CHAPTER 3 – AUTOMATIC FLIGHT CONTROL SYSTEM

Page

LIST OF ILLUSTRATIONS

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1. **INTRODUCTION**

The automatic flight control system (AFCS) provides integration of the autopilot and flight director systems. The system consists of two interlinked flight control computers, an autopilot, two yaw dampers, automatic elevator trim control and assorted servos and actuators.

The flight control computer receives mode selections from the flight control panel and sensor information from the air data system, navigation systems, inertial reference system, radio altimeter and surface position sensors. The flight control computer provides flight guidance commands to the autopilot. The autopilot provides the control signals to drive the aileron and elevator servos as well as the horizontal stabilizer trim. The flight director provides visual guidance using a command bar on the attitude director indicator portion of the primary flight displays. <1025>

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                              AUTOFLIGHT
                                  |
        +-------------------------+-------------------------+
        |                         |                         |
  INTEGRATED               AUTOMATIC               FLIGHT CONTROL
  AVIONICS              FLIGHT CONTROL               COMPUTER
  PROCESSING            SYSTEM (AFCS)            (FCC) DIAGNOSTICS
  SYSTEM (IAPS)                |
                               |
        +----------------------+----------------------+
        |                      |                      |
  FLIGHT DIRECTOR          AUTOPILOT             YAW DAMPER
                               |
                           AUTO TRIM
```

CRUISE MODES

ROLL	PITCH
HDG	ALT SEL
VOR	ALT HOLD
FMS	

DESCENT MODES

ROLL	PITCH
HDG	PITCH
VOR	VS
LOC	SPD
FMS	

CLIMB MODES

ROLL	PITCH
HDG	VS
VOR	SPD
FMS	PITCH

GO-AROUND MODES

ROLL	PITCH
HDG	10 DEGREES
ROLL HOLD	NOSE UP

APPROACH MODES

ROLL	PITCH
LOC	GS
VOR	
FMS	

TAKEOFF MODE

ROLL	PITCH
WINGS	NOSE UP
LEVEL	DEGREES
HDG	VARIES WITH
HOLD	SPEED AND
	FLAP SETTING

Auto Flight Systems and Modes − General
Figure 03−10−1

1. FLIGHT CONTROL AND GUIDANCE

Integration among the various avionics systems is provided by the integrated avionics processing system (IAPS) which is located in the avionics compartment. Two flight control computers (FCCs), mounted inside the IAPS, are the main computers for the automatic flight control system (AFCS). Control logic for the dual flight directors, the two axes autopilot with automatic pitch trim and the dual yaw dampers is contained in the two FCCs. The FCCs use the inertial reference system (IRS) and air data computer (ADC) system information to calculate flight path and control parameters for the AFCS. Other inputs to the flight control computers include selections made on the flight control panel, flight management computer outputs and radio system outputs. <1025>

The flight control panel is the mode selection panel for selecting and controlling the flight director and autopilot functions.

Autopilot Panel
Contains switches to couple, uncouple, transfer control and reduce gains on the autopilot.

Flight Control Panel Center Glareshield

Lateral Mode Panel
Contains switches for lateral modes.
• Heading select
• Bank angle
• Approach
• Back course approach
• Navigation (VOR/LOC)

Flight Director and Course Selector Panels
Contains switches to select basic pitch and roll modes (when not coupled) and set course on primary flight display.

Vertical Mode Panels
Contains switches for vertical modes.
• Speed
• Vertical speed
• Altitude
• IAS/Mach

Mode Indicators
When a mode switch is pressed, a mode request is sent to the on-side flight control computer. If conditions are within limits, the computer acknowledges by illuminating the green lights adjacent to the mode switch. The primary flight display indicates the selected mode.

Flight Control Panel − Layout
Figure 03−20−1

Using the flight control panel, the crew can select the following functions:

• Remove flight director cues from the primary flight display and revert to basic pitch and roll displays

• Set course and fly to the active navigation source

• Engage, disengage and transfer control of the autopilot

- Reduce autopilot gains

- Set and maintain airspeed, vertical speed, and altitude

- Set navigation, heading selection and approach modes

A. Flight Director

The flight director provides visual guidance, by means of command bars on the attitude director indicator, to fly the airplane manually or to visually monitor autopilot response to the guidance commands. The visual guidance commands (pitch and roll control) are integrated with the AFCS modes, selected on the flight control panel, for autopilot operation. AFCS operating modes can be selected to the flight directors with the autopilot disengaged. Pitch (including speed control) and roll guidance cues from the AFCS are displayed on the attitude director indicator portion of the primary flight displays.

The flight director system provides commands to perform the following:

- Hold a desired attitude

- Maintain a pressure altitude

- Hold a vertical speed

- Hold a Mach number or indicated airspeed

- Capture and maintain a preselected barometric-corrected altitude

- Capture and track a preselected heading

- Capture and track a selected navigation source (VOR, LOC, G/S or FMS)

- Capture and track a localizer and glideslope

- Maintain a wings-level, fixed pitch-up attitude for takeoff or go-around

- Provide windshear escape guidance
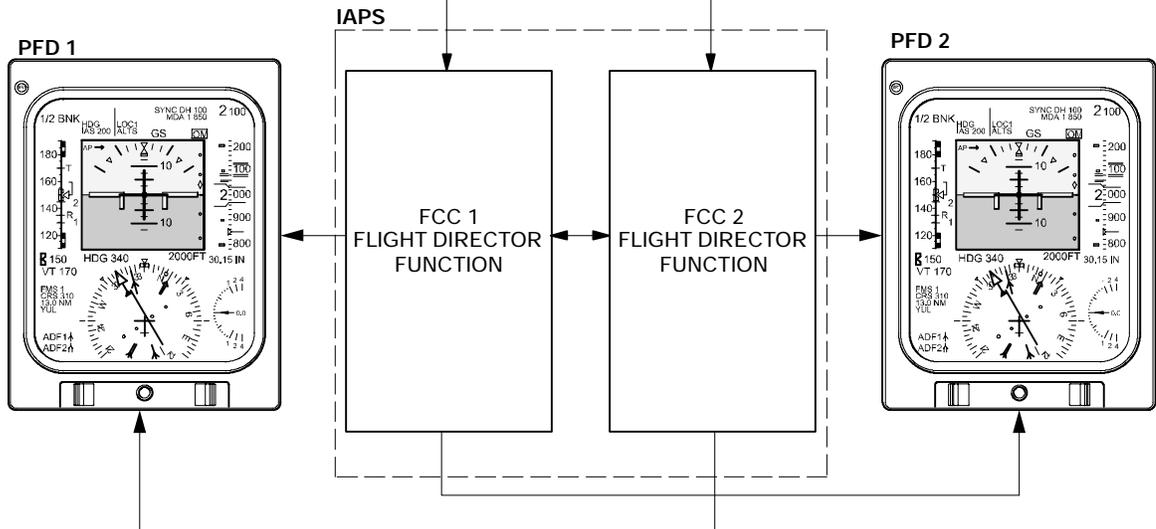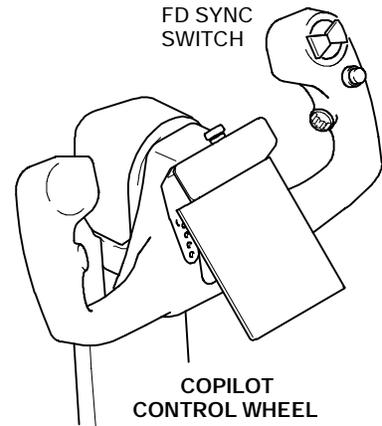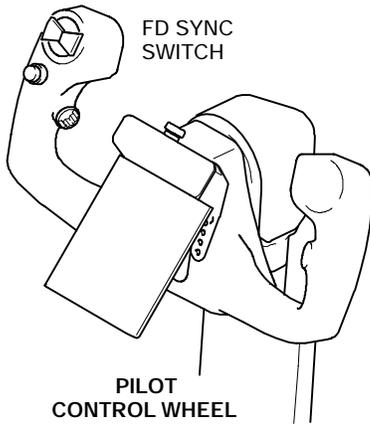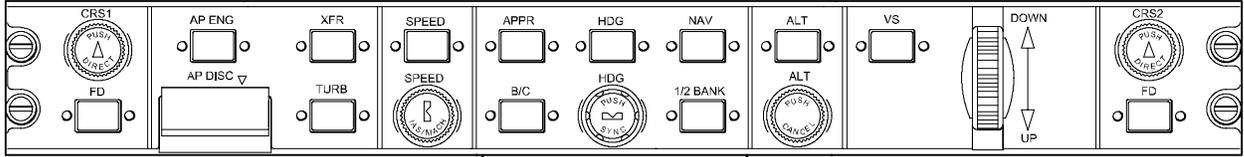
Flight Director − Schematic <1015>
Figure 03−20−2

Flight directors are simultaneously turned on by either selecting a vertical mode, selecting a lateral mode, or by engaging the autopilot. Flight director selection activates all flight control mode annunciations and presents steering commands for the selected mode(s). When both flight directors are turned on, by engaging the autopilot, basic modes (pitch and roll) are automatically selected. When both flight directors are turned on, by selecting a vertical or lateral mode, basic modes are automatically selected for the other axis.

Transfer mode controls the routing of flight guidance commands to the autopilot and flight directors. When transfer mode is selected, the copilot's flight guidance command drives both flight directors. When not transferred, the pilot's flight guidance command drives both flight directors.
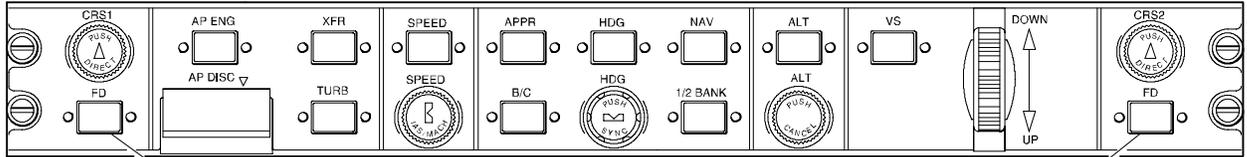
**Flight Control Panel
Center Glareshield**

FD
Used to select flight director off, when
autopilot is not coupled.
• When pushed, removes steering
and mode information from
respective primary flight display.
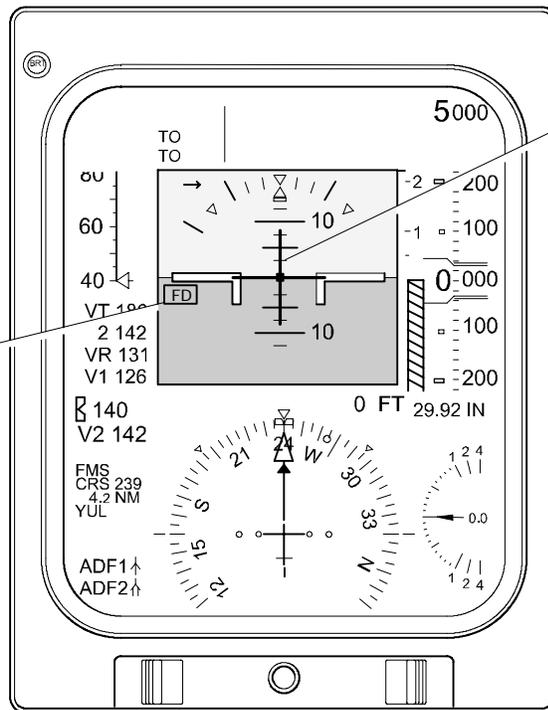
**Flight Director
(magenta)**

FD Flag (red)
Indicates that either the
pitch or roll data is invalid.

**Primary Flight Display
Pilot's and Copilot's Instrument Panels**

Flight Director – Controls and Indications <1015>
Figure 03–20–3

CRS 1 or 2
Used to set course pointer.
• When pressed, causes the course
  pointer to indicate the zero deviation
  course to the tuned VOR station.
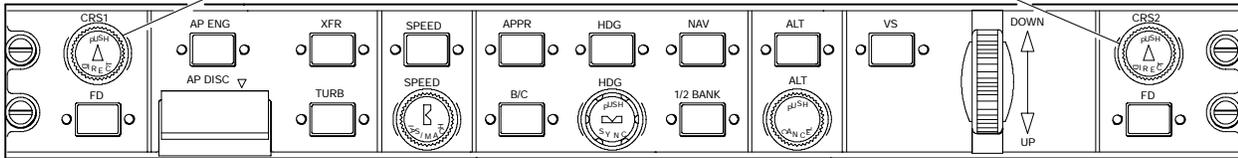
Flight Control Panel
Center Glareshield

Course Pointer
Indicates position on compass rose
that corresponds to selected course.
Color matches navigation source.

Selected Course Readout
Indicates selected course as set using
course knob on flight control panel.
Color matches navigation source.

Primary Flight Display
Pilot's and Copilot's Instrument Panels

To / From Indicator
Indicates direction to or from the
tuned station or waypoint. Color
matches navigation source.

Cross-Side Course Pointer (cyan)
Indicates position on compass rose that
corresponds to cross-side selected course.
Displayed when activated by navigation
source knob on display control panel.
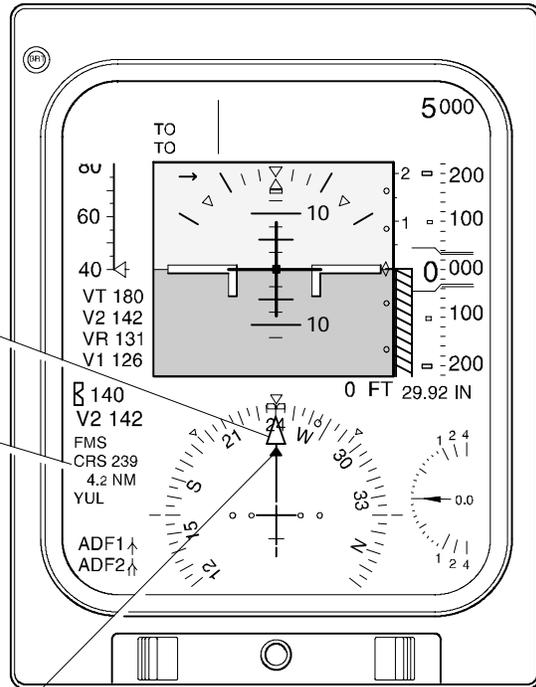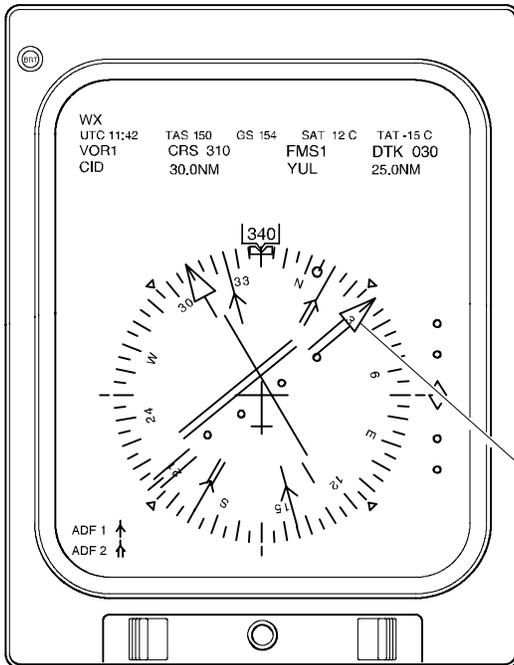
Multifunction Display - HSI Mode
Pilot's and Copilot's Instrument Panels

Course Pointer Control and Indication <1015>
Figure 03-20-4

B. Synchronization

Flight director synchronization is used to set the vertical and/or lateral reference to the current flight value. Selecting synchronization has no effect if the autopilot is engaged.

The vertical reference being synchronized is IAS (if in IAS mode), MACH (if in MACH mode), VS (if in VS mode), altitude hold memory (if in altitude hold, CLB or DES mode), or pitch angle memory (if in pitch mode). Overspeed and vertical capture modes are not affected by synchronization operation. The only lateral references that can be synchronized are the bank and heading memories of roll mode.

Synchronization is annunciated with a yellow SYNC on the primary flight display. The message will remain for 3 seconds, or until the sync switch is released, whichever is longer.

SYNC (yellow)
Displayed when flight director synchronization is selected.
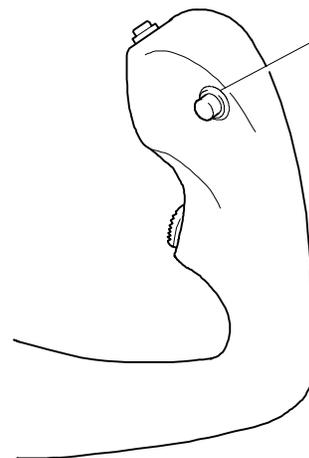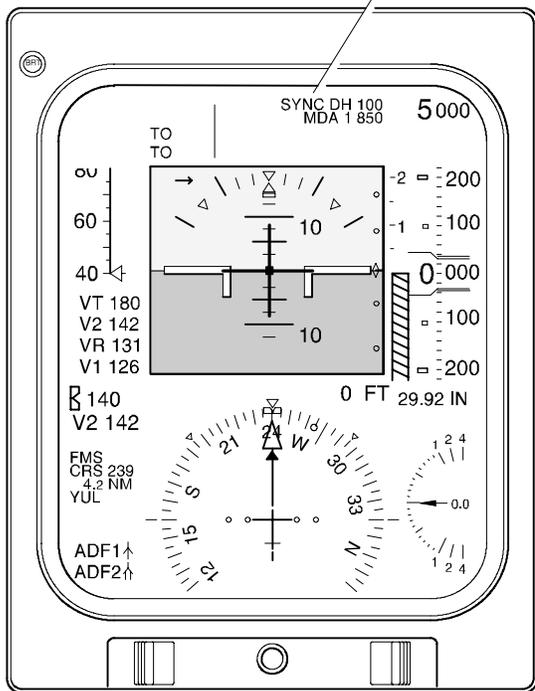
Flight Director Synchronization Switch (black)
Used when autopilot is not coupled, to synchronize vertical and lateral references to those currently flown.

Control Wheel Rear View

Primary Flight Display
Pilot's and Copilot's Instrument Panels

FD Synchronization <1015>
Figure 03-20-5

C. Flight Mode Annunciator

Flight mode annunciation is located above the blue (sky) portion of the attitude director Indicator. The flight mode annunciator presents flight mode information in two fields separated by a vertical cyan line. To the left of the line is the active or captured field (green) and to the right of the line is the armed field (white). The bottom line in each of the two fields contains vertical mode information and the upper lines contain lateral information.
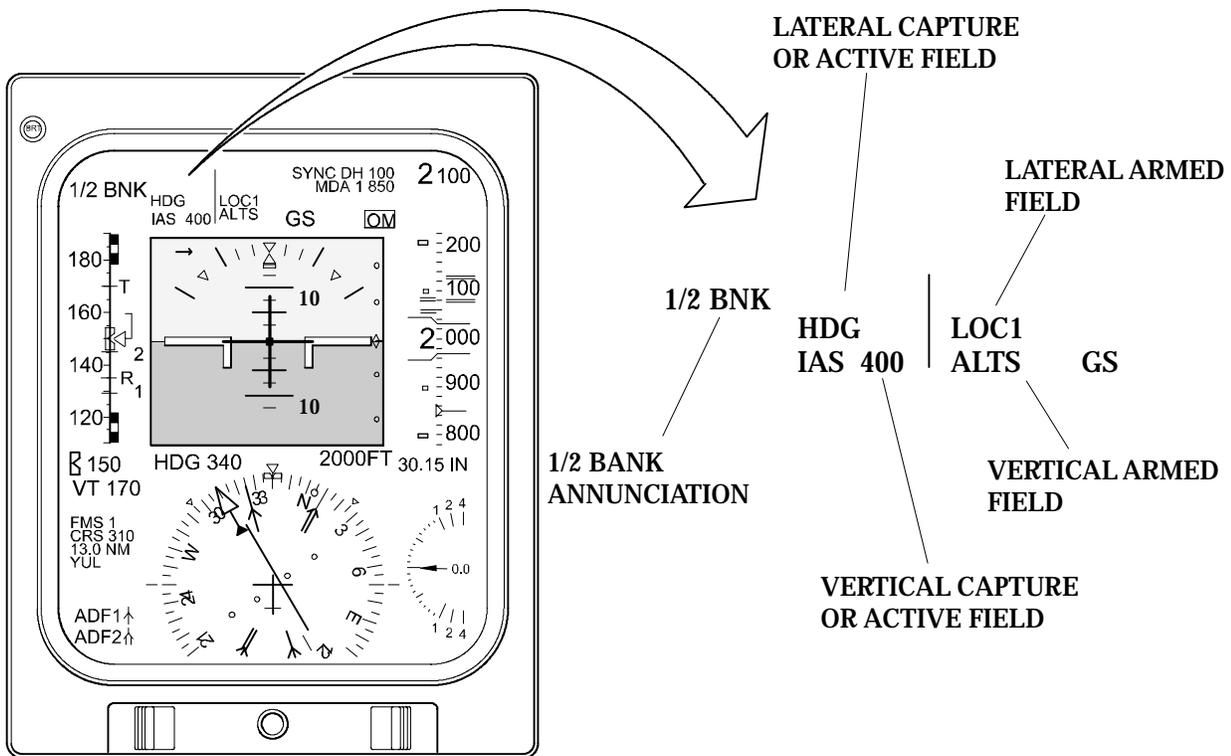
Primary Flight Display
Pilot's and Copilot's Instrument Panels

Flight Mode Annunciator <1015>
Figure 03-20-6

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			REV 3, May 03/05

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D.   **Lateral Modes of Operation**

(1)   Lateral Take-Off Mode

Lateral take-off mode generates a wings level command while on the ground. After take-off, it generates a heading hold command, with a 5-degree bank limit, using the heading which existed at take-off. Selecting a lateral take-off mode turns on both flight directors, disengages the autopilot and clears all other lateral modes.

Lateral take-off mode is selected by pushing one of the thrust lever-mounted TOGA switches while on the ground. Lateral take-off mode is cleared by the selection of flight director synchronization or another lateral mode.

Lateral take-off mode is annunciated with a green TO message in the lateral capture field on the primary flight display.

(2)   Navigation Mode

Navigation mode generates commands to capture and track a selected navigation source displayed on the primary flight display. Navigation mode is armed when selected, but cannot capture if the flight control computer is not receiving valid navigation data.

The capture point is a function of closure rate, with the capture point moving away from the radial/beam for high closure rates.

Navigation capture clears the heading selected. A localizer capture clears half bank and turbulence modes.

Dead reckoning is provided during VOR station passage. When DME data is available, dead reckoning region is approximately where the horizontal distance to the station is less than the altitude to the station. Without DME data, dead reckoning is based on a high rate of VOR deviation.

Navigation mode is selected by pushing the NAV switch on the flight control panel. Navigation mode is cleared by pushing the NAV switch again, by selecting another lateral mode or by changing the source of the on-side navigation signal.

Navigation mode arming is annunciated with two messages on the primary flight display, a green HDG message in the lateral capture field, and a white navigation source identifier (VOR1/2, LOC1/2 or FMS1/2) in the lateral arm field.

Navigation mode capture/tracking is annunciated with a green message in the lateral capture field on the primary flight display which identifies the navigation source (VOR1/2, LOC1/2 or FMS1/2). Dead reckoning operation is annunciated with a white DR message on the primary flight display.

(3) Heading Select Mode

Heading select mode generates commands to capture and maintain the selected digital heading readout and heading bug on the primary flight display. The selected heading can be changed by rotating the HDG knob (up to 360 degrees) on the flight control panel. Pushing the HDG knob will set the selected heading to the current heading.

Heading select mode is selected by pushing the HDG switch on the flight control panel. Heading select mode is cleared by pushing HDG switch or by selecting another lateral mode.

Heading select mode is annunciated with a green HDG message in the lateral capture field.

(4) Back Course Mode

Back course mode generates commands to capture and track the selected back course displayed on the primary flight display. Back course is armed when selected, but cannot capture if the flight control computer is not receiving valid localizer data.

The capture point is a function of closure rate, with the capture point moving away from the radial/beam for high closure rates. Back course capture clears turbulence, half bank and heading modes.

Back course mode is selected by pushing the B/C switch on the flight control panel. Back course mode is cleared by pushing the B/C switch again, by selecting another lateral mode, or by changing the source of the navigation signal to something other than a localizer.

Back course mode arming is annunciated with two messages on the primary flight display, a green HDG message in the lateral capture field, and a white navigation source identifier (B/C 1/2) in the lateral arm field. Back course mode capture/tracking is annunciated with a green message in the lateral capture field on the primary flight display which identifies the navigation source (B/C 1/2).

Back course steering information is invalidated when the navigation source is not a localizer.

(5) Roll Mode

Roll mode generates commands to hold the heading that exists when the mode is initiated, unless the roll angle upon initiation is over 5 degrees (commands are then generated to hold the roll angle). The roll mode reference is reset to the current heading, or current roll angle, upon autopilot engagement or synchronization.

Roll mode is automatically selected, when no other lateral mode is active, and the flight director is on. Roll mode is cleared by the selection of another lateral mode.

Roll mode is annunciated with a green ROLL message in the lateral capture field on the primary flight display.

(6)   Half Bank Mode

Half bank mode reduces the maximum commanded bank angle to 15 degrees.

Half bank mode is selected by pushing the 1/2 BANK switch on the flight control panel. Half bank mode is automatically selected when climbing through 31,600 feet (pressure altitude) or if the airplane is above the half bank transition altitude when the flight director is turned on. Selection is inhibited when in the take-off mode, go-around mode, on-side approach mode capture, or any on-side localizer capture.

Half bank mode is manually cleared by pushing the 1/2 BANK switch again, and is automatically cleared when descending through the half bank transition altitude.

Half bank is annunciated with a white 1/2 BNK message on the primary flight display.

(7)   Lateral Go-Around Mode

Lateral go-around mode generates a heading hold command, with a 5 degree bank limit. Selection of lateral go-around mode turns on both flight directors, disengages the autopilot, and clears all other lateral modes. Lateral and vertical go-around mode selections are coincident. When lateral go-around causes an autopilot disengage, the resultant autopilot disengage warning may be cancelled by another push of a TOGA switch, or by pushing the AP disconnect switch.

Lateral go-around mode is selected by pushing one of the thrust lever-mounted TOGA switches while airborne. Lateral go-around mode is cleared by selection of synchronization or another lateral mode.

Lateral go-around is annunciated with a green GA message in the lateral capture field on the primary flight display.

(8)   Approach Mode

Approach mode generates commands to capture and track the selected navigation source displayed on the primary flight display. Tracking performance is higher, than in navigation mode. Approach mode is armed when selected, but cannot capture if the flight control computer is not receiving valid navigation data.

The capture point is a function of closure rate, with the capture point moving away from the radial/beam for high closure rates.

If the other side does not concurrently capture, it will continue to operate in heading select, until it independently captures.

Approach mode may automatically select glideslope mode. An on-side localizer capture clears turbulence mode on both sides.

Dead reckoning is provided during VOR station passage. When DME data is available, dead reckoning region is where DME distance to the station is less than 0.6 nautical mile (DME). Without DME data, dead reckoning is based on a high rate of VOR deviation.

Approach mode is selected by pushing the APPR switch on the flight control panel. Approach mode is cleared by pushing the APPR switch again, by selecting another lateral mode, or by changing the source of the on-side navigation signal.

Approach mode arming is annunciated with two messages on the primary flight display, a green HDG message in the lateral capture field, and a white navigation source identifier (VOR1/2, LOC1/2 or FMS1/2) in the lateral arm field. Approach mode capture/tracking is annunciated with a green message in the lateral capture field on the primary flight display which identifies the navigation source (VOR1/2, LOC1/2 or FMS1/2). Dead reckoning operation is annunciated with a white DR message on the primary flight display.

E. Vertical Mode of Operation

(1) Vertical Take-Off Mode

Vertical take-off mode generates a variable fixed pitch-up command dependant on flap setting for takeoff and the spread between V2 and Vr. Loss of an engine reduces the pitch-up command.

Selecting vertical mode turns on both flight directors, disengages the autopilot, clears all other vertical modes and switches the flight guidance commands to a dual independent configuration. Lateral and vertical take-off mode selections are coincident.

When take-off causes an autopilot disengagement, the resultant warning may be cancelled by another push of a TOGA switch, or by pushing the autopilot disconnect switch.

Vertical take-off mode is selected by pushing one of the thrust lever-mounted TOGA switches while on the ground. Vertical take-off mode is cleared by engaging the autopilot, by selecting synchronization, or by the selection or capture of another active mode.

Vertical take-off mode is annunciated with a green TO message in the vertical capture field on the primary flight display.

(2) Pitch Mode

When pitch mode is selected, the pitch reference (pitch command on the primary flight display) is set to the current pitch angle. Pitch mode generates commands to maintain the pitch reference value.

The pitch reference value can be changed using the VS pitch wheel. Rotation of the VS pitch wheel will change the pitch reference by 1/2 degree per click. The pitch reference is reset to the current pitch attitude upon either autopilot engagement, transferring to pitch mode, or synchronization.

When the preselected altitude is captured, rotating the VS pitch wheel also rearms the altitude preselect mode.

When capturing or tracking a preselected altitude, a new preselected altitude must be chosen prior to the selection of pitch mode, to avoid an immediate recapture of the existing preselected altitude.

Pitch mode is automatically selected when no other vertical mode is active, and the flight director is on. Rotating the VS pitch wheel on the flight control panel will manually select pitch mode when the flight director is on, unless in glideslope capture or VS mode. Pitch mode is cleared by the selection of a vertical hold mode, or by a vertical mode capture.

Pitch mode is annunciated with a green PTCH message in the vertical capture field on the primary flight display.

(3)   Altitude Hold Mode

Altitude hold mode generates commands to capture and maintain the altitude reference. When altitude hold mode is selected, the altitude reference is set to the current pressure altitude.

The altitude reference is reset to current pressure altitude by selection of synchronization. There is no display of altitude reference value.

Altitude hold mode is selected by pushing the ALT switch on the flight control panel, or by changing the altitude preselect setting while in altitude preselected track. Selection is inhibited when in glideslope capture or overspeed.

Altitude hold mode is cleared by pushing the ALT switch again, by selection of a vertical hold mode, or by vertical mode capture.

Altitude hold mode is annunciated with a green ALT message in the vertical capture field on the primary flight display.

(4)   Altitude Preselect Mode

Altitude preselect mode generates commands to capture and track preselected altitudes. The barometric preselected altitude is displayed on the primary flight display, and controlled via the ALT knob on the flight control panel.

Altitude preselect mode is armed upon selection. The capture point is a function of closure rate, with the capture point moving away from the preselected altitude for high closure rates.

During altitude capture (within 200 ft of the preselect altitude), if the preselected altitude is changed or if the VS pitch wheel is rotated, the autopilot or flight director will continue to capture the original preselected altitude.

If a new preselect altitude is not set, then selection of IAS, MACH, PTCH or VS mode, will result in the current altitude being captured.

After capturing preselected altitude (altitude track), if preselect altitude is changed, altitude hold is automatically selected and altitude preselect rearmed.

Pushing in the ALT knob will cancel aural and visual alerts associated with the preselected altitude.

Altitude preselect mode is automatically selected upon selection of any vertical mode, except glideslope capture or overspeed. Altitude preselect mode is cleared by glideslope capture or overspeed.

Altitude preselect is annunciated on the primary flight display with a white ALTS message in the vertical arm field for arm; a green ALTS CAP message in the vertical capture field for capture, and a green ALTS message in the vertical capture field for track. Altitude captures, which are cleared without a subsequent selection of altitude track or arm, are annunciated with a yellow ALTS message on the primary flight display, which will remain for 10 seconds, or until altitude preselect is rearmed, whichever is shorter.

(5)   Speed Mode (CLB, DES, IAS)

Speed mode generates commands to maintain the airspeed reference value. When speed mode is selected, the IAS reference (primary flight display) is set to the current airspeed.

The airspeed reference can be manually set, using the speed knob. The airspeed reference is reset to current airspeed by the selection of autopilot engagement or synchronization.

Upon altitude capture, (selected altitude), speed mode is disabled.

Speed mode is displayed in either IAS CLB or DES. Selection of the speed readout is accomplished by pushing the SPEED knob on the flight control panel.

In DES mode, if a large reduction in target airspeed is commanded with simultaneous spoiler deployment, the autopilot may enter a Pitch Hold sub−mode (no annuciation of Pitch Hold sub−mode is provided). Pitch Hold sub−mode was designed to maintain a constant pitch attitude as a means of decelerating to the new target airspeed without sacrificing rate of decent or passenger comfort. The only indication that the autopilot has entered Pitch Hold sub−mode is that the airspeed is not decreasing and stays well above the target airspeed. In DES mode, if the airspeed is not decreasing, the Pilot can either disconnect the autopilot and assume manual control, or select another vertical mode such as VS or PTCH and adjust the vertical speed or pitch as required to resume deceleration to the target airspeed.

(6)   Vertical Speed Mode

Vertical speed mode generates commands to maintain the VS reference value. When vertical speed mode is selected, the VS reference (primary flight display) is set to the current vertical speed.

The VS reference value can be changed, throughout a ±12,000 feet/minute range, using the VS pitch wheel on the flight control panel. The VS reference is reset to the current vertical speed by the selection of autopilot engagement or synchronization.

When capturing or tracking a preselected altitude, a new preselected altitude must be chosen prior to selection of vertical speed mode, to avoid an immediate recapture of existing preselected altitude.

Vertical speed mode is manually selected by pushing the VS switch on the flight control panel. Selection is inhibited when in glideslope capture or overspeed. Vertical speed mode is cleared by pushing the VS switch again, by selecting a vertical hold mode, or by a vertical mode capture.

Vertical speed mode is annunciated with a green VS #.# ↑ or VS #.# ↓ in the vertical capture field on the primary flight display. The #.# is the VS reference value, in thousands of feet/minute (values over 10,000 feet/minute are displayed without a decimal point). The up arrow displays a positive reference and the down arrow displays a negative reference.

The flight control computer operates in the active mode. Capture will not occur if the localizer is not captured, or if the flight control computer is not receiving valid glideslope data. Upon glideslope capture, other vertical modes are automatically cleared on the captured side. If the other side does not concurrently capture the glideslope, it will continue to operate in the current active vertical mode, or ensuing vertical mode, until it independently captures glideslope.

Climb or descent rate is achieved by moving the rotary switch on the flight control panel.

(7)   Glideslope Mode

Glideslope mode will generate commands to capture and track the glideslope. Captures can be performed from above or below the beam.

The capture point is a function of closure rate, with the capture point moving away from the beam for high closure rates.

Glideslope mode is automatically selected when in an approach mode, inbound, with a valid localizer as the lateral navigation source. Glideslope mode is automatically cleared by the loss of approach mode. When armed, glideslope mode is also cleared by turning outbound, or by the loss of a valid localizer as the lateral navigation source. When captured, glideslope mode is cleared by changing the source of the lateral navigation signal to an invalid localizer.

Glideslope arming is annunciated with a white GS message in the vertical arm field on the primary flight display. Glideslope capture is annunciated with a green GS message in the vertical capture field on the primary flight display.

(8)   Vertical Go-Around Mode

Go-around mode generates a fixed pitch-up command, the value depending on whether both engines are operating or if one engine is inoperative (OEI).

Selection of vertical go-around mode turns on both flight directors, disengages the autopilot, clears all other vertical modes and switches the flight guidance commands to a dual-independent configuration. Vertical and lateral modes coincide.

When a go-around causes the autopilot to disengage, the autopilot warning can be cancelled by another push to the TOGA switch, or by pushing the autopilot disconnect switch.

Vertical go-around mode is selected by pushing either one of the thrust lever-mounted TOGA switches while airborne. Go-around mode is cleared by engaging the autopilot, by selecting synchronization or by the selection or capture of another active mode. Go-around mode is annunciated with a green GA message in the vertical capture field on the primary flight display.

F.   **Altitude Alert System**

The primary flight displays alert the pilots that the aircraft is approaching the preselected altitude, or that the aircraft is deviating from a previously selected and acquired altitude. Altitude advisories are indicated on the primary flight displays in the following locations: on the altimeter portion, at the preselect altitude digital readout (above the barometric tape), and at the preselect bugs, including the double bars (across the fine and coarse tapes).

The altitude alert system processes data from the air data computers and is independent of the autopilot or flight director mode. The ALT knob on the flight control panel is used to set the desired altitude.

The preselect digital readout and bugs change state and colour as follows:

• At the altitude alert threshold, the readout and bugs flash magenta for approximately four seconds, and a one-second aural tone sounds. The threshold is approximately 1,000 feet from the selected altitude.

• When within 200 feet from the selected altitude, the readout and bugs come on steady to indicate altitude capture.

• If the airplane subsequently deviates more than 200 feet from the selected altitude, the readout and altitude bugs (double bars) will flash amber and a 1 second tone will be heard. The readout and altitude bugs will continue to flash amber as long as the aircraft is deviated more than 200 feet or cancelled.

- When the aircraft is –200 feet below the selected altitude the flashing magenta bugs and readout will cancel.

- If the aircraft subsequently continues to deviate (±1000 feet) from the selected altitude, a 1 second tone will be heard.

- When the aircraft is again within 200 feet of the selected altitude, the readout and bugs will turn magenta and stop flashing.

Altitude alerts can be cancelled by pushing the ALT switch or selecting a different altitude. Altitude alerts are inhibited if the glideslope is captured.
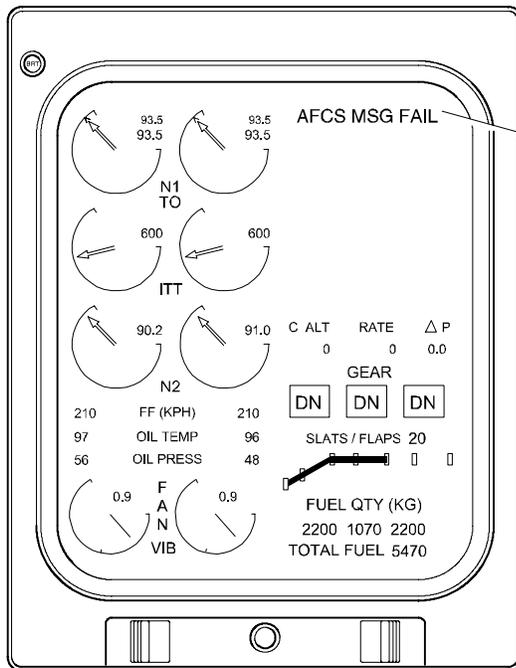
Primary Page

AFCS MSG FAIL warning (red)
Indicates all AFCS (IAPS) data
busses are invalid.

FD 1 or 2 FAIL status (white)
Indicates that the respective flight
director has failed.

IAPS DEGRADED status (white)
Indicates that an IAPS bus has failed.

IAPS OVERTEMP status (white)
Indicates that an IAPS overtemperature
condition has been detected.

SPEED REFS INDEP status (white)
Indicates that pilot and copilot vertical−
speed selection is not synchronized or
air data computer cross−talk has failed.
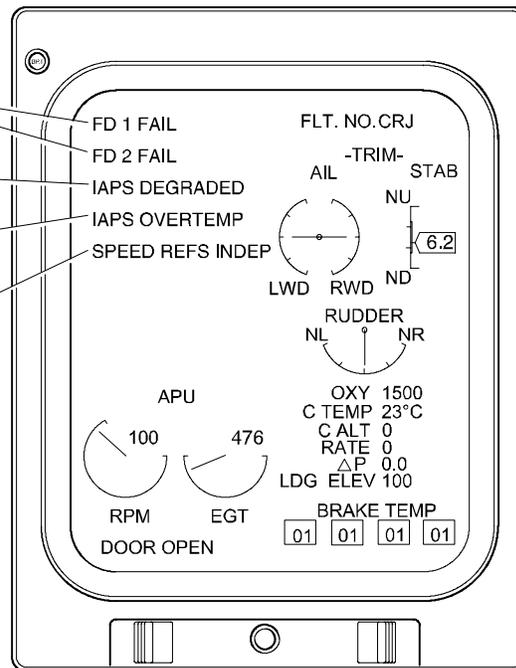
Status Page

AFCS EICAS Indications <1001>
Figure 03−20−7

G. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Automatic Flight Control System	IAPS	IAPS L	DC BUS 1	1	H1	
		IAPS R	DC BUS 2	2	H1	
		IAPS L FAN	BATTERY BUS		P7	
		IAPS R FAN	DC BUS 2		H3	
		IAPS L AFCS / MDC	BATTERY BUS		P6	
		IAPS R AFCS	DC BUS 2		H2	

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1.   **AUTOPILOT**

The automatic flight control system (AFCS) provides a two axes, digital, fail-passive autopilot. The fail-passive autopilot system is protected against internal single hardware faults and limits any malfunctioning commands to a response that is easily controlled by the pilot. Command inputs to the ailerons and elevators are provided by servos controlled by the flight control computers (FCCs). The FCCs input the yaw damper system to control the rudder. The autopilot controls the aircraft in response to flight director commands by actuating the appropriate control surfaces.

To engage the autopilot, the following is required.

- Both flight control computers must be operative

- At least one channel of the horizontal stabilizer trim is operative

- At least one yaw damper is engaged

- At least one IRS system is operable <1025>

- At least one air data computer (ADC) is operative

- There is no significant instability of the aircraft

Turbulence mode reduces autopilot gain so that flight control computer response to turbulent flight conditions is slowed and aircraft motion is smoother. On approach, an on-side localizer capture automatically clears the autopilot turbulence mode.

FCP
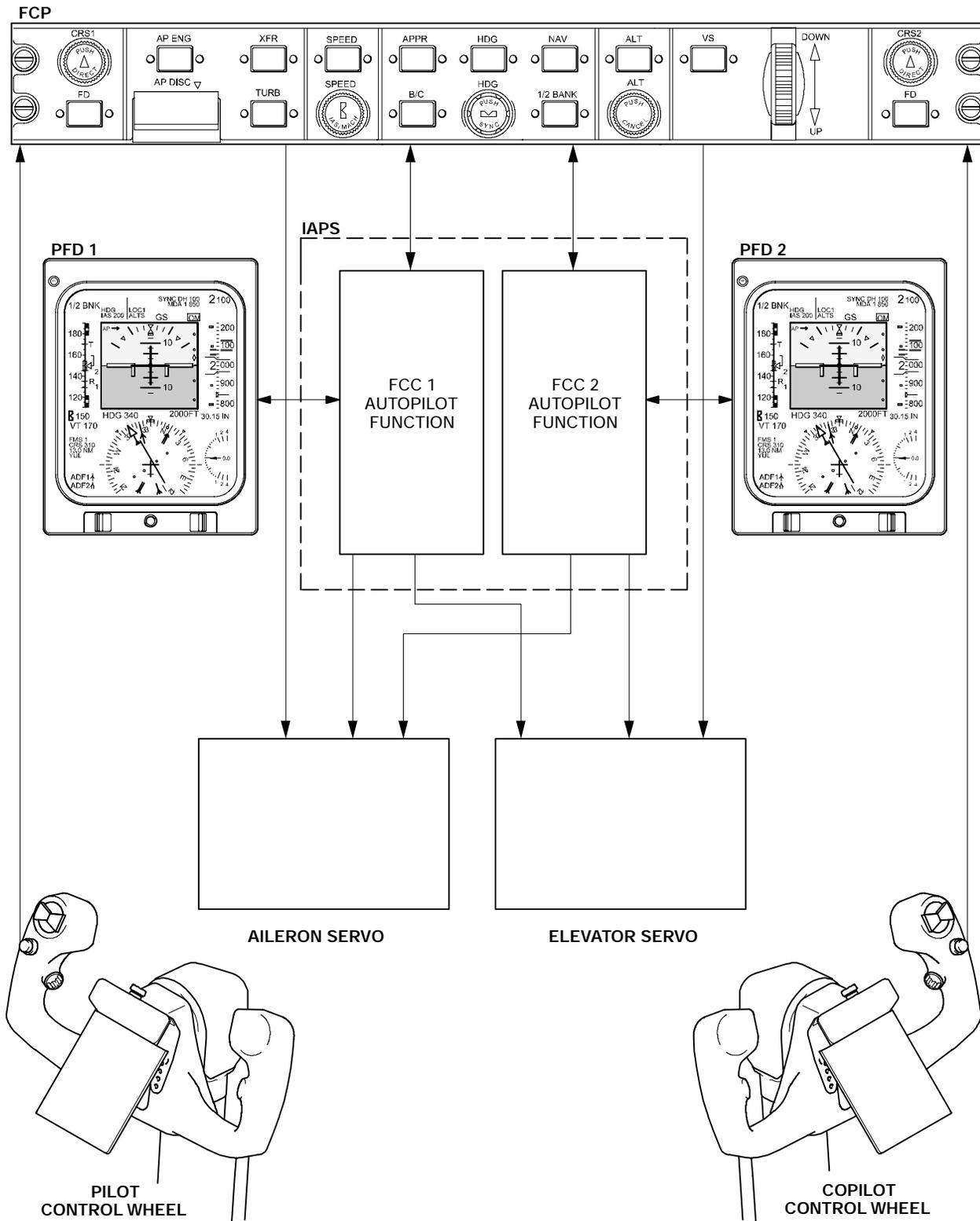
Autopilot Schematic <1015>
Figure 03-30-1

AP ENG
Used to engage and
disengage autopilot.

XFR
Used to transfer autopilot control from
one flight control computer to the other.
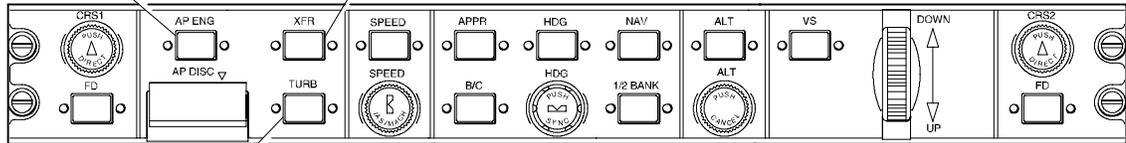
TURB
Used to engage and
disengage turbulence mode.

**Flight Control Panel
Center Glareshield**

Autopilot Engagement Indication
- AP →(green) - Autopilot engaged.
- AP →(red) - Autopilot disengaged.
- →(white) - Autopilot not engaged.

Arrow pointing left indicates autopilot is
coupled to flight director 1.
Arrow pointing right indicates autopilot is
coupled to flight director 2.

NOTE

Green indicator lights on either
side of switch indicate engaged.
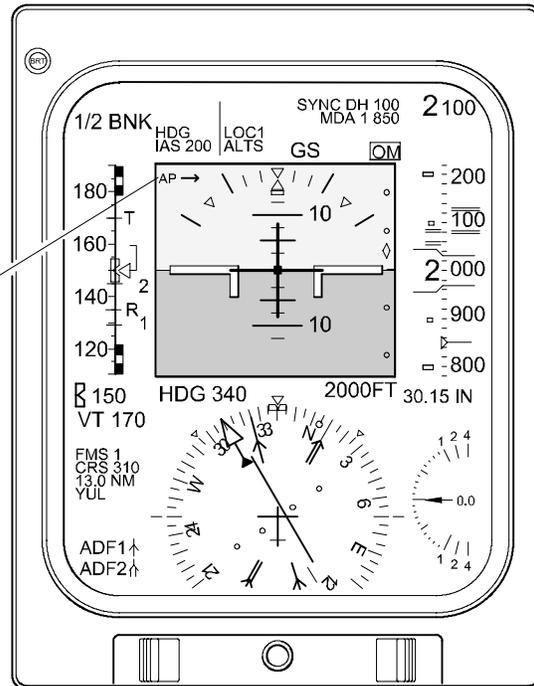
**Primary Flight Display
Pilot's and Copilot's Instrument Panels**

Autopilot – General <1015>
Figure 03-30-2

Flight Control Panel
Center Glareshield
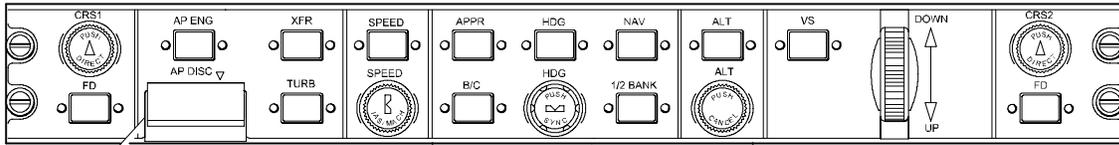
AP DISC
Lowering bar disengages autopilot.
Red line becomes visible.

AP / SP DISC (red)
When pressed, disengages
autopilot and deactivates
stick pusher. When
released, stick pusher
system is immediately
reactivated, but autopilot
remains disengaged.

Take-Off/ Go-Around
(TOGA) Switches
Momentary pushbutton
switches associated with
the take-off/ go-around
mode of the flight director.
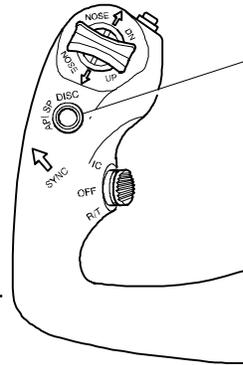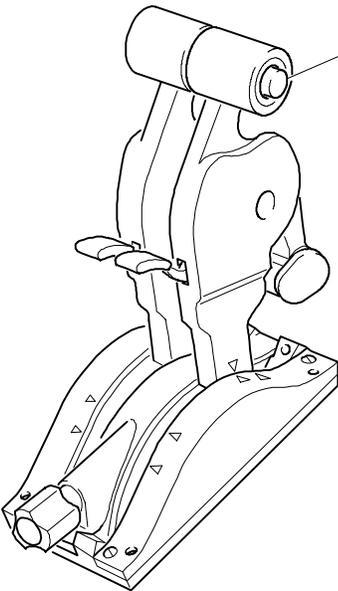
Pilot's Control Wheel
(Copilot's Opposite)

CAVALRY
CHARGE

DISC
Used to disengage
yaw dampers.

YAW DAMPER

YD 1   YD 2

DISC   ——— ENGAGE ———
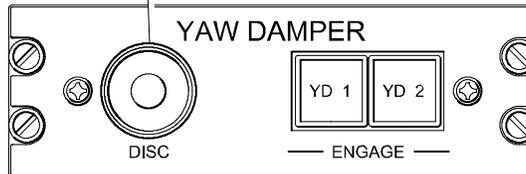
Yaw Damper Panel
Center Pedestal

Autopilot – Controls
Figure 03–30–3

The autopilot can be disengaged manually by any of the following:

- Pushing either AP/SP DISC switch on the control wheels

- Pushing the AP ENG switch on the flight control panel

- Lowering the AP DISC switch-bar on the flight control panel (a red line becomes visible)

- Operating either stabilizer trim switch on the control wheels

- Pressing either TOGA switch on the thrust levers

- Pressing the yaw damper DISC pushbutton on the yaw damper panel

Disengagement of the autopilot causes a cavalry charge aural alert and the AP indication on the primary flight display (PFD) to turn red. The autopilot disengage warning will automatically cancel, after approximately two repetitions of the cavalry charge, when a disengagement is mutually induced.

Automatic disengagement of the autopilot occurs:

- If both yaw dampers are disengaged or fail

- If a failure condition is detected by the FCC monitoring circuits

- If a stall warning occurs

- During windshear avoidance procedures

The autopilot is automatically disengaged two seconds after a windshear warning (if the autopilot has not already been disengaged). During those two seconds, the autopilot will follow the windshear commands.

In the event that the autopilot is disengaged due to a system fault, pressing the AP/SP DISC switch or either TOGA switch will cancel the red flashing AP indication on the PFD and silence the aural warning.

The automatic flight control system monitors both axes of the autopilot when engaged. If a control surface is detected to be significantly out of trim, an indication will appear on the PFD and a caution message will be displayed on the EICAS primary page to indicate in which direction that the control surface is out of trim.

Elevator Mistrim Indicator (yellow)
Indicates that the horizontal stabilizer
is in a mistrim condition, when the
autopilot is engaged.

Aileron Mistrim Indicator (yellow)
Iindicates that the ailerons are in a
mistrim condition, when the autopilot
is engaged.
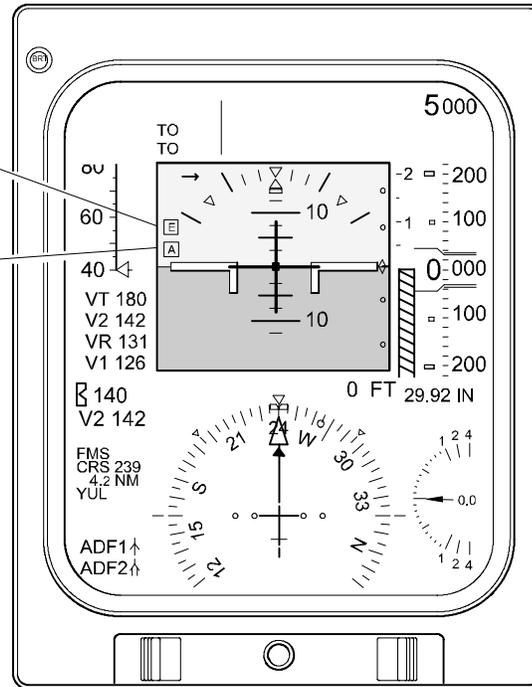
Primary Flight Display
Pilot's and Copilot's Instrument Panels

Autopilot — PFD Flags <1015>
Figure 03−30−4
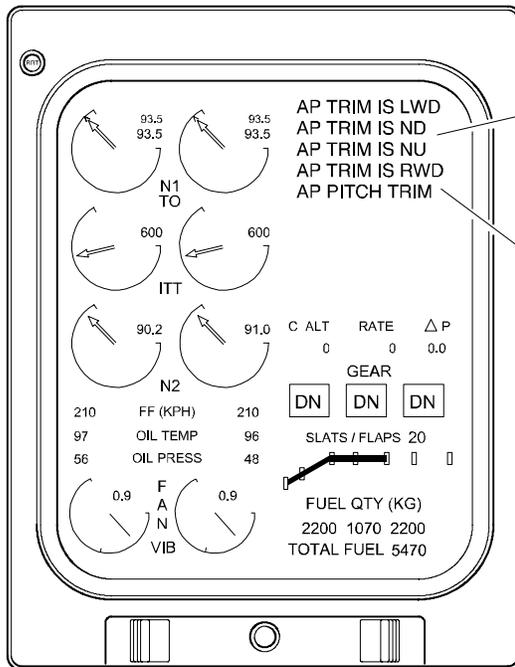
Primary Page

AP TRIM IS LWD, ND, NU or RWD caution (amber)
Indicates that a significant mistrim has been detected.
- LWD - Left wing down
- ND - Nose down
- NU - Nose up
- RWD - Right wing down

AP PITCH TRIM caution (amber)
Indicates that autopilot pitch trim has failed.

Autopilot – EICAS Messages <1001>
Figure 03–30–5

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