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AUTOMATIC FLIGHT CONTROL SYSTEMS (CASA ATPL)

CHAPTER 7 – B767 AUTOFLIGHT SYSTEM

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INTRODUCTION

The CASA syllabus frequently refers to the Boeing 767 as the example aircraft to be used for autoflight systems. This Chapter describes the B767 system and contains information extracted from the aircraft's Flight Crew Operating Manual (FCOM).

The automatic flight control system in the B767 consists of the Autopilot Flight Director System (AFDS) and the Autothrottle System (A/T).

The AFDS consists of three Flight Control Computers (FCCs), the Mode Control Panel and associated engage/disengage switches.

The three Flight Control Computers (FCCs), left, centre and right, control separate hydraulically powered autopilot control servos to operate the flight controls. The autopilot(s) control ailerons and elevators in normal flight. Rudder commands are added only during a multiple autopilot approach. Nosewheel steering is also added during rollout from an automatic landing.

The three Flight Control Computers provide flight director commands on the Electronic Attitude Director Indicator (EADI).

Flight profiles from the Flight Management System (FMS) may be used to control the aircraft via the Vertical and Lateral navigation modes. Maximising the use of these modes ensures operations for best economy.

The autothrottle system consists of the Thrust Management Computer (TMC), Thrust Mode Select Panel (TMSP) and the thrust lever actuator. Refer to Figure 7-1.

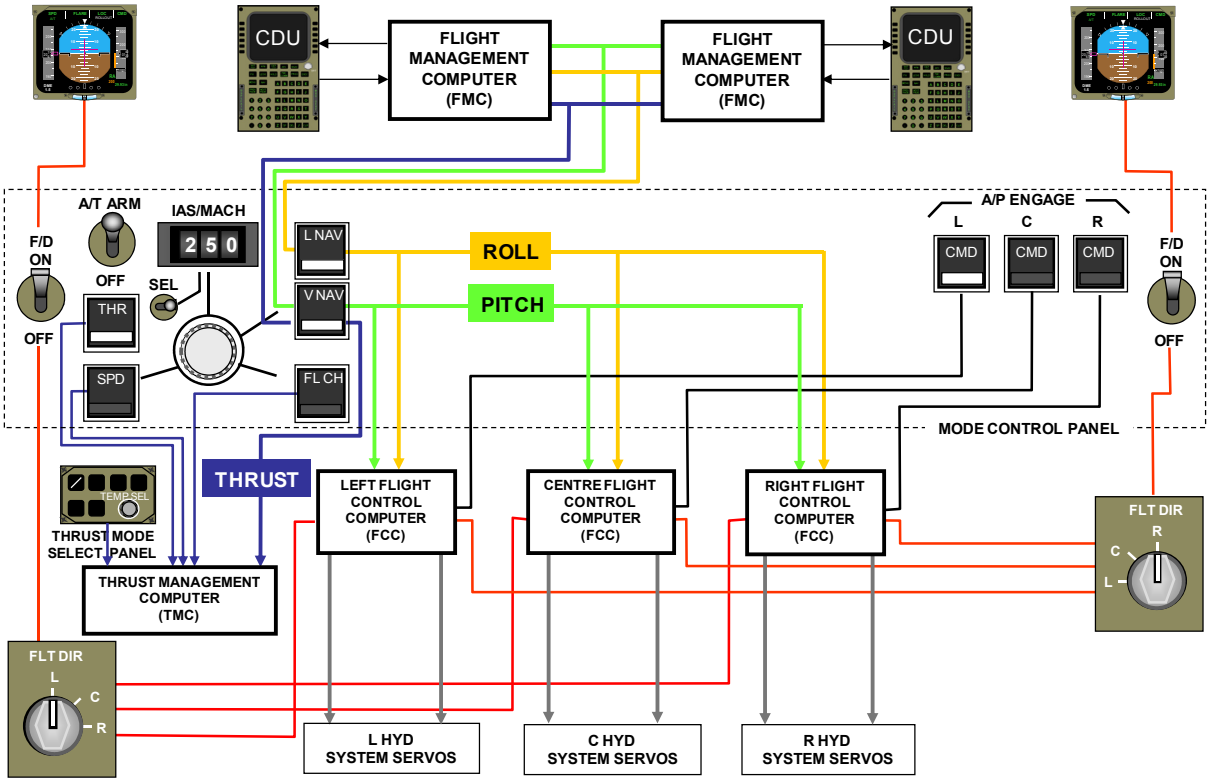


Figure 7-1 B767 Autoflight System Architecture

AFDS AND A/T CONTROLS AND DISPLAYS

Mode Control Panel (MCP)

The Mode Control Panel is located on the centre glareshield panel and is the interface between the pilots and the AFDS and A/T. It contains the controls for the Autopilots, Flight Directors, Autothrottle and Altitude Alert System. It allows the pilot to select different modes of operation of the AFDS and A/T and to couple the AFDS to the aircraft's Flight Management System and other navigational aids such as the ILS. Refer to Figure 7-2.

Switches on the Mode Control Panel arm and engage the flight director, autopilots and autothrottle. A bar in the switches illuminates to indicate the mode is armed or active (engaged).The MCP control selections will be detailed later in this Chapter.

Figure 7-2 Mode Control Panel (MCP)

Remote Switches

Switches remote from the Mode Control Panel allow quick disengagement of the autopilot and autothrottle. An autopilot disengagement pushbutton is located on each pilot control wheel and an autothrottle disengagement pushbutton is located in each thrust lever knob.

Also located at the thrust levers are switches used to initiate a go-around manouevre. Refer to Figure 7-3.

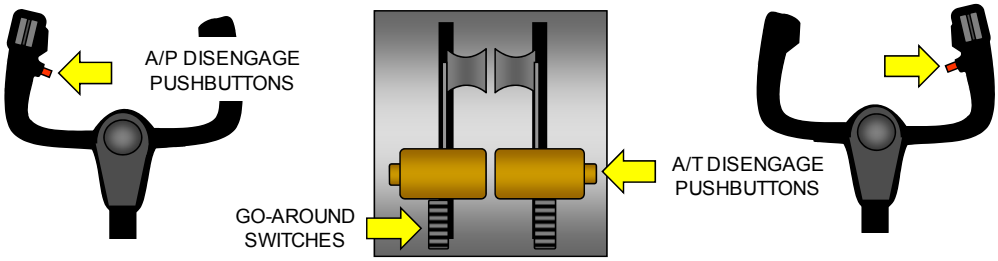


Figure 7-3 Remote Switches

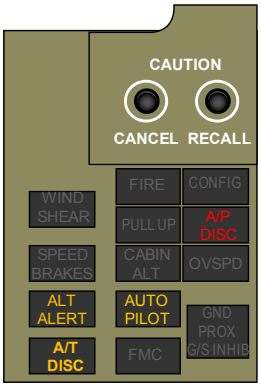
Control Display Units (CDUs)

Two Control and Display Units provide the interface to the Flight Management Computers allowing the pilots to enter planned navigational routes. Refer to Figure 7-4.

Figure 7-4 Control Display Units

Discrete Annunciator Panel and Primary EICAS Display

Normal and failure disengagenents, and other associated malfunctions of the AFDS and A/T system are displayed on the annunciator panel and the primary EICAS display. Altitude alerts are also annunciated here. Refer to Figure 7-5.



MESSAGE	LIGHT	AURAL	CONDITION
AUTOPILOT DISC	A/P DISC	SIREN	The autopilot has disconnected. Extinguished by pushing either A/P disengage switch
AUTOPILOT	AUTO PILOT	BEEPER	The engaged autopilot is operating in a degraded mode. Engaged pitch and/or roll mode may have failed. Extinguished if another autopilot is selected
AUTOTHROT DISC	A/T DISC	BEEPER	The autothrottle has disconnected. Extinguished by pushing either A/P disengage switch

Figure 7-5 Discrete Annunciator Panel and EICAS Display

Autoland Status Annunciator (ASA)

Two autoland status annunciators indicate the redundancy status of the AFDS for autolanding. The three possible status displays are shown. Refer to Figure 7-6.

Figure 7-6 B767 Autoland Status Annunciator (ASA)

Thrust Mode Select Panel (TMSP)

The Thrust Mode Select Panel allows the pilot to select reference thrust for autothrottle operation. Refer to Figure 7-7.

Figure 7-7 Thrust Mode Select Panel

Flight Mode Annunciator

At the top of the EADI is the section called the Flight Mode Annunciator. From left to right it displays A/T modes and status, pitch modes and status, roll modes and status and Autopilot/Flight Director status. Modes are boxed for 10 seconds when engaged and ruled through if inoperative. Refer to Figure 7-8.

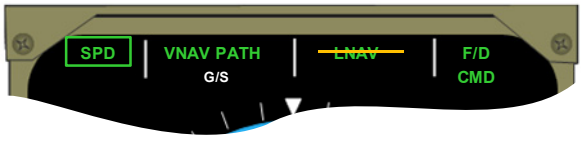


Figure 7-8 Flight Mode Annunciator

MODES OF OPERATION

The following figure lists the armed and engaged modes that can appear on the Flight Mode Annunciator (FMA). Modes that appear in white are ARMED and modes that appear in green are ENGAGED. Refer to Figure 7-9.

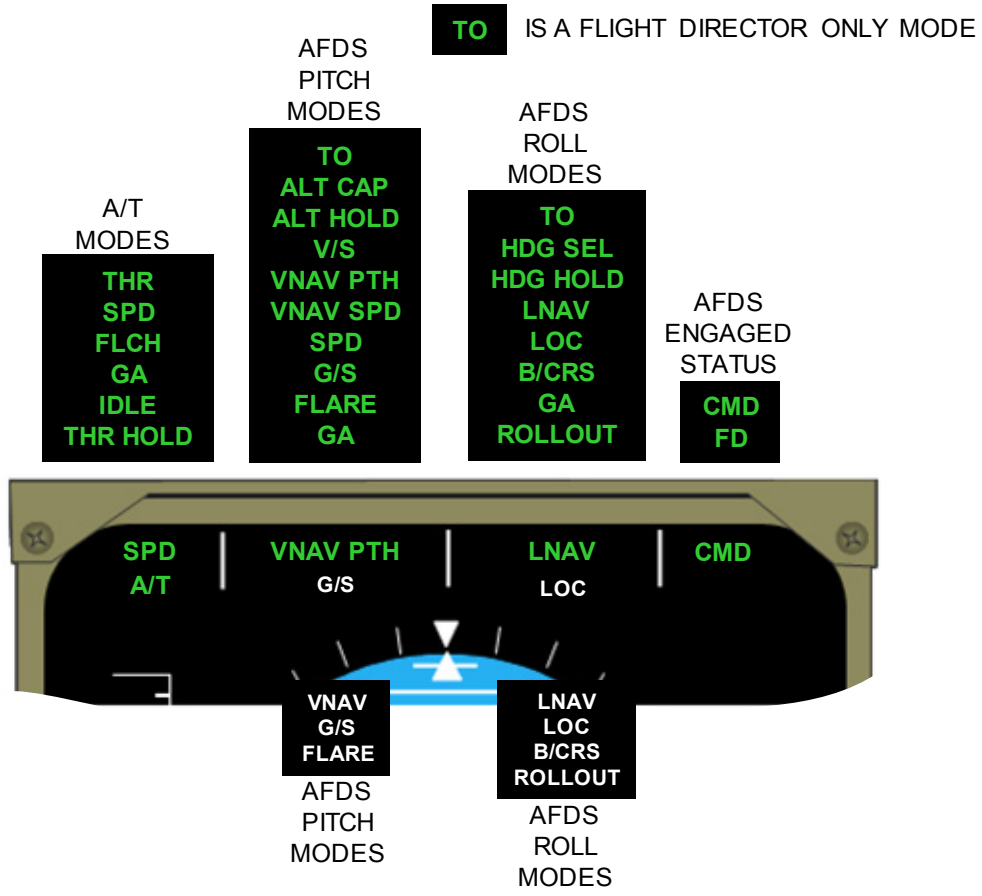


Figure 7-9 Mode Annunciations

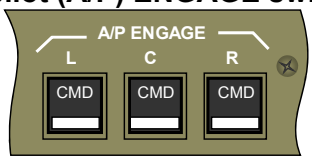
Only one pitch or roll mode can be **ENGAGED** at a time.

A pitch or roll mode may be **ARMED** with another pitch or roll mode **ENGAGED**

When the GA mode is armed it is not displayed.

MODE CONTROL PANEL SWITCHES

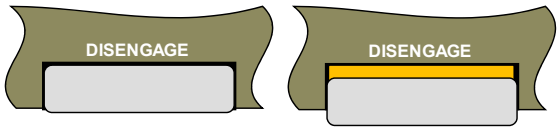
Autopilot (A/P) ENGAGE switches



Push (bar in view):

- If either FD is ON engages respective A/P in CMD in active FD mode(s), except TO and GA;
- If both FD switches are OFF, A/P engages in V/S as the pitch mode and HDG HOLD as the roll mode;
- **CMD** appears on both EADIs;
- **CMD** replaces **FD** if it was displayed.

Autopilot DISENGAGE bar



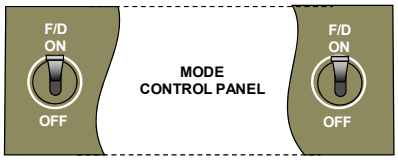
Push down – (exposes amber stripe):

- Disengages all three autopilots from flight control servos;
- Prevents autopilot engagement.

Lift up – (conceals amber stripe):

- Permits autopilot engagement.

Flight Director (F/D) switches



The left and right flight director switches activate flight director steering indications on their respective EADIs.

ON – respective pilots command bars operate in current AFDS mode:

- On the ground with no autopilot engaged and both F/D switches OFF, the first F/D switch positioned to ON arms the flight director in the take-off (T/O) roll and pitch modes. **FD** appears on the FMA.
- In flight, with the autopilot engaged and both F/D switches OFF, the first F/D switch positioned to ON activates the flight director in the selected autopilot mode(s). **CMD** appears on the FMA.
- In flight with no autopilot engaged and both F/D switches OFF, the first F/D switch positioned to ON engages the flight director in V/S as the pitch mode and HDG HOLD as the roll mode.

OFF – flight director steering indications do not display unless:

- The go-around switch is pushed when airspeed is greater than 80 knots
- The flaps are not retracted.

Autothrottle (A/T) ARM switch

ARM – arms autothrottle system for mode selection:

- Autothrottle operates when N1, SPD, VNAV, FLCH, or GA switch pushed
- Autothrottle operates when SPD switch is pushed and pitch mode is ALT HLD, V/S or G/S.

OFF – disconnects autothrottle and prevents autothrottle engagement.

N1 Switch (may be EPR or THR) (autothrottle mode)

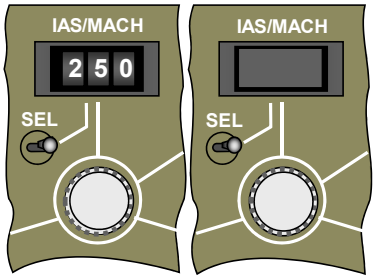
Push – (bar in view):

- Selects autothrottle N1 mode.
- **N1** annunciates on each FMA.
- Autothrottle holds reference thrust value displayed on EICAS subject to maximum speed limits.
- Changes thrust reference from TO to CLB if above 400 feet radio altitude.

Speed (SPD) Switch (autothrottle mode)

Push – (bar in view):

- Selects autothrottle SPD mode.
- **SPD** appears on each FMA.
- Autothrottle controls thrust to maintain IAS or MACH displayed in speed window subject to minimum and maximum speed limits.
- Changes thrust reference from TO to CLB if above 400 feet radio altitude.



IAS / MACH Window

- Displays selected speed when IAS/MACH selector is controlling the command airspeed bugs.
- Blank when FMC is controlling command airspeed bugs.
- Displays 200 knots when power first applied.
- In climb, automatically changes from IAS to MACH at .80 MACH.
- In descent, automatically changes from MACH to IAS at 300 KIAS.

Small Select (SEL) Switch

Select: alternatively changes the IAS/MACH window between IAS and MACH.

Rotary IAS/MACH Selector

Rotate:

- Sets speed in IAS/MACH window and positions command airspeed bugs.
- Inoperative when IAS/MACH window is blank.

Push:

- When VNAV mode is engaged, alternately changes IAS/MACH window between current IAS or MACH and a blank display.
- If VNAV is active, the window opens and speed control will transfer from the FMC target speed to the speed selected by the rotary selectors.
- Speed window does not blank if SPD, FL CH, TO or GA is active.

Lateral Navigation (LNAV) Switch (AFDS roll mode)

Push – (bar in view) Arms, Engages or Disarms LNAV as the roll mode:

- Displays LNAV in white (armed) on the roll flight mode annunciator when armed: the previous roll mode remains active (green).
- LNAV engages if the airplane is above 50 feet radio altitude and;
  - Within 2.5 NM of the active leg.
  - If not within 2.5 NM of the active leg and on an intercept heading to the active leg, remains armed **LNAV** then engages when approaching the active leg.
  - When engaged, displays **LNAV** on roll FMA.
- Selection of LNAV with the airplane not on a heading which intercepts the active leg, displays NOT ON INTERCEPT HEADING in the CDU scratch pads.
- Selection of LNAV when an active FMC route is not available displays NO ACTIVE ROUTE in the CDU scratchpad.

LNAV maintains current heading when:

- Passing the last active route waypoint
- Passing the last waypoint prior to a route discontinuity
- Passing the last route offset waypoint
- Activating the inactive route or activating an airway intercept and not within LNAV engagement criteria.

LNAV deactivates (bar not in view):

- By selecting heading hold (HDG HOLD) or heading select (HDG SEL)
- When localizer is captured
- If there is a dual Flight Management Computer (FMC) failure
- By pushing LNAV switch a second time when LNAV is armed.

Vertical Navigation (VNAV) Switch (AFDS pitch mode) (autothrottle mode)

Push – (bar in view) engages VNAV which is an AFDS pitch mode but will use the A/T to achieve the requirement. AFDS and A/T follow instructions from the FMC:

- **VNAV PTH** or **VNAV SPD** Displays on each FMA.
  - *If* **VNAV PTH** *displays the pitch mode follows a vertical path created by the FMC and the A/T receives thrust adjustments from the FMC. Autothrottle will display* **SPD**.
  - *If* **VNAV SPD** *displays on each FMA the pitch mode follows a speed set by the FMC and the A/T uses the thrust reference from the TMSP. Autothrottle will display* **N1**.
- Automatically changes the thrust reference from TO to CLB if above 400 feet radio altitude.

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

When in VNAV mode, pushing the IAS/MACH selector knob permits the a manual speed selection by the pilot. The FMC will now use the manually selected speed.

VNAV deactivates:

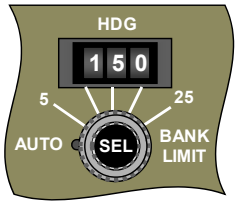
- By selecting GA, FLCH, SPD, N1, V/S or ALT HOLD
- By pushing VNAV switch a second time when VNAV is armed
- When glideslope is captured
- In climb or descent, reaching altitude displayed in altitude window prior to reaching FMCs target altitude
- Passing top of descent point if the MCP is not set to an altitude below cruise altitude.

When VNAV is armed it appears as **VNAV** on the FMA.

Flight Level Change (FLCH) Switch (autothrottle mode)(AFDS pitch mode)

Push – (bar in view) Selects FLCH mode:

- Sets IAS/MACH window and command airspeed bugs to current airspeed.
- **FLCH** displays on FMA for autothrottle. **SPD** displays for pitch mode.
- AFDS pitch holds existing airspeed.
- Autothrottle sets required thrust, limited by the thrust limit for climb and idle for descent.
- When selected altitude is reached, pitch mode changes to **ALT HOLD** and autothrottle changes to **SPD** mode.
- With FLCH mode displayed, pushing switch resets IAS/MACH window and commands airspeed bugs to current airspeed.
- Changes thrust reference from TO to CLB if above 400 feet radio altitude.



Heading (HDG) Window

Displays selected heading and positions EHSI map display selected heading markers. HDG window and map display headings set to 000 when power first applied. Automatically changes to selected ILS front course heading at **LOC** capture.

Heading Select (SEL) Switch (rotating selector)) (AFDS roll mode)

Push – Engages HDG SEL roll mode:

- **HDG SEL** displays on each FMA.
- AFDS controls roll to acquire and hold heading shown in heading window and on map display heading markers.
- Bank is limited by bank limit selector.

Heading Rotating Selector (inner)

Rotate – Sets heading in heading window and positions selected heading marker on both EHSI map displays.

Bank Limit Rotating Selector (outer)

Rotate – Sets AFDS commanded bank limit when in **HDG SEL** roll as follows:
AUTO – bank angle varies between 15 to 25 degrees, depending on true airspeed.

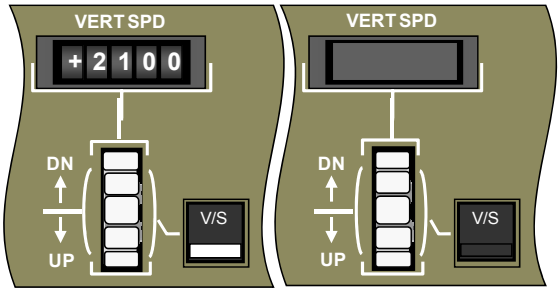
- At slower true airspeeds the bank angle limit is 25 degrees.
- As true airspeed increases, the bank angle limit decreases.

5, 10, 15, 20, 25 – the selected value is maximum regardless of airspeed.

Heading Hold (HOLD) Switch) (AFDS roll mode)

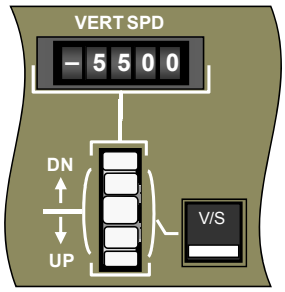
Push – (bar in view) Selects HDG HOLD roll mode:

- **HDG HOLD** displays on each FMA
- AFDS rolls wings level, then holds present heading



Vertical (VERT SPD) Window

- Displays selected vertical speed
- Blank when V/S pitch mode is not engaged
- Display range is from -8000 to +6000 fpm in 100 fpm increments.



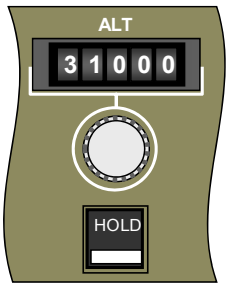
Vertical Speed Selector Wheel (DN/UP)

Roll – UP or Down (DN) – sets vertical speed in VERT SPD window.

Vertical Speed (V/S) Switch (AFDS pitch mode)

Push – (bar in view) Selects VERT SPD pitch mode:

- **V/S** displays on each FMA.
- Displays current vertical speed in VERT SPD window
- When selected altitude reached, pitch flight mode annunciation changes to **ALT HOLD**
- AFDS pitch commands vertical speed displayed in the VERT SPD window
- If V/S switch is pushed from **FLCH** or from **VNAV** the autothrottle automatically engages in **SPD** mode if armed.



Altitude (ALT) Window

- Displays selected altitude
- Displayed altitude is reference altitude, for altitude alerting and level off
- Display range is from 0 to 50,000 feet in 100 feet increments
- ALT window set to 10,000 feet when power is first applied.

Altitude Rotary Selector

Rotate – Sets altitude in ALT window.

Altitude Hold (HOLD) Switch (AFDS pitch mode)

Push – (bar in view) Selects altitude ALT HOLD pitch mode:

- **ALT HOLD** displays on FMA
- AFDS commands pitch to maintain the altitude when the switch was pushed.

Localizer (LOC) Switch (AFDS roll mode)

Push – (bar in view) Arms, Disarms, Captures LOC as a roll mode:

- Displays **LOC** armed on FMAs before localizer capture – the current roll mode of LNAV, HDG SEL, or HDG HOLD remains active until LOC capture.
- **LOC** displays on FMA after localizer capture.
- Arms AFDS to capture and track inbound on front course; capture point varies based on range and intercept angle.
- Localizer capture can occur when intercept track angle is within 120 degrees of the localizer course.

Localizer mode can be disarmed before localizer capture by:

- Pushing LOC switch a second time
- Arming LNAV.

Localizer mode can be deactivated after localizer capture by:

- Pushing a go-around (GA) switch
- Selecting a roll mode other than LNAV
- Disengaging the autopilot and turning both F/D switches off.

Note:

The LOC mode is a single autopilot function only. Multiple autopilots cannot be engaged with this mode.

Backcourse (B/CRS) Switch (AFDS roll mode)
(must be used with LOC switch)

Push – (bar in view) Arms, Disarms, Captures B/CRS as a roll mode:

- Displays **B/CRS** armed on FMAs before localizer capture – the current roll mode LNAV, HDG SEL, or HDG HOLD remains active until B/CRS capture
- **B/CRS** displays on FMA after localizer capture
- Arms AFDS to capture and track inbound on BACKCOURSE of localiser
- Capture point varies based on range and intercept angle
- If the localiser is captured before pushing the B/CRS switch the AFDS will track the localiser front course.
- G/S, FLARE and ROLLOUT are not available in B/CRS mode.

Backcourse and Localizer modes can be disarmed before localizer capture by:

- Pushing LOC switch a second time.

Backcourse mode can be disarmed before localizer capture by:

- Pushing B/CRS switch a second time – LOC remains armed.

Note:

B/CRS mode is a single autopilot function only. Multiple autopilots cannot be engaged with this mode.

Approach (APP) Switch (AFDS roll and pitch mode)

Push – (bar in view) Arms remaining autopilots. Arms, Disarms, Captures LOC as a roll mode and glideslope (G/S) as a pitch mode:

- 

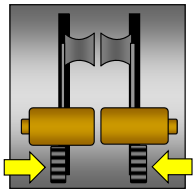
Arms the other A/P systems (CMD switch bars in view) for subsequent automatic engagement which occurs when localiser and glideslope are captured and radio altitude is below 1500 ft. Autopilots are connected to separate electrical power sources.
- **LOC** and **G/S** displayed armed on the FMA prior to localiser and glideslope capture.
- **LOC** and **G/S** displayed engaged on the FMA after each one is captured.
- AFDS captures and tracks localiser as in LOC mode and captures glideslope upon interception (either localiser or glideslope can be captured first).
- LOC capture can occur when intercept angle is within 120° of the localiser course.
- G/S capture can occur when intercept track angle is within 80° of the localiser course.

Approach mode can be disengaged under the following conditions and actions:

- Before LOC or G/S capture push the APP switch a second time
- Before LOC or G/S capture select another pitch or roll mode
- With **LOC** captured and **G/S** armed select another roll mode
- With **G/S** captured and **LOC** armed select another pitch mode
- After **LOC** and **G/S** captured, PUSH either go-around switches on the thrust levers and engage pitch and roll **GA** mode.
- After **LOC** and **G/S** captured, disengage autopilots and turn both FDs OFF.

REMOTE MODE CONTROL SWITCHES

Go-around (GA) ENGAGE switches (AFDS roll and pitch mode)(autothrottle mode)



Go-around must be ARMED

GA is armed automatically whenever flaps are away from the fully up position OR the glideslope is captured. When armed, GA does not display on the FMA. GA remains armed until 2 seconds after the aircraft has passed through 5 feet RA.

A go-around can be flown using multiple autopilots, single autopilot or flight director only.

The pilot is responsible for manually operating the gear and flaps.

GA cannot be engaged once reverse thrust is operated.

Push – (either switch) Go-around engaged for Autopilot (s), Flight Director and Autothrottle if they are engaged:

- The FMA will display **GA** for Pitch, Roll and A/T Modes.
- GA pitch will hold existing airspeed or adjust to MCP speed whichever is the highest.
- GA roll will maintain ground track.
- GA autothrottle increases thrust to maintain a climb rate of at least 2000 fpm to a maximum of GA reference thrust.

The aircraft will automatically climb to the altitude set in the MCP altitude window. At the selected altitude:

- **GA** pitch mode changes to .**ALT HOLD**
- **GA** autothrottle mode changes to **SPD** and thrust decreases to maintain selected speed.
- **GA** roll mode remains in **GA** until another roll mode is engaged.

Go-around mode may be terminated:

- Below 400 feet RA:
    - Disengaging A/T, disengaging A/Ps and turning FDs off.
- Above 400 feet RA:
    - Select a different pitch or roll mode, the first A/P engaged remains engaged, the others disengage.
    - Select A/T SPD mode.

Notes:

1. GA will remain engaged even though the aircraft touches down whilst conducting the go-around.
2. If the Flight Director switches are not ON pushing the switch displays the Flight Director command bars.
3. If the A/P systems are compensating for an asymmetric thrust condition when they revert to a single autopilot in CMD configuration, the rudder will return to the trimmed position unless the pilot exerts the rudder pedal force required to maintain the rudder position.

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