GENERAL

The automatic flight control system (AFCS) on the Challenger 605 is a subsystem of the Collins Pro Line 21 Avionics System. It is a fully integrated flight control system that includes a dual channel two-axis autopilot, each with integrated dual flight directors, dual yaw dampers, and automatic pitch trim control. The flight control system consists primarily of the following equipment:

- Four flight control computers;
- One flight control panel;
- Aileron and elevator servos; and
- Two linear actuators for the rudder (yaw damping).

The flight control computers (FCCs) receive pilots' input from the selections made on the flight control panel (FCP). Electronic signals from the FCCs send guidance commands to the aileron and elevator servos, the yaw damper linear actuators, and the horizontal stabilizer trim control unit (HSTCU).

When the autopilot is engaged, the AFCS maneuvers the aircraft, while the pilot monitors the flight path by observing the flight guidance information presented on the EFIS primary flight display (PFD).

When the autopilot is disengaged, the pilot manually flies the aircraft in response to guidance provided by the flight director (FD) command bars on the PFD.

The Safe Flight enhanced autothrottle system (ATS) incorporates dual–servo control of the thrust levers to enable thrust and speed control for all phases of flight, including a go–around mode. The ATS will be explained in detail at the end of this chapter.

FLIGHT CONTROL COMPUTERS

Description

The flight control computers (FCCs) process information from the inertial reference system (IRS), air data computers (ADCs), navigational (NAV) systems and various cockpit control panels, to calculate flight path and flight guidance parameters.

Components and Operation

Each FCC is capable of generating independent flight director commands.

The FCCs provide output data to the following:

- Flight control panel;
- Flight directors on the PFDs;
- Autopilot servomotors (elevator, aileron);
- Yaw damper actuators; and
- Pitch trim, horizontal stabilizer trim control unit (HSTCU).

Each AFCS uses the following FCCs:

- AFCS 1 – FCC 1A and 2A.
- AFCS 2 – FCC 1B and 2B.

Only one system of FCC pairs (AFCS 1 or AFCS 2) can be active at any time. The inactive system is on standby, and a manual selection is required to switch from AFCS 1 to AFCS 2, or vice versa.

FLIGHT CONTROL COMPUTERS (CONT'D)

The AFCS SEL switch, located on the bottom right hand corner of the reversionary panel, selects the active pair of FCCs (AFCS 1 or AFCS 2) that provide steering commands to the aileron and elevator servos, and to the HSTCU.

The FCCs receive 28V DC power to operate the following buses:

Flight Control Computers Power Supply

FCC	NORMAL POWER
1A	BATT BUS
2A	DC ESS BUS
1B	BATT BUS
2B	DC BUS 2

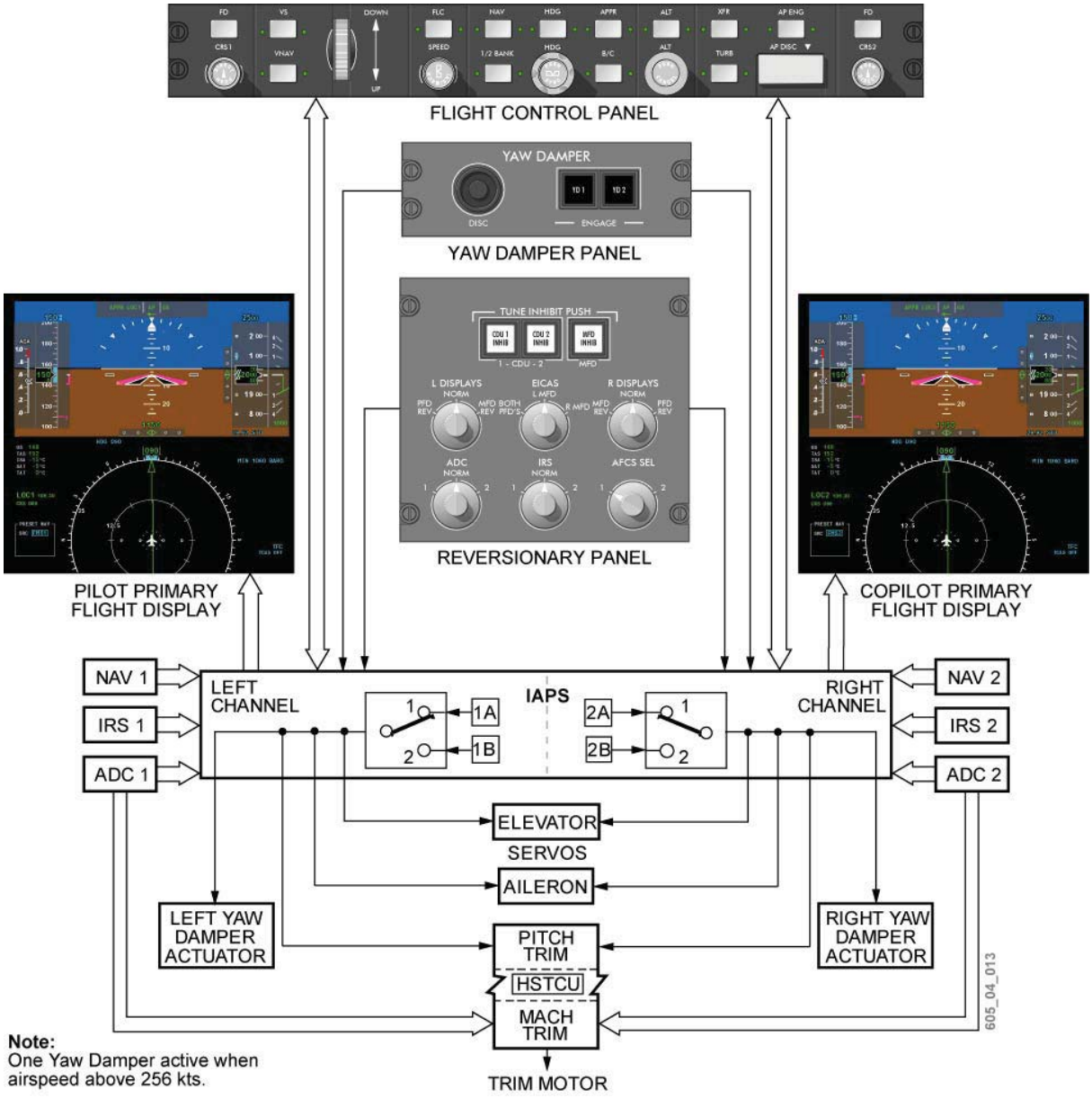
NOTE

FCC 2B not powered during EMER POWER ONLY conditions.

Integrated Avionics Processing System (IAPS)

The integrated avionics processing system (IAPS) is a physical housing (card cage) containing the four flight control computers (FCCs) and other avionics systems computers and modules. The IAPS provides power to the avionics components, and enables these components to communicate with each other and with aircraft systems.

FLIGHT CONTROL COMPUTERS (CONT'D)



Automatic Flight Control System Configuration
Figure 04–10–1

Flight Control Panel (FCP)

The flight control panel (FCP) is the mode selection panel that controls the flight director and autopilot functions. The FCP is located on the glareshield, and is accessible to both pilots.

FLIGHT CONTROL COMPUTERS (CONT'D)

Flight Control Panel
Figure 04–10–2

FCC Status Indicator Lights

There are two green status indicator lights, one on either side of each mode button. When a pilot selects an FCP button, the request is sent to both active FCCs (1A and 2A, or 1B and 2B). When the FCCs determine that conditions are correct for the selected mode, they send acknowledgement signals back to the FCP, and illuminate the green lights on either side of the selected button.

The left light indicates that FCC 1 (A or B) has acknowledged the request. The right light indicates that FCC 2 (A or B) has acknowledged the request.

NOTE

Illumination of the status indicator lights does not provide the flight crew with a complete representation of active or armed flight director modes. The flight mode annunciator must always be cross-checked to confirm current lateral and vertical FD mode status.

FD Buttons

The FD buttons are used to turn on or turn off the flight directors. When the autopilot is not engaged, pressing the FD button, associated with the active flight director, will remove the command bars and vertical and lateral guidance information from both PFDs. The inactive side FD button can be used to alternately display or remove the flight director command bar from the associated PFD.

Course Select Knob

The course select knobs are used to set the course arrow when navigating with a VOR or localizer. CRS1, when rotated, changes the selected course as displayed on the left primary flight display. A course arrow and digital course readout on PFD 1 indicate the course setting. The button in the center of the knob (PUSH DIRECT button), when pressed, causes the course pointer and digital readout to indicate a “direct-to” course to the tuned VOR station.

The CRS2 course select knob operates in an identical manner for the right PFD.

AUTOPILOT

Description

The Challenger 605 is equipped with a dual-channel, two-axis, fail-passive autopilot system. The autopilot provides an interface between the AFCS and flight controls for roll and pitch commands. Yaw dampers provide turn coordination and yaw damping.

The autopilot is integrated with the flight director to automatically control and direct the flight path of the aircraft. When engaged, the autopilot controls the aircraft’s pitch and roll axes in accordance with the coupled flight director commands.

AUTOPILOT (CONT'D)

Operation

Autopilot Pitch Trim

Automatic pitch trim is enabled whenever the autopilot is engaged. The autopilot issues commands to the horizontal stabilizer trim control unit (HSTCU) to remove continuous loads from the elevator servomotor.

Protracted trim operation causes the trim clacker aural to sound. Autopilot pitch trim failure is annunciated by an **AP PITCH TRIM** caution EICAS message.

Autopilot Mistrim Conditions

The AFCS continuously monitors both axes of the autopilot when it is engaged. A significant elevator mistrim condition causes the EICAS to display an **AP HOLDING NOSE UP** or **AP HOLDING NOSE DOWN** caution EICAS message (autopilot is counteracting a significant nose-up or nose-down mistrim). For a significant aileron mistrim condition, an **AP HOLDING LWD** or **AP HOLDING RWD** caution EICAS message (indicating left or right wing down) is displayed.

NOTE

When the autopilot is disengaged during a mistrim condition, expect an abrupt change in control force.

NOTE

Autopilot monitors aileron mistrim conditions but cannot change aileron trim settings.

Autopilot Servomotors

When the autopilot is engaged, the active pair of FCCs direct roll and pitch commands to the aileron and elevator servos, and stabilizer trim commands through the HSTCU. When a change in roll or pitch is required, the FCCs signal the aileron servo or elevator servo to bias the control cables and displace the associated control surface.

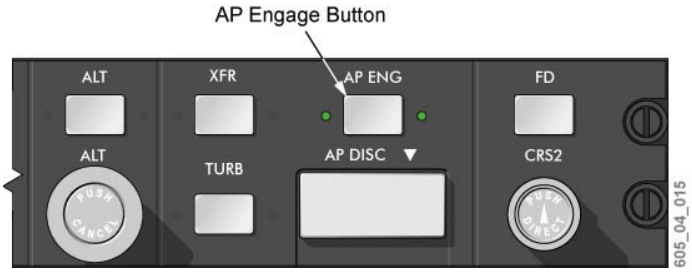
The aileron servo is located on the control cable run for the right aileron. Since the left and right ailerons are normally interconnected, the servo is capable of moving both ailerons.

The elevator servo is located on the left elevator cable run. Both elevators move unless disconnected.

Autopilot Engagement

The autopilot is engaged by pressing the AP ENG button located on the flight control panel. Autopilot engagement is indicated by the illumination of a green indicator light along each side of the AP button. In addition, an AP engage annunciation is provided on the centre of the FMA display of each PFD (see Figure 04–10–4).

AUTOPILOT (CONT'D)



AP Engage Button
Figure 04–10–3

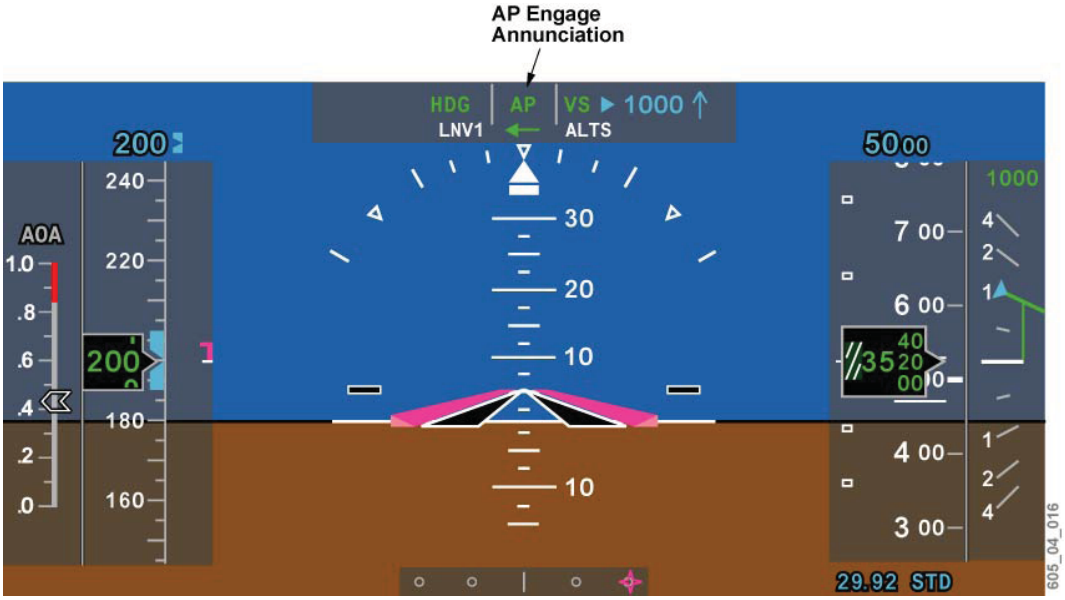
Once engaged, the autopilot will couple to, and follow the guidance commands from, the selected flight director. If no FD modes are commanded prior to autopilot engagement, the autopilot automatically activates, and follows guidance from the basic lateral (ROLL) and vertical (PITCH) modes.

When the autopilot is not engaged, a left- or right-pointing arrow, in white, indicates which flight director the autopilot will couple to upon engagement.

Autopilot Engagement Criteria

The autopilot can be engaged provided the following conditions exist:

- At least one yaw damper is engaged (normally, both YDs are engaged);
- No faults detected in the active pair of flight control computers (FCCs); and
- No significant instability exists, including:
  - Adverse pitch/roll/yaw rates;
  - G-loads exceeding predetermined values; or
  - Adverse pitch/roll attitudes exceeding predetermined values.



Autopilot Engagement
Figure 04–10–4

AUTOPILOT (CONT'D)

Autopilot Disengagement

Manual (Pilots Action) Disengagement

The autopilot is normally disengaged by pressing the red autopilot/stick pusher (AP/SP DISC) disconnect button on the outboard horn of either control wheel.

The autopilot may also be manually disengaged by any one of the following actions:

- Operating either stabilizer trim switch;
- Pushing the AP ENG button on the FCP;
- Selecting takeoff or go-around (TOGA) button;
- Switching the AFCS SEL selector to the other AFCS (1 or 2); or
- Pressing the yaw damper DISC switch.

Whenever the autopilot is manually disengaged (by pilot action), the PFD green engage annunciation turns red and flashes for 5 seconds, the green status indicator lights beside the AP button extinguish, and the autopilot disconnect (cavalry charge) aural sounds. The autopilot disconnect warning will automatically cancel after a few repetitions of the cavalry charge.

Monitored Disengagement

The FCCs continually monitor aircraft sensors, servo data, the automatic pitch trim system and internal parameters for faults. The autopilot will automatically disengage if any of the following conditions occur:

- Internal FCC monitors detect a failure in any axis;
- Any power source to an FCC of the active pair is lost;
- Loss of either inertial reference system (IRS) system input;
- Dual yaw damper failure;
- Aircraft is at an excessive attitude (pitch angle beyond +25° or –17°, roll angle beyond ±45°);
- Either stick shaker activates; or
- Switch from one AFCS to the other.

A monitored disengagement is annunciated in the same manner as a manual disengagement, with the exception that the flashing on the PFD and the aural warning will continue until cancelled by the flight crew. Pressing either pilot's AP/SP DISC switch or TOGA button, or reengaging the autopilot, will cancel the flashing on the PFD and the aural warning.

YAW DAMPER SYSTEM

Description

Each yaw damper is a dual-channel, fully independent yaw damper system, providing yaw damping, turn entry, steady-state turn coordination, and turn exit for the full flight envelope.

The yaw dampers operate independently of the autopilot.

NOTE

The yaw damper will not compensate for a sustained adverse yaw created by an engine power asymmetry or improper rudder inputs.

YAW DAMPER SYSTEM (CONT'D)

Operation

Yaw Damper Engagement

The yaw dampers are engaged by pushing both YD 1 and YD 2 switch/lights on the YAW DAMPER panel. Selective engagement of the switch/lights activates the corresponding yaw damper channel. Yaw damper engagement is indicated by the absence of YAW DAMPER (status and caution) EICAS messages and PFD indications.

Normally, both yaw dampers are engaged for all phases of flight. One yaw damper channel will provide adequate yaw damping and turn coordination during flight. At speeds greater than 256 kts, only one yaw damper will be active.

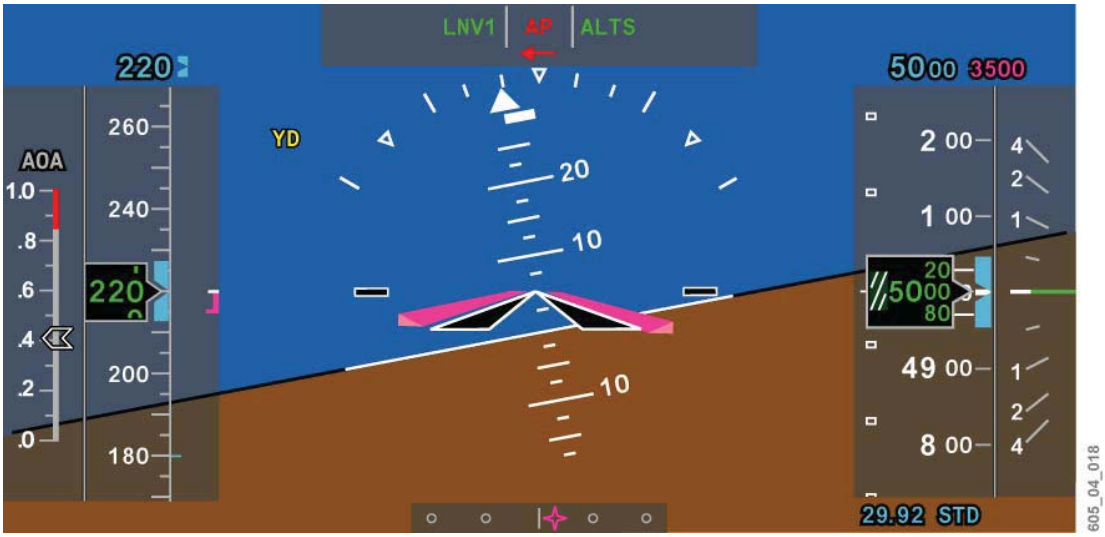
Yaw Damper Disengagement

The DISC button on the YAW DAMPER panel disengages both yaw damper channels when pressed. When both yaw damper channels are disengaged, an amber YD annunciation is displayed on the upper left side of the PFDs, and a **YAW DAMPER** caution EICAS message appears.

A single disengaged (or inoperative) yaw damper channel is indicated by a **YD 1(2) INOP** status EICAS message.

YAW DAMPER Panel
Figure 04–10–5

YAW DAMPER SYSTEM (CONT'D)



Yaw Damper Disengaged Annunciation
Figure 04–10–6

FLIGHT DIRECTORS

Description

The flight directors (FDs) are the visual representation of the commands generated by the flight control computers.

Operation

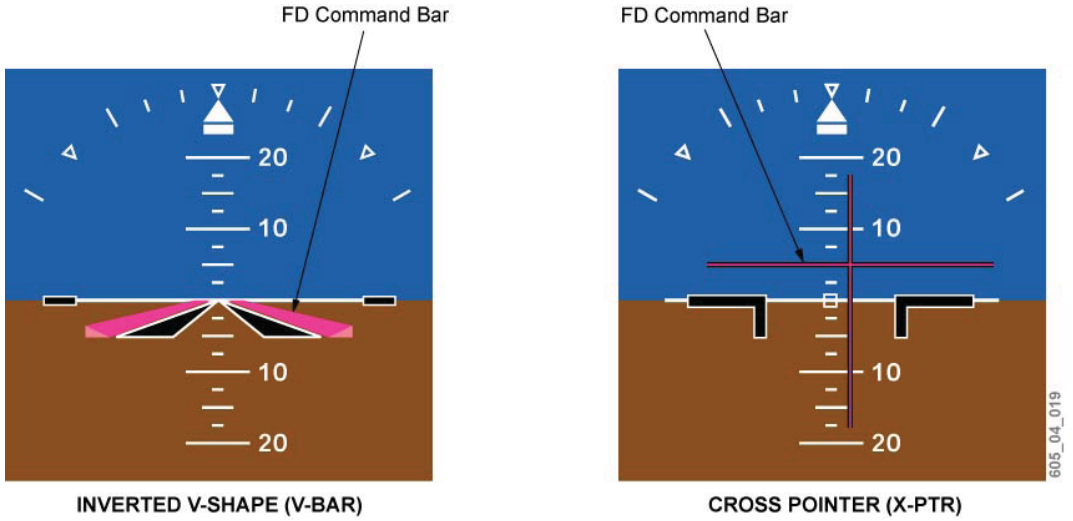
Flight Director Command Bars

The flight directors provide integrated pitch and roll guidance by means of magenta inverted V-shaped (V-BAR) or cross pointer (X-PTR) command bars on the ADI of the PFD.

The command bars are always in view when the flight director is being used or when the autopilot is engaged. The command bars are out of view when the flight director is turned off or flagged, or when the aircraft's attitude is extreme.

The pilot can manually fly the aircraft by following the command bar guidance cues. When the autopilot is engaged, the FCCs issue steering commands to the aileron and elevator servos according to the flight director guidance instructions.

FLIGHT DIRECTORS (CONT'D)



Flight Director Command Bar
Figure 04–10–7

Flight Director Selection

There are two independent flight directors for each AFCS channel. They are designated as per the following table:

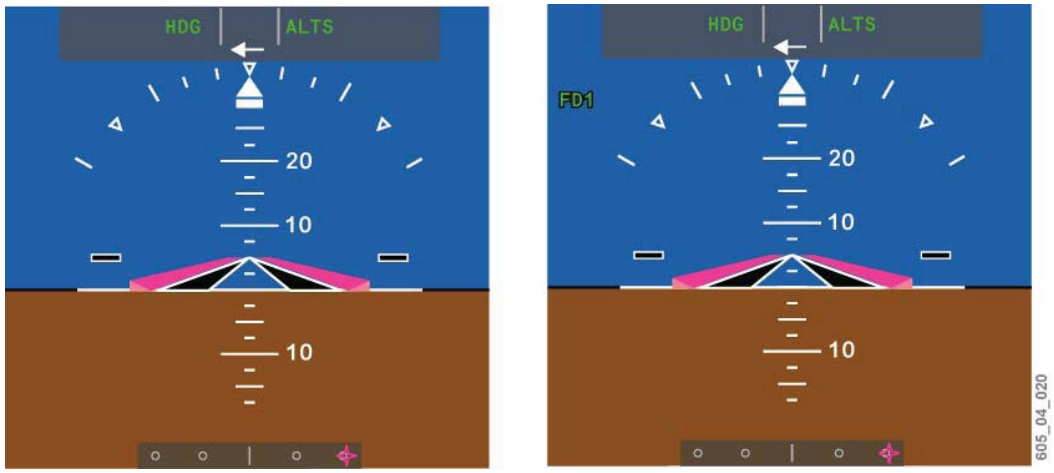
Flight Director Designation

AFCS CHANNEL	LEFT SIDE FCC	RIGHT SIDE FCC
1	FD 1	FD 2
2	FD 1	FD 2

In most flight director modes, only one FD provides guidance commands and flight mode annunciations to both PFDs. The other FD operates as a standby. This ensures that all FD mode annunciation and command cues displayed on the left and right PFD remain synchronized.

At power-up, both flight directors are off. FD 1 defaults as the active flight director, following selection of any lateral or vertical mode on the FCP. When FD 1 is active and the autopilot is disengaged, a white left-pointing arrow is displayed in the FMA area of both PFDs. The right PFD also displays a green FD 1 annunciation below and to the left of the FMA area, to indicate that right side FD commands are being supplied by FD 1.

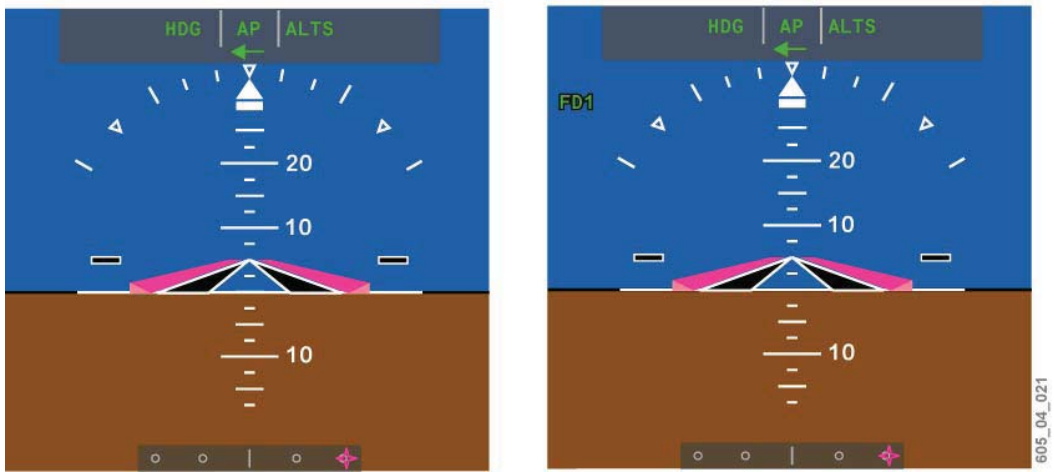
FLIGHT DIRECTORS (CONT'D)



Flight Director Couple Arrow
Figure 04–10–8

When the autopilot is engaged with FD 1 active, a green AP annunciation is displayed on both PFDs over the left-pointing FD arrow.

When the left-seated pilot has control of the aircraft, FD 1 is normally selected and all flight guidance commands are derived using the left side systems (ADC 1, IRS 1, left side navigation source selection).



AP/FD Engagement
Figure 04–10–9

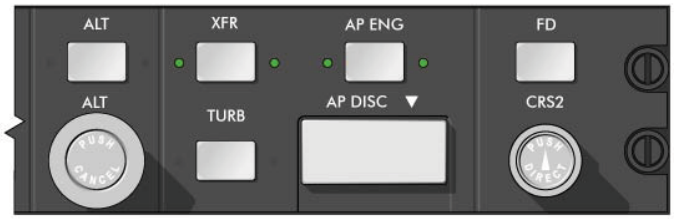
AP/FD Transfer (XFR) Mode

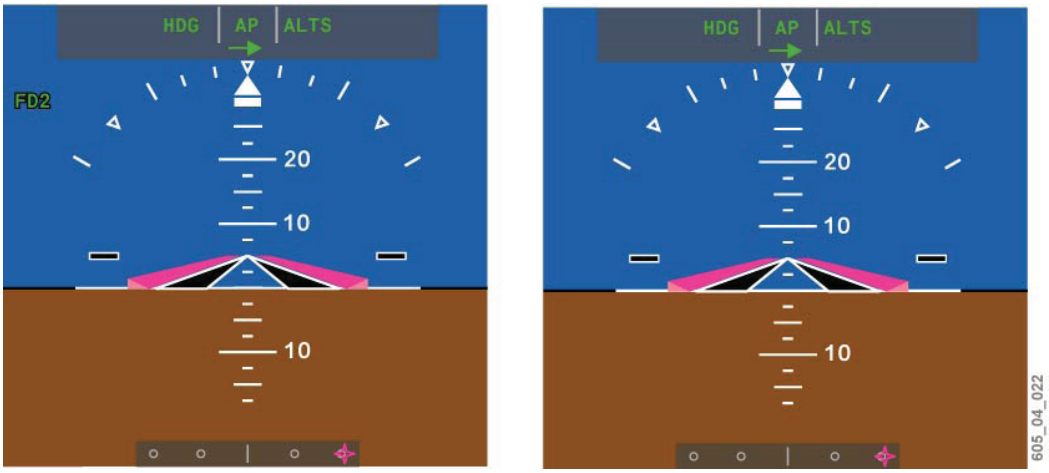
Selecting XFR on the flight control panel transfers to the cross-side active FD. It determines which FD guidance the autopilot will follow when engaged. The following table illustrates the PFD display based upon XFR switch selection.

In addition, the green status indicator lights beside the XFR button illuminate to indicate that transfer mode is active.

FLIGHT DIRECTORS (CONT'D)

	AUTOPILOT NOT ENGAGED		AUTOPILOT ENGAGED	
XFR	Left Side	Right Side	Left Side	Right Side
OFF		FD1	AP	AP FD1
ON	FD2		AP FD2	AP





AP/FD Transfer
Figure 04–10–10

Dual Independent FD Operation

Both FDs become active and supply independent flight guidance commands to their associated PFD (dual independent operation) when in the following flight director modes:

- Takeoff mode;
- Go-around mode; and
- Approach (APPR) mode.

FLIGHT DIRECTORS (CONT'D)

When operating independently, the coupled side channel supplies steering commands to the autopilot, and dual independent flight guidance computations are supplied to the flight directors (“split” flight directors). The left channel supplies flight guidance commands to the left flight director, and the right channel supplies flight guidance commands to the right flight director.

In the above modes, the FD1 and FD2 annunciations are not displayed on the PFDs.

Independent "Split" FD Mode
Figure 04–10–11

Flight Mode Annunciator (FMA)

Lateral and vertical FD modes are presented in the flight mode annunciator (FMA) displayed on each PFD. The FMA is located above the PFD ADI display.

The FMA is divided into two fields, separated by vertical cyan lines. The left field displays the lateral flight director modes. The right field displays the vertical FD modes. Each field has two lines, the top indicates the active or captured mode (green), the bottom line indicates the armed modes (white). Certain conditions will trigger the use of yellow, and will be explained under each mode.

FMA Active/Captured Mode Display

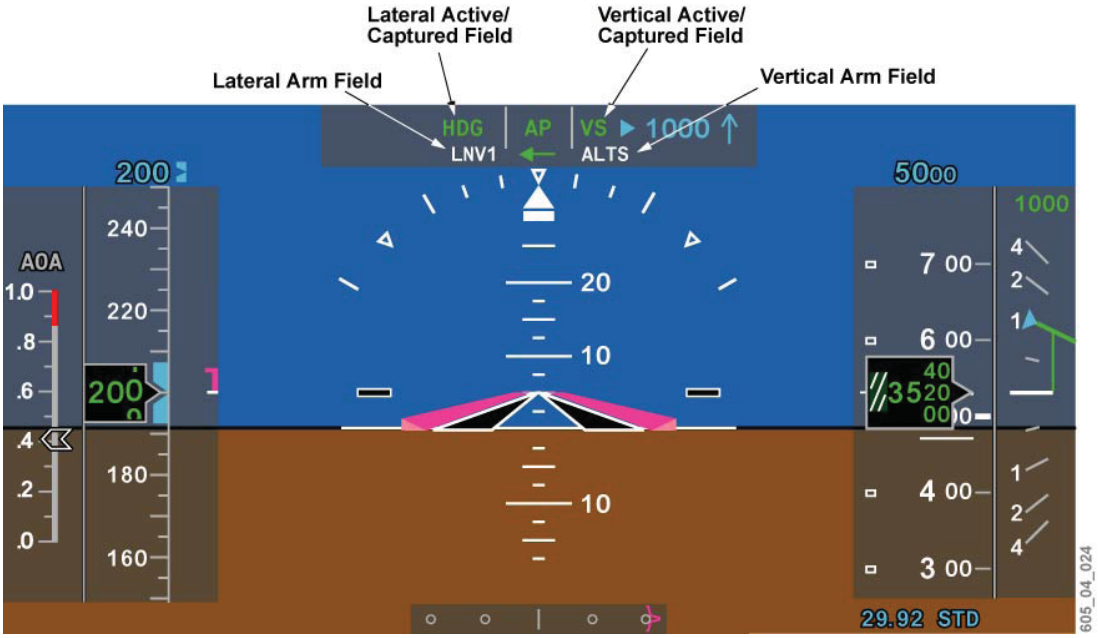
The active/captured lateral and vertical modes are displayed in steady green text. Lateral and vertical modes that are capturing are displayed in flashing green text for five seconds, then change to steady green text.

If the active lateral or vertical mode becomes invalid (sensor data), the flight control system removes the invalid steering commands from the affected flight director. A red horizontal line is superimposed over the affected active mode annunciation (e.g. VOR1).

FMA Armed Mode Display

The armed lateral and vertical modes are normally displayed in steady white text in the lower portion of the lateral or vertical field. Up to two vertical modes may be armed simultaneously.

FLIGHT DIRECTORS (CONT'D)



Flight Mode Annunciator (FMA)
Figure 04–10–12

FD Activation

There are three methods to activate the flight director:

- Selecting a lateral or vertical mode on the flight control panel;
- Engaging autopilot; or
- Pushing takeoff/go-around (TOGA) switches.

FD Deactivation

The flight director is deactivated with the FD button on the FCP.

When the autopilot is not engaged, pressing the FD button on the offside will deactivate the offside flight director only. Pressing the onside FD button disengages both flight directors.

When the autopilot is engaged, pressing the FD button on the offside will deactivate the offside flight director only. Pressing the onside FD button has no effect.

The FD button is inhibited during an overspeed condition.

FD Synchronization

The FD SYNC switch synchronizes the FD command bar reference values to the values flown at the time of selection. The FD SYNC switch is located on the back outboard horn of the pilot's and copilot's control wheels.

FLIGHT DIRECTORS (CONT'D)

The following flight director modes can be synchronized to the current aircraft conditions when the FD SYNC switch is depressed:

- FLC (indicated airspeed/Mach);
- VS (vertical speed);
- ALT (barometric altitude hold);
- PTCH (pitch angle); and
- ROLL (roll angle).

When any flight director mode listed above is active, pressing the FD SYNC switch causes a yellow SYNC message to appear on both PFDs. The SYNC message will be removed when the FD SYNC switch is released.

Pressing the FD SYNC switch while the autopilot is engaged releases the aileron and elevator servo clutches, which allows the flight crew to manually fly the airplane without disengaging the autopilot. The AP engage annunciation will also appear in yellow whenever the FD SYNC switch is being pressed with the autopilot engaged.

NOTE

While the FD SYNC switch is pressed, trimming the horizontal stabilizer will not disengage the autopilot.

AP/FD Synchronization
Figure 04–10–13

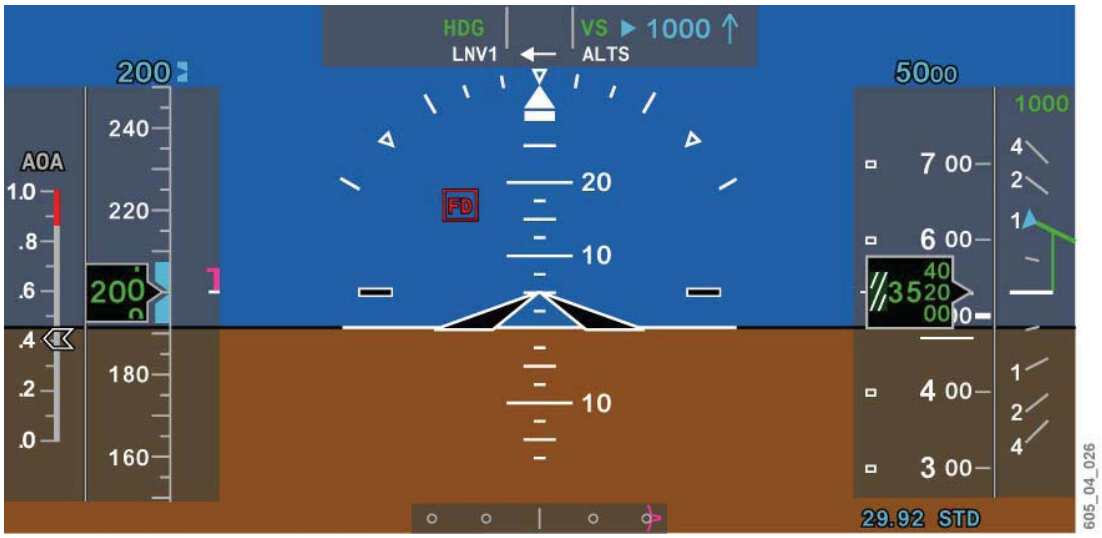
FD Failure

If the active flight director fails, the flight director command bars are removed from both PFDs and replaced by a red boxed FD annunciation. An **FD 1(2) FAIL** status EICAS message may also be displayed.

If the active FD fails, selecting the XFR button on the FCP deselects the failed flight director and allows the cross-side flight director to become active.

FLIGHT DIRECTORS (CONT'D)

Selecting the other AFCS (1 or 2) enables the second pair of FCCs, which would then allow the autopilot to be reengaged.



FD Failure Indications
Figure 04–10–14

Flight Director Lateral Modes

There are eight flight director lateral modes (bold letters refer to the FCP button selections):

- Roll
- Heading select (**HDG**)
- Half bank (**1/2 BANK**)
- Navigation; FMS, VOR, LOC (**NAV**)
- Approach; FMS, VOR, LOC (**APPR**)
- Back course (**B/C**)
- Takeoff
- Go-around

Lateral modes are armed or activated by push-buttons on the flight control panel or on the thrust levers. In general, deselecting the active lateral mode is accomplished by reselecting the active FCP mode push-button, or by selecting another lateral mode.

Roll Mode

ROLL is the basic lateral operating mode, and is automatically selected when no other lateral mode is active and the flight director is on. A green ROLL annunciation appears in the active lateral field of the FMA when roll mode is active.

Roll mode generates commands to maintain a reference bank angle. If the roll attitude (bank angle) is more than five degrees from level when roll mode is selected, the FCC generates commands to maintain the bank angle. If the roll attitude is less than five degrees, the FCC generates commands to maintain heading by rolling to zero bank (wings level).

FLIGHT DIRECTORS (CONT'D)

The pilot flying may adjust the roll reference to a desired roll angle by pushing the FD SYNC button and manually setting a bank angle up to 30 degrees. If the pilot selects a bank angle greater than 30 degrees, but less than 45 degrees, the FD will generate commands to return to 30 degrees' bank upon release of the FD SYNC button.

Roll mode is automatically cleared by selection of another lateral mode.

NOTE

Roll mode is automatically selected if the data required to fly the active lateral mode becomes invalid.

Roll Mode
Figure 04–10–15

Heading Select Mode

Pushing the HDG button on the FCP alternately selects and clears heading select mode. A green HDG annunciation appears in the active lateral field of the FMA when the mode is active.

Heading select mode generates commands to capture and maintain the selected heading (heading bug). When heading mode is selected, the direction of turn will be the shortest turn to the heading bug. The desired heading can be changed by turning the HDG knob on the FCP. With heading mode active, the direction of turn will always be in the direction the heading bug is moved. The heading bug may be synchronized to the aircraft's current heading by pressing the PUSH SYNC button in the center of the heading knob.

Heading mode is automatically cleared by selection or capture of another lateral mode, or by pressing the HDG button again.

FLIGHT DIRECTORS (CONT'D)

Heading Mode
Figure 04–10–16

Half Bank Mode

Pushing the 1/2 BANK button on the FCP alternately selects and clears half bank mode. When the mode is active, a white 1/2 BNK annunciation appears to the left of the active/captured roll mode on the PFDs, and a green arc is displayed at the top of the roll scale. Half bank mode may be selected simultaneously with heading (HDG) or FMS navigation mode.

When active, half bank mode (1/2 BANK) reduces the roll limit to half the normal value for the active lateral mode.

Half bank mode is cleared automatically by activation of a noncompatible lateral mode (TO, GA, onside approach mode or localizer capture), or can also be cleared by pressing the 1/2 BANK button again.

Automatic Half Bank

Half bank is automatically selected if either flight director is selected and the airplane climbs through a transition altitude of 31,600 feet MSL, or if the airplane is above this altitude when the flight director is turned on. Half bank mode automatically clears when the airplane descends below 31,600 feet MSL. Manual operation of half bank mode overrides the FCC automatic transitions to or from half bank mode.

FLIGHT DIRECTORS (CONT'D)

Half Bank Mode
Figure 04–10–17

NAV Mode

Pushing the NAV button on the FCP alternately selects and clears the navigation mode, and causes the flight director to generate lateral commands to capture and track the active navigation source (VOR, LOC, FMS).

The displayed navigation source will determine which navigation submode will be in operation.

NAV Source Selection

The navigation source may be selected using the PRESET NAV box or the PFD menu.

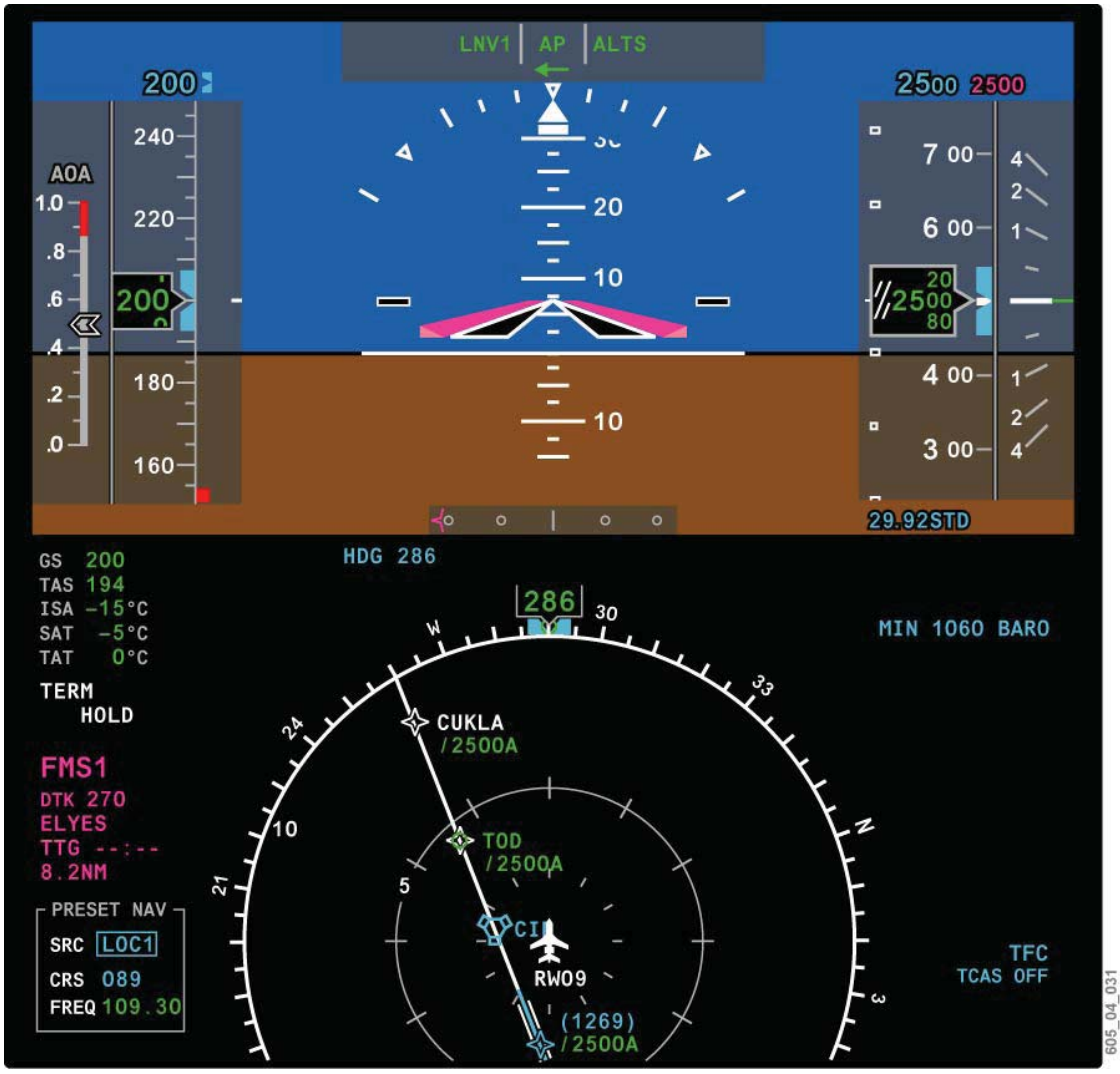
- PRESET NAV box: Select desired preset NAV source by rotating the data knob on the DCP, then push the NAV SRC swap button.
- PFD menu: Press MENU button on the DCP, and use the menu ADV/DATA knob to select the desired NAV source.

LOC or VOR navigation source is determined by the ground station frequency set in the radio tuning window.

All NAV mode annunciations appear in the lateral field of the FMA: armed modes in white, and active/captured modes in green. Captures that are inhibited due to invalid data are annunciated on the PFDs as a red horizontal line through the mode annunciation.

FLIGHT DIRECTORS (CONT'D)

Display Control Panel
Figure 04–10–18



Navigation Source Selection Display
Figure 04–10–19

FLIGHT DIRECTORS (CONT'D)

VOR Navigation Mode

In the VOR navigation mode, the flight director generates lateral steering commands to capture and track the selected VOR radial (inbound or outbound), using the course displayed on the active navigation source.

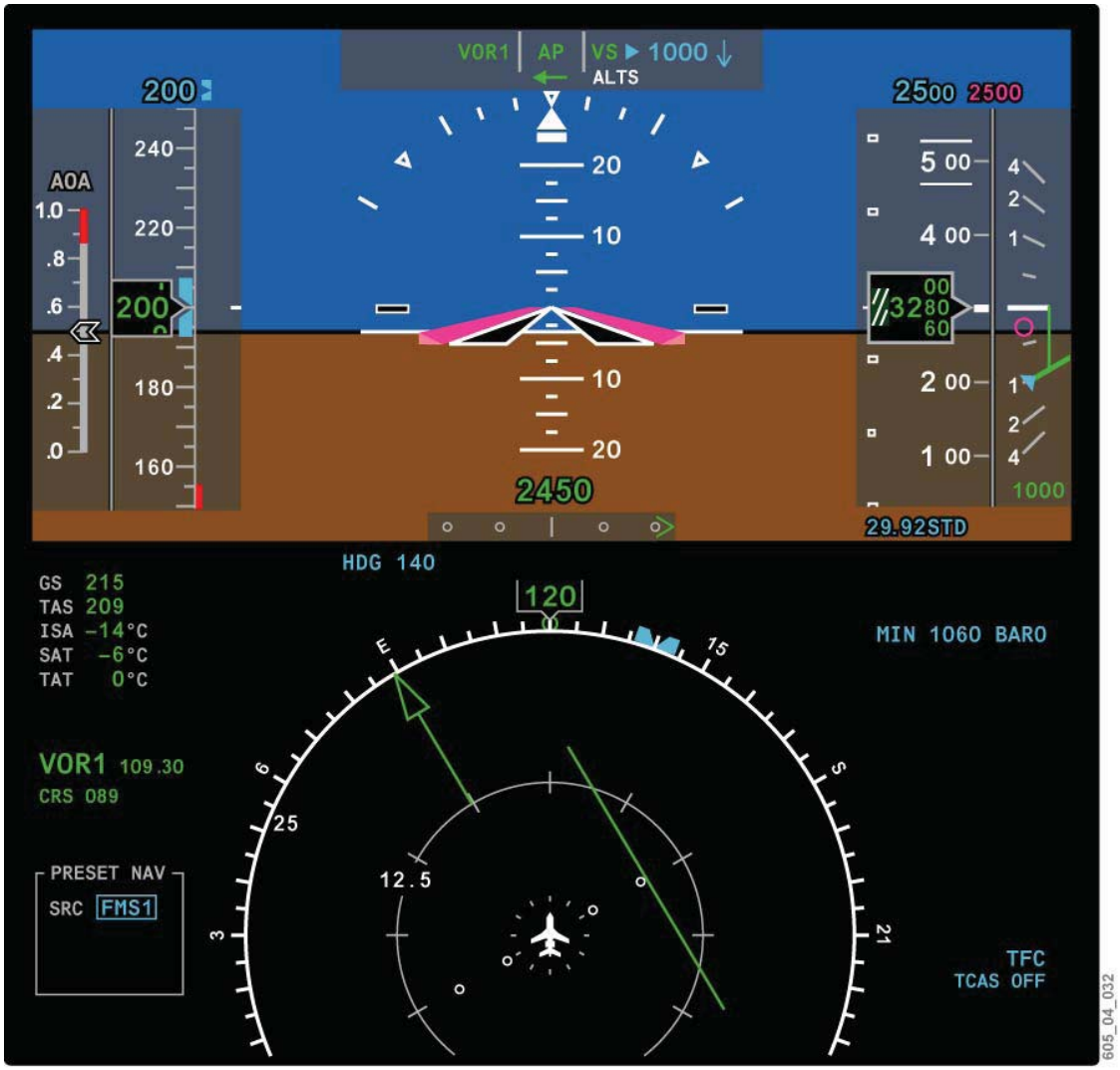
When the NAV button is pressed and the active navigation source is VOR1 or VOR2, the VOR navigation mode is armed. The armed lateral mode field on both PFDs shows a white VOR1 (or VOR2) annunciation. When the VOR mode is captured, the armed annunciations are removed, and a green VOR1 (or VOR2) annunciation is displayed in the active lateral mode field on the PFDs.

The CRS1 and CRS2 knobs, located on the FCP, provide the means to select the desired course on the left and right PFD HSI respectively. Pressing the PUSH DIRECT knob within the CRS knob synchronizes the corresponding course display, and provides a “direct-to” VOR course.

VOR navigation mode is designed to permit tracking over station, and allow for course changes while tracking. When over a VOR station, the system can accept and follow a course change of up to 90°. Dead reckoning operation (based on memorized heading) is provided during VOR station passage. A white DR annunciation appears next to the active VOR mode annunciation during dead reckoning operation.

When captured, VOR navigation mode is cleared automatically by selection of another lateral mode, by changing the active NAV source, or by loss of the VOR signal. VOR navigation mode can also be cleared by pressing the NAV button again.

FLIGHT DIRECTORS (CONT'D)



VOR Navigation Mode
Figure 04–10–20

Localizer Navigation Mode

In localizer navigation mode, the flight director provides lateral steering commands to capture and track the front course localizer from the active navigation source.

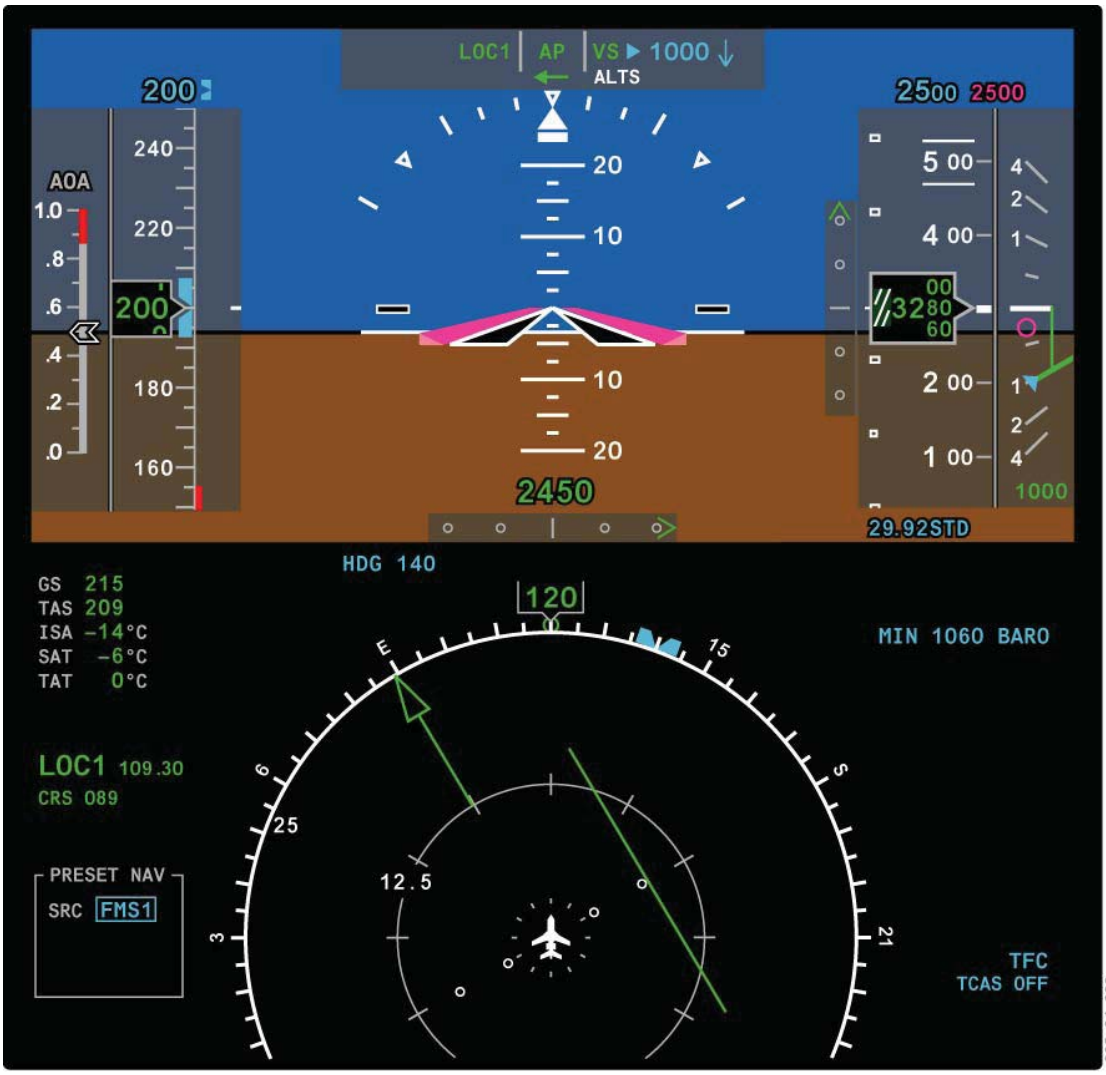
Whenever LOC navigation mode arms, a white LOC1 (or LOC2) annunciation is displayed in the armed lateral mode field on both PFDs. When the LOC mode is captured, the armed annunciation is removed, and a green LOC1 (or LOC2) is displayed in the active lateral mode field on both PFDs.

FLIGHT DIRECTORS (CONT'D)

When captured, LOC navigation mode is cleared automatically by:

- Selection of another lateral mode,
- Changing the active NAV source, or
- Loss of localizer signal.

LOC mode can also be cleared by pressing the NAV button again.



LOC Navigation Mode
Figure 04–10–21

FMS Navigation Mode

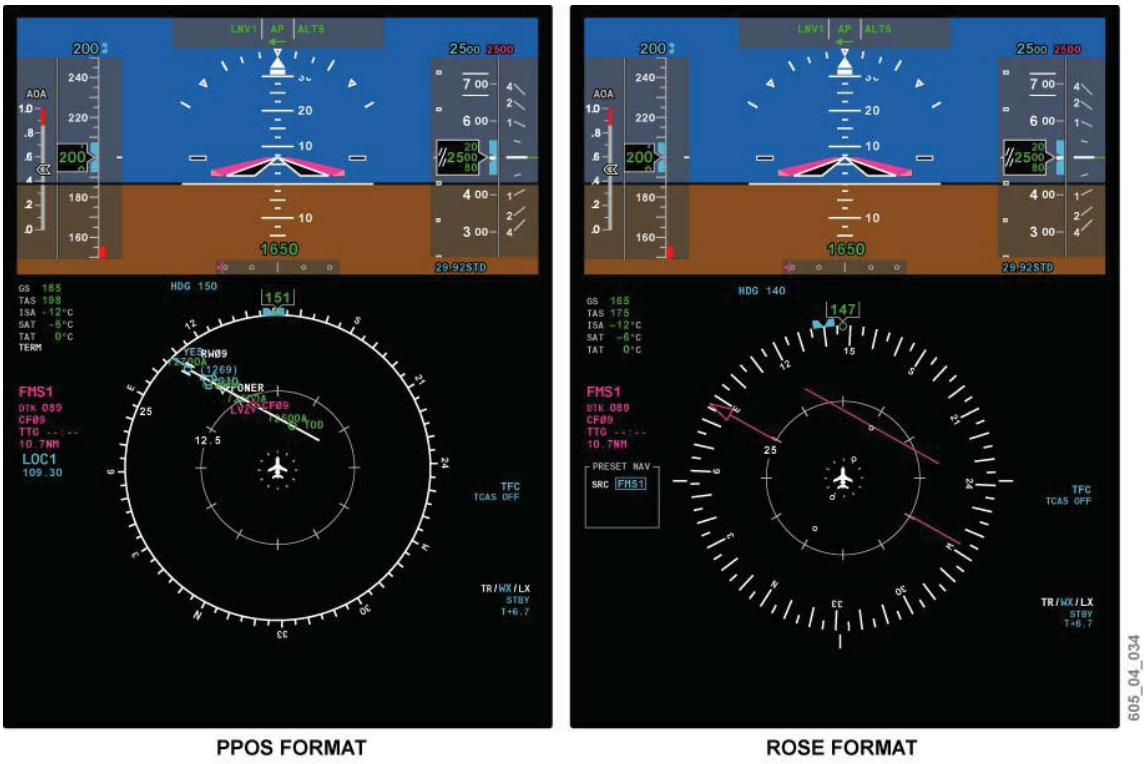
In FMS navigation mode, the flight director uses lateral steering commands from the active flight management computer (FMC) to capture and track the desired track to the “TO” waypoint.

FLIGHT DIRECTORS (CONT'D)

When the NAV button is pressed, and the active navigation source is FMS1 or FMS2, the FMS navigation mode arms, and a white LNV1 (or LNV2) annunciation is displayed in the armed lateral mode field on both PFDs. When the FMC capture criteria are met, the armed annunciation is removed, and a green LNV1 (or LNV2) annunciation is displayed in the active lateral mode field on both PFDs.

Depending on the display selected on the PFD, a white track is displayed in PPOS format, or a magenta deviation bar is displayed in ROSE format.

When captured, FMS navigation mode is cleared automatically by selection of another lateral mode, by changing the active NAV source, or by loss of FMS steering validity. FMS navigation mode can also be cleared by pressing the NAV button again.



PPOS FORMAT ROSE FORMAT

FMS Navigation Mode
Figure 04–10–22

Approach Mode

Approach mode is used to fly a localizer-based (ILS) or FMS-based nonprecision approach. During approach mode, the flight directors operate in dual independent mode.

Approach mode is selected by pressing the APPR button on the FCP. The displayed navigation source will determine which approach submode will be in operation.

ILS-Based Approach

Pushing the APPR button alternately selects and clears approach mode. Approach mode localizer capture functions the same as localizer navigation (NAV) mode. Additionally, glideslope (GS) mode is armed for capture.

FLIGHT DIRECTORS (CONT'D)

Automatic NAV-to-NAV Transfer

When a localizer-based approach is selected from the FMS and the aircraft is within 30 nm of the airport, the localizer frequency is automatically tuned and the course display is set to the appropriate inbound course. The localizer deviation scale and pointer are superimposed in cyan on the PFD HSI, and a cyan LOC1 (or LOC2) navigation source is displayed below the active navigation source (FMS 1 or FMS 2).

With approach mode armed (APPR button selected on FCP) during localizer intercept, the active navigation source will automatically change from FMS to LOC (automatic NAV to NAV transfer) at localizer capture. If required, approach mode can then be canceled and navigation mode selected by pressing the NAV button on the FCP.

FLIGHT DIRECTORS (CONT'D)

ILS Approach Mode
Figure 04–10–23

FLIGHT DIRECTORS (CONT'D)

FMS-Based Approach

Pushing the APPR button alternately selects and clears approach mode. The FMS-based approach mode functions the same as FMS navigation (LNV) mode. Additionally, glide path (GP) mode is armed for capture, to track the desired glide path from the FMS if VNAV is selected.

Refer to the Collins FMS–6000 Flight Management System Pilot’s Guide for additional information on FMS-based approaches.

FLIGHT DIRECTORS (CONT'D)

FMS Approach Mode
Figure 04–10–24

FLIGHT DIRECTORS (CONT'D)

Localizer Back Course Mode

Back course mode (B/C) generates commands to track a localizer signal using reverse-sensing.

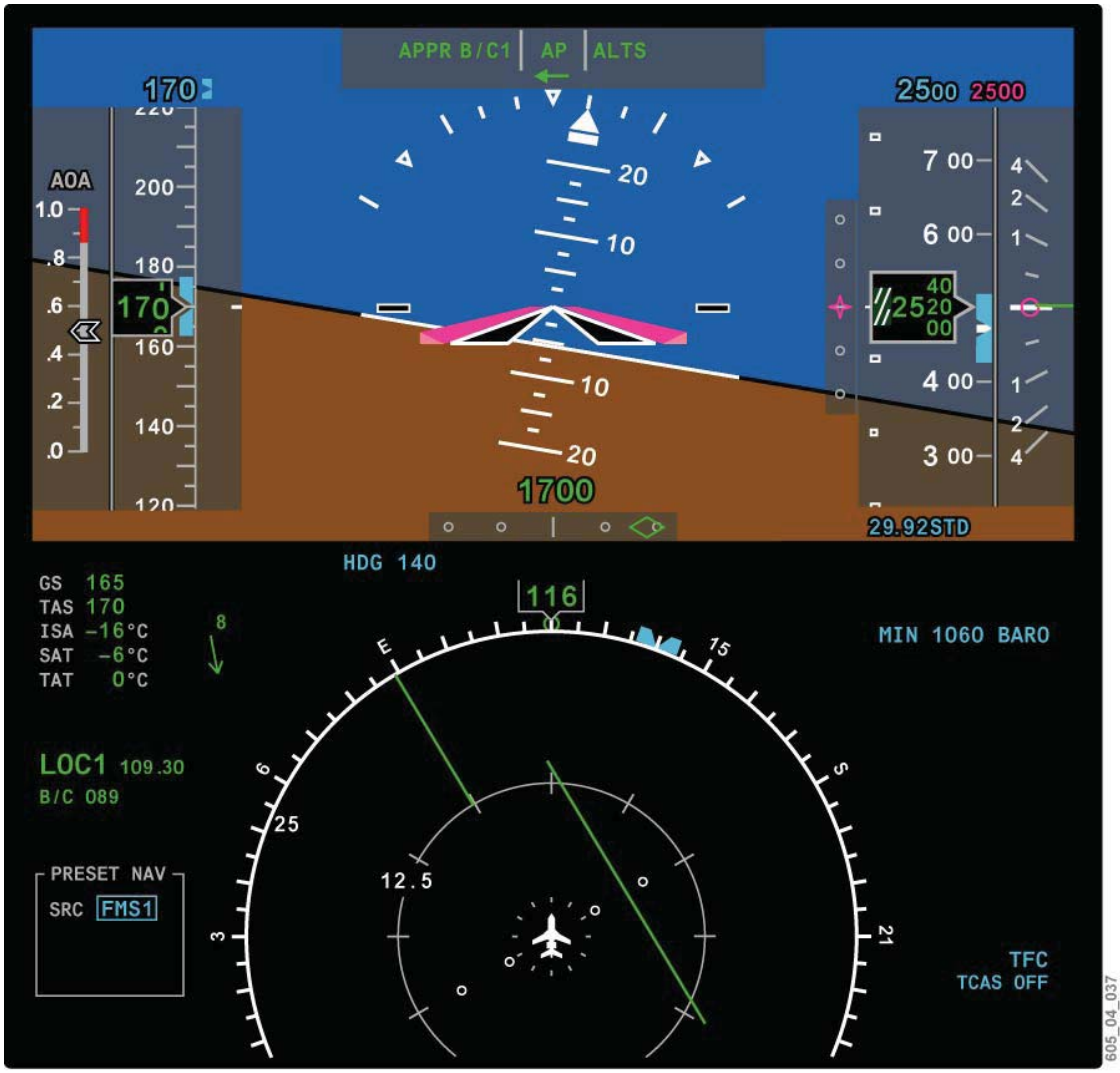
Back course mode is armed by pressing the B/C button on the FCP. Back course mode localizer capture is the same as NAV mode; B/C1 (or B/C2) shows in white in the armed lateral mode field on both PFDs. When armed, the FCC operates in a heading select submode until capture of the localizer occurs.

If the back course approach is selected from the FMS, the localizer frequency is tuned automatically and the course display is set to the appropriate inbound course. With back course mode armed, the active navigation source will automatically change from FMS to LOC (automatic NAV to NAV transfer) at localizer capture.

After capture, the FCC generates commands to track the reciprocal of the selected course. The front course track must be set in order to have valid B/C guidance. Capture of the back course is indicated by a green B/C1 or B/C2 in the active field of the FMA. Glideslope is inhibited when B/C mode is active.

Back course mode is cleared by selecting another lateral mode, or by changing the active side navigation source or frequency.

FLIGHT DIRECTORS (CONT'D)



Back Course Mode
Figure 04–10–25

FLIGHT DIRECTORS (CONT'D)

Lateral Takeoff

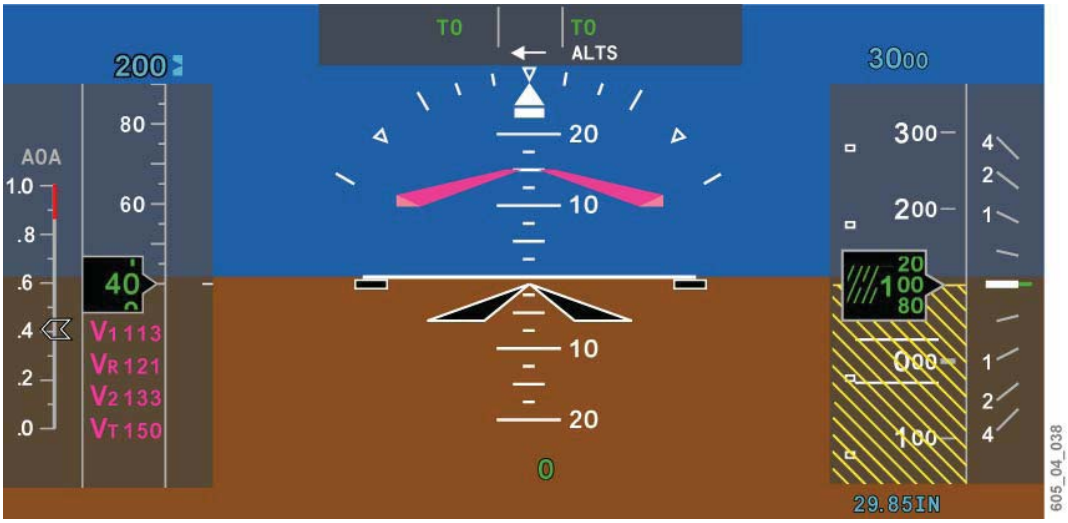
On the ground, pushing either TOGA (takeoff/go-around) button, mounted on the thrust levers, selects takeoff mode and clears all other lateral modes. Lateral and vertical takeoff mode selections are coincident. When takeoff mode is active, a green TO appears in the active lateral field of the FMA. During takeoff mode, the flight directors operate in dual independent mode.

NOTE

The autopilot will disengage whenever a TOGA button is pressed on the ground or in-flight. The autopilot visual and aural disengage warnings may be canceled by pushing either TOGA button again, or by pushing any AP/SP DISC switch.

With takeoff mode selected, the heading reference is continuously set to the current aircraft heading while maneuvering on the ground. After lift-off (weight off wheels), the takeoff mode generates a heading hold command, with a five-degree bank limit, using the heading which existed at the moment of lift-off. These heading references are independent of the HDG bug.

Takeoff lateral mode is cleared by selecting another lateral mode.



Lateral Takeoff Mode
Figure 04–10–26

FLIGHT DIRECTORS (CONT'D)

Lateral Go-Around Mode

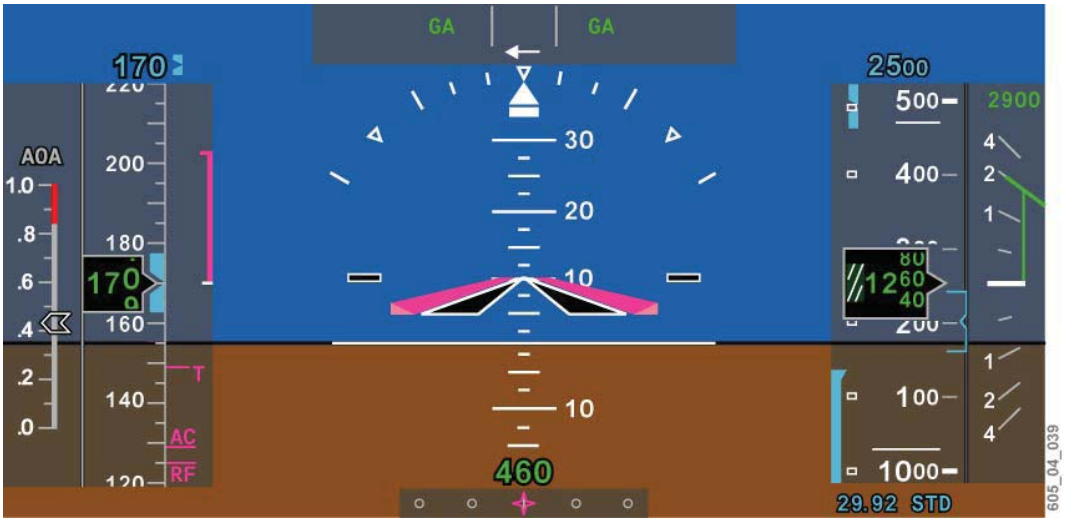
In the air, pushing either TOGA (takeoff/go-around) button, mounted on the thrust levers, selects the go–around mode and clears all other lateral modes. Lateral and vertical go–around mode (GA) selections are coincident. When go–around mode is active, a green GA appears in the active lateral field of the FMA. During go-around mode, the flight directors operate in dual independent mode.

NOTE

The autopilot will disengage whenever a TOGA button is pressed on the ground or in-flight. The autopilot visual and aural disengage warnings may be canceled by pushing either TOGA button again, or by pushing any AP/SP DISC switch.

The lateral component of go-around mode (GA) generates commands to maintain the heading that existed at the moment of GA mode activation. Go-around mode generates a heading hold command with a five-degree bank limit. This heading reference is independent of the HDG bug.

Go-around mode is cleared by selecting another lateral mode.



Lateral Go-Around Mode
Figure 04–10–27

Flight Director Vertical Modes

There are nine vertical flight director modes (bold letters refer to the flight control panel button selections):

- Pitch
- Altitude preselect
- Altitude hold (**ALT**)
- Vertical speed (**VS**)
- Flight level change (**FLC**)
- Takeoff

FLIGHT DIRECTORS (CONT'D)

- Go-around
- Glideslope
- FMS vertical navigation (**VNAV**)

Vertical modes are armed or activated by the FCP push-buttons, a pitch wheel on the flight control panel, or by TOGA switches on the thrust levers. In general, disabling the active vertical mode is accomplished by reselecting the active FCP push-button, or by selecting another vertical mode.

Pitch Mode

Pitch mode (PTCH) is the basic vertical operating mode, and is automatically selected when no other vertical mode is active and the flight director is on. A green PTCH annunciation appears in the vertical active field of the FMA when pitch mode is active.

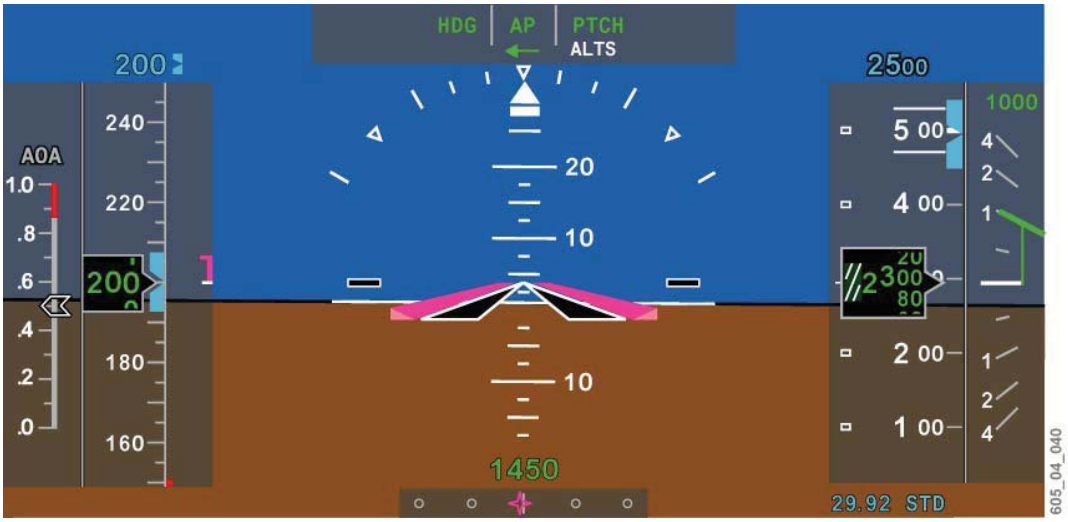
When PTCH mode is active, the FCC generates commands to maintain the aircraft's pitch angle reference. The pitch angle reference value may be adjusted by rotating the VS/pitch wheel on the FCP in the desired direction. Each click of the wheel results in 0.5 degrees of pitch attitude change.

NOTE

All flight director vertical modes reset to PTCH mode when the VS/pitch wheel is rotated, except if vertical speed (VS) or glideslope capture (GS) modes are active. VS/pitch wheel rotation has no effect after glideslope capture.

The pilot may also adjust the pitch reference to a desired pitch angle by pushing the FD SYNC button, and manually setting a pitch angle between +20 to –10 degrees. If the pilot selects a pitch angle greater than the maximum limits, the FD will generate commands to return the pitch angle to within limit upon release of the FD SYNC button.

Pitch mode is automatically cleared by selection or capture of another vertical mode.



Pitch Mode
Figure 04–10–28

FLIGHT DIRECTORS (CONT'D)

Altitude Preselect Mode

The altitude preselect mode (ALTS) causes the flight director to generate commands to capture and level off at the preselected altitude. It is comprised of armed, capture and track states. Altitude preselect mode commands are based on the coupled side barometric altimeter.

The preselected altitude is set by the ALT knob on the FCP, and is displayed as a cyan digital readout on the top right corner of the PFDs, and by a cyan altitude (double-bar) bug on the barometric altimeters.

The ALTS mode is automatically armed upon selection of any vertical mode, except altitude hold (ALT), vertical approach (GS or VGP), or go-around (GA) modes. When ALTS mode is armed, the FCCs calculate the capture point for the preselected altitude, while operating in the current active vertical mode. The capture point is a function of closure rate, with the capture point occurring earlier for high closure rates. A white ALTS annunciation appears in the vertical armed field of the FMA when altitude preselect mode is armed.

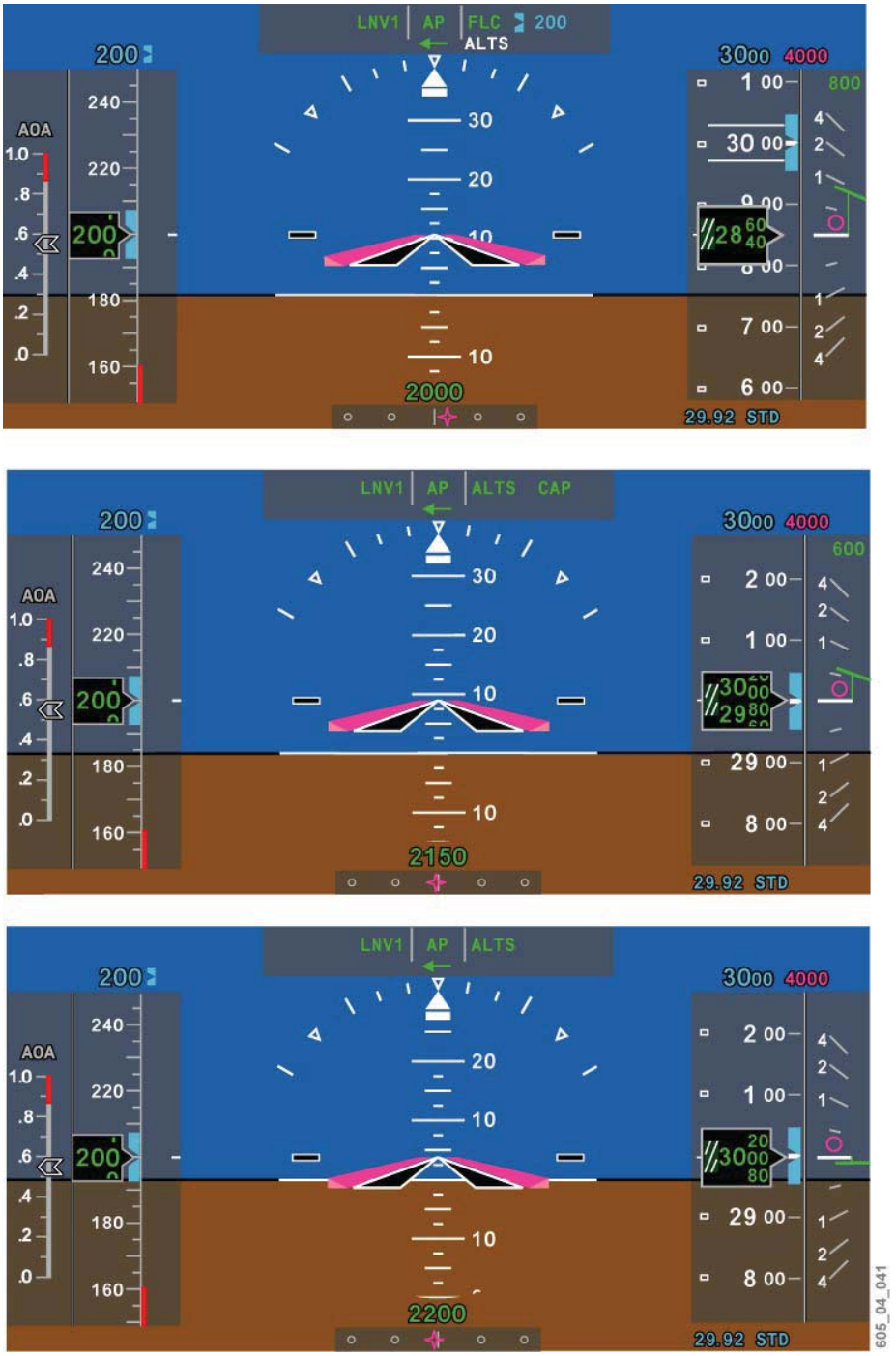
When the airplane is in a position to capture the preselected altitude, the system generates commands to level off (capture) and track the preselected altitude. During the altitude capture sequence, a green ALTS CAP annunciation is displayed in the vertical capture field of the FMA, and the armed annunciation is removed.

When the capture (level-off) is completed, the flight director generates commands to track the preselected altitude. A green ALTS annunciation remains displayed in the vertical capture field of the FMA.

NOTE

If the preselected altitude is changed during altitude capture, the ALTS CAP display is replaced by ALT, and a yellow ALTS annunciation is temporarily displayed in the vertical armed field of the FMA. The FCCs will continue to capture and track the original preselected altitude displayed while ALTS CAP was active.

FLIGHT DIRECTORS (CONT'D)



Altitude Capture Sequence
Figure 04–10–29

FLIGHT DIRECTORS (CONT'D)

Altitude Alert System

The altitude alert system provides aural and visual indications of preselected altitude capture and tracking. It also provides aural and visual indications of altitude deviations from the preselected altitude (ALTS).

The altitude alerting system processes data from the air data computers (ADCs), and is independent of the flight director or autopilot modes. Altitude alert annunciations are based on the baro-corrected altitude of the coupled side altimeter.

Capture Alert

At 1,000 feet prior to the preselected altitude, the preselected digital readout and bug flash, and an aural tone (C-chord) sounds.

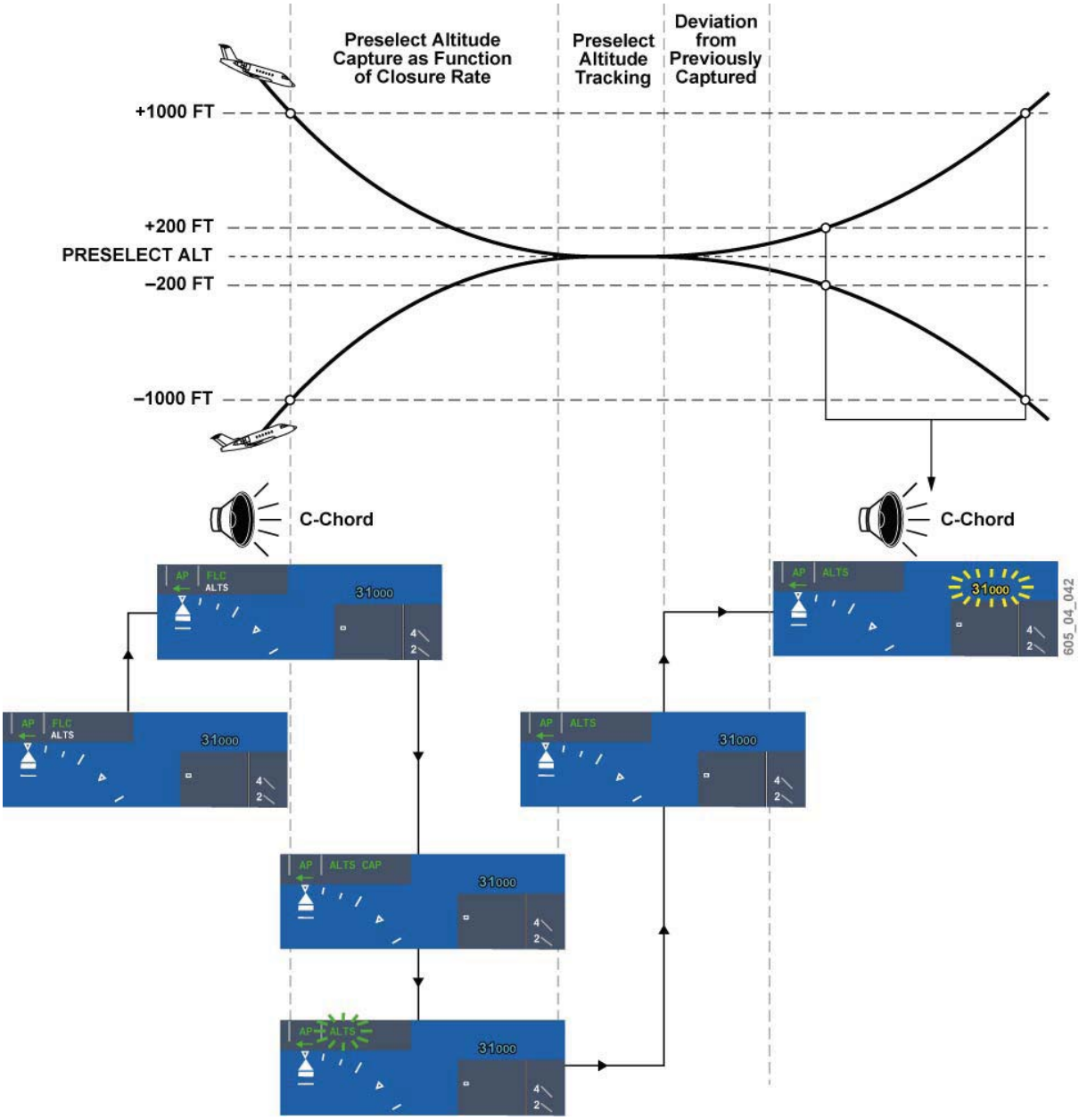
Deviation Alert

If the aircraft deviates by more than 200 and/or 1,000 feet from the preselected altitude, the altitude bugs and digital readout flash yellow, and an aural tone (C-chord) is heard.

Altitude alerts can be canceled by pushing the PUSH CANCEL inset of the ALT knob, or by selecting a new preselect altitude.

Altitude alerts are inhibited if the glideslope (GS) or FMS glide path (VGP) is captured.

FLIGHT DIRECTORS (CONT'D)



Altitude Alert Annunciations
Figure 04–10–30

Altitude Hold Mode

Altitude hold mode (ALT) generates commands to maintain the pressure altitude at the time of selection. Altitude hold mode commands are based on the baro-corrected altitude of the coupled side barometric altimeter. When active, a green ALT annunciation appears in the active vertical field of the flight mode annunciator.

Altitude hold mode is activated by pushing the ALT button on the FCP, or by changing the preselected altitude while in altitude select track mode (ALTS active).

FLIGHT DIRECTORS (CONT'D)

Altitude hold mode is inhibited whenever glideslope (GS) mode is active.

NOTE

If the ALT button on the FCP is pushed during a climb or descent, it is possible for the aircraft to temporarily overshoot the desired altitude while the FCCs compensate for the aircraft's vertical speed at the moment of ALT mode selection.

The pilot may adjust the altitude reference by pushing the FD SYNC button and manually flying to the desired altitude. The FD will generate commands to maintain the new altitude reference upon release of the FD SYNC button.

Altitude hold mode may be cleared by:

- Pushing the ALT button;
- Selecting another vertical mode; or
- Capturing an armed vertical mode.

Altitude Hold Mode
Figure 04–10–31

Vertical Speed Mode

The vertical speed mode (VS) generates commands to maintain a vertical speed reference value.

Pushing the VS button on the FCP selects the vertical speed mode. A green VS annunciation is displayed in the active vertical field of the FMA, the selected vertical speed value is displayed in cyan, and ALTS mode is automatically armed to capture the preselected altitude.

The VS reference value will default to the existing vertical speed at the moment of mode selection. The VS reference value will also reset to the existing vertical speed whenever the autopilot is engaged and VS mode is active.

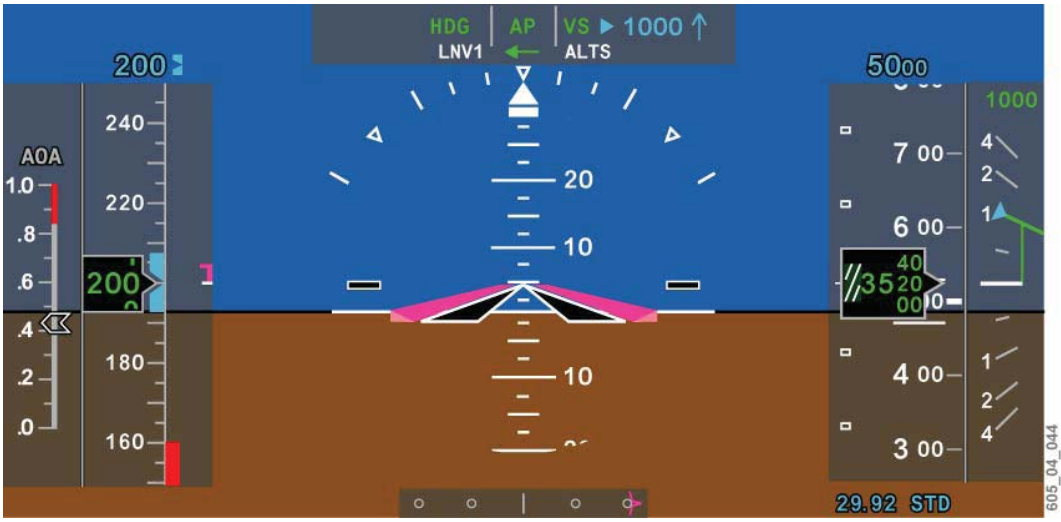
FLIGHT DIRECTORS (CONT'D)

The VS reference may be changed by rotating the VS/pitch wheel in the desired direction. The VS reference changes by ±100 fpm per click. The selected vertical speed reference is displayed on the vertical speed scale as a cyan triangular bug, and as a cyan digital readout with an up/down arrow right of the VS indication in the FMA.

The pilot may adjust the VS reference by pushing the FD SYNC button while maneuvering the airplane to a new VS reference. The FD will generate commands to maintain the new VS reference upon release of the FD SYNC button.

Vertical speed mode is cleared by:

- Pushing the VS button on the FCP;
- Selecting another vertical mode; or
- Capturing an armed vertical mode.



Vertical Speed Mode
Figure 04–10–32

Flight Level Change Mode

Flight level change mode (FLC) generates commands to maintain either the airspeed/Mach reference value, or a 100 ft/min vertical speed toward the preselected altitude, whichever yields the greater closure rate to the preselected altitude.

Pushing the FLC button selects flight level change mode. A green FLC annunciation is displayed in the active vertical field of the FMA, and ALTS is automatically armed to capture the preselected altitude.

When FLC mode is selected manually, or by the FMS, the airspeed/Mach reference displayed on the PFDs (speed bug) is automatically set to the aircraft's current airspeed/Mach. The airspeed/Mach reference is also synchronized to the aircraft's current airspeed/Mach when the autopilot is engaged with the active vertical mode in FLC. The airspeed/Mach reference can be manually adjusted using the SPEED knob on the FCP, and is displayed in cyan next to the FLC mode annunciation.

Automatic transition between IAS and Mach airspeed reference occurs at 33,600 feet MSL. Mach reference automatically selects when the airplane climbs through 33,600 feet MSL, and IAS reference automatically selects when the airplane descends through 33,600 feet MSL.

FLIGHT DIRECTORS (CONT'D)

FLC mode is cleared by:

- Pushing the FLC button;
- Selecting another vertical mode, or
- Capturing an armed vertical mode.

FLC Overspeed Protection Mode

The FCCs incorporate an overspeed protection mode to limit the aircraft indicated airspeed/Mach from exceeding V_{MO}/M_{MO}. Overspeed protection is applied with the flight directors off, and in any active vertical flight director mode except GS, ALTS or ALT.

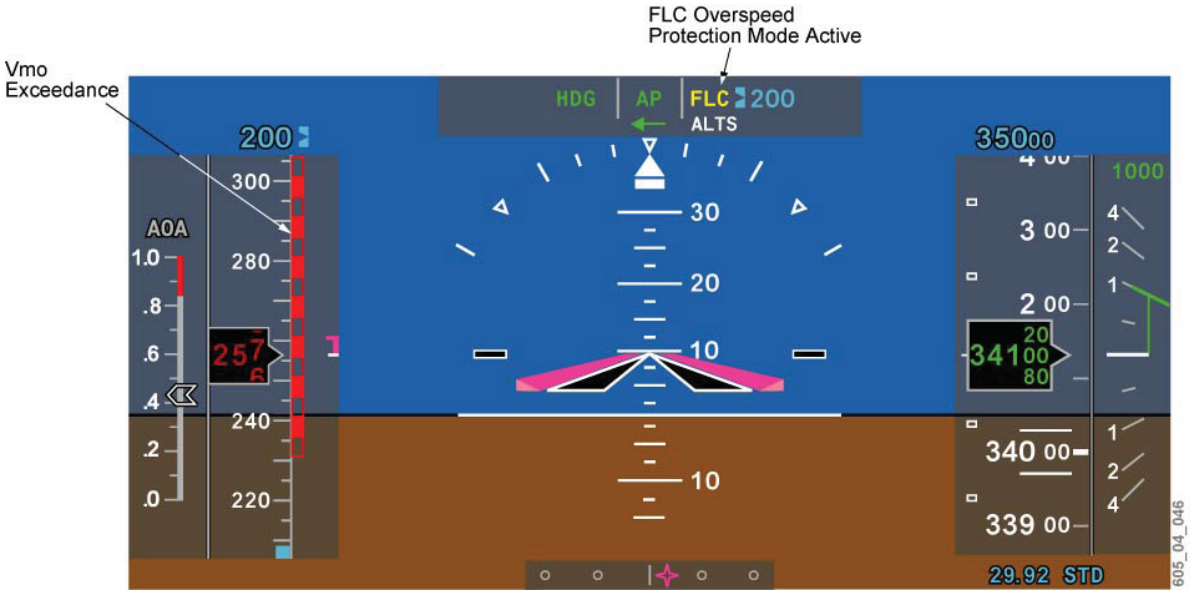
FLC overspeed mode is activated automatically in the event of an overspeed condition; when the airspeed is 10 KIAS above V_{MO}, or Mach number is 0.015 M above M_{MO}. When FLC overspeed mode is active, a flashing yellow FLC annunciation is displayed in the active vertical field of the FMA. The flight directors, if not in view, automatically appear, and provide pitch commands to reduce airspeed 5 knots below V_{MO}, or 0.02 Mach below M_{MO}. FLC overspeed mode is automatically cleared when this airspeed/Mach reference is reached. The vertical mode will revert to FLC mode when the FLC overspeed mode is cleared.

NOTE

FLC overspeed mode cannot be cleared by pressing the FLC button. As well, the flight directors cannot be selected off during FLC overspeed mode operation.

Flight Level Change Mode
Figure 04–10–33

FLIGHT DIRECTORS (CONT'D)



FLC Overspeed Protection Mode
Figure 04–10–34

Vertical Takeoff Mode

On the ground, pushing either TOGA (takeoff/go-around) button, mounted on the thrust levers, selects the takeoff mode and clears all other vertical modes. Lateral and vertical takeoff mode (TO) selections are coincident. During takeoff mode, the flight directors operate in dual independent mode. When takeoff mode is active, a green TO annunciation appears in the vertical active field of the FMA, and ALTS mode is automatically armed to capture the preselected altitude.

NOTE

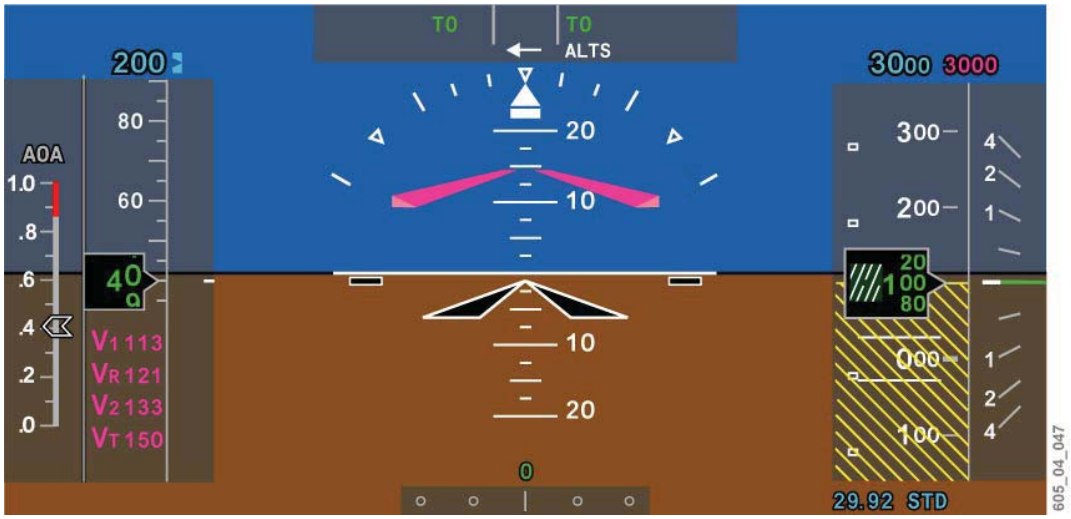
The autopilot will disengage whenever a TOGA button is pressed on the ground or in-flight. The autopilot visual and aural disengage warnings may be canceled by pushing either TOGA button again, or by pushing the AP/SP DISC switch.

The vertical component of takeoff mode (TO) normally generates a 14-degree pitch-up command. Loss of engine during takeoff changes the pitch-up reference to 10 degrees.

Takeoff vertical mode is cleared by:

- Selecting or capturing another active mode;
- Engaging the autopilot; or
- Pressing the FD SYNC button.

FLIGHT DIRECTORS (CONT'D)



Vertical Takeoff Mode
Figure 04–10–35

Vertical Go-Around Mode

In the air, pushing either TOGA (takeoff/go-around) button, mounted on the thrust levers, selects the go-around mode and clears all other vertical modes. Lateral and vertical go-around mode (GA) selections are coincident. During go-around mode, the flight directors operate in dual independent mode. When go-around mode is active, a green GA annunciation appears in the vertical active field of the FMA.

NOTE

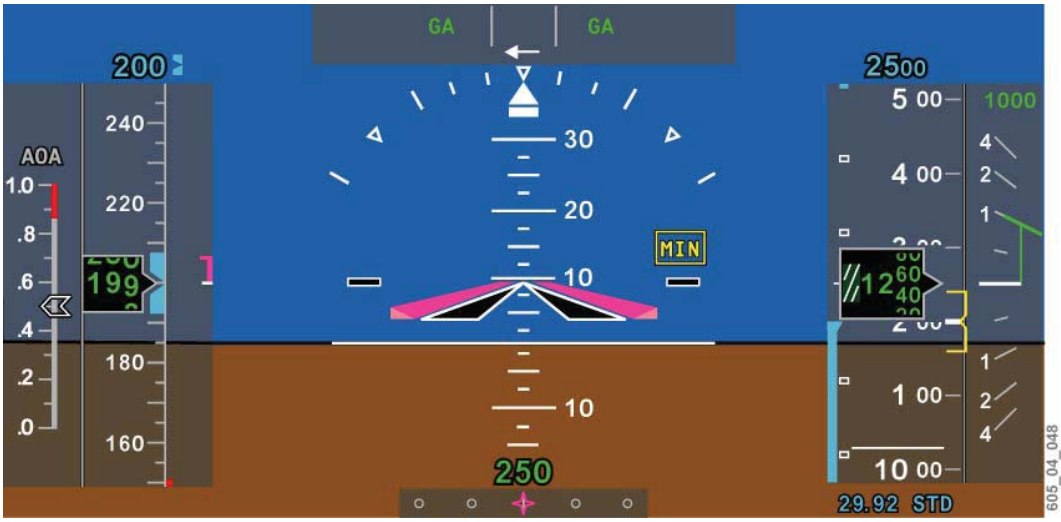
The autopilot will disengage whenever a TOGA button is pressed on the ground or in-flight. The autopilot visual and aural disengage warnings may be canceled by pushing either TOGA button again, or by pushing the AP/SP DISC switch.

The vertical component of go-around mode (GA) generates a 10-degree pitch-up command.

Go-around vertical mode is cleared by:

- Selecting or capturing another active mode;
- Engaging the autopilot; or
- Pressing the FD SYNC button.

FLIGHT DIRECTORS (CONT'D)



Vertical Go-Around Mode
Figure 04–10–36

Glideslope Mode

Glideslope mode (GS) generates commands to capture and track the glideslope of an ILS approach. Each flight director captures independently in approach mode, and operates in the dual independent configuration.

Glideslope mode becomes armed automatically when the aircraft is inbound and in approach mode (APPR button selected), with less than 105 degrees between heading and LOC course. When armed, a white GS annunciation appears in the vertical armed field of the FMA.

Glideslope capture can only occur after LOC capture, and is possible from above or below the glideslope beam. Prior to GS capture, the FCCs operate in the current active vertical mode. Upon GS capture, the previously active vertical mode clears automatically, and a green GS annunciation is displayed in the vertical capture field of the FMA. The capture point is a function of the closure rate, and the capture will always occur if the deviation is less than 10% of full-scale deflection (under 0.2 dots).

Glideslope mode is cleared by:

- Selection of NAV mode;
- Loss of approach mode; or
- Loss of localizer (NAV SOURCE change or loss of signal).

Vertical Navigation

Pushing the VNAV button on the FCP alternately selects and clears vertical navigation mode. VNAV is active when it is selected and valid. VNAV is valid when the following conditions are met:

- An active flight plan with a TO waypoint exists in the FMS;
- The active navigation source is either a valid FMS or localizer; and
- Preselected altitude, barometric altitude, and airspeed or Mach are all valid.

FLIGHT DIRECTORS (CONT'D)

When VNAV is active, the letter “V” appears in front of the active/captured vertical mode annunciation of the FMA. Other distinct VNAV modes may also be annunciated on the vertical armed or active/captured fields of the FMA.

Selecting vertical navigation mode (VNAV) allows the FMS to provide vertical steering commands to the flight director, to ensure the vertical flight profile of the active flight plan is honored. With VNAV active, the FMS will automatically sequence the vertical flight modes, and set target airspeeds and altitudes to follow the programmed flight profile. The flight crew may also manually select other vertical modes (pitch, flight level change, vertical speed, altitude hold), and modify airspeed/Mach references while VNAV is active. These actions will suspend FMS control, but do not prevent subsequent mode activation by the FMS.

NOTE

The altitude preselector overrides any VNAV commands except FMS glide path (GP) mode.

In the event the FMS vertical flight plan is not valid when VNAV is selected, a yellow VNAV annunciation appears in the vertical armed field of the FMA.

VNAV mode is cleared by:

- Pushing the VNAV button;
- Capturing an ILS glideslope;
- Changing the NAV SOURCE on the coupled side; or
- Pushing the TOGA button.

For additional information on VNAV, refer to the Collins FMS–6000 Flight Management System Pilot’s Guide.

Turbulence (TURB) Mode

When turbulence mode is active, the FCC reduces autopilot gains for turbulent flight conditions. This prevents the FCC from instantaneously responding to pitch and roll changes brought about by flight through turbulent air.

Turbulence mode is available when the autopilot is engaged, and can be selected by pressing the TURB button on the FCP. The green status indicator lights on each side of the TURB button illuminate when turbulence mode is selected. There is no indication of TURB mode selection on the PFDs.

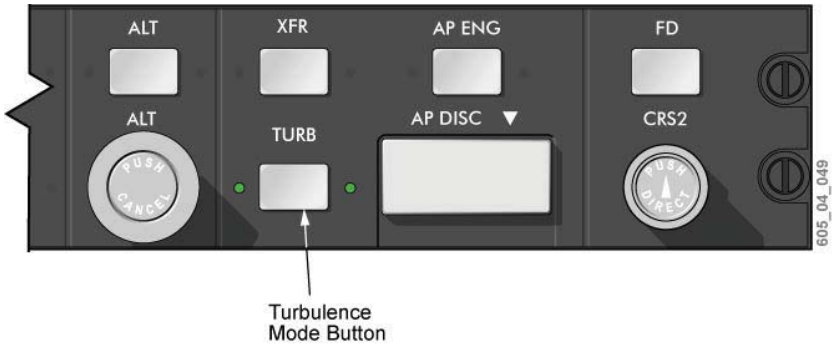
TURB mode is cleared by any one of following:

- Pushing the TURB button again;
- On-side LOC capture; or
- Autopilot disengagement.

NOTE

The maximum IAS or MACH for turbulent air penetration is 280 KIAS or 0.75 MACH.

FLIGHT DIRECTORS (CONT'D)



Turbulence Mode Button
Figure 04–10–37

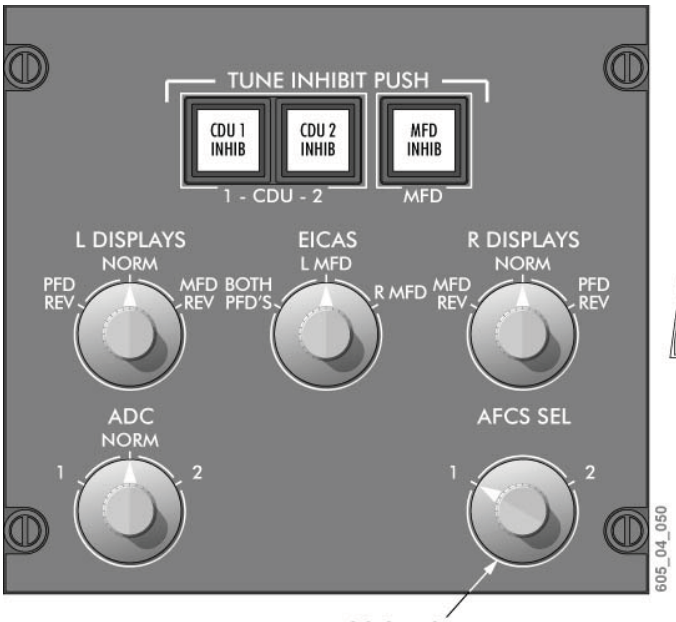
CONTROLS AND INDICATORS

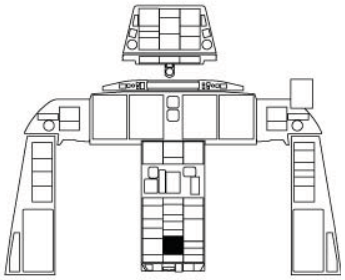
General

The flight control panel (FCP) provides the majority of controls for flight director and autopilot operation. The reversionary/inhibit panel allows selection between AFCS 1 and 2. Both the pilot's and copilot's control wheel incorporates push-buttons for autopilot disconnect and flight director synchronization.

The PFD flight mode annunciator (FMA) provides an indication of autopilot and flight director status. The EICAS primary and status pages provide the system warning, caution and status messages respectively.

Reversionary/Inhibit Panel





AFCS SEL Switch

1 – Selects FCC pair 1A and 2A as the active FCCs

2 – Selects FCC pair 1B and 2B as the active FCCs

Note: Selection of AFCS 1 or 2 during AP/FD operation will cause the autopilot to disengage and all lateral and vertical flight director modes to clear.

Reversionary/Inhibit Panel
Figure 04–10–38

CONTROLS AND INDICATORS (CONT'D)

Flight Control Panel (FCP) – Autopilot/Flight Director Modes

Pilot's FD Button (momentary-action)
With autopilot engaged:
- No effect if FD1 is the active flight director
- Alternately removes or displays pilot's FD command bars if FD2 is the active FD (pilot's FMA annunciations remain in view)

With autopilot disengaged:
- No effect if no FD modes are selected
- Removes both pilot's and copilot's FD command bars and FMA annunciations if FD1 is the active FD
- Alternately removes or displays pilot's FD command bars if FD2 is the active FD (pilot's FMA annunciations remain in view)

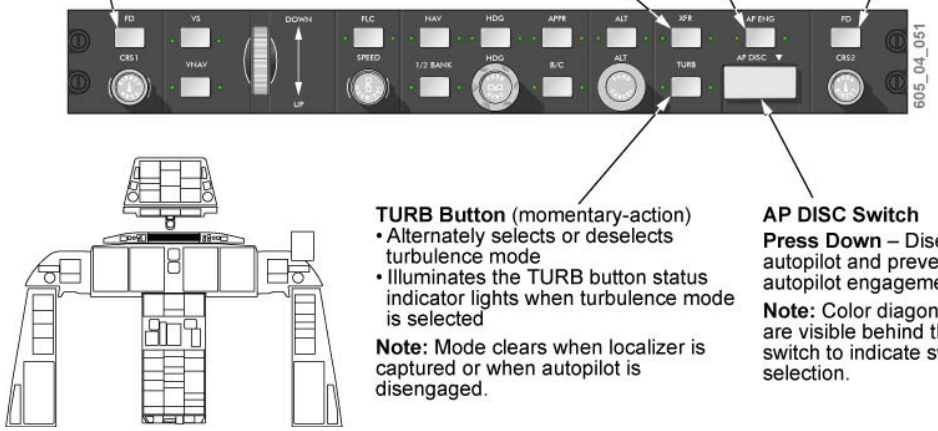
Copilot's FD Button (momentary-action)
With autopilot engaged:
- No effect if FD2 is the active flight director
- Alternately removes or displays copilot's FD command bars if FD1 is the active FD (copilot's FMA annunciations remain in view)

With autopilot disengaged:
- No effect if no FD modes are selected
- Removes both pilot's and copilot's FD command bars and FMA annunciations if FD2 is the active FD
- Alternately removes or displays copilot's FD command bars if FD1 is the active FD (copilot's FMA annunciations remain in view)

XFR Button (momentary-action)
- Selects copilot's side flight director (FD2) as the active flight director
- Illuminates the XFR button status indicator lights when transfer mode is selected
- Defaults to pilot's side flight director (FD1) at power-up

Note: When engaged, the autopilot flies flight guidance commands from the selected flight director only.

AP ENG Button (momentary-action)
- Alternately engages or disengages the autopilot
- Illuminates the AP ENG button status indicator lights when the autopilot is engaged



TURB Button (momentary-action)
- Alternately selects or deselects turbulence mode
- Illuminates the TURB button status indicator lights when turbulence mode is selected

Note: Mode clears when localizer is captured or when autopilot is disengaged.

AP DISC Switch

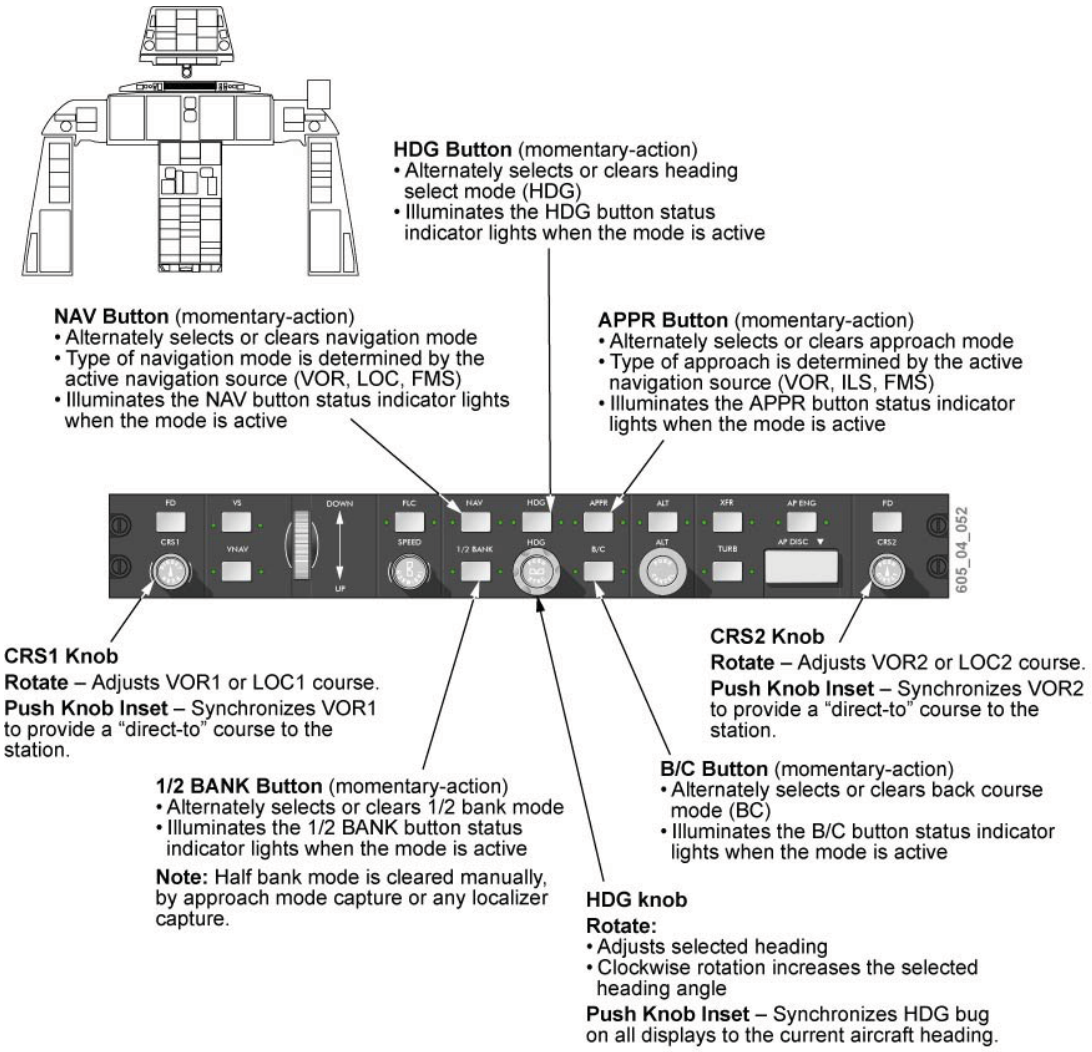
Press Down – Disengages the autopilot and prevents further autopilot engagement.

Note: Color diagonal markings are visible behind the AP DISC switch to indicate switch selection.

Flight Control Panel (FCP) – Autopilot/Flight Director Modes
Figure 04–10–39

CONTROLS AND INDICATORS (CONT'D)

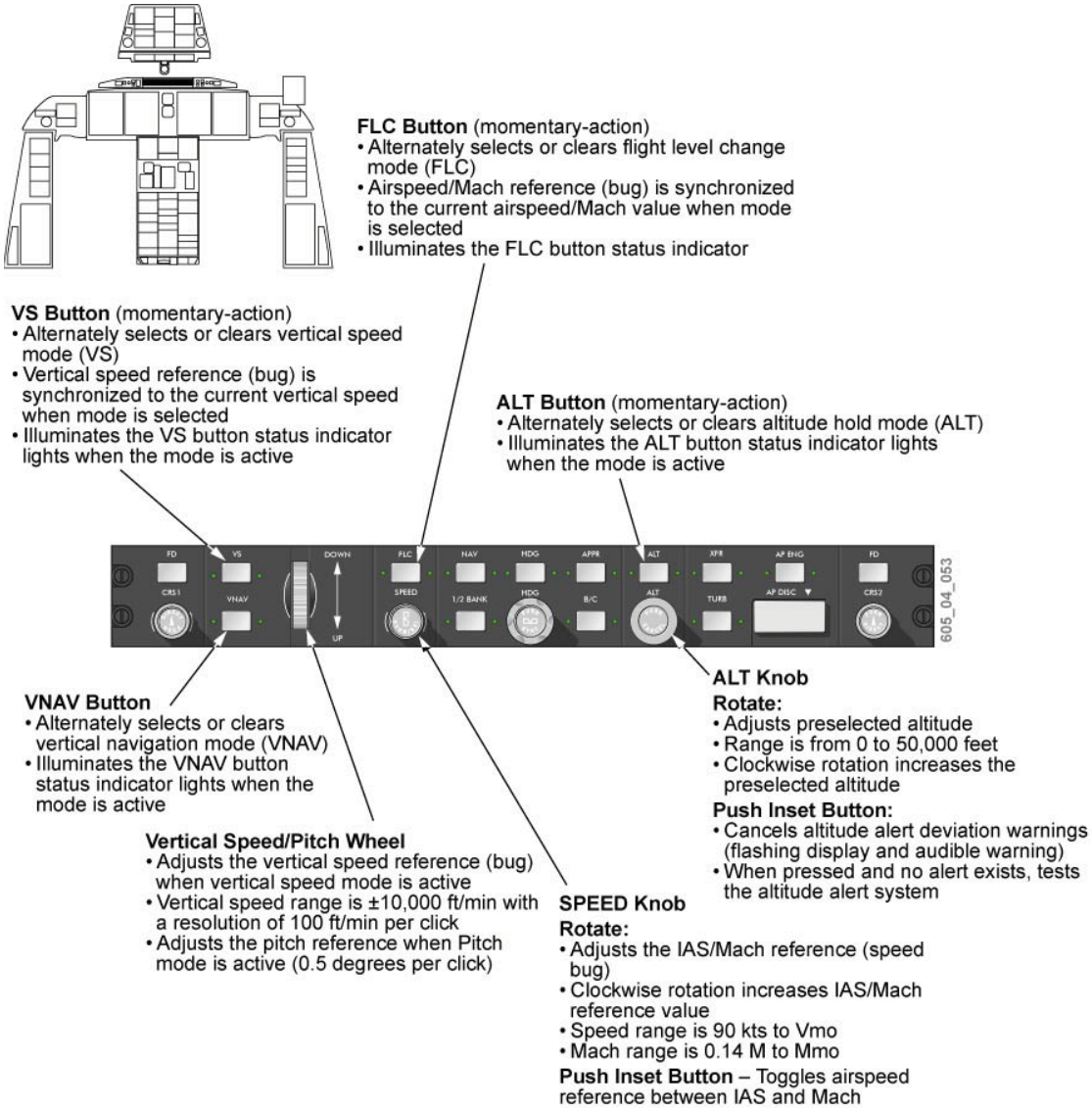
Flight Control Panel (FCP) – Lateral Modes



Flight Control Panel (FCP) – Flight Director Lateral Modes
Figure 04–10–40

CONTROLS AND INDICATORS (CONT'D)

Flight Control Panel (FCP) – Vertical Modes



Flight Control Panel (FCP) – Flight Director Vertical Modes
Figure 04–10–41

CONTROLS AND INDICATORS (CONT'D)

AFCS Cockpit Switches

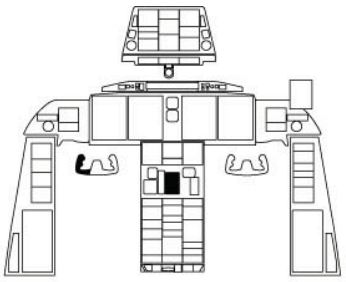
AP/SP (Autopilot/Stick Pusher Disconnect) Button
Disengages autopilot and deactivates stick pusher.

Note: When released, stick pusher system is immediately reactivated.

PILOT'S
(FRONT VIEW)

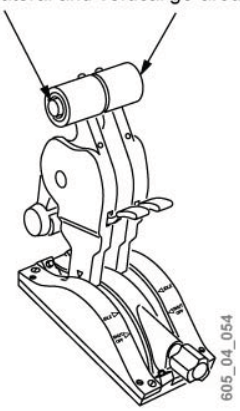
FD SYNC Switch
- Uncouples the autopilot servo clutches if the autopilot is engaged (while the button is being held)
- Synchronizes the vertical mode flight director reference values to the values being presently flown by the aircraft when in FLC, VS, ALT, PTCH or ROLL modes

PILOT'S
(REAR VIEW)



TOGA (Takeoff/Go-Around) Buttons
On the ground:
- Disengages the autopilot
- Activates lateral and vertical takeoff modes

In flight:
- Disengages the autopilot
- Activates lateral and vertical go-around modes



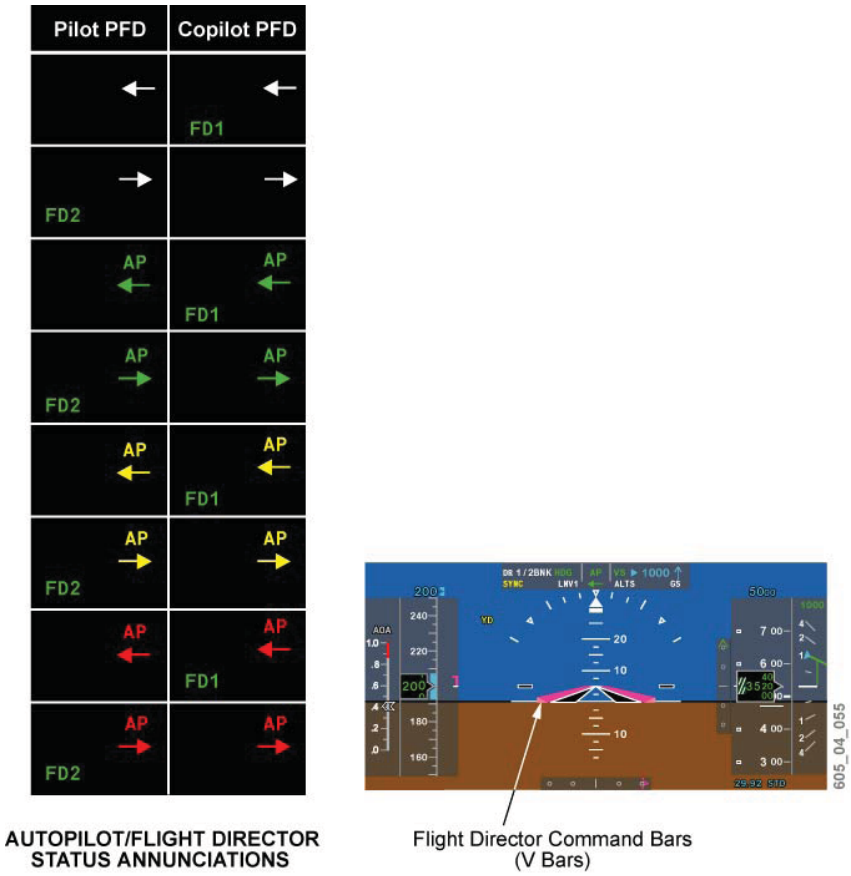
THRUST LEVERS

Cockpit Switches – Autopilot/Flight Director Function
Figure 04–10–42

CONTROLS AND INDICATORS (CONT'D)

PFD Annunciations

The following figure and table provide a summary of FCC-related annunciations which may be presented on the PFD.



PFD Annunciations
Figure 04–10–43

PFD Messages

INDICATION	DESCRIPTION
←	Autopilot is not engaged, and flight guidance commands are coupled to pilot side flight director (annunciated on pilot's PFD).
← FD1	Autopilot is not engaged, and flight guidance commands are coupled to pilot side flight director (annunciated on copilot's PFD).
→	Autopilot is not engaged, and flight guidance commands are transferred to copilot side flight director (annunciated on copilot's PFD).
→ FD2	Autopilot is not engaged, and flight guidance commands are transferred to copilot side flight director (annunciated on pilot's PFD).
1/2 BNK	Half bank mode is selected.

CONTROLS AND INDICATORS (CONT'D)

INDICATION	DESCRIPTION
ALT	Attitude hold mode – tracking.
ALTS	Altitude select mode – tracking.
ALTS	Altitude select mode – armed.
ALTS	Altitude select mode – aborted capture.
ALTS CAP	Altitude select mode – capturing.
ALTV	Vertical navigation mode – vertical mode is armed to capture FMS target altitude.
AP ←	Autopilot is engaged, flight guidance commands are coupled to pilot side flight director (annunciated on pilot's PFD).
AP ← FD1	Autopilot is engaged, flight guidance commands are coupled to pilot side flight director (annunciated on copilot's PFD).
AP →	Autopilot is engaged, flight guidance commands are coupled to copilot side flight director (annunciated on copilot's PFD).
AP → FD2	Autopilot is engaged, flight guidance commands are coupled to copilot side flight director (annunciated on pilot's PFD).
AP →	Autopilot is engaged, with FD/AP synchronization in progress. Flashes for 5 seconds, then steady (aileron and elevator servo clutches are released).
AP ←	
AP →	Autopilot disengaged warning for a manual disengagement flashes for 5 seconds, then blanks. For a monitored disengagement, flashes until acknowledged by pressing an AP/SP DISC button.
AP ←	
APPR LNV1 APPR LNV2 APPR LNV3 APPR LOC1 APPR LOC2 APPR VOR1 APPR VOR2	Approach mode – capture/tracking (identified by the navigation source).
APPR LNV1 APPR LNV2 APPR LNV3 APPR LOC1 APPR LOC2 APPR VOR1 APPR VOR2	Approach mode – armed (identified by the navigation source).
B/C1 B/C2	Back course mode – capture/tracking.

CONTROLS AND INDICATORS (CONT'D)

INDICATION	DESCRIPTION
B/C1 B/C2	Back course mode – armed.
DR	Dead reckoning operation.
FD	Flight director fail flag (annunciated within the attitude indicator).
FLC	Flight level change mode – active.
FLC	Flight level change mode – armed, VNAV has armed FLC mode (climb phase only), while aircraft is holding at a VNAV target altitude.
FLC	Flight level change overspeed mode – active (flashing).
GA	Lateral go-around mode – active.
	Vertical go-around mode – active.
GP	Vertical navigation glide path mode – armed, vertical navigation mode is active and approach mode is armed.
GS	Glideslope mode – captured/tracking.
GS	Glideslope mode – armed.
HDG	Heading select mode – active.
LNV1 LOC1 LNV2 LOC2 LNV3 VOR1 VOR2	Navigation mode – capture/tracking (identified by the navigation source).
LNV1 LOC1 LNV2 LOC2 LNV3 VOR1 VOR2	Navigation mode – armed (identified by the navigation source).
LNV1 LNV2 LNV3	FMS NAV is invalid.
PATH	VNAV path mode – armed, vertical navigation mode is active (in cruise or descent phase). VNAV path is armed.
PATH	Vertical navigation mode is armed, but is unable to capture vertical path..
PTCH	Pitch mode – active.
PTCH	Vertical navigation mode is active and has automatically armed pitch mode (in descent).
ROLL	Roll mode – active.
SYNC	Flight director synchronization is in progress.
TO	Lateral takeoff mode – active.
	Vertical takeoff mode – active.
VALT	Vertical navigation mode is selected and altitude hold mode is active.
VALTS	Vertical navigation mode is selected and altitude select mode is active.

CONTROLS AND INDICATORS (CONT'D)

INDICATION	DESCRIPTION
VALTS CAP	Vertical navigation mode is selected and capturing.
VALTV	Vertical navigation mode is selected – tracking FMS target altitude.
VALTV CAP	Vertical navigation mode is selected – capturing FMS target altitude.
VFLC	Vertical navigation mode is selected and FLC mode is active (in climb phase).
VFLC	Vertical navigation mode, FMS VNAV is valid and flight level change overspeed mode is active (flashes).
VGP	Vertical navigation mode and glide path are captured.
VPATH	Vertical navigation mode – capturing/tracking a vertical path.
VPTCH	Vertical navigation mode selected and pitch mode is active.
VNAV	Vertical navigation mode, and FMS VNAV is invalid (annunciated in the vertical arm field).
VS	Vertical speed mode – active.
VVS	Vertical navigation mode selected and vertical speed mode is active.
YD	Both yaw damper channels are disengaged or have failed.

AUTOTHROTTLE SYSTEM

General

The autothrottle system (ATS) is computer-operated and monitors aircraft airspeed. The ATS controls engine power to maintain the reference airspeed or engine fan speed (N_1). ATS control is provided via the ATS control panel in the glareshield, and ATS modes of operation are displayed on the glareshield mode status display (MSD) units.

The TOGA switch on the throttle lever is normally used to arm the ATS operation. The ATS provides full-time automatic N_1 synchronization, and includes pilot selectable N_2 engine synchronization in flight.

ATS thrust and speed modes are automatic and dependent on the AFCS mode logic. The AFCS airspeed reference (speed bug) is used to select ATS speed targets, as displayed on the primary flight display (PFD).

The ATS incorporates dual-servo control of the throttle levers to enable thrust and speed control for the following phases of flight:

- Takeoff;
- Climb;
- Cruise;
- Descent;
- Landing; and
- Go-around (Certification pending).

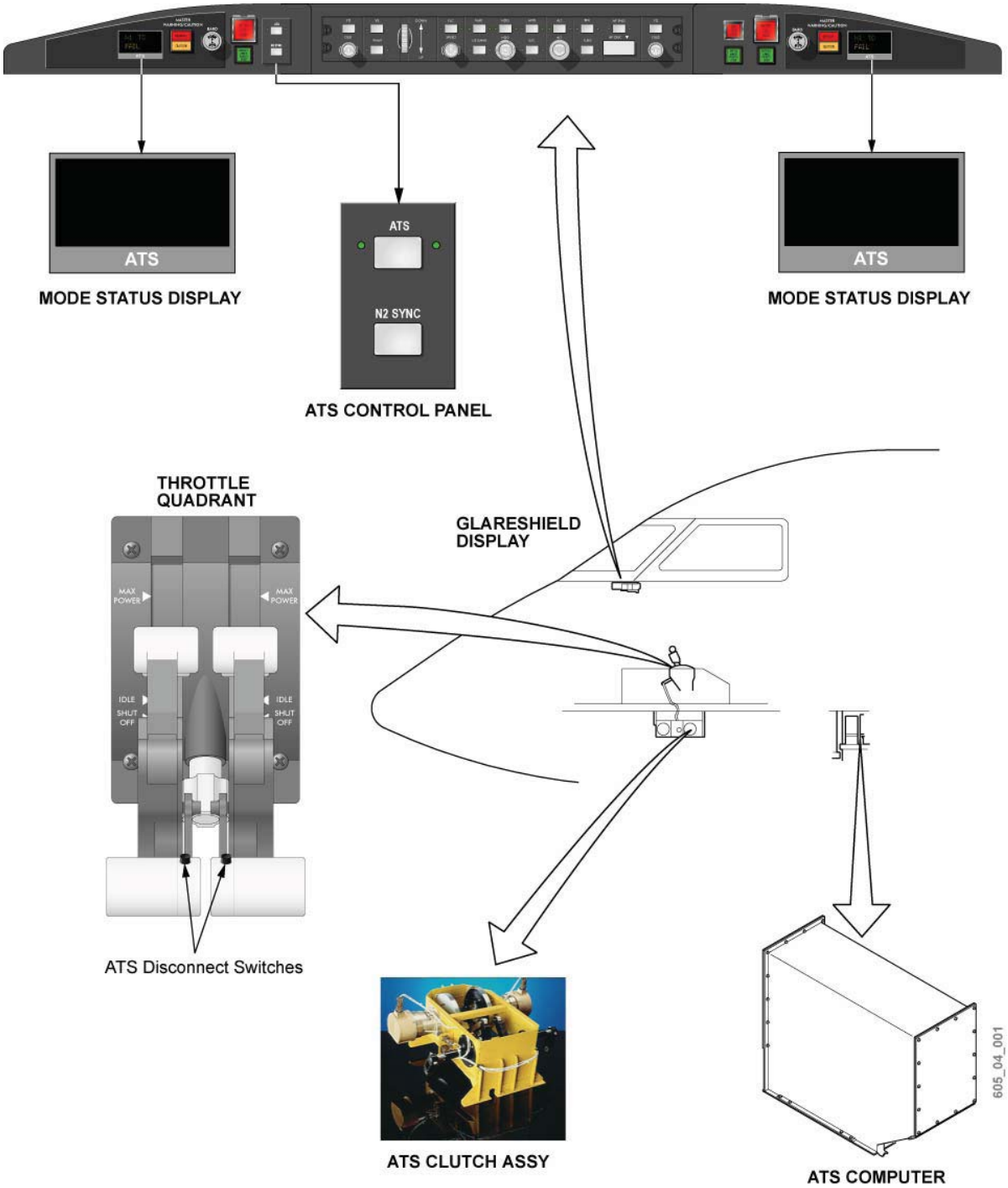
AUTOTHROTTLE SYSTEM (CONT'D)

The ATS is available in AFCS coupled (autopilot or flight director) and disengaged modes of operation.

NOTE

ATS is not available for single engine operations.

AUTOTHROTTLE SYSTEM (CONT'D)



Autothrottle System Overview
Figure 04–10–44

AUTOTHROTTLE SYSTEM (CONT'D)

Description

The autothrottle system drives the throttle lever cables directly which, in turn, provides automatic throttle lever input commands to the engines.

The ATS is comprised of the following:

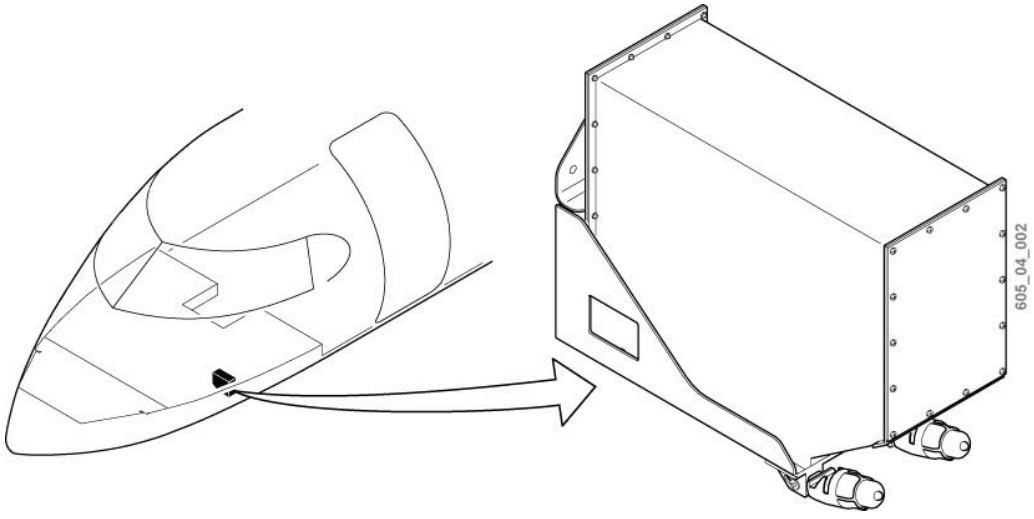
- Computer;
- Dual servo-clutch pack assembly;
- Control panel, and the mode status display (MSD); and
- Disconnect switches (ATS DISC).

Components

ATS Computer

The ATS computer is located in the avionics bay, and receives inputs from various aircraft systems, sensors and switches, and supplies power for ATS control and the servo drive assembly. The ATS performs an automatic self-test when all the sensors become valid following computer power-up.

The ATS computer only receives data inputs from the pilot's side that includes FD 1, IRS 1, ADC 1, etc. When the AFCS transfer (XFR) mode is selected, the flight control computers use the copilot side data, and ATS operation is not available.



Autothrottle Computer
Figure 04–10–45

Dual Servo-Clutch/Servomotor

Each power lever assembly is linked to one servo-motor drive with a clutch assembly. This dual assembly is installed in the main avionics bay area, attached below the cockpit center console, and is mechanically interconnected with the throttle control cables.

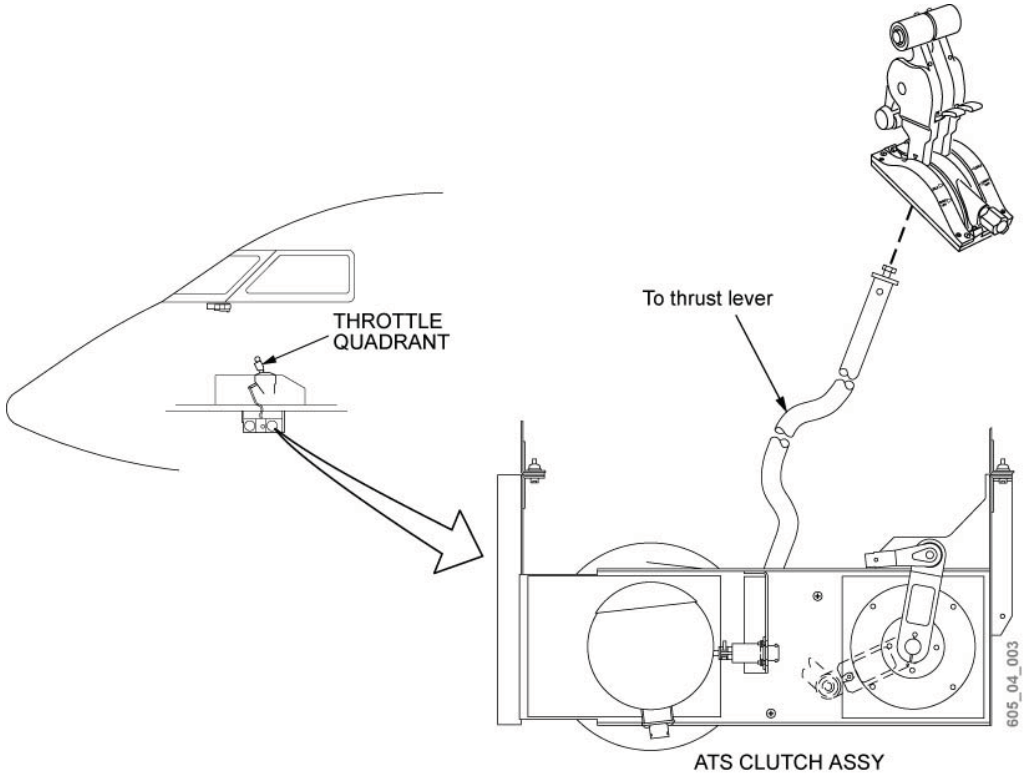
The mechanical clutches, that are driven by each servo, provide identical feel to the pilot when manually operating the throttle levers with the ATS engaged, disengaged, or when overriding the ATS.

AUTOTHROTTLE SYSTEM (CONT'D)

When the ATS is driving the throttles, the pilot's throttle levers move in the same manner as if they were being positioned manually. The engine throttle levers react in unison with respect to each other's movement, and manual operation of any one throttle lever does not affect the other.

The throttle lever friction mechanism is set at a predetermined fixed value for throttle lever operations. Therefore, adjustment of the throttle lever friction is not required, and the throttle levers do not experience any creep caused by vibration.

The throttle levers may be manually overridden when the ATS is engaged, and upon release the ATS servos resume control of the throttle levers.



Dual Servo Clutch/Servomotor
Figure 04–10–46

ATS Control Panel

The ATS is controlled by a glareshield-mounted ATS control panel that incorporates a system engage pushbutton (ATS), two green LED engaged annunciators, plus an N_2 synchronization pushbutton (N2 SYNC).

Whenever the ATS servos are engaged, the two green LED annunciators located immediately left and right of the ATS pushbutton illuminate.

AUTOTHROTTLE SYSTEM (CONT'D)

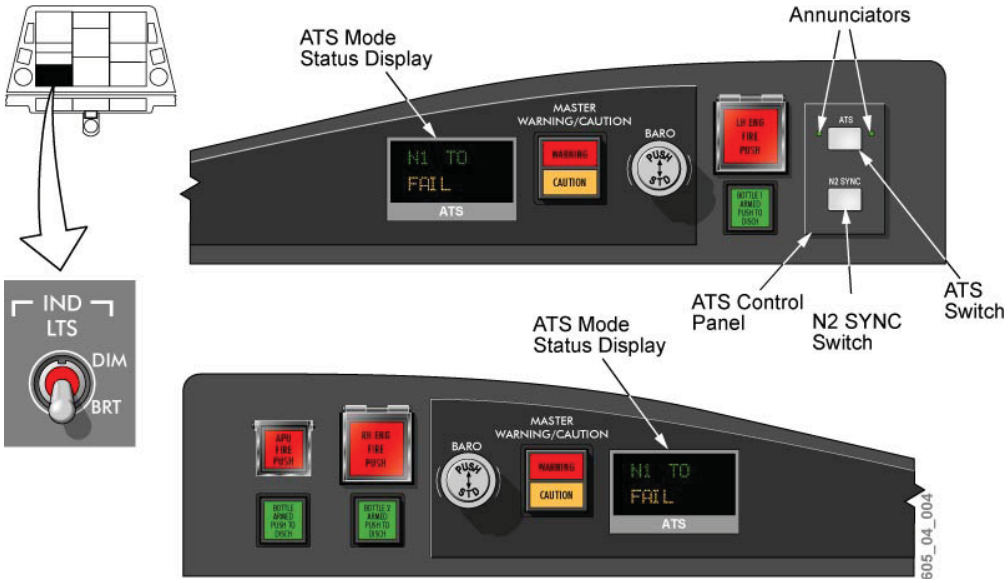
ATS Mode Status Display

Two mode status display (MSD) units, located in the glareshield (pilot and copilot positions), provide mode annunciation and caution messages for the ATS.

Each MSD incorporates a 2-line, 8-character LED alphanumeric display. The top line is green, and displays ATS mode messages. The bottom line is amber, and displays ATS caution and disengaged messages.

Lighting

The ATS control backlighting intensity is controlled by the center instrument panel lighting dimmer control. The MSD intensity and the ATS control engaged annunciator intensity are controlled by the IND LTS BRT/DIM intensity selector on the overhead panel. If the ATS is powered up with the IND LTS switch in the DIM position, the ATS control green LED annunciators and MSD remain in bright mode until the BRT/DIM switch is cycled.



ATS Control Panel
Figure 04–10–47

ATS Modes of Operation

There are two modes of operation for the ATS:

- N_1 mode – The ATS computer develops a throttle drive command derived from the FMS N_1 computation for takeoff, based on pilot input from the FMS.
- Speed mode – Controlled by using the SPEED knob on the FCC control panel.

The ATS is capable of controlling engine thrust from takeoff to touchdown, using the AFCS vertical modes and VNAV-plan speeds. The system uses the FMS thrust management table-based N_1 limit and target calculations, displayed on the EICAS N_1 fan speed displays. ATS thrust or speed mode selections are automatic, based on the AFCS mode logic. The AFCS airspeed reference (speed bug) is used to select ATS speed targets, displayed on the primary flight display (PFD). In VNAV-plan speeds, the ATS tracks the PFD magenta speed cursor.

The following table is a summary of the ATS operating modes and displays.

AUTOTHROTTLE SYSTEM (CONT'D)

ATS Operating Modes and MSD Messages

ATS MODE	THRUST/SPEED MODE	MSD MESSAGE	AFCS
TAKEOFF	N 1	N1 TO	TO
TAKEOFF (≥80 KIAS to 320 ft above takeoff elevation)	SERVO COMMANDS CEASE	N 1HOLD	TO
CLIMB (except FLC)	MACH or IAS	SPEED	ANY (except FLC)
CLIMB (FLC)	N 1	N1 CLB	FLC
CRUISE	MACH or IAS	SPEED	Altitude
CRUISE (N2 SYNC)	MACH	SPEED N2	Altitude
DESCENT (except FLC)	MACH or IAS	SPEED	ANY (except FLC)
DESCENT (FLC)	SERVO COMMANDS CEASE	DESCENT	FLC
MANEUVERING/ APPROACH	IAS	SPEED	ANY (except FLC)
LANDING (<50 FT RA)	THROTTLE LEVER RETARD	RETARD	DISENGAGED
GO-AROUND (Certification pending)	N 1	N1 TO	GA

ATS Operation

The following section provides a summary of autothrottle system operations during aircraft power-up, and for all phases of flight.

ATS Tests

ATS Computer Self-Test

The ATS performs an automatic self-test when all sensors become valid following autothrottle computer power-up. Prior to all sensors becoming valid and completion of the ATS self-test, the ATS MSD displays an amber FAIL message.

AUTOTHROTTLE SYSTEM (CONT'D)

The computer's satisfactory self-test function results in illumination of two green LEDs, located on the ATS panel, and an MSD scrolling SELFTEST message is indicated. This test ensures system integrity and logic to allow ATS engagement only if specific system requirements are satisfied. At the completion of the self-test, the green LED annunciators will extinguish, and both MSDs will blank. If the system detects a failure, the ATS FAIL message in the MSD is annunciated.

NOTE

The LED displays in the MSDs and the ATS control panel can be tested by selecting and holding the LAMP TEST switch in position 1 or 2. The ATS will also perform a system self-test and each MSD returns to a blank display upon release of the LAMP TEST switch.

If the ATS is powered up with the IND LTS on DIM, cycle the selector to BRT, then DIM, to establish intensity control after the SELFTEST function has passed.

ATS Ground Test Function

ATS ground testing is accomplished by:

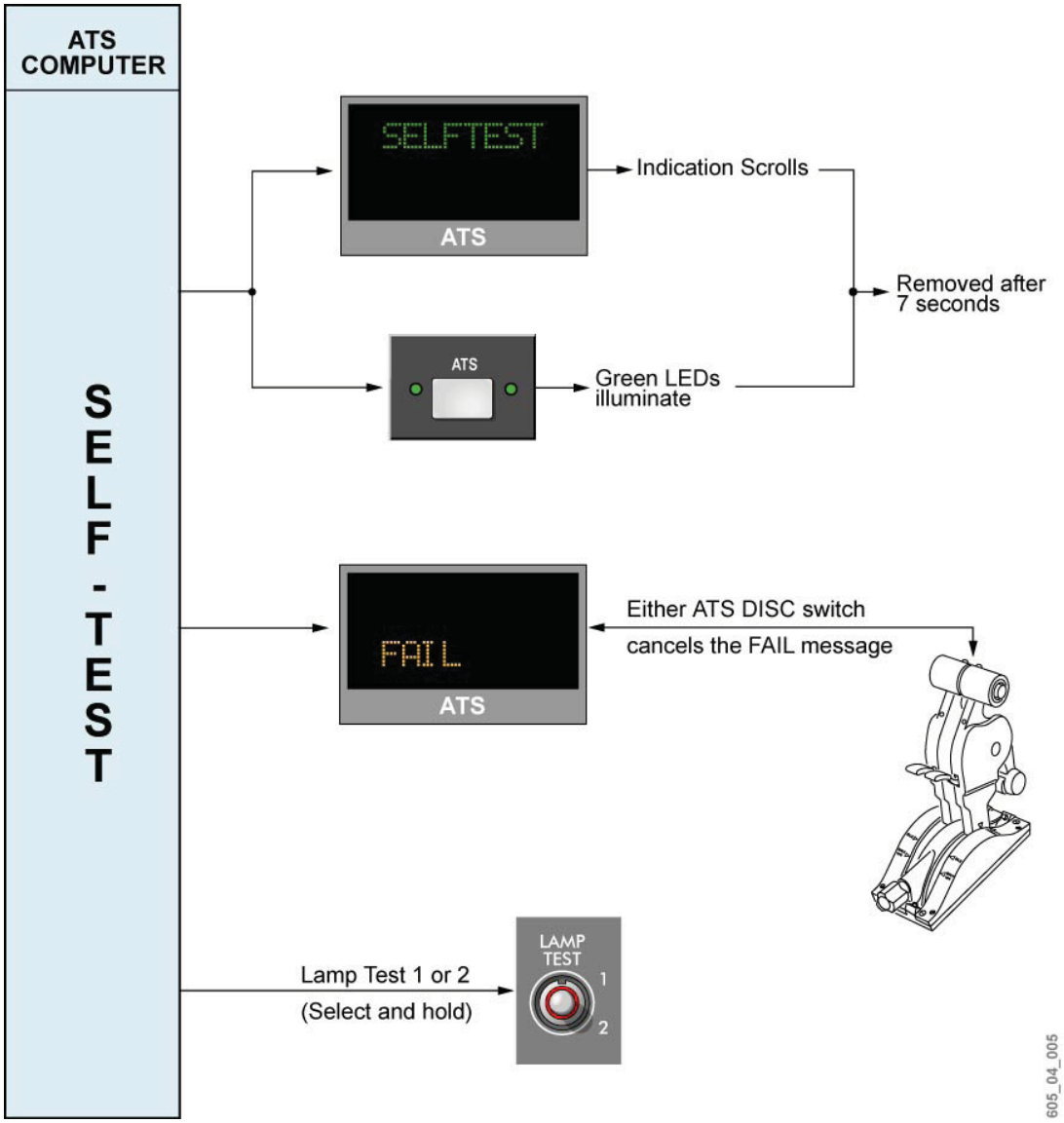
- Placing the throttles at the mid-travel position
- Selecting the LAMP TEST switch to position 1 or 2, and within 15 seconds
- Pressing and holding the ATS engage button.

The following events occur during the test:

- SERVOTEST message is displayed on the MSD for 7 seconds, and the MSD will blank;
- Throttle levers will retard to the FLIGHT IDLE position.

The ATS ground test that has been previously described is not represented on the illustration that follows, because it is considered a ground maintenance test function. The test is carried out to check the throttle levers to engine interface circuit.

AUTOTHROTTLE SYSTEM (CONT'D)



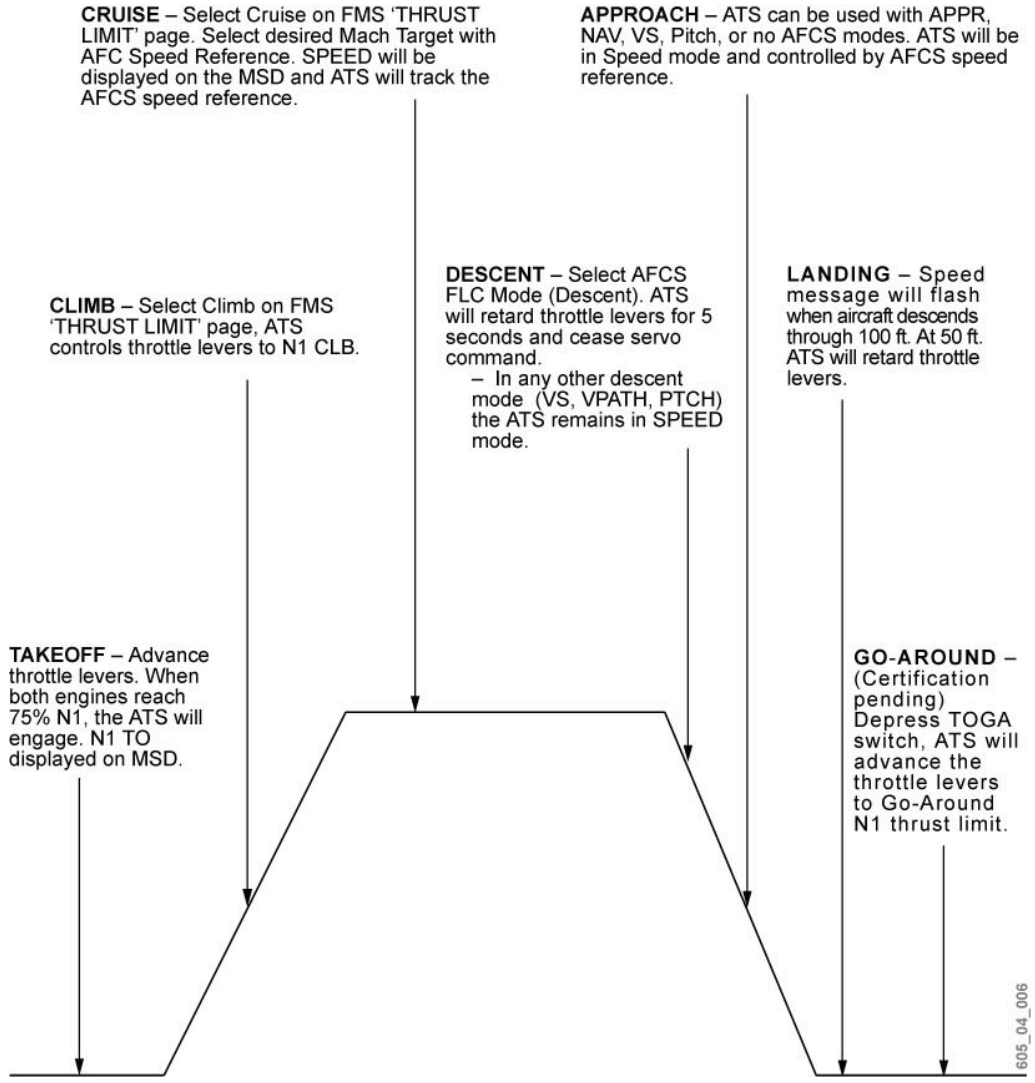
ATS Computer Testing
Figure 04–10–48

Autothrottle Mode of Operation

The flight guidance vertical mode is normally determined by the flight director or autopilot, and is influenced by the FMS during vertical navigation control. The autothrottle mode of operation results in autothrottle thrust control, which complements the pitch control being performed by the flight guidance system.

The following graphic outlines the integrated functional control provided by the autothrottle for the various control modes of the autopilot/flight director and FMS. The graphic represents specific phases of a typical flight, and an explanation of each phase is detailed within the next several pages.

AUTOTHROTTLE SYSTEM (CONT'D)



ATS Takeoff Mode
Figure 04–10–49

Takeoff

The takeoff thrust limit is selected in the FMS "THRUST LIMIT" page, and confirmed on the EICAS in the form of N_1 display.

At aircraft line-up, the pilot presses the TOGA switch and confirms that the N1 TO message is shown in the ATS mode status display (MSD) unit.

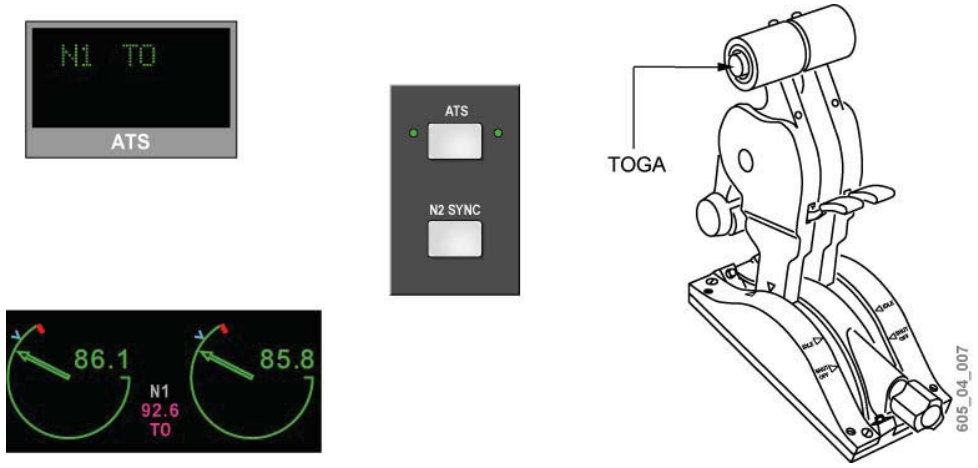
The ATS may be engaged for takeoff using either method described:

- Automatic engagement – Advance the throttle levers for takeoff. When both engines reach 75% N_1, the ATS engages, the green LEDs illuminate on the ATS control panel, and the ATS servos advance the throttle levers to the takeoff N_1 thrust limit computed by the FMS.

AUTOTHROTTLE SYSTEM (CONT'D)

- Manual engagement – Press the ATS engage pushbutton on the ATS control panel. The ATS engages, the green LEDs illuminate on the ATS control panel, and the ATS servos advance the throttle levers to the takeoff N_1 thrust limit computed by the FMS.

Confirm that engine power is set to takeoff N_1 limit prior to 80 KIAS, which is the speed that the ATS ceases servo commands. The N1 HOLD message replaces the N1 TO message in the MSD, and the green LEDs extinguish.



ATS Takeoff
Figure 04–10–50

During strong headwind takeoff, it is possible that takeoff thrust may not be set by the ATS prior to reaching 80 KIAS, and the crew must position the thrust levers, as required, to attain takeoff thrust.

At 329 ft barometric altitude above takeoff elevation, the ATS re-engages the throttle lever servos, the N1 HOLD message is replaced by the N1 TO message, and the green LEDs illuminate on the ATS control panel.

During initial climb, the ATS remains at N1 TO mode, and continues to adjust engine thrust in accordance with the N_1 takeoff thrust limit schedule calculated by the FMS.

Climb

The ATS remains in the N1 TO mode unless the following occurs:

- Autopilot is engaged, causing the ATS to transition to the SPEED mode (except in AFCS FLC mode);
- Airspeed increases to within 10 KIAS below the AFCS airspeed reference (speed bug), causing the ATS to transition to the SPEED mode (except in AFCS FLC mode or go-around mode); or
- New FMS thrust limit is chosen. Climb (CLB), cruise (CRZ) or N_1 target (TGT) thrust limit may be selected.

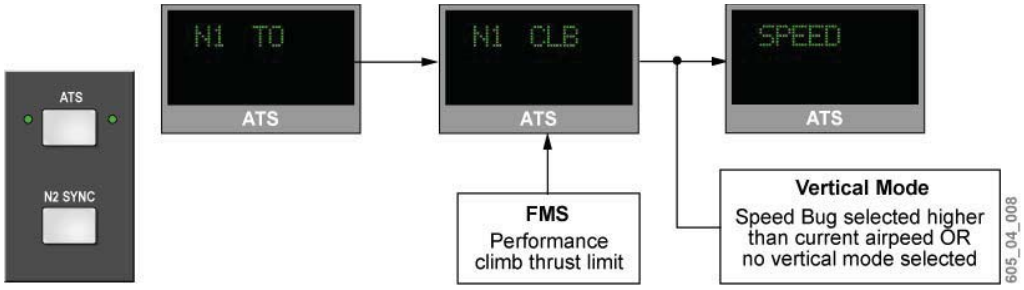
Selecting climb (CLB) in the FMS “THRUST LIMIT” page results in transition to N_1 climb mode, and the N1 CLB message replaces the N1 TO message.

AUTOTHROTTLE SYSTEM (CONT'D)

Selecting the desired AFCS vertical mode:

- AFCS FLC – ATS remains in N_1 climb mode, and continues to adjust the throttle levers in accordance with the FMS climb thrust limit.
- AFCS non-FLC – If vertical mode is selected, and the AFCS speed bug is selected higher than the current airspeed, the ATS transitions to speed mode and captures and tracks the AFCS airspeed reference. The SPEED message replaces the N1 CLB message in the MSD. If vertical mode is selected, and the AFCS speed bug is selected below the current airspeed, the ATS remains in N_1 mode and tracks the FMS thrust limit.

If the ATS is engaged in flight with no AFCS vertical mode selected, the ATS engages in speed mode. When wing and/or cowl anti-ice is selected at or above 30,000 ft, the ATS posts a FAIL message, and disengages.



ATS Climb
Figure 04–10–51

N_1 Thrust Target

If target (TGT) is set on the FMS “THRUST LIMIT” page, the target N_1 percentage can be set from 76 to 98.5. The ATS will set engine thrust to this target regardless of the aircraft’s operating limit. Note that this mode is not available for ATS takeoff.

Cruise

Desired cruise airspeed is set with the AFCS airspeed reference (speed bug) and desired thrust limit in the FMS “THRUST LIMIT” page. The SPEED message is displayed in the ATS mode status display. The aircraft accelerates with the selected thrust limits until the AFCS airspeed reference is attained. The ATS then reduces thrust as necessary to hold the AFCS airspeed reference.

N_2 Sync

N_2synchronization is available if the following conditions are met:

- Autopilot is engaged;
- AFCS altitude hold is engaged;
- ATS is in speed mode;
- Airspeed is stabilized at the airspeed reference (speed bug);
- Airspeed reference in Mach is displayed on the PFD; and

AUTOTHROTTLE SYSTEM (CONT'D)

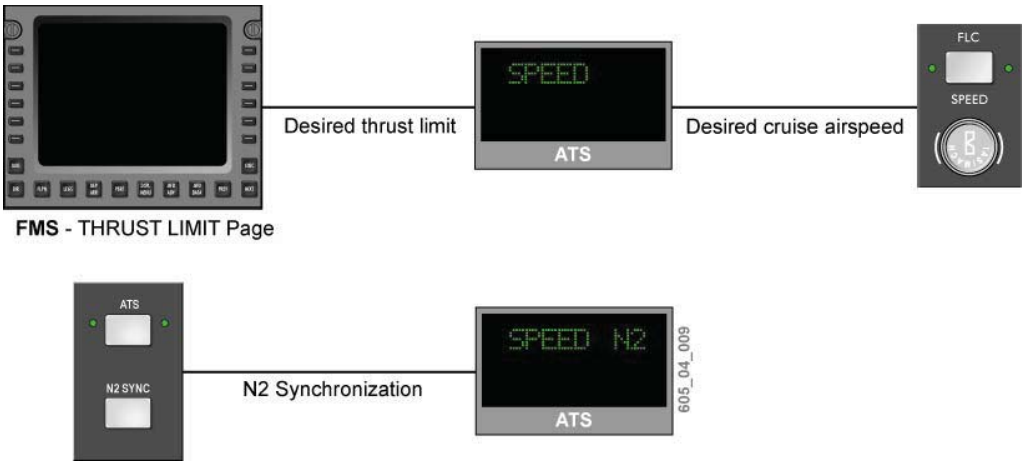
- Engine N_1 fan speeds are within 0.6% at the time of engagement.

NOTE

All parameters must be stable for a minimum of 30 seconds prior to N2 SYNC engagement.

When the N2 SYNC pushbutton is engaged, the SPEED N2 message is displayed on the ATS mode status display. The system returns to N_1 synchronization mode for any of the following conditions:

- Pressing the N2 SYNC pushbutton a second time after engagement;
- Changing the AFCS airspeed reference; or
- Airspeed changes more than 20 KIAS since N2 SYNC was engaged.



ATS Cruise
Figure 04–10–52

Descent

Descent operation in the AFCS flight level change (FLC) mode:

- DESCENT message displayed in the MSD;
- Four–second thrust reduction will occur, then servo commands stop; and
- ATS control panel green LEDs extinguish.

The throttle levers must be controlled manually to set engine thrust, to accomplish the desired descent rate.

Descent operation in non-FLC mode:

- SPEED message displayed in the MSD; and
- Select desired airspeed with speed bug or FMS, VNAV PLAN SPD.

The ATS will control engine thrust to maintain the desired airspeed reference.

AUTOTHROTTLE SYSTEM (CONT'D)

Approach

The ATS may be used during approach with the following:

- APPR, NAV, VNAV, VS, Pitch or with no AFCS modes selected.

The ATS will be in SPEED mode, and is controlled by the AFCS airspeed reference.

NOTE

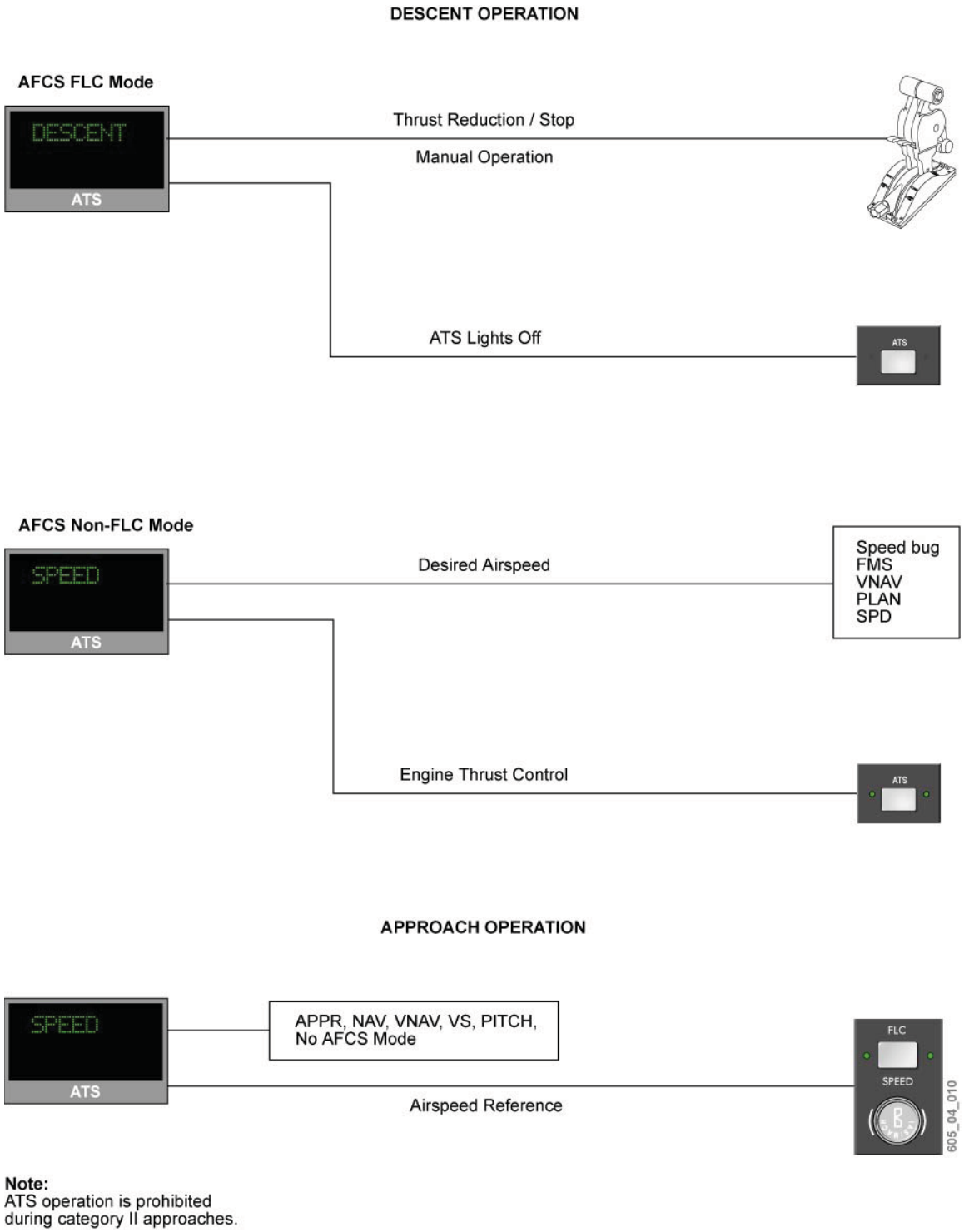
ATS operation is prohibited during category II approaches.

When the landing gear is down and the flaps are positioned at 45 degrees:

- The autothrottle system inputs a HI gain mode to the ATS servos, which provide a more accurate speed tracking.

This gain allows for a more rapid engine response, due to the higher power lever angle (PLA) rate of movement.

AUTOTHROTTLE SYSTEM (CONT'D)



Note:
ATS operation is prohibited during category II approaches.

Descent/Approach Modes
Figure 04–10–53

AUTOTHROTTLE SYSTEM (CONT'D)

Landing

The SPEED message begins to flash while descending through 100 feet radio altitude, to indicate that retard mode is set. If flashing SPEED message is not present, the ATS must be disengaged, and the throttle levers manually controlled.

NOTE

The ATS must be disengaged if flap settings other than 45 degrees are used for landing. The “retard” function is not active with flap settings other than 45 degrees.

At 50 feet radio altitude, the ATS RETARD message replaces the flashing SPEED message, and the ATS retards the throttle levers at a scheduled fixed rate.

At main landing gear weight-on-wheels, the ATS will fully retard the throttle levers, then disengage three seconds after touchdown. The green ATS control annunciators extinguish, and the MSD goes blank.

After landing, when the airspeed falls below 40 KIAS, the ATS may display a flashing amber fail message in the MSD. This condition is the result of FMS data no longer being valid, and pressing either ATS DISC switch cancels the FAIL message.

Go-Around

NOTE

Certification of the ATS go-around mode of operation is pending. The aircraft must be flown manually for all go-around or missed approach procedures.

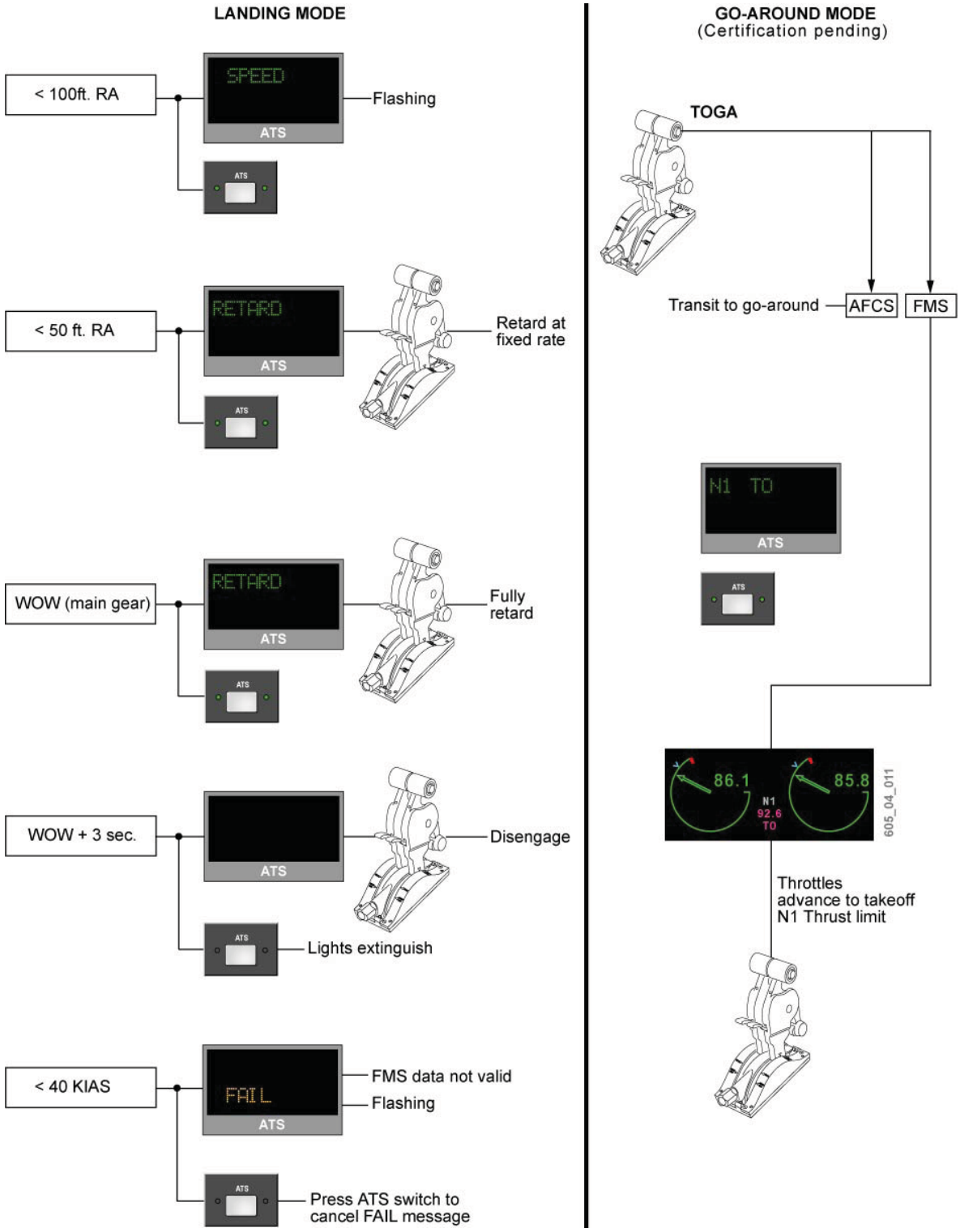
Selection of either TOGA switch results in the following:

- FMS automatically posts the takeoff N_1 limit in the EICAS N1 speed display;
- The AFCS transitions to the go–around mode;
- ATS MSD units display the N1 TO message; and
- ATS servos quickly advance the throttle levers to achieve takeoff N_1 thrust limit.

ATS takeoff thrust can be initiated at any time before shutdown, which is defined by the landing gear weight-on-wheels signal being valid.

During go-around climb, the ATS disregards the AFCS airspeed reference and the altitude preselector, and remains in the N1 TO thrust limit until another AFCS vertical mode is selected.

AUTOTHROTTLE SYSTEM (CONT'D)



Landing and Go-Around Modes
Figure 04–10–54

AUTOTHROTTLE SYSTEM (CONT'D)

ATS Disengagement

The ATS is disengaged automatically by the ATS, or manually by pilot selection.

ATS Automatic Disengagement

The ATS automatically disengages, and the flashing amber DISENG'D message is displayed under any of the following conditions:

- N_1 split of 13% or greater occurs;
- Either thrust reverser unlocks; or
- Engine N_1 speed greater than 98.4% is detected.

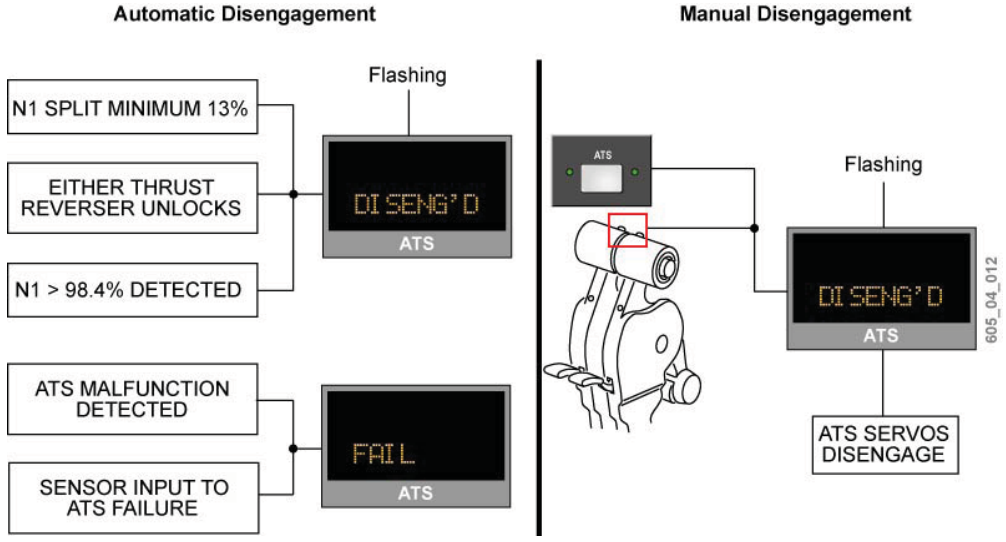
The ATS automatically disengages, and displays the FAIL message, if the disengagement was due to an auto-throttle system or sensor fault. Example: ATS malfunction detected, or aircraft sensor input to the ATS fails.

ATS Manual Disengagement

In the even of an undesirable throttle lever event (ATS engaged), the crew manually overrides the throttle levers and disengages the ATS by one of the following methods:

- Pressing the ATS pushbutton on the ATS control panel, the flashing amber DISENG'D message displays and ATS servos disengage; or
- Pressing either ATS DISC switch located on the forward face of the throttle lever, the flashing amber DISENG'D message displays and ATS servos disengage.

The DISENG'D message can be cancelled by pressing either ATS DISC switch.



ATS Disconnect
Figure 04–10–55

AUTOTHROTTLE SYSTEM (CONT'D)

Low Speed Protection

ATS low speed protection is provided in the event that the AFCS airspeed reference is set below 1.2 V_S for the flap configuration in SPEED mode. When the AOA equivalent (plus any AOA rate speed increment) is reached, the system uses the corresponding airspeed reference as the target, and adjusts the throttle levers in an attempt to maintain this target. The flashing amber AOA LIMIT message replaces the SPEED message on the MSD. Reset is accomplished by setting the AFCS reference airspeed higher than the AOA equivalent limit speed.

Thrust Limit Protection

If the airspeed is 20 KIAS below the AFCS reference airspeed, engine thrust is within 1% N_1 of the FMS thrust limit, and the aircraft's deceleration is greater that 0.1 knots/sec for more than 10 seconds, the flashing amber SPEED message is displayed, if the ATS is engaged in SPEED mode.

Overspeed Protection

If the V_{MO}/M_{MO} overspeed warning is activated, the flashing amber VMO LIMIT or MMO LIMIT message is displayed in the ATS MSD. If the ATS is in any N1 mode, the ATS reverts to the SPEED mode. The ATS will retard the throttle levers for four seconds in an attempt to protect the V_{MO}/M_{MO} limit, and then the servo commands stop. The LIMIT message cancels when the airspeed is below the limit speed, and the ATS remains in the SPEED mode.

MSD Messages

Mode Status Display Messages & Logic

MESSAGE	COLOR/STATE	DEFINITION
AOA LIMIT	Amber – Flashing	ATS protecting AOA limit
DESCENT	Green – Steady	Descent mode – with AFCS FLC
DISENG'D	Amber – Flashing	ATS disengaged
FAIL	Amber – Flashing	ATS failed
FAIL	Amber – Steady	ATS failed, prior to selftest, or power loss to computer
N1 APR	Green – Steady	APR thrust limit mode (FMS) – prohibited mode
N1 CLB	Green – Steady	Climb N_1 limit mode (FMS)
N1 CRZ	Green – Steady	Cruise N_1 limit mode (FMS)
N1 HOLD	Green – Steady	TO mode, airspeed >80Kts, alt <320ft
N1 MCT	Green – Steady	MCT limit mode (FMS) – prohibited mode
N1 TGT	Green – Steady	Pilot selected thrust limit mode (FMS)

AUTOTHROTTLE SYSTEM (CONT'D)

MESSAGE	COLOR/STATE	DEFINITION
N1 TO	Green – Flashing	TO mode, airspeed >80Kts + 4 min.
N1 TO	Green – Steady	TO mode
RETARD	Green – Steady	Throttle retard mode, RA <50ft
SELFTEST **SELFTEST**	Green – Scrolling Amber – Scrolling	Self test in progress
SERVOTST	Green – Steady	Servo test in progress (ground maintenance test function only)
SPEED	Amber – Flashing	Speed mode, airspeed 20Kt/.06M below speed bug + 10 sec, and N_1 at limit
SPEED	Green – Flashing	Speed mode, RA <100 ft
SPEED	Green – Steady	Speed mode
SPEED N2	Green – Steady	N_2 synchronization set
SPEED **MMO LIMIT**	Green – Steady Amber – Flashing	ATS protecting M_{MO} limit, speed mode activated
SPEED **VMO LIMIT**	Green – Steady Amber – Flashing	ATS protecting V_{MO} limit, speed mode activated

MSD Error Messages

The following MSD error messages may be displayed, with only one error message displayed at a time. If multiple error conditions exist, that error condition must be corrected in order to display the next message.

If an amber fail message is displayed, the ATS pushbutton can be pressed and held until a fail fault message is displayed, to help in troubleshooting the failure.

The following table describes the error messages and color logic, but does not cover the definition of each message due to the complexity of interface between components and systems configuration. Reference should be obtained from the Aircraft Maintenance Manual for message definition description.

Mode Status Display Error Messages

MESSAGE	COLOR/STATE
ADC ERR	Amber – Steady
AFCS ERR	Amber – Steady
AOA ERR	Amber – Steady
ATS COMM FAIL	Green – Steady Amber – Steady
BRAKE ERR	Amber – Steady
FCC ERR	Amber – Steady

AUTOTHROTTLE SYSTEM (CONT'D)

MESSAGE	COLOR/STATE
FLAPS ERR	Amber – Steady
FMC ERR	Amber – Steady
GEAR ERR	Amber – Steady
IRS ERR	Amber – Steady
PFD ERR	Amber – Steady
SERVO ERR	Amber – Steady
SW ERR	Amber – Steady

EICAS MESSAGES

MESSAGE	MEANING	AURAL WARNING (IF ANY)
AFCS MSGS FAIL	No valid AFCS messages received from either IAPS side.	WARNING “Triple Chime”
CONFIG AP	Autopilot is engaged with the aircraft in takeoff mode.	“CONFIG AUTOPILOT”
AP TRIM IS LWD	Autopilot is engaged with a left wing down out-of-trim condition.	
AP TRIM IS ND	Autopilot is engaged with a nose down out-of-trim condition.	
AP TRIM IS NU	Autopilot is engaged with a nose up out-of-trim condition.	
AP TRIM IS RWD	Autopilot is engaged with a right wing down out-of-trim condition.	
AP PITCH TRIM	Autopilot pitch trim function has failed.	
YAW DAMPER	Both yaw damper channels are disengaged or failed.	
AFCS 1 INOP	The respective automatic flight control system is inoperative.	
AFCS 2 INOP		
FD 1 FAIL	Respective flight director is inoperative.	
FD 2 FAIL		
IAPS DEGRADED	One or more IAPS quadrant(s) failed, with either WOW or both PSEU channel invalid.	
IAPS OVERTEMP	Overtemperature condition in one or more IAPS quadrant(s).	
YD 1 INOP	Respective yaw damper channel is off or failed and the other channel is engaged and not failed.	
YD 2 INOP		

POWER SUPPLY AND CIRCUIT BREAKER SUMMARY

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Integrated Avionics Processor System	Left IAPS	L IAPS AFCS 2 FMS 1	DC BUS 1	1	M2	
		L IAPS AFCS 1 MDC	DC BATT	1	Q4	
		L IAPS FAN	DC BATT	1	Q5	
		AFCS 2	DC BUS 1	1	K4	
	Right IAPS	R IAPS AFCS 2 FMS 2	DC BUS 2	2	K3	
		R IAPS AFCS 1 FMS 3	DC ESS	4	D3	
		R IAPS FAN	DC ESS	4	D2	