# Automatic Flight

## Table of Contents

### Controls and Indicators

- Mode Control Panel (MCP) .................................................. 4.10.1
- Speed Controls .............................................................. 4.10.1
- Vertical Navigation ......................................................... 4.10.5
- Lateral Navigation .......................................................... 4.10.11
- Autopilot / Flight Director ............................................... 4.10.16
- Autopilot / Autothrottle Controls ..................................... 4.10.20
- Autopilot / Autothrottle Indicators ................................... 4.10.21
  - Autoland Warning ....................................................... 4.10.22
- Thrust Mode Display ....................................................... 4.10.23
- Flight Mode Annunciations (FMAs) .................................... 4.10.25

### System Description

- General ................................................................. 4.20.1
- Autopilot Flight Director System (AFDS) .............................. 4.20.1
  - MCP Mode Selector Switches ......................................... 4.20.1
  - Autopilot Engagement Criteria ..................................... 4.20.2
- Autopilot Disengagement ............................................... 4.20.2
- AFS Failures ............................................................. 4.20.3
- Flight Director Display ................................................ 4.20.3
- AFDS Status Annunciation ............................................. 4.20.4
- Fail-Operational Autoland Status Annunciations .................... 4.20.5
- AFDS Flight Mode Annunciations ..................................... 4.20.5
- Autopilot Control Wheel Steering .................................... 4.20.8
- Autothrottle System .................................................... 4.20.9
  - Autothrottle Engagement ............................................ 4.20.10
  - Autothrottle Disengagement ........................................ 4.20.10
- Automatic Flight Operations .......................................... 4.20.11
  - Automatic Flight Takeoff and Climb ............................... 4.20.11
  - Automatic Flight Takeoff Profile .................................. 4.20.14
## Table of Contents

- Automatic Flight En Route ........................................... 4.20.15
- Automatic Flight Approach and Landing ......................... 4.20.16
- Automatic Flight Approach Profile ................................. 4.20.22
- Go–Around .................................................................. 4.20.25
- Automatic Flight Go–Around Profile ............................... 4.20.29
- AFS Operation in Windshear ......................................... 4.20.30
  - General .................................................................... 4.20.30
  - Takeoff or Go–Around ............................................... 4.20.31
  - Approach and Landing ............................................... 4.20.31
- Command Speed Limiting and Reversion Modes .............. 4.20.31
  - Command Speed Limiting .......................................... 4.20.31
  - Reversion Modes .................................................... 4.20.32
Mode Control Panel (MCP)

[Option - Collins MCP with speed and altitude intervention]

[Option - Honeywell MCP without speed and altitude intervention]

Speed Controls

[Option - With speed and altitude intervention]
1. **Autothrottle (A/T) ARM Switch**

ARM – Arms A/T for engagement. Magnetically held at ARM. A/T engages automatically when following AFDS modes are engaged:

- LVL CHG
- ALT ACQ
- V/S
- VNAV
- ALT HOLD
- G/S capture
- TO/GA.

The indicator light illuminates green when A/T ARM switch is in the ARM position.

OFF – disengages A/T and prevents A/T engagement.

2. **Changeover (C/O) Switch**

Push –

- changes IAS/MACH display between IAS and MACH
- automatic changeover occurs at approximately FL260.

3. **MCP Speed Condition Symbols**

Overspeed or underspeed limiting symbol appears when commanded speed cannot be reached.

Underspeed limiting (flashing character “A”) – minimum speed
Overspeed limiting (flashing character “8”) –
- Vmo or Mmo limit
- landing gear limit
- flap limit.

4 IAS/MACH Display

Displays speed selected by IAS/MACH selector
- display is blank when:
  - VNAV mode engaged
  - A/T engaged in FMC SPD mode
  - during 2 engine AFDS go–around
- displays 100 knots when power is first applied
- display range is:
  - 100 KIAS – Vmo in 1 knot increments
  - .60M – Mmo in .01M increments.

5 N1 Switch

Push – (light not illuminated)
- engages A/T in N1 mode if compatible with AFDS modes already engaged
- illuminates N1 switch light
- annunciates N1 autothrottle mode.

Push – (light illuminated)
- deselects N1 mode and extinguishes switch light
- engages autothrottles in ARM mode.

N1 Mode
- A/T maintains thrust at N1 limit selected from FMC CDU. N1 mode engaged manually by pushing N1 switch if N1 mode is compatible with existing AFDS modes. N1 mode engages automatically when:
  - engaging LVL CHG in climb (except during inhibit period for 2 1/2 minutes after lift-off)
  - engaging VNAV in climb.

6 SPEED Switch

Push – (light not illuminated)
- engages A/T in SPEED mode if compatible with engaged AFDS modes
- illuminates SPEED switch light
- annunciates MCP SPD autothrottle mode
- maintains speed in MCP IAS/MACH display.
Push – (light illuminated)
- deselects speed mode and extinguishes switch light
- engages A/T in ARM mode.

Speed Mode
Autothrottle holds speed in IAS/MACH display or a performance or limit speed. Speed mode engaged manually by pushing SPEED switch if speed mode is compatible with existing AFDS modes. Speed mode engages automatically when:
- ALT ACQ engages
- ALT HOLD engages
- V/S engages
- G/S capture occurs.

A/T does not set thrust above displayed N1 limit, however, A/T can exceed N1 value manually set by N1 Manual Set Knob.

7 IAS/MACH Selector

Rotate –
- sets speed in IAS/MACH display and positions airspeed cursor
- selected speed is reference speed for AFDS and A/T
- not operative when IAS/MACH display is blank.

8 Speed Intervention (SPD INTV) Switch

[Option - With speed and altitude intervention]

Push (when VNAV engaged) –
- IAS/MACH display alternately shows selected IAS/Mach and blanks
- when IAS/MACH display is unblanked, FMC speed intervention is active, FMC target speed is displayed, and IAS/MACH Selector may be used to set desired speed
- when IAS/MACH display is blank, FMC computed target speed is active and displayed on the airspeed indicator.
**Vertical Navigation**

[Option - With speed and altitude intervention]

1. VNAV Switch
   - Push –
     - VNAV switch light illuminates

[Option - With VNAV ALT enabled]
   - pitch mode annunciates VNAV SPD, VNAV PTH, or VNAV ALT
   - A/T mode annunciates FMC SPD, N1, RETARD, or ARM
   - IAS/MACH display blanks and airspeed cursors positioned to FMC commanded airspeed.

VNAV Mode
The FMC commands AFDS pitch and autothrottle to fly vertical profile selected on FMC CDUs. Profile includes climb, cruise, descent, speeds, and can also include waypoint altitude constraints.

Climb –
- autothrottle holds FMC thrust limit
- AFDS holds FMC target speed
- automatic level-off occurs at MCP altitude or VNAV altitude, whichever is reached first

[Option - With VNAV ALT enabled]
- MCP constrained altitude annunciates VNAV ALT
- VNAV constrained altitude annunciates VNAV PTH.

Cruise –
- autothrottle holds FMC target speed
- AFDS holds FMC altitude
- selecting a lower MCP altitude arms FMC to automatically begin descent upon arrival at FMC top of descent point.

Descent –
- VNAV SPD descent
  - autothrottle holds idle
  - AFDS holds FMC target speed.
- VNAV PTH descent
  - autothrottle holds idle but can command FMC SPD mode if ground speed becomes too low to maintain FMC vertical path
  - AFDS tracks FMC descent path.
  - automatic level-off occurs at MCP altitude or VNAV altitude, whichever is reached first
    - MCP constrained altitude annunciates VNAV ALT
    - VNAV constrained altitude annunciates VNAV PTH.

Inhibited below 400 ft RA or if performance initialization not complete.

VNAV mode is terminated by any one of the following:
- selecting another pitch mode
- glideslope capture
- reaching end of LNAV route

[Option - FMC update 10.3 and later]
- transition of glideslope intercept waypoint if G/S is armed

[Option - FMC update 10.3 and later]
- crosstrack deviation exceeds twice the RNP value during PTH descent for an active leg with a database vertical angle and LNAV not engaged

In the event of glideslope intercept waypoint transition, VNAV can be re-engaged.
2 **ALTITUDE Display**

Displays selected altitude

- displayed altitude is reference for altitude alerting and automatic level–offs

[Option - ELS/EHS/ES]

- with Mode S transponders installed, the displayed altitude is transmitted to ATC

[Option - With 100 foot increments]

- altitude range is 0 to 50,000 feet in 100 foot increments
- displays previously selected altitude when power first applied.

3 **Vertical Speed (VERT SPEED) Display**

Displays:

- blank when V/S mode not active
- present V/S when V/S mode is engaged with V/S switch
- selected V/S when V/S set with thumbwheel
- range is –7900 to +6000 fpm.

Display increments are:

- 50 fpm if V/S is less than 1000 fpm
- 100 fpm if V/S is 1000 fpm or greater.

4 **Vertical Speed Thumbwheel**

Rotate –

- DN –
  - sets vertical speed in VERT SPEED display
  - increases rate of descent or reduces rate of ascent.
- UP –
  - sets vertical speed in VERT SPEED display
  - increases rate of ascent or reduces rate of descent.

5 **Level Change (LVL CHG) Switch**

Push –

- LVL CHG switch light illuminates
- pitch mode annunciates MCP SPD for climb or descent
- autothrottle mode annunciates N1 for climb and RETARD followed by ARM for descent
- IAS/MACH display and airspeed cursors display target speed.

LVL CHG Mode
The LVL CHG mode coordinates pitch and thrust commands to make automatic climbs and descents to preselected altitudes at selected airspeeds.

A LVL CHG climb or descent is initiated by:

- selecting a new altitude
- pushing LVL CHG switch
- setting desired airspeed.

Climb –
- autothrottle holds limit thrust
- AFDS holds selected airspeed.

Descent –
- autothrottle holds idle thrust
- AFDS holds selected airspeed.

Airspeed –
- if a speed mode is active when LVL CHG is engaged, this speed is retained as target speed
- if a speed mode is not active when LVL CHG is engaged, existing speed becomes target speed
- speed can be changed with MCP IAS/MACH Selector.

The LVL CHG mode is inhibited after glideslope capture.

### Approach (APP) Switch
(See Lateral Navigation)

### Altitude Selector (SEL)

Rotate –
- sets altitude in ALTITUDE display in 100 foot increments
- arms V/S mode if rotated while in ALT HOLD at selected altitude.

### Altitude Hold (ALT HLD) Switch

Push –
- engages ALT HOLD command mode
- commands pitch to hold uncorrected barometric altitude at which switch was pressed
- annunciates ALT HOLD pitch mode and illuminates ALT HLD switch light.

Altitude Hold Command Mode
ALT HOLD mode commands pitch to hold either:

- MCP selected altitude
  - pitch mode annunciates ALT HOLD
  - ALT HLD switch light extinguishes.

- uncorrected barometric altitude at which ALT HLD switch was pressed if not at MCP selected altitude
  - pitch mode annunciates ALT HOLD
  - ALT HLD switch light illuminates.

When in ALT HOLD at selected MCP altitude:

- selecting a new MCP altitude illuminates the ALT HLD switch light and arms V/S mode
- LVL CHG, V/S, and VNAV climb and descent functions are inhibited until a new MCP altitude is selected.

ALT HOLD mode is inhibited after G/S capture.

The selected MCP altitude is referenced to:

- Captain’s barometric altimeter setting for A A/P and F/D
- First Officer’s barometric altimeter setting for B A/P and F/D.

Note: After ALT HOLD engages, changes in altimeter barometric settings do not change the selected altitude reference.

9 Vertical Speed (V/S) Switch

Push –

- arms or engages V/S command mode
- commands pitch to hold vertical speed
- engages A/T in speed mode to hold selected airspeed
- annunciates V/S pitch mode and illuminates V/S switch light.

Vertical Speed Command Mode

The V/S mode commands pitch to hold selected vertical speed and engages A/T in SPEED mode to hold selected airspeed. V/S mode has both an armed and an engaged state.

Engaged –

- annunciates V/S pitch mode
- vertical speed display changes from blank to present vertical speed
- desired vertical speeds can be selected with vertical speed thumbwheel.

V/S becomes armed if:

- pitch mode is ALT HLD at selected MCP altitude and
- new MCP altitude is selected (more than 100 feet from current altitude).

With V/S armed, V/S mode is engaged by moving vertical speed thumbwheel.
V/S mode automatically engages if ALT ACQ mode is engaged and a new MCP altitude is selected which is more than 100 feet different from previously selected altitude.

- vertical speeds can be selected which command flight toward or away from selected altitude.

Inhibited if:
- ALT HOLD mode is active at selected MCP altitude
- glideslope captured in APP mode.

### Altitude Intervention (ALT INTV) Switch

**[Option - With speed and altitude intervention]**

Allows manual deletion of next FMC altitude constraint via altitude SEL and ALT INTV switch.

Push – (during VNAV climb)
- lowest FMC altitude constraint below selected MCP altitude is deleted
- if airplane is currently at an FMC altitude constraint, deletion allows airplane to resume climb. MCP altitude must be set above current altitude
- for each press of switch, one deletion occurs
- if MCP altitude is set above current FMC altitude, FMC cruise altitude resets to MCP altitude. FMC cruise altitude cannot be decreased using ALT INTV switch.

Push – (during VNAV cruise)
- if MCP altitude is set above current FMC cruise altitude, FMC resets cruise altitude to MCP altitude and initiates a cruise climb
- if MCP altitude is set below current FMC cruise altitude, an early descent is initiated. Lower FMC cruise altitude cannot be entered using ALT INTV switch.

Push – (during VNAV descent)
- the highest FMC altitude constraint above MCP altitude is deleted
- if airplane is currently at an FMC altitude constraint, deletion allows airplane to continue descent. MCP altitude must be set below current altitude

**[Option - Prior to FMC U10.6]**
- if all FMC altitude constraints are deleted during VNAV path descent, an automatic transition to a VNAV speed descent is made.
Lateral Navigation

[Option - With speed and altitude intervention]

1 COURSE Display
Displays course set by course selector.

Note: Different courses and frequencies on two VHF NAV receivers can cause disagreement between Captain and FO F/D displays and affect A/P operation.

2 Heading Selector
Rotate –
• sets heading in HEADING display
• positions selected heading bugs on the DUs.
3 HEADING Display

Displays selected heading.

4 LNAV Switch

Push –

• commands AFDS roll to intercept and track the active FMC route
• annunciates LNAV as roll mode and illuminates LNAV switch light.

LNAV Mode

In LNAV mode, the FMC controls AFDS roll to intercept and track active FMC route. Active route is entered and modified through FMC CDUs and can include SIDs, STARs, and instrument approaches.

LNAV engagement criteria on the ground:

• origin runway in flight plan
• active route entered in FMC
• track of first leg within 5 degrees of runway heading
• LNAV selected prior to TO/GA. Once TO/GA is engaged, the LNAV switch light is extinguished until 400 feet AGL
  • LNAV guidance becomes active at 50 feet AGL

[Option - Bank angle limit is 30 degrees above 200 AGL]
[Option - Honeywell FCC -708 and on]
  • bank angle is limited to 8 degrees below 200 feet and 30 degrees above 200 feet AGL.

LNAV engagement criteria in flight:

• active route entered in FMC
• within 3 NM of active route, LNAV engagement occurs with any airplane heading
• outside of 3 NM, airplane must:
  • be on intercept course of 90 degrees or less
  • intercept route segment before active waypoint.

LNAV automatically disconnects for following reasons:

• reaching end of active route
• reaching a route discontinuity
• intercepting a selected approach course in VOR LOC or APP modes (VOR/LOC armed)
• selecting HDG SEL
• loss of capture criteria.
5 VOR Localizer (LOC) Switch

Push –

- commands AFDS roll to capture and track selected VOR or LOC course
- annunciates VOR/LOC armed or engaged as roll mode and illuminates VOR LOC switch light.

VOR LOC Mode

Pushing the VOR LOC switch selects VOR mode if a VOR frequency is tuned or selects LOC mode if a localizer frequency is tuned.

The VOR mode provides roll commands to track selected VOR course.

The LOC mode provides roll commands to track selected localizer course along inbound front course bearing.

The selected course can be intercepted while engaged in:

- LNAV
- HDG SEL
- CWS R if an autopilot is engaged in CMD.

The capture point is variable and depends on intercept angle and closure rate. Localizer capture occurs not later than 1/2 dot deviation. Course capture is indicated when VOR/LOC annunciation changes from armed to engaged.

While engaged in VOR or LOC modes:

- A autopilot and Captain’s F/D use information from Captain’s course selector and No. 1 VHF NAV receiver
- B autopilot and First Officer’s F/D use information from First Officer’s course selector and No. 2 VHF NAV receiver
- different courses and/or frequencies for two VHF NAV receivers can cause disagreement between the Captain’s and First Officer’s F/D displays and affect A/P operation.

Note: When a localizer frequency is selected, VHF NAV radios automatically switch from tail antenna to nose antenna when VOR/LOC is annunciated (armed or engaged). If antenna switching does not occur, LOC mode is inhibited.

Note: Localizer backcourse tracking is not available.

6 Course Selector

Sets course in COURSE display for related VHF NAV receiver, AFDS and DU.
Two course selectors and COURSE displays are located on the MCP.
Rotate Captain’s course selector – provides selected course information to:
- A FCC
- No. 1 VHF NAV receiver
- Captain’s course pointer and course deviation bar.

**Note:** In VOR LOC or APP mode, the A A/P and Captain’s F/D use selected course and navigation data from the No. 1 VHF NAV receiver.

Rotate First Officer’s course selector – provides selected course information to:
- B FCC
- No. 2 VHF NAV receiver
- First Officer’s course pointer and course deviation bar.

**Note:** In VOR LOC or APP mode, B A/P and First Officer’s F/D use selected course and navigation data from No. 2 VHF NAV receiver.

### 7 Bank Angle Selector

Rotate –
- sets maximum bank angle for AFDS operation in HDG SEL or VOR modes
- commanded bank angle can be selected at 10, 15, 20, 25, or 30 degrees.

### 8 Heading Select (HDG SEL) Switch

Push –
- engages HDG SEL command mode
- commands roll to follow selected heading
- annunciates HDG SEL as FMA roll mode and illuminates HDG SEL switch light.

**Heading Select Command Mode**

The HDG SEL mode commands roll to turn to and maintain heading shown in MCP HEADING display:
- initial selection commands turn in shortest direction toward selected heading bug
- after mode engagement, roll commands are given to turn in same direction as rotation of heading selector
- bank angle limit is established by bank angle selector
- HDG SEL mode automatically disengages upon capture of selected radio course in VOR LOC and APP modes (VOR/LOC armed).
Approach (APP) Switch

Push –

- illuminates APP switch light
- arms the AFDS for localizer and glideslope capture
- roll mode annunciates VOR/LOC armed
- pitch mode annunciates G/S armed
- enables engagement of both autopilots.

APP Mode

The approach mode arms AFDS to capture and track localizer and glideslope and can be engaged for dual or single autopilot operation.

One VHF NAV receiver must be tuned to an ILS frequency before approach mode can be engaged. With one VHF NAV receiver tuned, onside AFDS is enabled for guidance and operation.

For dual autopilot operation, both VHF NAV receivers must be tuned to the ILS frequency and both autopilots must be selected in CMD prior to 800 feet RA.

APP mode operation:

[Option - G/S capture inhibited before LOC capture]
- localizer must be captured prior to glideslope
- localizer can be intercepted in HDG SEL, LNAV, or CWS R

[Option - EFIS/MAP]
- 1 CH annunciates in A/P Status Display after localizer capture
  - for single autopilot approach, 1 CH remains annunciated for entire approach
  - for dual autopilot approach, 1 CH annunciation extinguishes when second autopilot engages and FLARE armed is annunciated

[Option - PFD/ND]
- SINGLE CH annunciates in A/P Status Display after localizer capture
  - for single autopilot approach, SINGLE CH remains annunciated for entire approach

[Option - Fail-Operational Autoland]
- for dual autopilot approach, SINGLE CH annunciation extinguishes when second autopilot engages and ROLLOUT armed and FLARE armed are annunciated
- for dual autopilot approach, SINGLE CH annunciation extinguishes when second autopilot engages and FLARE armed is annunciated
- glideslope capture occurs at 2/5 dot below glideslope
- APP switch light extinguishes after localizer and glideslope capture.
After localizer and glideslope capture, APP mode can be disengaged by:

- pushing a TO/GA switch
- disengaging autopilot(s) and turning off both F/D switches
- retuning the VHF NAV receiver.

While engaged in the APP mode:

- the A autopilot and Captain’s F/D use information from Captain’s Course Selector and No. 1 VHF NAV receiver
- the B autopilot and First Officer’s F/D use information from First Officer’s Course Selector and No. 2 VHF NAV receiver
- different courses and/or frequencies for the two VHF NAV receivers can cause disagreement between Captain’s and First Officer’s F/D displays and affect A/P operation.

[Option - CWS deactivated on approach]

Note: After localizer and glideslope capture, CWS cannot be engaged by manually overriding pitch and roll. Manual override of autopilots causes autopilot disengagement.

**Autopilot / Flight Director**

Pushing a CMD or CWS switch engages related A/P in CMD or CWS and illuminates switch lights. A/P can operate in CMD, CWS, or a combination of CMD and CWS.
Command Engage (CMD ENGAGE) Switch (A or B):

Push –

- engages A/P
- enables all command modes
- displays CMD in A/P status display
- pushing an engage switch for second A/P, while not in approach mode, engages second A/P and disengages first A/P
- enables CWS operation
- CWS engages if:
  - pitch or roll mode not selected
  - pitch or roll mode deselected
  - pitch or roll mode manually overridden with control column force.

[Option - CWS deactivated on approach]

Note: After localizer and glideslope capture during a dual autopilot approach, CWS cannot be engaged by manually overriding pitch and roll. Manual override of autopilots causes autopilot disengagement.

- CWS engaged displays:
  - CWS P and/or CWS R in A/P status display
  - blank in pitch and/or roll mode FMA
  - when approaching a selected altitude in CWS P, the pitch mode engages in ALT ACQ and ALT HOLD when reaching selected altitude
• when approaching a selected radio course in CWS R with VOR/LOC or approach mode armed, VOR/LOC engages when course is intercepted
• if pitch is manually overridden while in ALT HOLD and control force is released within 250 feet of selected altitude, A/P pitch mode engages in ALT ACQ and returns to selected altitude in ALT HOLD mode.

**Note:** During F/D only operation while pitch or roll commands are more than 1/2 scale from center, pushing a CMD A or B switch engages the A/P in CWS for pitch and/or roll and the related F/D bar(s) retract.

**2 Control Wheel Steering Engage (CWS ENGAGE) Switch (A or B):**

Push –
• engages A/P
• engages pitch and roll modes in CWS. Other pitch and roll modes not enabled
• displays CWS P and CWS R in A/P status display
• CMD not displayed in A/P status display
• F/Ds, if ON, display guidance commands and FD annunciates in A/P status display. A/P does not follow commands while in CWS
• A/P pitch and roll controlled by pilot with control wheel pressure
• when control pressure released, A/P holds existing attitude. If aileron pressure released with 6 degrees or less bank, the A/P rolls wings level and holds existing heading. Heading hold feature inhibited:
  • below 1500 feet RA with gear down
  • after LOC capture in APP mode
  • after VOR capture with TAS 250 knots or less.

**3 Autopilot Disengage (DISENGAGE) Bar**

Pull down –
• exposes yellow background
• disengages both A/Ps
• prevents A/P engagement.

Lift up –
• conceals yellow background
• enables A/P engagement.

**4 Master (MA) Flight Director Indicators (white letters)**

If a F/D switch is ON, the light indicates which FCC is controlling the F/D modes.
• illuminated – related FCC is controlling F/D modes.
• extinguished – F/D modes are controlled from opposite FCC
• both lights illuminated – each FCC is controlling modes for related F/D.
5 Flight Director (F/D) Switch

[Option - Split Axis]
Left F/D switch activates command bars on the Captain’s attitude indicator. Right F/D switch activates command bars on the First Officer’s attitude indicator.

[Option - Integrated Cue]
Left F/D switch activates the command bar on the Captain’s attitude indicator. Right F/D switch activates the command bar on the First Officer’s attitude indicator.

ON –
• in flight with A/P ON and F/Ds OFF, turning a F/D switch ON engages F/D in currently selected A/P modes
• displays FD in A/P status display if A/P is OFF or engaged in CWS
• enables command bar display on related pilot’s attitude indicator

[Option - Split Axis]
• command bars are displayed if command pitch and/or roll modes are engaged

[Option - Integrated Cue]
• command bar is displayed if command pitch and roll modes are engaged

[Option - Wings Level Takeoff Roll Mode ]
• on ground, arms pitch and roll modes for engagement in TO/GA and wings level when TO/GA switch is pushed.

[Option - Heading Select Takeoff Roll Mode ]
• on ground, arms pitch and roll modes for engagement in TO/GA and HDG SEL when TO/GA switch is pushed.

[Option - Split Axis]
OFF – command bars retract from related pilot’s attitude indicator.

[Option - Integrated Cue]
OFF – command bar retracts from related pilot’s attitude indicator.
Autopilot / Autothrottle Controls

1. **Autopilot Disengage Switch**
   - Push –
     - disengages both autopilots
     - A/P disengage lights flash
     - A/P disengage warning tone sounds for a minimum of two seconds
     - second push extinguishes disengage lights and silences disengage warning tone
     - if autopilot automatically disengages, extinguishes A/P Disengage lights and silences A/P warning tone.

2. **Autothrottle Disengage Switches**
   - Push –
     - disengages autothrottle
     - A/T disengage lights flash
     - A/T ARM switch trips OFF
     - second press extinguishes A/T disengage lights
     - extinguishes A/T disengage lights after automatic A/T disengagement.

3. **Takeoff/Go–Around (TO/GA) Switches**
   - Push – engages AFDS and A/T in takeoff or go–around mode if previously armed.
Autopilot / Autothrottle Indicators

1. Autopilot (A/P) Disengage Light
   Illuminated (red) –
   • flashes and tone sounds when autopilot has disengaged
   • reset by pushing either disengage light or either A/P disengage switch
   • steady for any of following conditions:
     • stabilizer out of trim below 800 feet RA on dual channel approach
     • ALT ACQ mode inhibited during A/P go-around if stabilizer not
       trimmed for single A/P operation
     • disengage light test switch held in position 2
     • automatic ground system tests fail.

   Illuminated (amber) –
   • steady – disengage light test switch held in position 1.

[Option - CWS warning activated]
   • flashing – A/P automatically reverts to CWS pitch or roll while in CMD.
     Resets by pushing either light or selecting another mode.

[Option - Fail-Operational Autoland]
   • steady – with disengage light test switch not held in position 1, indicates a
     downgrade in autoland capability.
2 Autothrottle (A/T) Disengage Light

Illuminated (red) –
- flashing – autothrottle has disengaged
- steady – disengage light test switch held in position 2.

Illuminated (amber) –
- steady – disengage light test switch held in position 1

[Option - Airspeed deviation warning activated]
- flashing – indicates A/T airspeed error under following conditions:
  - in flight
  - flaps not up
  - airspeed differs from commanded value by +10 or -5 knots and is not approaching commanded value.

3 Disengage Light Test (TEST) Switch

TEST 1 – illuminates autopilot/autothrottle disengage and FMC alert lights steady amber.

TEST 2 – illuminates autopilot/autothrottle disengage lights steady red and FMC alert light steady amber.

Spring–loaded to center position.

4 Stabilizer Out Of Trim (STAB OUT OF TRIM) Light

Operates only with autopilot engaged. Remains extinguished with autopilot not engaged.

Illuminated (amber) – autopilot not trimming stabilizer properly.

Autoland Warning

[Option]

1 AUTOLAND Warning Light

Armed during dual ILS A/P approach below 500 feet
Flashes (red) if:

- A/P disengages
- Stabilizer trim warning occurs
- ILS deviation occurs below 200 feet.

**Thrust Mode Display**

[Option - Side by side display]

[Option - Over/Under display]

[Option - Over/Under display]

**Thrust Mode Display**

N1 limit reference is the active N1 limit for autothrottle and manual thrust control. N1 limit reference is also displayed by N1 reference bugs with N1 SET control in AUTO position.
N1 limit reference is normally calculated by the FMC.

[Option]
Thrust mode display annunciations are:
- TO – takeoff
- TO 1 – derated takeoff one
- TO 2 – derated takeoff two
- D-TO – assumed temperature reduced thrust takeoff
- D-TO 1 – derate one and assumed temperature reduced thrust takeoff
- D-TO 2 – derate two and assumed temperature reduced thrust takeoff

[Option]
- TO B – takeoff bump thrust
- CLB – climb
- CLB 1 – derated climb one
- CLB 2 – derated climb two
- CRZ – cruise
- G/A – go–around
- CON – continuous
- ––– – FMC not computing thrust limit.

Thrust mode display annunciations are:
- TO – takeoff
- R-TO – reduced takeoff
- R-CLB – reduced climb

[Option]
- TO B – takeoff bump thrust
- CLB – climb
- CRZ – cruise
- G/A – go–around
- CON – continuous
- ––– – FMC not computing thrust limit.

Note: R-TO does not indicate the type of reduced takeoff. The N1 limit may be reduced due to the entry of an assumed temperature, a takeoff thrust derate or a combination of both assumed temperature and takeoff thrust derate.

2 Autothrottle Limit (A/T LIM) Indication

Illuminated (white) – the FMC is not providing the A/T system with N1 limit values. The A/T is using a degraded N1 thrust limit from the related EEC.
Flight Mode Annunciations (FMAs)

[Option – PFD/ND]

1 Autothrottle (A/T) Engaged Mode
- N1 (green)
- GA (green)
- Retard (green)
- FMC SPD (green)
- MCP SPD (green)
- THR HLD (green)
- ARM (white)

2 Roll Engaged Mode
- HDG SEL (green)
- VOR/LOC (green)
[Option – Integrated Approach Nav]
- FAC (green)
[Option – Fail-Operational Autoland]
- ROLLOUT (green)

3 Roll Armed Mode
- VOR/LOC (white)
[Option – Integrated Approach Nav]
- FAC (white)
[Option – Fail-Operational Autoland]
- ROLLOUT (white)
4 Pitch Engaged Mode
- TO/GA (green)
- V/S (green)
- MCP SPD (green)
- ALT/ACQ (green)
- ALT HOLD (green)
[Option – Integrated Approach Nav]
- G/P (green)
- G/S (green)
- FLARE (green)
- VNAV SPD (green)
- VNAV PTH (green)

5 Mode Highlight Change Symbol
A mode change highlight symbol (rectangle) is drawn around each pitch, roll, CWS, A/P status, and thrust engaged mode annunciation for a period of 10 seconds after each engagement.

6 CWS Roll Engaged
- CWS R (amber)

7 Autopilot Status
- CMD (green)
- FD (green)
[Option]
- SINGLE CH (amber)
[Option – Integrated Approach Nav]
- AUTOPilot (amber)
[Option – Fail-Operational Autoland]
- LAND 2 (green)
[Option – Fail-Operational Autoland]
- NO AUTOLAND (amber)
[Option – Fail-Operational Autoland]
- LAND 3 (green)

8 CWS Pitch Engaged
- CWS P (amber)

9 Pitch Armed Mode
- G/S (white)
- V/S (white)
- FLARE (white)
- G/S V/S (white)
[Option – Integrated Approach Nav]
- G/P (white)
[Option – Integrated Approach Nav]
- G/P V/S (white)
1. **Autothrottle (A/T) Engaged Mode**
   - N1 (green)
   - GA (green)
   - Retard (green)
   - FMC SPD (green)
   - MCP SPD (green)
   - THR HLD (green)
   - ARM (white)

2. **Pitch Engaged Mode**
   - TO/GA (green)
   - V/S (green)
   - MCP SPD (green)
   - ALT ACQ (green)
   - ALT HOLD (green)
   - G/S (green)
   - FLARE (green)
   - VNAV PTH (green)
   - VNAV SPD (green)
   - [Option]
   - VNAV ALT (green)

3. **Roll Engaged Mode**
   - HDG SEL (green)
   - VOR/LOC (green)
   - LNAV (green)

4. **Autopilot Status**
   - CMD (green)
   - FD (green)

   [Option]
   - 1 CH (amber)
5 **CWS Pitch Engaged**
- CWS P (amber)

6 **Mode Highlight Change Symbol**
A mode change highlight symbol (rectangle) is drawn around each pitch, roll, CWS, A/P status, and thrust engaged mode annunciation for a period of 10 seconds after each engagement.

7 **Pitch Armed Mode**
- G/S (white)
- V/S (white)
- G/S V/S (white)
- FLARE (white)

8 **Roll Armed Mode**
- [Option – BP_04 or later Software Upgrade]
  - LNAV VOR/LOC (white)

9 **CWS Roll Engaged**
- CWS R (amber)
General

The automatic flight system (AFS) consists of the autopilot flight director system (AFDS) and the autothrottle (A/T). The flight management computer (FMC) provides N1 limits and target N1 for the A/T and command airspeeds for the A/T and AFDS.

The AFDS and A/T are controlled using the AFDS mode control panel (MCP) and the FMC. Normally, the AFDS and A/T are controlled automatically by the FMC to fly an optimized lateral and vertical flight path through climb, cruise and descent.

AFS mode status is displayed on the flight mode annunciation on each pilot’s primary display.

Autopilot Flight Director System (AFDS)

The AFDS is a dual system consisting of two individual flight control computers (FCCs) and a single mode control panel.

The two FCCs are identified as A and B. For A/P operation, they send control commands to their respective pitch and roll hydraulic servos, which operate the flight controls through two separate hydraulic systems.

For F/D operation, each FCC positions the F/D command bars on the respective attitude indicator.

MCP Mode Selector Switches

The mode selector switches are pushed to select desired command modes for the AFDS and A/T. The switch illuminates to indicate mode selection and that the mode can be deselected by pushing the switch again. While a mode is active, deselection can be automatically inhibited and is indicated by the switch being extinguished.

When engagement of a mode would conflict with current AFS operation, pushing the mode selector switch has no effect. All AFDS modes can be disengaged either by selecting another command mode or by disengaging the A/P and turning the F/Ds off.
Autopilot Engagement Criteria

Each A/P can be engaged by pushing a separate CMD or CWS engage switch. A/P engagement in CMD or CWS is inhibited unless both of the following pilot–controlled conditions are met:

- no force is being applied to the control wheel
- the STAB TRIM AUTOPILOT cutout switch is at NORMAL.

Only one A/P can be engaged at a given time unless the approach (APP) mode is engaged. Approach mode allows both A/Ps to be engaged at the same time. Dual A/P operation provides control through landing flare and touchdown or an automatic go–around.

In single A/P operation, full automatic flare and touchdown capability and A/P go–around capability are not available.

Autopilot Disengagement

The A/P automatically disengages when any of the following occurs:

- pushing either A/P disengage switch
- pushing either Takeoff/Go-around (TO/GA) switch with a single A/P engaged in CWS or CMD;
  - below 2000 feet RA or,
  - with flaps not up or,
  - G/S engaged

[Option - A/P auto-disengages for TO/GA above 2000 feet RA]
[Option - Honeywell -708 FCC and on]
- pushing either Takeoff/Go-around (TO/GA) switch with a single A/P engaged in CWS or CMD above 2000 feet RA with flaps not up or G/S engaged.

[Option - Fail-Operational Autoland]
- pushing either TO/GA switch after touchdown with both A/Ps engaged in CMD (except with LAND 3 or LAND 2 annunciated)
- pushing either TO/GA switch after touchdown with both A/Ps engaged in CMD
- pushing an illuminated A/P ENGAGE switch
- pushing the A/P DISENGAGE bar down

[Option - Fail-Operational Autoland]
- activating either pilot’s control wheel trim switch (except with LAND 3 or LAND 2 annunciated)
- activating either pilot’s control wheel trim switch
- moving the STAB TRIM AUTOPILOT cutout switch to CUTOUT
- either left or right IRS system failure or FAULT light illuminated

September 28, 2006
• loss of electrical power or a sensor input which prevents proper operation of the engaged A/P and mode
• loss of respective hydraulic system pressure.

**Note:** Loss of the system A engine-driven hydraulic pump, and a heavy demand on system A, may cause A/P A to disengage.

**[Option - Fail-Operational Autoland]**

**Note:** During a fail-operational landing with LAND 3 or LAND 2 annunciated, pressing TO/GA after touchdown or activating the manual electric trim will not disconnect the autopilot.

**AFS Failures**

Power interruption or loss may cause disengagement of the AFDS and/or A/T. Re-engagement is possible after power is restored.

Dual channel A/P operation is possible only when two generators are powering the busses.

Two independent radio altimeters provide radio altitude to the respective FCCs. With a radio altimeter inoperative, the autopilot will disconnect two seconds after LOC and GS capture.

**Flight Director Display**

Turning a F/D switch ON displays command bars on the respective pilot’s attitude indicator if command pitch and roll modes are engaged. If command pitch and roll modes are not engaged, the F/D command bars do not appear. The F/Ds can be operated with or without the A/P and A/T. F/D command modes can be used with an A/P engaged in CWS.

F/D commands operate in the same command modes as the A/P except:
• the takeoff mode is a F/D only mode
• dual F/D guidance is available for single engine operation
• the F/D has no landing flare capability. F/D command bars retract from view at approximately 50 feet RA on an ILS approach.

Normally, FCC A drives the captain’s command bars and FCC B drives the first officer’s command bars. With both F/D switches ON, the logic for both pilots’ F/D modes is controlled by the master FCC, and both FMA displays show the same mode status.

The master FCC is indicated by illumination of the respective master (MA) F/D indicator light. The master FCC is determined as follows:
• with neither A/P engaged in CMD, the FCC for the first F/D turned on is the master
• with one or both A/Ps engaged in CMD, the FCC for the first A/P in CMD is the master FCC, regardless of which F/D is turned on first.
F/D modes are controlled directly from the respective FCC under certain conditions. This independent F/D operation occurs when neither A/P is engaged in CMD, both F/D switches are ON and one of the following mode conditions exists:

- APP mode engaged with LOC and G/S captured
- GA mode engaged and below 400 feet RA
- TO mode engaged and below 400 feet RA.

Independent F/D operation is indicated by illumination of both MA lights. When independent operation terminates, the MA light extinguishes on the slaved side.

If a generator is lost during a F/D TO or GA, or while in dual F/D APP mode below 800 feet, the FCC on the unaffected side positions the F/D command bars on both attitude indicators. If the F/D MA light on the affected side had been illuminated, it extinguishes upon electrical bus transfer.

**AFDS Status Annunciation**

The following AFDS status annunciations are displayed in the A/P status display located above the attitude indicator on the outboard display unit:

- CMD (one or both autopilots are engaged)
- FD (the flight director is ON and the autopilot is either OFF or engaged in CWS)
- CWS P (pitch mode engaged in CWS)
- CWS R (roll mode engaged in CWS)

[Option - EFIS/MAP]
- 1 CH (for single A/P ILS approach, annunciates after localizer capture and remains on for entire approach. For dual A/P ILS approach, annunciates after localizer capture and extinguishes after pitch monitor confidence test is successfully completed).

[Option - PFD/ND]
- SINGLE CH (for single A/P ILS approach, annunciates after localizer capture and remains on for entire approach. For dual A/P ILS approach, annunciates after localizer capture and extinguishes after pitch monitor confidence test is successfully completed).
Fail-Operational Autoland Status Annunciations

[Option - Fail-Operational Autoland]
The following annunciations provide the flight crew with autoland system mode and status:

- **LAND 3** – two autopilots, three inertial sources, and the associated sensors are operating normally for an automatic landing and rollout.
- **LAND 2** – a failure has occurred above Alert Height and redundancy is reduced; but the autoland system is still capable of making an automatic landing and rollout.
- **NO AUTOLAND** – the system is unable to make an automatic landing.

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

With a LAND 2 (fail passive) indication, the level of redundancy is such that a single fault cannot cause a significant deviation from the flight path.

The NO AUTOLAND status is annunciated if a system failure has occurred. FLARE and ROLLOUT will not arm when NO AUTOLAND is annunciated.

An advisory message is displayed on the Upper Engine Display for any fault which limits the capability of the automatic landing system. NO LAND 3 indicates the autoland system does not have the required redundancy for LAND 3 operations. NO AUTOLAND indicates autoland is not available.

Should any single failure occur below Alert Height and the system is still capable of continuing the autoland and rollout, LAND 3 will remain displayed and the airplane will land and roll out normally without failure annunciation. Failure or autoland downgrade annunciations will then be displayed when the airplane has decelerated below 40 kts and the autopilots have been disengaged.

**AFDS Flight Mode Annunciations**
The flight mode annunciations are displayed just above the attitude indicator on the outboard display unit. The mode annunciations, from left to right, are:

[Option - EFIS/MAP]
- autothrottle
- pitch
- roll

[Option - PFD/ND]
- autothrottle
- roll
- pitch.
Engaged or captured modes are shown at the top of the flight mode annunciation boxes in large green letters. Armed modes are shown in smaller white letters at the bottom of the flight mode annunciation boxes.

**Autothrottle Modes**

- **N1** – the autothrottle maintains thrust at the selected N1 limit displayed on the thrust mode display, including full go-around N1 limit
- **GA** – the autothrottle maintains thrust at reduced go–around setting
- **RETARD** – displayed while autothrottle moves thrust levers to the aft stop. RETARD mode is followed by ARM mode
- **FMC SPD** – the autothrottle maintains speed commanded by the FMC. The autothrottle is limited to the N1 value shown on the thrust mode display
- **MCP SPD** – the autothrottle maintains speed set in the MCP IAS/MACH display. The autothrottle is limited to the N1 value shown on the thrust mode display
- **THR HLD** – the thrust lever autothrottle servos are inhibited; the pilot can set the thrust levers manually
- **ARM** – no autothrottle mode engaged. The thrust lever autothrottle servos are inhibited; the pilot can set thrust levers manually. Minimum speed protection is provided

**Pitch Modes**

- **TO/GA** – Takeoff
  Engaged for takeoff by turning both F/D switches ON and pushing either TO/GA switch. Both F/Ds must be ON to engage TO/GA prior to starting takeoff.
  The AFDS commands pitch attitude in the following order:
  - 10 degrees nose down until 60 knots IAS
  - 15 degrees nose up after 60 knots IAS
  - 15 degrees nose up after lift–off until a sufficient climb rate is acquired. Then, pitch is commanded to maintain MCP speed plus 20 knots.
  TO/GA can also be engaged for takeoff with F/D switches OFF if a TO/GA switch is pushed after 80 knots IAS below 2000 feet AGL and prior to 150 seconds after lift–off.
- **TO/GA** – Go–around
  Engaged for go–around by pushing the TO/GA switch under the following conditions:
  - inflight below 2000 feet radio altitude
  [Option - A/P auto-disengages for TO/GA above 2000 feet RA]
  [Option - Honeywell 708 FCC and on]
  - inflight above 2000 feet radio altitude with flaps not up or G/S captured
• not in takeoff mode
• either F/D ON or OFF.

When engaged, the F/Ds command roll to hold the ground track, and 15 degrees nose up pitch. After reaching a programmed rate of climb, pitch commands the target airspeed for each flap setting based on maximum takeoff weight calculations.

• VNAV (engaged) – VNAV is engaged by pushing the VNAV switch. With a VNAV mode engaged, the FMC commands AFDS pitch and A/T modes to fly the vertical profile
  • VNAV SPD – the AFDS maintains the FMC speed displayed on the airspeed indicator and/or the CDU CLIMB or DESCENT pages
  • VNAV PTH – the AFDS maintains FMC altitude or descent path with pitch commands.
  • VNAV ALT – when a conflict occurs between the VNAV profile and the MCP altitude, the airplane levels at the MCP altitude and the pitch flight mode annunciation becomes VNAV ALT. VNAV ALT maintains altitude.

• V/S (armed) – V/S mode can be engaged by moving Vertical Speed thumbwheel
• V/S (engaged) – commands pitch to hold selected vertical speed
  • ALT ACQ – transition maneuver entered automatically from a V/S, LVL CHG, or VNAV climb or descent to selected MCP altitude. Engages but does not annunciate during VNAV transition
  • ALT HOLD – commands pitch to hold MCP selected altitude or uncorrected barometric altitude at which ALT HOLD switch was pushed
  • MCP SPD – pitch commands maintain IAS/MACH window airspeed or Mach
• G/S (armed) – the AFDS is armed for G/S capture
• G/S (engaged) – the AFDS follows the ILS glideslope
• G/P (armed) – the AFDS is armed for G/P capture
• G/P (engaged) – the AFDS follows the IAN glidepath
• FLARE (armed) – during a dual A/P ILS approach, FLARE is displayed after LOC and G/S capture and below 1500 feet RA. The second A/P couples with the flight controls and A/P go–around mode arms
• FLARE (engaged) – during a dual A/P ILS approach, flare engages at 50 feet radio altitude. FLARE accomplishes the autoland flare maneuver.

Roll Modes
• LNAV (engaged) – the AFDS intercepts and tracks the active FMC route. Either of the following capture criteria must be met:
  • on any heading and within 3 NM of the active route segment
  • if outside of 3 NM of active route segment, airplane must be on an intercept course of 90 degrees or less and intercept the route segment before the active waypoint.
Automatic Flight -
System Description

- HDG SEL – the airplane is turning to, or is on the heading selected in the MCP Heading Display
- VOR/LOC (armed) – AFDS is armed to capture selected VOR or LOC COURSE
- VOR/LOC (engaged) – AFDS tracks selected VOR course or tracks selected localizer course along the inbound front course bearing.
- FAC (armed) – the AFDS is armed to capture the IAN final approach course
- FAC (engaged) – the AFDS tracks the IAN final approach course along the inbound course bearing.
- B/CRS (armed) – the AFDS is armed to capture the localizer final approach back course
- B/CRS (engaged) – the AFDS tracks the localizer final approach course along the inbound back course bearing.

[Option - Fail-Operational Autoland]
- ROLLOUT (armed) – annunciates below 1500 feet radio altitude and engages below 2 feet.

[Option - Fail-Operational Autoland]
- ROLLOUT (engaged) – at touchdown the AFDS uses rudder and nose wheel steering to keep the airplane on the localizer centerline.

Autopilot Control Wheel Steering

CWS Engage Switch Selected

Pushing a CWS engage switch engages the A/P pitch and roll axes in the CWS mode and displays CWS P and CWS R on the FMAs.

With CWS engaged, the A/P maneuvers the airplane in response to control pressures applied by either pilot. The control pressure is similar to that required for manual flight. When control pressure is released, the A/P holds existing attitude.

If aileron pressure is released with 6 degrees or less bank, the A/P rolls the wings level and holds existing heading. This heading hold feature with bank less than 6 degrees is inhibited when any of the following conditions exists:

- below 1,500 feet RA with the landing gear down
- after F/D VOR capture with TAS 250 knots or less
- after F/D LOC capture in the APP mode.
Pitch CWS with a CMD Engage Switch Selected

The pitch axis engages in CWS while the roll axis is in CMD when:

- a command pitch mode has not been selected or was deselected
- A/P pitch has been manually overridden with control column force. The force required for override is greater than normal CWS control column force. This manual pitch override is inhibited in the APP mode with both A/Ps engaged.

CWS P is annunciated on the FMAs while this mode is engaged. Command pitch modes can then be selected.

When approaching a selected altitude in CWS P with a CMD engage switch selected, CWS P changes to ALT ACQ. When at the selected altitude, ALT HOLD engages.

If pitch is manually overridden while in ALT HOLD at the selected altitude, ALT HOLD changes to CWS P. If control force is released within 250 feet of the selected altitude, CWS P changes to ALT ACQ, the airplane returns to the selected altitude, and ALT HOLD engages. If the elevator force is held until more than 250 feet from the selected altitude, pitch remains in CWS P.

Roll CWS with a CMD Engage Switch Selected

The roll axis engages in CWS while the pitch axis is in CMD when:

- a command roll mode has not been selected or was deselected
- A/P roll has been manually overridden with control wheel force. The force required for override is greater than the normal CWS control wheel force.

CWS R is annunciated on the FMAs while this mode is engaged.

CWS R with a CMD engage switch illuminated can be used to capture a selected radio course while the VOR/LOC or APP mode is armed. Upon intercepting the radial or localizer, the F/D and A/P annunciations change from CWS R to VOR/LOC engaged, and the A/P tracks the selected course.

Autothrottle System

The A/T system provides automatic thrust control from the start of takeoff through climb, cruise, descent, approach and go–around or landing. In normal operation, the FMC provides the A/T system with N1 limit values.

The A/T moves the thrust levers with a separate servo motor on each thrust lever. Following manual positioning, the A/T may reposition the thrust levers to comply with computed thrust requirements except while in the THR HLD and ARM modes.
The A/T system operates properly with the EECs ON or in ALTN. In either case, the A/T uses the FMC N1 limits. During A/T operation, it is recommended that both EECs be ON or both be in ALTN, as this produces minimum thrust lever separation.

**Autothrottle Engagement**

Moving the A/T Arm switch to ARM, arms the A/T for engagement in the N1, MCP SPD or FMC SPD mode. The A/T Arm switch is magnetically held at ARM and releases to OFF when the A/T becomes disengaged.

A general summary of A/T mode engagement is as follows:

- A/T SPD or N1 modes automatically engage when AFDS command pitch modes become engaged
- engaging LVL CHG or VNAV climb modes automatically engages the A/T N1 mode
- engaging LVL CHG or VNAV descent modes automatically engages the A/T in RETARD and then ARM when thrust is at idle
- if not in a VNAV mode, engagement of ALT ACQ or ALT HOLD automatically engages the A/T in the MCP SPD mode; otherwise the A/T remains in FMC SPD
- engagement of G/S capture automatically engages the A/T in the MCP SPD mode
- alpha floor automatically engages the A/T when armed.

**Autothrottle Disengagement**

Any of the following conditions or actions disengages the A/T:

- moving the A/T Arm switch to OFF
- pushing either A/T Disengage switch
- an A/T system fault is detected
- two seconds have elapsed since landing touchdown

[Option - Honeywell MCP without Quiet Climb]
- thrust levers become separated more than 10 degrees during a dual channel approach after FLARE armed is annunciated

[Option - Collins MCP without Quiet Climb]
- thrust levers become separated more than 10 degrees

[Option - Collins MCP with Quiet Climb]
- thrust levers become separated more than 10 degrees, except during takeoff, with a cutback N1 selected

[Option - Collins MCP without Quiet Climb]
- significant thrust difference along with control wheel roll input of 10 degrees or more at any point throughout the entire flight envelope.
Automatic Flight Operations

The phases of flight for automatic flight operations are:

- Takeoff and climb
- Enroute
- Approach and landing
- Go–around

Automatic Flight Takeoff and Climb

Takeoff is a flight director only function of the TO/GA mode. Flight director pitch and roll commands are displayed and the autothrottle maintains takeoff N1 thrust limit as selected from the FMC. The autopilot may be engaged after takeoff.

[Option - Flight director commands wings level on takeoff]
Both F/Ds must be ON to engage the takeoff mode prior to starting the takeoff. The F/D takeoff mode is engaged by pushing the TO/GA switch on either thrust lever. The FMAs display FD as the A/P status, TO/GA as the pitch mode, and blank for the roll mode.

[Option - Flight director commands HDG SEL on takeoff]
Both F/Ds must be ON to engage the takeoff mode prior to starting the takeoff. The F/D takeoff mode is engaged by pushing the TO/GA switch on either thrust lever. The FMAs display FD as the A/P status, TO/GA as the pitch mode, and HDG SEL as the roll mode.

During takeoff, pushing a TO/GA switch engages the autothrottle in the N1 mode. The A/T annunciation changes from ARM to N1 and thrust levers advance toward takeoff thrust. The F/D can also be engaged in the takeoff mode with the F/D switches off. If a TO/GA switch is pushed after 80 knots below 2000 feet AGL and prior to 150 seconds after lift–off, the F/D command bars automatically appear for both pilots.

[Option - Flight director commands wings level on takeoff]
During takeoff, prior to 60 KIAS:
- the pitch command is 10 degrees nose down
- the roll command is wings level
- the autothrottle is engaged in the N1 mode

A/T disengagement is followed by A/T Arm switch releasing to OFF and flashing red A/T Disengage lights. The A/T Disengage lights do not illuminate when the A/T automatically disengages after landing touchdown.

[Option - Collins MCP with Quiet Climb]
- significant thrust difference along with control wheel roll input of 10 degrees or more throughout the entire flight envelope, except during takeoff, with a cutback N1 selected.
• thrust levers advance until the engines reach takeoff thrust
• the FMAs display N1 for the autothrottle mode, TO/GA for the pitch mode, and blank for the roll mode.

[Option - Flight director commands HDG SEL on takeoff]
During takeoff, prior to 60 KIAS:
• the pitch command is 10 degrees nose down
• the roll command is HDG SEL
• the autothrottle is engaged in the N1 mode
• thrust levers advance until the engines reach takeoff thrust
• the FMAs display N1 for the autothrottle mode, TO/GA for the pitch mode, and HDG SEL for the roll mode.

At 60 knots, the F/D pitch commands 15 degrees nose up.

At 84 knots, the A/T mode annunciates THR HLD.

At lift–off:
• the pitch command continues at 15 degrees until sufficient climb rate is acquired. Pitch then commands MCP speed (normally V2) plus 20 knots
• if an engine failure occurs during takeoff, the pitch command target speed is:
  • V2, if airspeed is below V2
  • existing speed, if airspeed is between V2 and V2 + 20
  • V2 + 20, if airspeed is above V2 + 20

[Option - Flight director commands wings level on takeoff]
• the roll command maintains wings level.

[Option - Flight director commands HDG SEL on takeoff]
• the roll command maintains HDG SEL. Bank angle is limited to 8 degrees below 400 feet, and 10–30 degrees selectable above 400 feet AGL.

After lift–off:
• the A/T remains in THR HLD until 800 feet RA. A/T annunciation then changes from THR HLD to ARM and reduction to climb thrust can be made by pushing the N1 switch

[Option - Without automatic thrust reduction after takeoff]
• automatic thrust reduction to climb power occurs when VNAV, ALT ACQ or ALT HOLD is engaged. Until 2 1/2 minutes after liftoff, automatic thrust reduction is inhibited when engaging LVL CHG or V/S modes
[Option - Automatic thrust reduction after takeoff, FMC update 10.1 and later]

- automatic reduction to climb thrust occurs upon reaching the selected thrust reduction altitude which is shown on the FMC CDU TAKEOFF REF page 2/2 during preflight, or when the airplane levels off in ALT HOLD or VNAV PTH. Pilot entries can be made to override the default value. Allowable entries are 800 feet to 9999 feet.

- flight director engaged status is terminated by engaging an autopilot in CMD (CMD replaces FD in A/P status display)
  - pitch engages in LVL CHG and pitch mode FMA is MCP SPD unless another pitch mode has been selected
  - MCP IAS/Mach display and airspeed cursor change to V2 + 20 knots
  - roll mode engages in HDG SEL unless another roll mode has been selected.

To terminate the takeoff mode below 400 feet RA, both F/D switches must be turned OFF. Above 400 feet RA, selection of another pitch mode or engaging an autopilot will terminate the takeoff mode; other F/D roll modes can be also selected.
Automatic Flight Takeoff Profile

[Option - EFIS/MAP, flight director commands wings level on takeoff]

Engage A/P
- A/P engages in CMD
- Pitch mode engages in MCP SPD

Thrust Reduction
- A/T N1 mode engages at CLB power

800 ft RA –
- A/T ARM mode engages

Above 400 ft RA
- Select roll mode

84 knots –
- A/T THR HLD mode engage

Push TO/GA Switch
(both FD ON and A/T armed)
Automatic Flight En Route

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

Other roll modes available are:
- VOR course (VOR/LOC)
- heading select (HDG SEL).

Other pitch modes available are:
- altitude hold (ALT HOLD)
- level change (MCP SPD)
- vertical speed (V/S).
Automatic Flight Approach and Landing

The AFDS provides guidance for single A/P non-precision approaches. The VOR/LOC switch arms the AFDS for VOR or localizer tracking. Descent may be accomplished using VNAV, LVL CHG, or V/S. VOR/LOC, LNAV, or HDG SEL may be used for the roll mode.

The AFDS provides guidance for single or dual A/P precision approaches. The approach mode arms the AFDS to capture and track the localizer and glideslope.

Approach (APP) Mode Dual A/Ps

Approach mode allows both A/Ps to be engaged at the same time. Dual A/P operation provides fail-passive operation through landing flare and touchdown or an automatic go-around. During fail passive operation, the flight controls respond to the A/P commanding the lesser control movement. If a failure occurs in one A/P, the failed channel is counteracted by the second channel such that both A/Ps disconnect with minimal airplane maneuvering and with aural and visual warnings to the pilot.

[Option - Fail-Operational Autoland]

Approach mode allows both A/Ps to be engaged at the same time. Dual A/P operation provides either fail-operational or fail-passive operation through landing flare, touchdown and rollout, or through an automatic go-around. If a failure is detected, the flight controls respond to the A/P commanding the lesser control movement. If a failure occurs in one A/P, the failed channel is counteracted by the second channel such that both A/Ps disconnect with minimal airplane maneuvering and with aural and visual warnings to the pilot.

One VHF NAV receiver must be tuned to an ILS frequency before the approach mode can be selected. For a dual A/P approach, the second VHF NAV receiver must be tuned to the ILS frequency and the corresponding A/P engaged in CMD prior to 800 feet RA.

Localizer and Glideslope Armed

After setting the localizer frequency and course, pushing the APP switch selects the APP mode. The APP switch illuminates and VOR/LOC and G/S annunciate armed. The APP mode permits selecting the second A/P to engage in CMD. This arms the second A/P for automatic engagement after LOC and G/S capture and when descent below 1500 RA occurs.

The localizer can be intercepted in the HDG SEL, CWS R or LNAV mode.

[Option - G/S capture inhibited before LOC capture]

Glideslope (G/S) capture is inhibited prior to localizer capture.
Localizer Capture

[Option - EFIS/MAP]
The LOC capture point is variable and depends on intercept angle and rate of closure. Capture occurs no later than 1/2 dot. Upon LOC capture, VOR/LOC annunciates captured, 1 CH is annunciated for A/P status, the previous roll mode disengages and the airplane turns to track the LOC.

[Option - PFD/ND]
The LOC capture point is variable and depends on intercept angle and rate of closure. Capture occurs no later than 1/2 dot. Upon LOC capture, VOR/LOC annunciates captured, SINGLE CH is annunciated for A/P status, the previous roll mode disengages and the airplane turns to track the LOC.

Glideslope Capture

[Option - G/S capture inhibited before LOC capture]
Glideslope capture is inhibited prior to localizer capture.
The G/S can be captured from above or below. Capture occurs at 2/5 dot and results in the following:
- G/S annunciates captured
- previous pitch mode disengages
- APP light extinguishes if localizer has also been captured
- airplane pitch tracks the G/S
- GA displayed on thrust mode display (N1 thrust limit).

After VOR/LOC and G/S are both captured, the APP mode can be exited by:
- pushing a TO/GA switch
- disengaging A/P and turning off both F/D switches
- retuning a VHF NAV receiver.

After LOC and G/S Capture

Shortly after capturing LOC or G/S and below 1500 feet RA:
- the second A/P couples with the flight controls
- test of the ILS deviation monitor system is performed and the G/S or LOC display turns amber and flashes
- test of autopilot rudder servo is performed
- FLARE armed is annunciated
- ROLLOUT armed is annunciated

[Option - EFIS/MAP]
- the 1 CH annunciation extinguishes

[Option - PFD/ND]
- the SINGLE CH annunciation extinguishes
- A/P go-around mode arms but is not annunciated.
[Option - CWS deactivated on approach]

**Note:** After localizer and glideslope capture during a dual autopilot approach, CWS cannot be engaged by manually overriding pitch and roll. Manual override of autopilots causes autopilot disengagement.

The A/Ps disengage and the F/D command bars retract to indicate an invalid ILS signal.

**800 Feet Radio Altitude**

The second A/P must be engaged in CMD by 800 feet RA to execute a dual channel A/P approach. Otherwise, CMD engagement of the second A/P is inhibited.

**500 Feet Radio Altitude**

[Option – Fail-Operational Autoland]

The pilot is required to check for the presence of LAND 3 or LAND 2 in order to continue the autoland.

If the second autopilot in CMD remains armed and does not engage, LAND 2 or LAND 3 does not annunciate. Instead, the amber NO AUTOLAND annunciation alerts the pilot that dual control has not been established and the autoland is to be discontinued.

**450 Feet Radio Altitude**

[Option – Fail-Operational Autoland]

The alignment mode is enabled which provides rudder compensation for the purpose of decreasing large crab angles produced by crosswinds, and to control the adverse moments caused by an engine failure. The automatic correction for aircraft crab angle due to crosswinds and engine failure enhances flight crew runway perspective and provides optimal aircraft position for initiation of rollout control. In a strong crosswind, the airplane does not fully align with the runway but lands in a slight crab. Sideslip is limited to 5 degrees. This mode is not annunciated.

**400 Feet Radio Altitude**

The stabilizer is automatically trimmed an additional amount nose up. If the A/Ps subsequently disengage, forward control column force may be required to hold the desired pitch attitude.

If FLARE is not armed by approximately 350 feet RA, both A/Ps automatically disengage.
Flare

The A/P flare maneuver starts at approximately 50 feet RA and is completed at touchdown:

- FLARE engaged is annunciated and F/D command bars retract
- the A/T begins retarding thrust at approximately 27 feet RA so as to reach idle at touchdown. A/T FMA annunciates RETARD.
- the A/T automatically disengages approximately 2 seconds after touchdown.
- the A/P must be manually disengaged after touchdown. Landing rollout is executed manually after disengaging the A/P.

Rollout

[Option - Fail-Operational Autoland]

ROLLOUT arms when LAND 2 or LAND 3 annunciates.

At approximately two feet radio altitude, rollout activates:

- ROLLOUT replaces the VOR/LOC roll flight mode annunciation
- the autopilot controls the rudder and nose wheel steering to keep the airplane on the localizer centerline.
- rollout guidance continues until a full stop or until the autopilots are disengaged.

Approach (APP) Mode Single A/P

A single A/P ILS approach can be executed by engaging only one A/P in CMD after pushing the APP mode select switch. Single A/P approach operation is the same as dual, with the following exceptions:

- full automatic flare and touchdown capability is not available. FLARE is not annunciated and stabilizer trim bias is not applied

[Option - EFIS/MAP]

- A/P status of 1 CH is annunciated for the entire approach after localizer capture

[Option - PFD/ND]

- A/P status of SINGLE CH is annunciated for the entire approach after localizer capture
- an A/P go–around is not available.
ILS Beam Anomaly

[Option - Fail-Operational Autoland]
Prior to annunciation of LAND 3 or LAND 2, the autopilot will disconnect if a persistent localizer or glideslope beam anomaly is detected. If a beam anomaly is detected after annunciation of LAND 3 or LAND 2, the appropriate localizer or glideslope deviation scale will turn amber and the corresponding pointer will flash, a horizontal amber line will be drawn through the appropriate roll (VOR/LOC) or pitch (G/S) mode on the FMA, and the autopilot will disengage. For a single channel or F/D only approach, the autopilot will disconnect and/or the F/D bars will be removed.

In the event of a ground station failure, the appropriate localizer or glideslope deviation scale will blank, a horizontal amber line will be drawn through the appropriate roll (VOR/LOC) or pitch (G/S) mode on the FMA, but the autopilot will remain engaged.

Single Engine Landing

[Option – Fail-Operational Autoland]
If an engine fails and the APU is not used to provide a second electrical source, NO AUTOLAND is annunciated and autoland with rollout is prohibited. If an engine fails and the APU is used to provide a second electrical source prior to engagement of the second autopilot, a fail-passive autoland (LAND 2) with rollout may be flown. LAND 3 will be displayed, but fail-passive minimums must be used.

Automatic engine out rudder compensation is provided during A/P approach and landing.

In the event of a A/P go-around, the A/P will continue to compensate for asymmetric thrust until another roll mode is selected.

Approach (APP) Mode Integrated Approach Navigation

[Option – Integrated Approach Nav]
The Integrated Approach Navigation (IAN) modes are armed/engaged by selecting the APP button on the AFDS Mode Control Panel (MCP). Once armed, the autopilot/flight director will capture and track the localizer/final approach course and glide slope/glide path.

The following roll and pitch mode control annunciations of the FMA will be displayed:
• For an ILS approach, VOR/LOC and G/S will be the displayed roll and pitch modes
• For an FMC IAN approach, FAC and G/P will be the displayed roll and pitch modes
• For an ILS approach with G/S selected off or a localizer only approach, VOR/LOC and G/P will be the displayed roll and pitch modes.

• For a backcourse localizer approach, B/CRS and G/P will be the displayed roll and pitch modes.

The armed and engaged states of FAC and G/P follow the established convention. The flight control system resets the FAC and G/P modes (the modes blank on the display) for the following cases:

• Loss of deviation signals
• Loss of validity
• Detection of a FAC or G/P failure

When the modes are reset, the FCC will remove (bias out of view) the F/D bars, and disconnect the A/P. These are analogous to the VOR/LOC and G/S reset modes.
Automatic Flight Approach Profile

[Option - EFIS/MAP]

Select APP
Second A/P CMD

LOC capture
Set heading

G/S Capture
- GA displayed on Thrust Mode Display

Below 1500 ft RA
- Go-around mode armed but not annunci cated

50 ft RA
- FLARE maneuver begins
- F/D bars retract from view

27 ft RA
- A/T retards to idle

Touchdown
- Manually disconnect A/P
- A/T disconnects 2 seconds after touchdown

ILS APPROACH
Below 2000 feet RA
- FAC capture
- FAC G/P
- CH
- MCP SPD
- SINGLE

MDA/DA
- FAC G/P
- CH
- MCP SPD
- SINGLE

100 feet RA
- FAC G/P
- CH
- MCP SPD
- SINGLE

50 feet RA
- FAC G/P
- CH
- MCP SPD
- SINGLE

FAC capture
- Set heading
- MCP SPD
- ALT HOLD
- SINGLE

FAC bars retract from view
- MCP SPD
- CMD

G/P capture
- GA displayed on Thrust Mode Display
- MCP SPD
- ALT HOLD
- SINGLE

APP selected
- MCP SPD
- CMD

G/A selected
- MCP SPD
- CMD

IAN APPROACH
4.20.24 D6-27370-TBC

**FAIL-OPERATIONAL APPROACH**

**APP selected**
- MCP SPD
- HDG SEL
- VOR/LOC
- ALT HOLD
- G/S
- CMD

**G/S capture**
- GA displayed on Thrust Mode Display
- MCP SPD
- VOR/LOC
- G/S
- SINGLE CH

**450 feet radio altitude**
- Runway alignment starts

**50 feet RA**
- FLARE maneuver begins
- F/D bars retract from view

**Below 1500 feet RA**
- Go-around mode armed but not annunciated

**200 feet RA**
- LAND 2 and NO AUTOLAND annunciation inhibited

**27 feet radio altitude**
- A/T retards to idle

**Touchdown**
- A/T disconnects 2 sec after touchdown
- Rollout guidance ends when A/Ps are disengaged

**Localizer capture**
- Set heading

**Mode Display**
- MCP SPD
- VOR/LOC
- G/S
- SINGLE CH
- HDG SEL
- ALT HOLD
- CMD

**FAIL-OPERATIONAL Autoland**

March 29, 2004
Go–Around

Go–Around (GA) mode is engaged by pushing either TO/GA switch. An A/P go–around requires dual A/P operation and is armed when FLARE armed is annunciated. If both A/Ps are not operating, a manual F/D go–around is available.

With the A/T Arm switch at ARM, the A/T go–around mode is armed:

- when descending below 2000 feet RA

[Option - A/P auto disengages for TO/GA above 2000 feet RA]
[Option - Honeywell -708 FCC and on]
- when above 2000 feet RA with flaps not up or G/S captured
- with or without the AFDS engaged.

A/P Go–Around

The A/P GA mode requires dual A/P operation and is available after FLARE armed is annunciated and prior to the A/P sensing touchdown.

With the first push of either TO/GA switch:

- A/T (if armed) engages in GA and the A/T Engaged Mode annunciation on the FMA indicates GA
- thrust advances toward the reduced go–around N1 to produce 1000 to 2000 fpm rate of climb
- pitch mode engages in TO/GA and the Pitch Engaged Mode annunciation on the FMA indicates TO/GA
- F/D pitch commands 15 degrees nose up until reaching programmed rate of climb. F/D pitch then commands target airspeed for each flap setting based on maximum takeoff weight calculations
- F/D roll commands hold current ground track. The Roll Engaged Mode annunciation on the FMA is blank
- the IAS/Mach display blanks
- the command airspeed cursor automatically moves to a target airspeed for the existing flap position based on maximum takeoff weight calculations.

Note: If the go–around mode is selected after touchdown and prior to A/T disengagement, the A/Ps disengage and the A/Ts may command GA thrust.

With the second push of either TO/GA switch after A/T reaches reduced go–around thrust:

- the A/T advances to the full go–around N1 limit.
TO/GA mode termination from A/P go-around:

- below 400 feet RA, the AFDS remains in the go-around mode unless both A/Ps and F/Ds are disengaged

[Option - Fail-Operational Autoland]
- if the A/P is compensating for asymmetric thrust during the go-around, autopilot rudder control is disabled when a new pitch or roll mode is selected
- above 400 feet RA, select a different pitch or roll mode.
  - if the roll mode is changed first:
    - the selected mode engages in single A/P roll operation and is controlled by the A/P which was first in CMD
    - pitch remains in dual A/P control in TO/GA mode.
  - if the pitch mode is changed first:
    - the selected mode engages in single A/P pitch operation and is controlled by the A/P which was first in CMD
    - the second A/P disengages
    - the roll mode engages in CWS R.
- the A/T GA mode is terminated when:
  - another pitch mode is selected
  - ALT ACQ annunciates engaged.

Note: The pitch mode cannot be changed from TO/GA until sufficient nose–down trim has been input to allow single channel A/P operation. This nose–down trim is automatically added by the A/P to reset the trim input made by the A/P at 400 feet RA and at 50 feet RA during the approach.

With pitch mode engaged in TO/GA, ALT ACQ engages when approaching the selected altitude and ALT HOLD engages at the selected altitude if the stabilizer position is satisfactory for single A/P operation.

- if stabilizer trim position is not satisfactory for single A/P operation:
  - ALT ACQ is inhibited
  - A/P disengage lights illuminate steady red
  - pitch remains in TO/GA.

Note: To extinguish A/P disengage lights, disengage A/Ps or select higher altitude on MCP.
F/D Go–Around

If both A/Ps are not engaged, a manual F/D only go–around is available under the following conditions:

- Inflight below 2000 feet RA

[Option - A/P auto disengages for TO/GA above 2000 feet RA]
[Option - Honeywell -708 FCC and on]

- Inflight above 2000 feet RA with flaps not up or G/S captured
- Not in takeoff mode.

With the first push of either TO/GA switch:

- A/T (if armed) engages in GA and advances thrust toward the reduced go–around N1 to produce 1000 to 2000 fpm rate of climb. The A/T Engaged Mode annunciation on the FMA indicates GA
- Autopilot (if engaged) disengages
- Pitch mode engages in TO/GA and the Pitch Engaged Mode annunciation on the FMA indicates TO/GA
- F/D pitch commands 15 degrees nose up until reaching programmed rate of climb. F/D pitch then commands target airspeed for each flap setting based on maximum takeoff weight calculations
- F/D roll commands approach ground track at time of engagement. The Roll Engaged Mode annunciation on the FMA is blank
- The IAS/Mach display blanks
- The command airspeed cursor automatically moves to a target airspeed for the existing flap position based on maximum takeoff weight calculations.

With the second push of either TO/GA switch (if A/T engaged and after A/T reaches reduced go–around thrust):

- The A/T advances to the full go–around N1 limit

TO/GA mode termination from F/D go–around:

- Below 400 feet RA, both F/D switches must be turned off.
- Above 400 feet RA, select a different pitch or roll mode.
  - If the roll mode is changed first:
    - F/D roll engages in the selected mode
    - The F/D pitch mode remains in TO/GA.
  - If the pitch mode is changed first:
    - F/D pitch engages in the selected mode.
    - The F/D roll mode automatically changes to HDG SEL
    - The A/T GA mode (if engaged) is terminated when:
      - Another pitch mode is selected
      - ALT ACQ annunciates engaged.

Note: Engaging an A/P in CMD automatically engages the A/P and F/Ds in LVL CHG for pitch and HDG SEL for roll.
4.20.28  D6-27370-TBC  September 28, 2006

737 Flight Crew Operations Manual

Single Engine F/D Go–Around

With a push of either TO/GA switch:

- F/D roll commands hold current ground track. The Roll Engaged Mode annunciation on the FMA is blank
- pitch mode engages in TO/GA and the Pitch Engaged Mode annunciation on the FMA indicates TO/GA
- the F/D target speed is displayed on IAS/Mach display
- the F/D target speed is displayed on the airspeed cursor
- F/D pitch commands 13 degrees nose up. As climb rate increases, F/D pitch commands maintain a target speed.
  - if engine failure occurs prior to go–around engagement, then F/D target speed is the selected MCP speed.
  - if engine failure occurs after go–around engagement, then F/D target speed depends on whether ten seconds have elapsed since go–around engagement:
    - if prior to ten seconds, the MCP selected approach speed becomes target speed
    - if after ten seconds and the airspeed at engine failure is within five knots of the go–around engagement speed, the airspeed that existed at go–around engagement becomes target speed
    - if after ten seconds and the airspeed at engine failure is more than five knots above go–around engagement speed, then the current airspeed becomes target speed.

Note: The target speed is never less than V2 speed based on flap position unless in windshear conditions.

F/D commanded acceleration cannot occur until a higher speed is selected on the MCP IAS/Mach display.

Go–Around Roll Mode – LNAV in Lieu of Trackhold

[Option - TOGA to LNAV Go–Around Roll Mode]

When multiple arm modes such as LNAV and VOR/LOC are set, they will appear on the FMA side by side in white.

When a missed approach exists in the flight plan and the FCCs are capable of entering go-around, LNAV arm will be annunciated on the FMA. The roll go–around trackhold mode will automatically transition to LNAV during a missed approach.

During autoland operations with FLARE arm or FLARE engage displayed, if TO/GA is pressed with LNAV arm annunciated on the FMA, then LNAV will engage when the airplane is above 400 feet. Below that altitude the roll mode will be trackhold.
During an approach without FLARE arm or FLARE engage displayed, if TO/GA is pressed with LNAV arm annunciated on the FMA, the flight director LNAV mode will engage when the airplane is above 50 feet. Below that altitude the mode will be trackhold.

Single channel autopilot minimum engage and use heights are not affected. This feature is recommended to support RNP RNAV operations for terminal procedures requiring definitive course guidance.

**Automatic Flight Go–Around Profile**

[Option - EFIS/MAP]
AFS Operation in Windshear

General

The autopilot and flight director provide positive corrective action to counteract most windshears. The autothrottle system also aids in windshear recovery by providing quick response to any increase or decrease in speed. The commanded levels of power may be beyond what the average pilot considers necessary but, in fact, are required by the situation.
Takeoff or Go–Around

If windshear is encountered during F/D takeoff or go–around, the F/D pitch command bar provides commands to maintain \( V_2 + 20 \) kts until vertical speed decreases to approximately +600 fpm. At this point, the F/D pitch bar commands a 15 degree nose–up pitch attitude. If vertical speed continues to decrease, the F/D continues to command a 15 degree pitch attitude until a speed of approximately stick shaker is reached. It then commands pitch attitudes which result in intermittent activation of the stick shaker. As the airplane transits the windshear condition, the F/D programming reverses. As climb rate increases above approximately +600 fpm, the F/D commands pitch attitudes which result in acceleration back to \( V_2 + 20 \) kts. The A/P and F/D both operate in a similar manner during A/P or F/D go–around.

Approach and Landing

If windshear is encountered during an ILS approach, both the F/D and A/P attempt to hold the airplane on altitude, or on glideslope after glideslope capture, without regard to angle of attack or stick shaker limitations. Airspeed could decrease below stick shaker and into a stall if the pilot does not intervene by pushing the TO/GA switch or disconnecting the A/P and flying manually.

**WARNING:** Although the F/D, A/P and A/T may be performing as previously described, severe windshear may exceed the performance capability of the system and/or the airplane. In this situation, the flight crew must, if necessary to avoid ground contact, be prepared to disconnect the autothrottle, advance thrust levers to the forward stop, disconnect the autopilot and manually fly the airplane.

Command Speed Limiting and Reversion Modes

AFS command limiting and reversion operation is independent of the stall warning and mach warning systems.

**Command Speed Limiting**

The AFS provides speed, pitch and thrust commands to avoid exceeding the following limit speeds:

- \( V_{mo}/M_{mo} \)
- wing flap placards
- landing gear placard
- minimum speed.

The commanded speed can be equal to, but does not exceed a limit speed.
Speeds greater than Vmo/Mmo cannot be selected from the MCP. Speeds can be selected which exceed flap and gear placards or are less than minimum speed.

Minimum speed is based on angle of attack and is approximately 1.3 Vs for the current flap configuration. It is sensed by the angle of attack vanes, one on either side of the forward fuselage.

If a speed greater than a placard speed, or less than minimum speed is selected, the AFS allows acceleration or deceleration to slightly short of the limit, then commands the limit speed. The overspeed or underspeed limiting symbol appears in the MCP IAS/Mach display when the commanded speed cannot be reached.

Either pitch or thrust, whichever is engaged in a speed mode, attempts to hold the limit speed. The commanded limit speed and MCP speed condition symbol, remain until another speed is selected which does not exceed the limit. A speed 15 knots greater than the minimum speed must be selected to remove the underspeed limiting symbol.

**Reversion Modes**

During some flight situations, speed control by the AFDS or A/T alone could be insufficient to prevent exceeding a limit speed. If this occurs, AFDS or A/T modes automatically revert to a more effective combination. The reversion modes are:

- placard limit reversion
- minimum airspeed reversion.

Mode reversion occurs slightly before reaching the limit speed. Both the AFDS and A/T have reversion modes which activate according to the condition causing the reversion.

**Placard Limit Reversion**

When one of the placard limit reversions (gear, flap or Vmo/Mmo) is reached, the overspeed limiting symbol appears in the MCP IAS/Mach display and the following occurs:

- if the AFDS is engaged but not in speed or CWS mode, and the A/T is armed but not in speed control, the A/T reverts to SPEED and controls speed to slightly below the placard limit
- if the AFDS or A/T is in speed control, speed is maintained slightly below the placard limit
- for VMO/MMO only, if the A/T is engaged in a speed mode and the thrust levers are at idle, the AFDS, if in a V/S mode, will automatically engage to LVL CHG mode.
- if the A/T is not available, no reversion response to gear or flap placard speeds is available. The AFDS reverts to speed control for Vmo/Mmo speed limiting.
Minimum Speed Reversion

The AFDS and A/T do not control to a speed which is less than minimum speed for the current flap configuration. This speed is approximately 1.3 Vs. Minimum speed, FMC speed, or selected speed, whichever is higher, becomes the AFS commanded speed. If actual speed becomes equal to or slightly less than the minimum speed, the underspeed limiting symbol appears in the MCP IAS/Mach Display, and if operating in the V/S mode, the AFDS reverts to LVL CHG. The AFDS will also revert to LVL CHG from VNAV PTH, except when flying a level segment.

The AFS commands a speed 5 knots greater than minimum speed. Reaching a speed 5 knots greater than minimum speed reactivates normal MCP speed selection control. The AFDS commands nose down pitch to increase airspeed if the thrust levers are not advanced. When actual speed becomes 5 knots greater than minimum speed, the underspeed limiting symbol disappears.

The A/P disengages and the F/D command bars retract when in a LVL CHG climb with a command speed equal to minimum speed and a minimum rate of climb cannot be maintained without decelerating.

Minimum speed reversion is not available when the A/T is OFF and the AFDS is in ALT HOLD or after G/S capture. Minimum speed reversion is also not available when in VNAV PTH and flying a level segment.
Intentionally
Blank