGES)

PFD:
- FIRST TO/GA PUSH, THE A/T MODE CHANGES TO THR
- SECOND TO/GA PUSH, THE A/T MODE CHANGES TO THR REF

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TMCS - A/T OPERATION - GO-AROUND

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Mode Selection

The TMCF commands the throttles to move aft when all these conditions are true:

- Flare retard command from the AFDS
- Autothrottle arm switches on
- Less than or equal to 25 feet radio altitude in a land configuration.

Operation

The TMCF sends a throttle rate command to the servo modules to cause the throttles to move aft. This action assists the AFDS flare maneuver in the final landing phase. The throttle retard action starts at 25 feet radio altitude. IDLE shows as the A/T mode on the PFD when flare retard starts.

The A/T disconnects when the flight crew applies reverse thrust. The landing phase inhibit logic prevents the display of the AUTHROTTLE DISC caution message on the EICAS display and does not let the caution aural operate.

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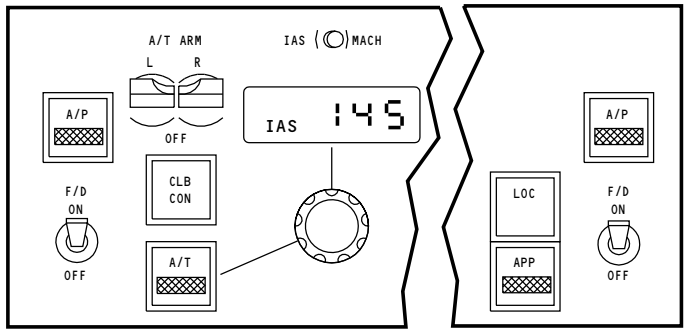
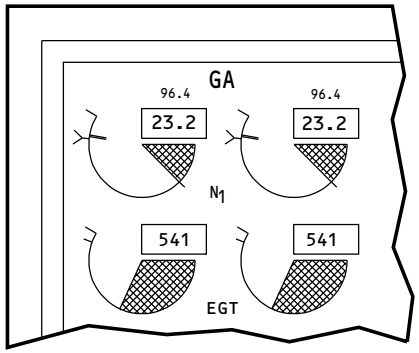
CONDITION:
- PASSING THRU FLARE HEIGHT

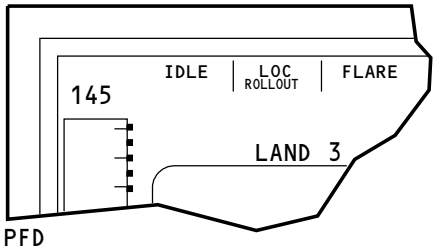


MCP

MCP:
- NO CHANGES ON MCP



EICAS DISPLAY:
- NO CHANGES ON THE ENGINE PRIMARY FORMAT



PFD

PFD:
- THE A/T MODE GOES FROM SPD TO IDLE
- AT TOUCHDOWN WITH REVERSE THRUST ACTIVE, THE A/T DISCONNECTS AND THE A/T MODE DISPLAY GOES BLANK

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TMCS - A/T OPERATION - FLARE RETARD

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TMCS - TMCF FUNCTIONAL DESCRIPTION - INTRODUCTION

General

The thrust management computing function (TMCF) controls engine thrust in response to commands from the guidance function of the flight management computing function (FMCF), the mode control panel, and flight deck switches.

The TMCF sub-functions are:

- Thrust limit calculation
- Engine trim equalization
- Autothrottle (A/T)
- BITE and fault monitoring
- TMCF annunciations.

The TMCF uses digital and analog inputs from external sensors, digital and analog inputs from flight deck components, internal AIMS cabinet interface signals, and cross cabinet AIMS interface signals.

Thrust limit Calculation

The TMCF calculates maximum thrust and thrust limits for these thrust limit modes:

- Takeoff (TO) thrust
- Go-around (GA)
- Climb (CLB)
- Continuous (CON)
- Cruise (CRZ)
- Temperature derated TO
- Fixed derated TO and CLB.

The TMCF uses these inputs to calculate thrust limits:

- Temperature
- Barometric altitude
- Barometric pressure
- Engine/airframe data bases
- Thrust model data base
- Flight deck inputs
- Air/ground.

The thrust limits show on the EICAS display.

Engine Trim Equalization

The TMCF calculates engine trim commands to decrease the thrust difference between the engines. The trim function receives actual engine thrust data from each engine to do this. The incremental engine trim command goes to the EECs to change the engine thrust.

Autothrottle (A/T)

The A/T sub-function sets the thrust levers to capture and hold a thrust setting, or to hold a target airspeed.

To calculate the A/T function, the TMCF uses these:

- Engage logic
- Control Laws
- Mode logic.

The A/T uses inputs from these sources:

- External sensor inputs
- Flight deck switches and sensors inputs
- Flight phase logic inputs
- FMCF thrust, mode, and guidance request inputs
- Internal and cross-cabinet AIMS inputs.

The engage logic determines the validity of the control law data and permits the software control laws to operate. The engage logic also sends logic that permits excitation voltage to the A/T servo motor (ASM). This permits the ASM to operate when it receives a command from the TMCF.

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The control laws calculate the A/T command. It looks at the desired command and the actual airplane condition for that command. The error from these two is the error command.

The mode logic lets allows manual or automatic selection of the available autothrottle mode, thrust limit mode, and thrust limits. The A/T mode, thrust limit mode, and thrust limits show on the PFD and EICAS display.

BITE and Fault Monitoring

The TMCF BITE circuits do tests at power-up and throughout the TMCF operation. When the fault monitor circuits receives a test failure from the BITE, it writes the faults in the TMCF memory and sends the faults to the PDF (primary display function) and the central maintenance computing function (CMCF).

TMCF Annunciations

These annunciations go to the primary display function for the PFD and EICAS display:

- A/T modes
- Thrust limits
- Thrust limit modes
- Fault messages.

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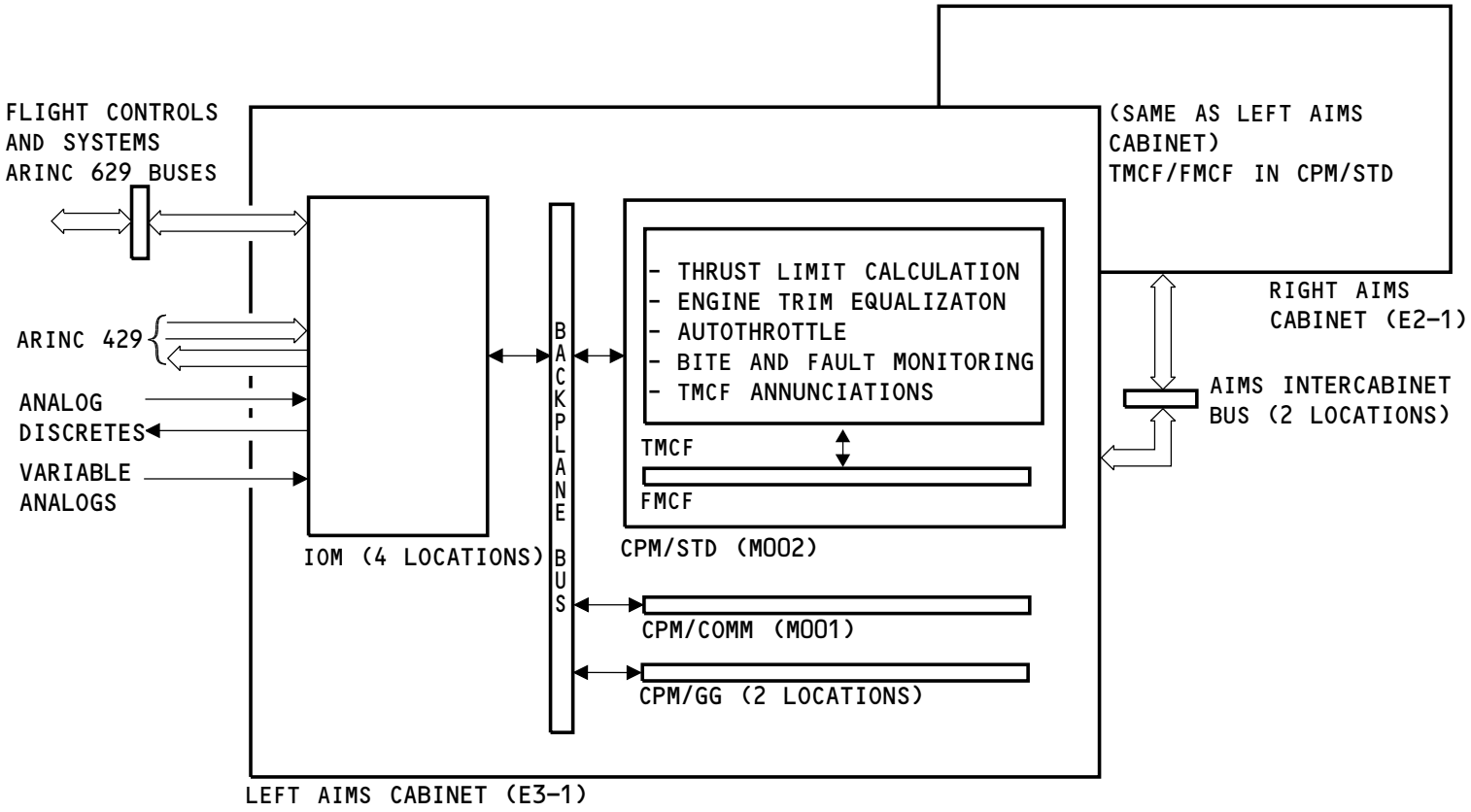

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TMCS - TMCF FUNCTIONAL DESCRIPTION - INTRODUCTION

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TMCS - TMCF FUNCTIONAL DESCRIPTION - AUTOTHROTTLE CONTROL LAWS

General

These are the four autothrottle control laws:

- Speed (SPD)
- Vertical speed (V/S)
- Thrust
- Trim equalization.

For mode logic, there are these five selectable autothrottle modes:

- A/T SPD
- VNAV (SPD/THR)
- FLCH
- Takeoff (TO)
- Go-around (GA).

Each control law uses these:

- Thrust limit protection
- Pilot override logic
- A/T servo motor control.

Mode logic determines which control law is active for servo control.

Speed

Two modes are available for the speed control law. They are VNAV SPD and MCP (A/T) SPD. The VNAV SPD mode uses a command true airspeed (TAS) from the FMCF. The MCP SPD mode uses the speed in the IAS/MACH window on the MCP as command speed. The TMCF compares the command speed with the air data inertial reference unit (ADIRU) speed and the difference is an error. The error goes to the A/T servo motor (ASM) as a rate command.

The control law uses throttle position and adjusts the rate command that drives the throttles. When the airplane is at the command speed from the FMCF (VNAV active in cruise) or the IAS/MACH window (A/T switch active) the error goes to zero.

The thrust limit protection supplies thrust commands to prevent engine thrust limit exceedance for that thrust limit mode.

Both of these modes operate to hold mach or airspeed.

Automatic Speed Mode Engagement

If the autothrottle is not engaged, it will automatically engage in the speed (SPD) mode when all these conditions are true:

- At least one autothrottle ARM switch is in the ARM position
- Airplane altitude above 100 feet RA on approach, or airplane barometic altitude 400 feet above airport on take off
- Engine thrust is below the engine thrust limit
- The autopilot or the flight director are not in a speed-through-elevator mode
- The airspeed is just above stall speed.

Vertical Speed (V/S)

The V/S control law calculates a vertical speed for the flight level change (FLCH) mode and the GA mode. The control law calculates a fixed thrust setting. When the actual V/S is less than the initial calculation, the thrust control law increases thrust. If the actual V/S is more than the initial calculation, the control law does not decrease its thrust calculation. The thrust limit protection prevents engine overboost.

For the FLCH mode, it supplies a vertical speed command to get to the MCP altitude in 125 seconds. THR shows for the A/T mode on the PFD.

During the FLCH mode, if a pilot moves the throttles, the A/T mode changes to throttle HOLD. HOLD shows as the A/T mode on the PFD. This occurs when a difference of eight degrees exists between the throttle position and the throttle command. This occurs for a pilot override or when the throttles move to the aft mechanical stop. When the throttles get to the aft mechanical stop, the ASM continues to drive electrically until there is a difference of eight degrees between the throttles and the servomotor command.

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The go-around (GA) mode controls V/S for the first TO/GA lever push. The control law calculates a thrust setting and compares actual V/S with 2,000 FPM. From this, the TMCF control law calculates a rate command to move the throttles to maintain the set vertical speed. THR shows for the A/T mode on the PFD. Push the TO/GA lever again for a full thrust calculation. The A/T mode changes to THR/REF on the PFD.

Thrust

The thrust control law operates to maintain engine thrust in takeoff (TO), GA (full GA thrust), or VNAV climb/descent thrust limit modes. The thrust limit protection process does not let the engines over boost, exceed the thrust for the thrust limit mode, or go over the maximum speed/maximum mach (Vmo/Mmo) limit. There is no thrust limit protection in the TO mode below 400 feet above ground level (AGL).

Flare retard is a thrust mode. Flare retard engages when the SPD mode is on and the autopilot flight director system (AFDS) sends a flare retard command. Flare retard occurs for both autoland and manual land in the final approach at 25 feet AGL. The AFDS commands the throttles to move aft at a 5 degree rate. IDLE shows as the A/T mode on the PFD.

Throttle and Engine Trim Equalization

Engine trim equalization is available in the manual and autothrottle modes of operation. Trim equalization commands go from the active TMCF directly to the EECs. There is no autothrottle servo movement.

The TMCF calculates the trim equalization command as the difference between the trim reference and each engine N1.

The trim equalization command from the TMCF to the EECs goes to zero when one of the engines N1 is more than 4.8% N1 below the engine with the higher N1 (9.6% N1 for altitudes above 20,000 feet).

The trim equalization command goes to zero if you move one throttle lever away from the other.

For autothrottle operation on the ground and in the air, trim equalization operates at A/T engagement and when these conditions are available:

- Both A/T arm switches are on
- The EECs show that the engines are not failed
- Both engines are in the same mode (normal/alternate)
- Valid data is present.

Thrust Limit Protection

Thrust limit protection provides airframe and engine envelope protection (engine exceedance) in the operating environment. Thrust limit protection shows as thrust limit on the EICAS display and as a speed limit on the primary flight display (PFD). In the TO mode and other A/T modes, the thrust limit protection process gives this protection:

- Maximum speed
- Placard speed
- Configuration speed.

This protection occurs when the airplane is above 400 feet AGL. Autothrottle wake-up mode is another name for this protection.

In the GA mode, maximum and flap placard speed protection occurs when the thrust control law commands the full GA thrust limit.

Pilot Override Logic

A pilot override occurs when a pilot moves the throttles manually to a position that differs from the ASM command by eight degrees. If the pilot does this when the autothrottle mode is FLCH (THR shows on the PFD), the A/T mode on the PFD changes to HOLD. The TMCF removes excitation power from the ASMs. The pilot must change to another autothrottle mode to reset the FLCH mode.

The throttles return to the A/T commanded position when a pilot override stops and the autothrottle is in any of these modes:

- Speed (SPD shows on the PFD)
- VNAV (SPD shows on the PFD)
- Takeoff (TO) thrust
- Go-around.

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A/T Servo Motor Control

Each control law (SPD, V/S, and THR) sends an error command for the A/T mode it calculates. The servo control integrates the error command and sends it to each A/T servo module.

The ASMs move the throttles in rate control. The ASMs move the throttles at eight degree per second forward or aft. Rate feedback increases until it agrees with the throttle rate command. This results in a constant output from the ASMs and the throttles move at a constant rate of eight degree per second.

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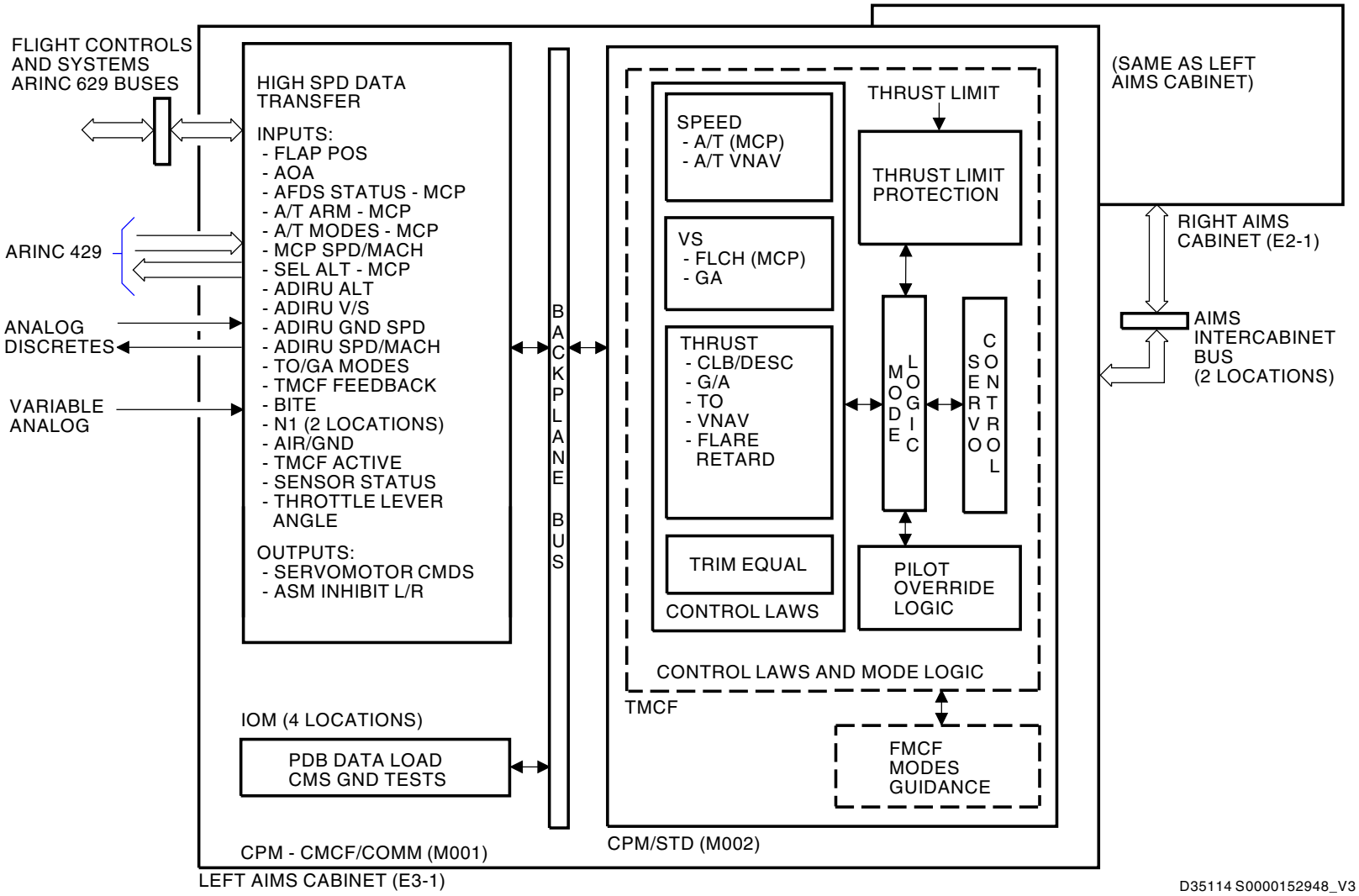

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TMCS - TMCF FUNCTIONAL DESCRIPTION - AUTOTHROTTLE CONTROL LAWS

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TMCS - TMCF FUNCTIONAL DESCRIPTION - THRUST LIMIT CALCULATION

General

The thrust limit calculation part of TMCF has the thrust rating mode logic, limit calculation equations and the associated logic and data base.

The TMCF thrust limit calculations are:

- Maximum thrust
- Thrust limits for A/T thrust limit modes.

Maximum Thrust

The maximum thrust calculation uses these inputs:

- Baro altitude from the ADIRU
- Temperature from the ADIRU
- Baro pressure from the ADIRU
- Gross weight from the FMCF
- Engine/airframe data from the performance data base (PDB).

This is the maximum thrust the engine can deliver. Maximum thrust shows on the main EICAS display thrust indicators. A thrust derate (fixed and/or temperature) can not decrease this calculation. However, a derate can decrease the takeoff (TO) thrust limit calculation of the day.

All the thrust limit modes show on the CDU and the EICAS display.

Thrust Limits

The thrust limit calculation for A/T modes uses these inputs:

- CDU thrust limit mode request
- MCP A/T mode request
- Air/ground
- Flaps not up or glideslope capture
- Ambient conditions (ALT, TEMP and pressure).

The CDU supplies both the thrust limit mode requests and the fixed and temperature derate selections on the THRUST LIMIT page. The fixed derate applies to the TO and CLB thrust limit modes. Temperature derate applies to the TO thrust limit mode only.

The MCP A/T mode request (A/T or FLCH) causes the thrust limit process to calculate and show the CLB thrust limit. This shows on the EICAS display as a digital readout and a green thrust cursor.

For a VNAV A/T mode request on the MCP, the thrust limit process recalculates the thrust limit mode for FMCF comparison. When VNAV engages, FMCF supplies the thrust limit modes and thrust limits to the EICAS display in the climb, cruise, and descent flight phases. The thrust limit process calculates the GA thrust limit when the flaps are not up, at glideslope capture or GA A/T engagement.

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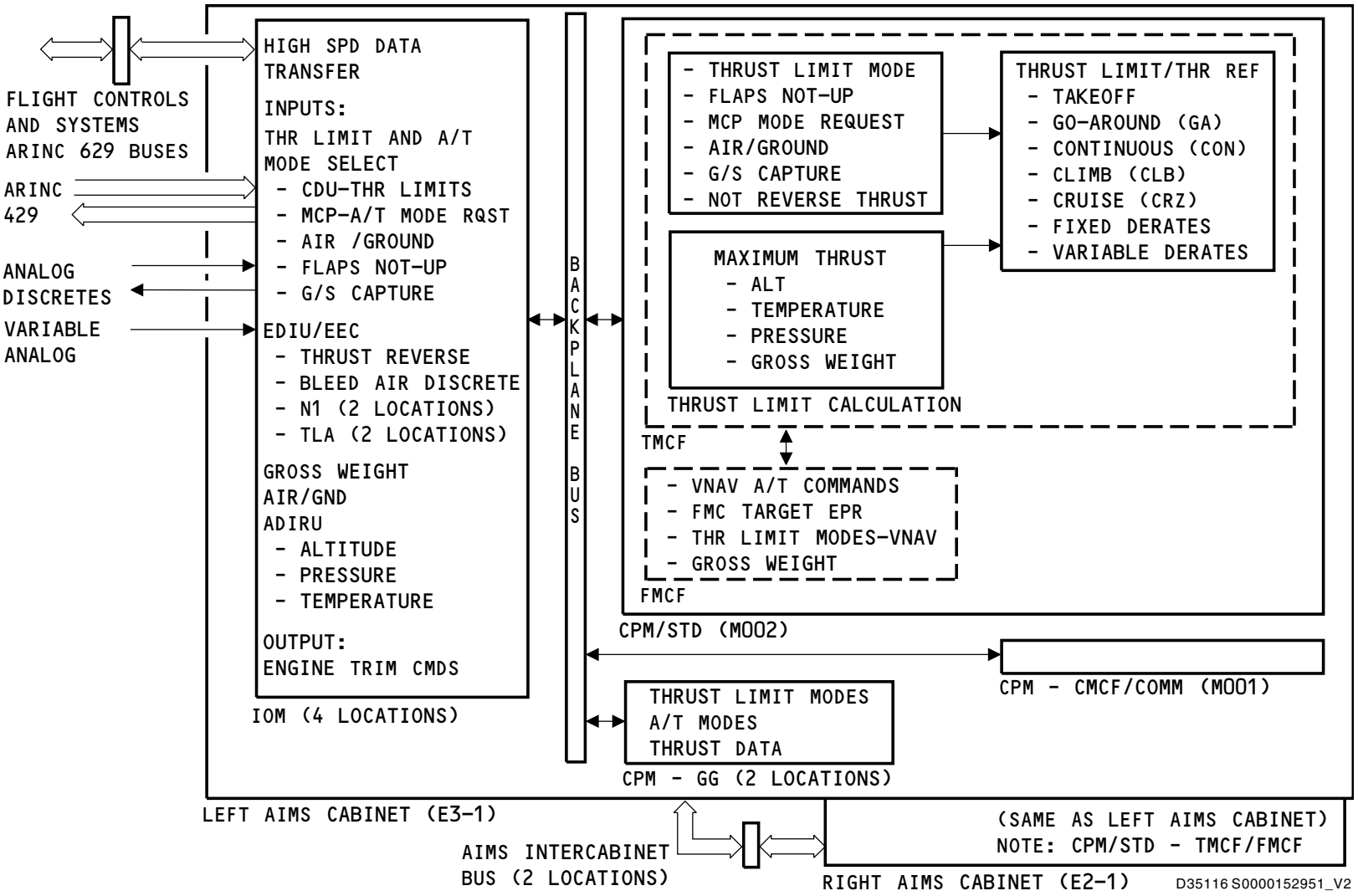

TMCS - TMCF FUNCTIONAL DESCRIPTION - THRUST LIMIT CALCULATION

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TMCS - TMCF FUNCTIONAL DESCRIPTION - ENGAGE LOGIC

General

The A/T engage logic process monitors the TMCF parameters for A/T mode engage. The TMCF sends an analog enable discrete to the A/T servo motors (ASM) when conditions are valid. The logic also generates ASM commands and an autothrottle disconnect signal.

Servo Loop Monitor

When the A/T engages, the control law sends rate commands to the ASMs. The ASMs send rate feedback (tachometer data) to the TMCFs. The servo loop monitor compares these two signals and sets the inhibit logic when they do not agree. This causes the ASMs to disconnect. BITE (TMCF and ASM) failures also set the inhibit.

Autothrottle Disconnect

When the A/T disconnects automatically or manually, the AUTOTHROTTLE DISC caution message shows on the engine primary format display. BITE sets the A/T disconnect. Push an A/T disconnect switch to cause a manual A/T disconnect.

The A/T also disconnects on the ground when the flight crew applies reverse thrust. For this, there is no A/T disconnect message or caution aural.

The AUTOTHROTTLE DISC is a caution message that causes the master caution lights to come on and an aural four beep alert to sound in the flight deck.

Inhibit L/R

The active TMCF causes the ASMs to disconnect when it sets the left and right inhibit switches.

TMCF Selection

The TMCF selection is similar to the FMCF selection. Use the FMC selector to make the left or right TMCF active.

The FMC selector is a three position switch; L (left), AUTO, and R (right). In the L position, the left TMCF and FMCF are active. If the left TMCF fails, there is no active TMCF. In the AUTO position, a random selection of the active TMCF and FMCF occurs after power is supplied. If the active TMCF fails, the other TMCF becomes active. In the R position, the right TMCF and FMCF are active. If the right TMCF fails, there is no active TMCF.

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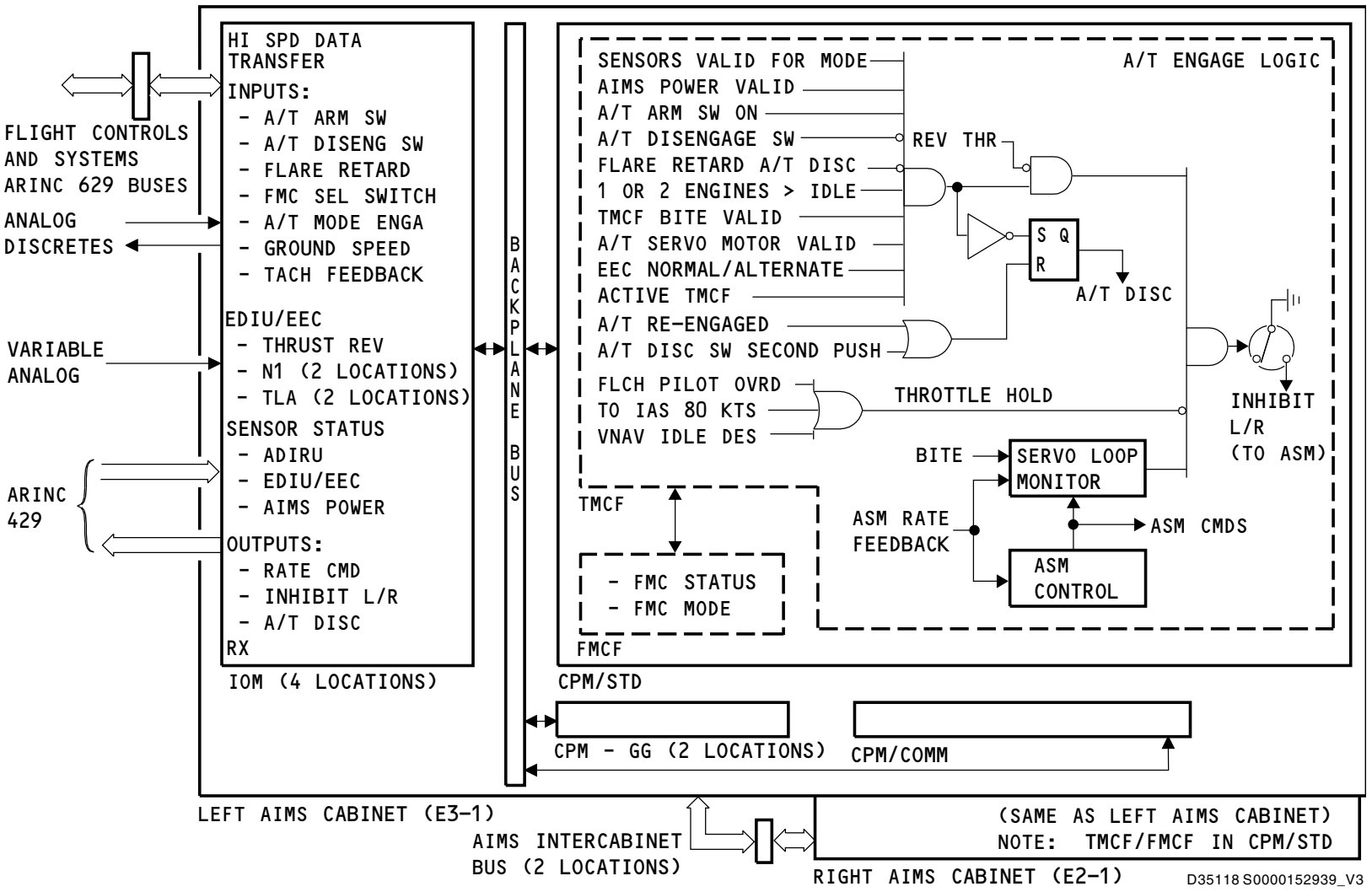

TMCS - TMCF FUNCTIONAL DESCRIPTION - ENGAGE LOGIC

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TMCS - FUNCTIONAL DESCRIPTION - A/T SERVO MOTOR

General

These are the functions of the autothrottle servo motor (ASM):

- ARINC 429 rate command decoding
- Tachometer and power feedback decoding
- Enable/disable logic
- Inner loop servo motor rate control.

The ASM has these components:

- Power supply unit (PSU)
- Power switching module (PSM)
- Electronic control module (ECM)
- DC motor.

Power Supply Unit

The PSU provides internal power for the ECM and the PSM.

Power Switching Module

The PSM has a series of enable switches that send an output to a power switching bridge. These switch inputs are based on these inputs to the input controller:

- Left and right arm from the MCP
- Left TMCF and right TMCF inhibit
- Left, right or auto from the FMC selector.

The output to the power switching bridge lets the bridge process the drive signals.

The enable switches also send an output to the ECM.

Electronic Control Module

The ECM contains the circuitry to calculate the drive commands for the DC motor. The ECM gets inputs through the ARINC 429 receivers and the input controller. It also gets feedback signals from the rate sensors of the DC motor.

DC Motor

The DC motor is a 28v dc brushless motor. The output shaft of the motor connects to a gearbox. The gearbox connects to the throttle lever assembly.

The motor also has a friction brake/clutch assembly that lets a pilot manually override the throttle lever.

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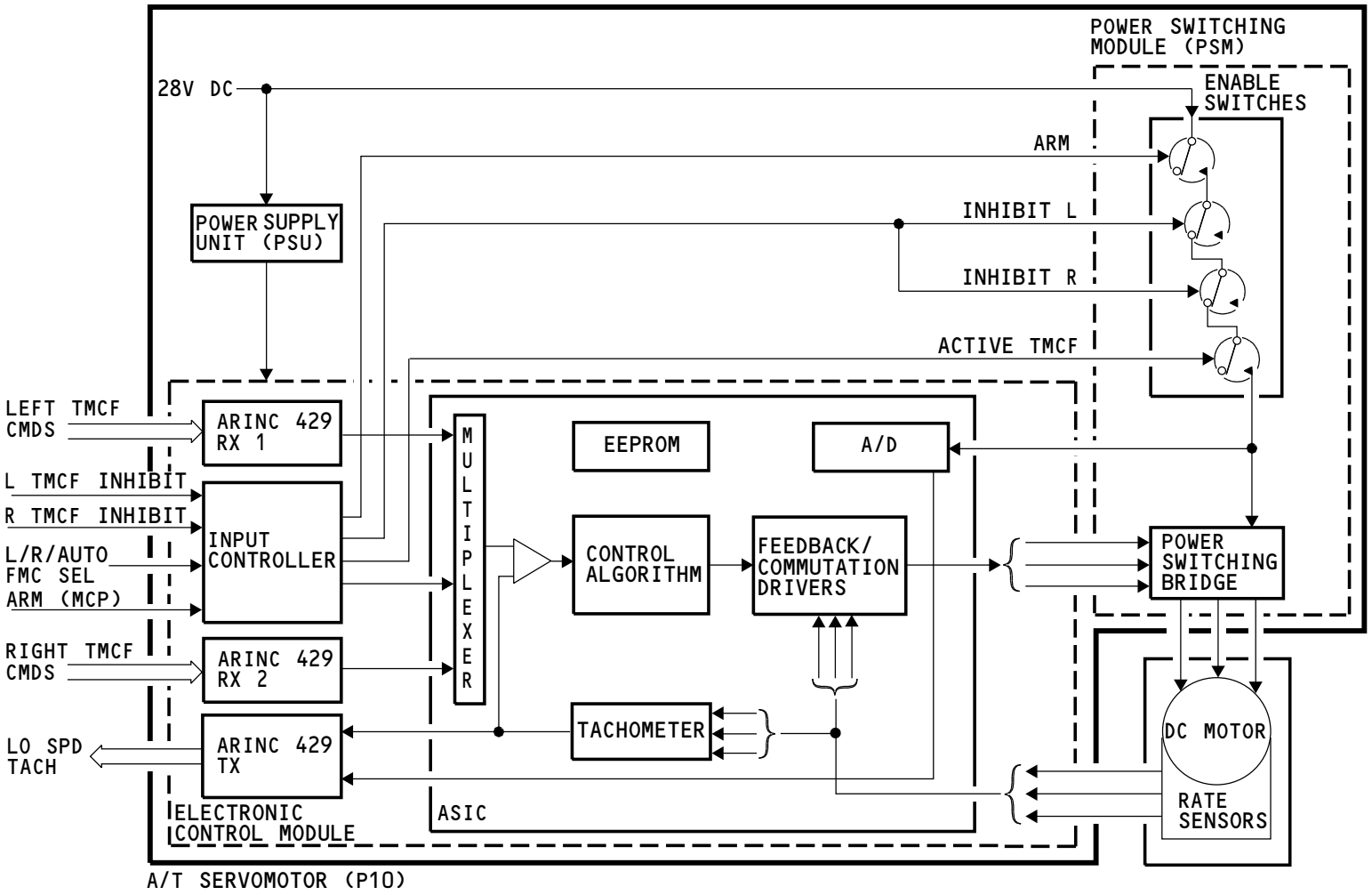

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TMCS - FUNCTIONAL DESCRIPTION - A/T SERVO MOTOR

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TMCS - TMCF FUNCTIONAL DESCRIPTION - BITE AND FAULT MONITORING

General

The TMCF has internal and external fault monitors. The TMCF records BITE faults into TMCF memory. It sends faults to the central maintenance computing function (CMCF) and causes fault messages to show on the EICAS display. BITE logic removes the A/T and thrust limit modes when TMCF BITE detects an internal or external failure.

Internal Fault Monitors

The TMCF does these checks:

- Compatibility
- Miscomparisons
- Active TMCF selection
- Cross cabinet synchronization checks.

The TMCF does these checks when the core processor module (CPM) and cabinet level BITE is valid, the back plane bus is valid, and the input/output (I/O) modules are valid.

The TMCF does these compatibility checks:

- Operational program software (OPS)/hardware
- Engine/airframe
- Operational program configuration (OPC)/OPS
- Engines/ratings
- Ratings/thrust limit data base (TLDB)
- Left and right engine ratings disagree.

The TMCF stores BITE disagree data into BITE history. With a BITE disagree, the TMCF causes all outputs to go invalid and prevents thrust limit calculation (TLC) and autothrottle engage.

At power up, the TMCF does these cross-cabinet miscomparison checks:

- OPS
- Engine/airframe data bases
- OPC
- TLC database.

When a disagree occurs, the TMCF BITE stores each miscompare in BITE history and the TMCF operation shuts down.

AIMS Cross-Cabinet Synchronization

Continuous cross-cabinet synchronization occurs between the active and inactive TMCF. This ensures common modes of operation, A/T commands, and engine trim commands do not change when there is a master TMCF transfer.

External Fault Monitors

The TMCF also monitors these external interfaces for the autothrottle ASMs:

- Servo
- Power removal or no power
- Tachometer feedback, scheduled or zero
- Servo rate within 2 degrees/second
- Stopper, detects inability to remove power from servo during takeoff less than 50 knots.

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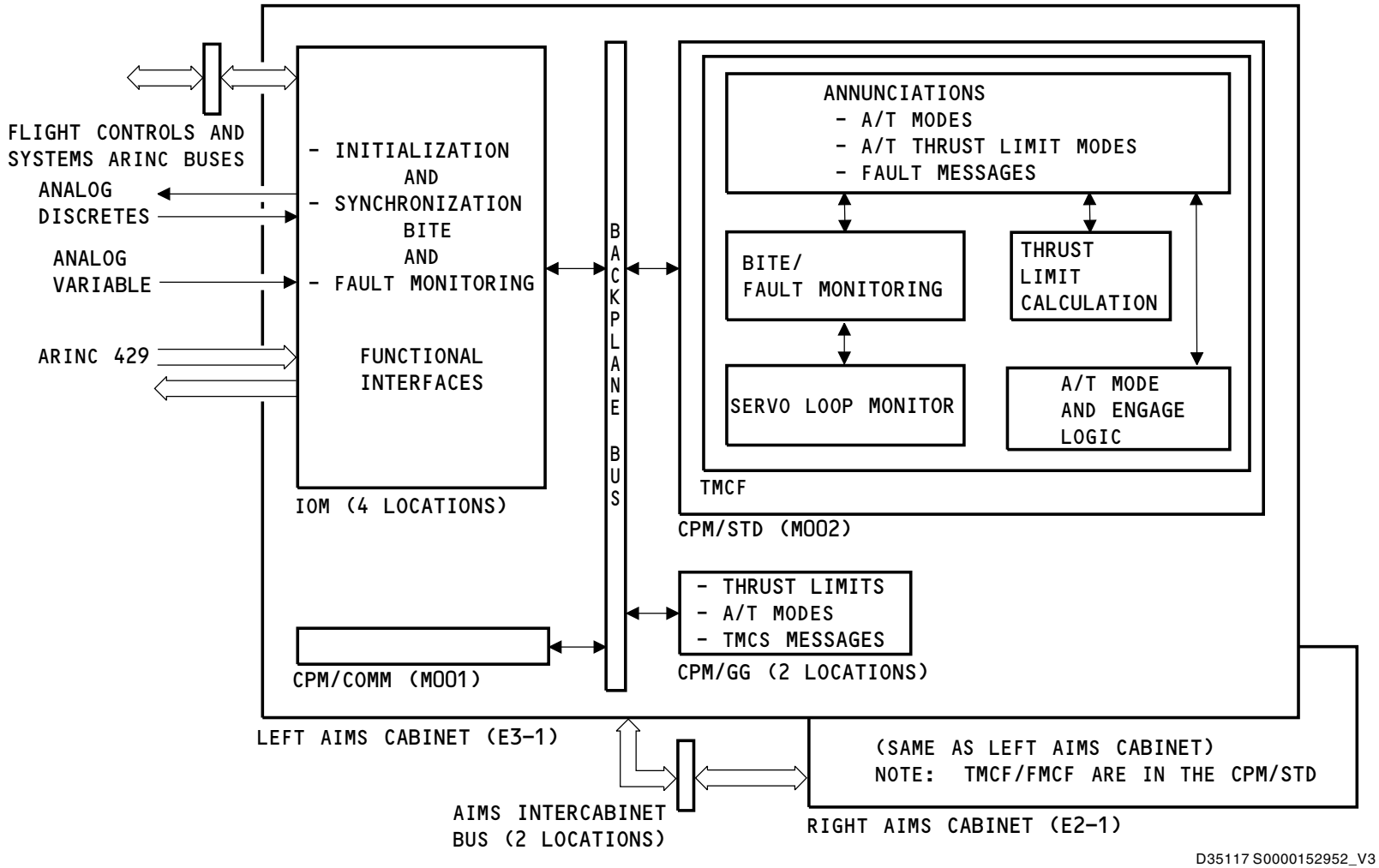

D35117 S0000152952_V3

TMCS - TMCF FUNCTIONAL DESCRIPTION - BITE AND FAULT MONITORING

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General

These are the servo loop system tests for the left and right TMCF:

- Left cabinet servo loop test
- Right cabinet servo loop test.

Servo Loop Test

The servo loop test makes sure that the TMCF in the left and right AIMS and the autothrottle servomotors (ASMs) operate correctly.

The thrust levers on the P10 control stand move during the test.

This test does a test of the ASM rate drive. It also does a test to find if the TMCF can remove power from the ASMs.

The test has four steps. The first step is the initial command. The initial command has a thrust lever angle (TLA) rate of -8 degrees/second for 7 seconds. It also moves the thrust levers aft to the mechanical stop. There is no pass/fail for this first step.

The second step is the throttle stopper test. This test makes sure the TMCF removes power from the ASMs and that the ASMs do not drive in the autothrottle HOLD mode.

The third step is the forward command. This test has a TLA rate of 8 degrees/second for 5 seconds. During the thrust lever movement, the average tach feedback must be between +6 and +10 degrees/second.

The fourth step is the reverse command. This test has a TLA rate of -8 degrees/second for 5 seconds. During the thrust lever movement, the average tach feedback must be between -6 and -10 degrees/second.

The TMCF provides pass/fail information for each servo loop test to show on the MAT.

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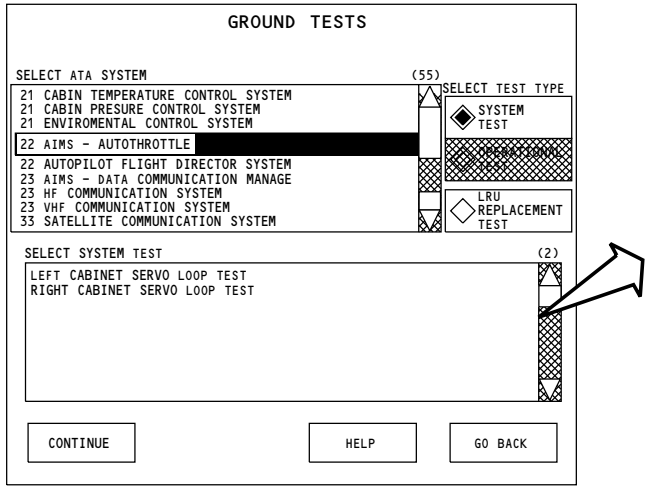

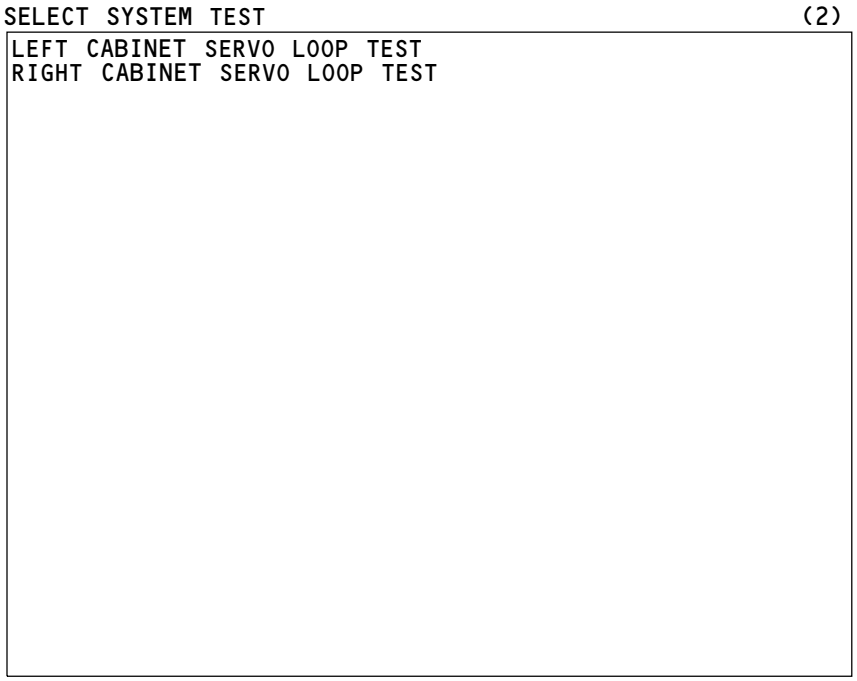

M37854 S000612754_V1

TMCS - SYSTEM TESTS

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TMCS - LRU REPLACEMENT TESTS

General

The LRU Replacement tests for the TMCS are the left and right cabinet analog discrete input tests.

Analog Input Discrete Test

This test makes sure that the TMCF in the AIMS and the takeoff/go-around switches, the autothrottle disconnect switches, and the autothrottle arm switches operate correctly.

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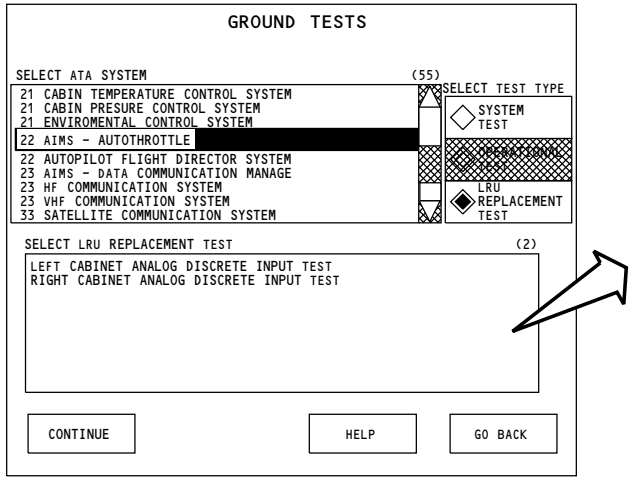

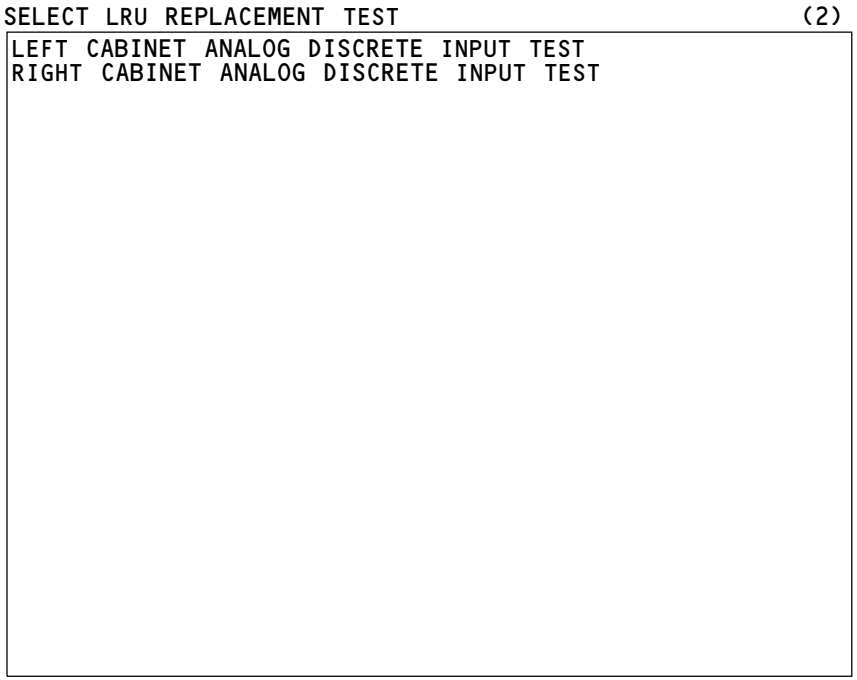

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TMCS - LRU REPLACEMENT TESTS

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