B777



Automatic Flight

DO NOT USE FOR FLIGHT

Mode Control Panel (MCP)



Autopilot Flight Director System Controls



1 Autopilot (A/P) Engage Switches

Push (either switch can engage the autopilot) -

• if either flight director switch is ON, the autopilot engages in the selected flight director mode(s)

[Option – A/P ATT Hold Engage]

- if both flight director switches are OFF, the autopilot engages in:
 - heading hold (HDG HOLD) or track hold (TRK HOLD) as the roll mode, or if bank angle is greater than five degrees, attitude hold (ATT)
 - vertical speed (V/S) or flight path angle (FPA) as the pitch mode.

2 Autopilot Engaged Light

Illuminated (green) – all operating autopilots are engaged.

3 Autopilot (A/P) DISENGAGE Bar

Pull down -

- · prevents autopilot engagement
- generates EICAS advisory message NO AUTOLAND
- disables bank angle protection
- exposes the amber and black stripes
- if an autopilot is engaged:
 - it disconnects
 - displays the EICAS warning message AUTOPILOT DISC
 - sounds an aural warning
 - illuminates the master warning lights.

Lift up -

- · permits autopilot engagement
- hides the amber and black stripes.

4 Flight Director (F/D) Switches

The left flight director switch activates the flight director steering indications on the left PFD. The right flight director switch activates the flight director steering indications on the right PFD.

ON –

[AFDS -506/-507/-508/-509 s/w not installed]

• On the ground with both flight director switches OFF, the first flight director switch positioned ON arms the flight director in the takeoff go–around (TO/GA) roll and pitch modes. The flight mode annunciation appears on both PFDs. Positioning the second switch ON displays the flight director steering indications on the second PFD.

[AFDS -506/-507/-508/-509 s/w allows ALT mode engagement on gnd]

• On the ground with both flight director switches OFF, the first flight director switch positioned ON arms the flight director in takeoff go-around (TO/GA) roll mode. In addition, the first switch arms the flight director in TO/GA pitch mode when MCP selected altitude differs more than 20 feet from displayed baro altitude, or engages the flight director in altitude (ALT) pitch mode when selected altitude is within 20 feet of displayed baro altitude. If ALT mode engages, selecting an altitude more than 20 feet from displayed baro altitude and recycling the first switch arms the flight director in TO/GA roll and pitch modes. The flight mode annunciation appears on both PFDs. Positioning the second switch ON displays the flight director steering indications on the second PFD.

[Option – A/P ATT Hold Engage]

- In flight, with the autopilot disengaged and both flight director switches OFF, the first flight director switch positioned to ON engages the flight director in:
 - heading hold (HDG HOLD) or track hold (TRK HOLD) as the roll mode, or if bank angle is greater than five degrees, attitude hold (ATT)
 - vertical speed (V/S) or flight path angle (FPA) as the pitch mode.
- In flight, with the autopilot engaged and both flight director switches OFF, the first flight director switch positioned to ON engages the flight director in the currently selected autopilot mode(s).

OFF –

- the flight director steering indications are not displayed
- the flight director steering indications are displayed on the PFDs if a TO/GA switch is pushed when airspeed is greater than 80 knots on takeoff, or on a go-around with the flaps not retracted.

Autothrottle System Controls



1 Autothrottle (A/T) ARM Switches

The left autothrottle arm switch controls the left engine autothrottle. The right autothrottle arm switch controls the right engine autothrottle.

L and/or R – arms the selected autothrottle for mode activation. The selected autothrottle activates when an AFDS mode (VNAV, FLCH, or TO/GA) is selected.

OFF –

- disconnects the selected autothrottle
- prevents selected autothrottle activation.

2 Climb/Continuous (CLB/CON) Thrust Switch

On the ground and below 400 feet during takeoff, the switch is inoperative.

Push –

- with two engines operating, changes the engine thrust limit to the FMC selected climb thrust
- with only one engine operating, changes the thrust limit to maximum continuous (CON).

3 Autothrottle (A/T) Switch

Push – above 400 feet, with the autothrottle armed, activates the appropriate autothrottle mode for the selected AFDS pitch mode, or if no pitch mode, in the speed (SPD) mode.

4 Autothrottle Light

Illuminated (green) – an autothrottle mode is activated.

Autopilot Flight Director IAS/Mach Controls



1 IAS/MACH Window

Displays the speed selected by the IAS/MACH selector.

Blank when the FMC controls the speed. When changing from TO/GA to V/S, FPA, or ALT, the window automatically displays:

- the flap placard speed minus 5 knots (flaps extended)
- 250 knots (flaps up), or
- a speed value entered in the IAS/MACH window after TO/GA was pushed.

The display range is:

- 100 399 KIAS
- .40 .95 Mach.

The selected speed is displayed as the PFD selected speed.

Displays 200 knots when power is first applied.

During climb, automatically changes from IAS to Mach at .84 Mach.

During descent, automatically changes from Mach to IAS at 310 KIAS.

2 IAS/MACH Reference Switch

Push –

- alternately changes the IAS/MACH window between IAS and Mach displays (Mach must be 0.4 or greater to switch from IAS to Mach)
- inoperative when the IAS/MACH window is blank.

3 IAS/MACH Selector

Rotate -

- Sets the speed in the IAS/MACH window and on the PFD as the selected speed.
- Inoperative when the IAS/MACH window is blank.

- With VNAV engaged, alternately opens or closes the IAS/MACH window:
 - when the window is closed, the FMC computed target speed is active and is displayed on the PFD
 - when the window is open, FMC speed–intervention is active and the IAS/MACH selector may be used to set the desired speed.
- Blanks when not in SPD, FLCH, or TO/GA.

Autopilot Flight Director Roll and Pitch Controls



1 Lateral Navigation (LNAV) Switch

- Arms, engages, or disarms LNAV as the roll mode.
- Displays LNAV in white (armed) on the PFD roll flight mode annunciator when armed. The previous roll mode remains active.
- 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 then engages when approaching the active leg
 - when engaged, displays LNAV in green on the PFD roll flight mode annunciator.
- Selection of LNAV with the airplane not on a heading to intercept the active leg, displays NOT ON INTERCEPT HEADING in the CDU scratch pad.
- 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 is disengaged:

- by selecting heading hold (HDG HOLD) or track hold (TRK HOLD)
- by selecting heading select (HDG SEL) or track select (TRK SEL)
- when the localizer captures
- if there is a dual FMC failure (LNAV may be re-engaged if there is an active CDU ALTN NAV route available).

LNAV is disarmed by pushing the LNAV switch a second time, or by arming LOC or APP.

2 LNAV Light

Illuminated (green) - the LNAV mode is armed or engaged.

3 Vertical Navigation (VNAV) Switch

- Arms, engages, or disarms VNAV as the pitch mode.
- Displays VNAV in white (armed) on the PFD pitch flight mode annunciator below 400 feet.
- VNAV engages 400 feet above runway elevation.
- If VNAV is selected and the FMC has insufficient data to provide VNAV guidance (such as the gross weight is invalid or there is no end-of-descent point in descent) displays PERF/VNAV UNAVAILABLE in the CDU scratchpad.
- VNAV SPD, VNAV PTH or VNAV ALT pitch mode is displayed in green (engaged) on the PFD pitch flight mode annunciator.
- In the VNAV SPD pitch mode, the AFDS commands pitch to hold target airspeed. The autothrottle operates in the THR REF, THR, IDLE or HOLD mode, as required by the phase of flight.
- In the VNAV PTH pitch mode, the AFDS commands pitch to maintain FMC target altitude or the VNAV path. The autothrottle maintains speed.
- In the VNAV ALT pitch mode, the AFDS commands pitch to maintain the MCP selected altitude when that altitude is lower than the VNAV commanded altitude in climb or higher than the VNAV commanded altitude in descent.
- If VNAV is selected and VNAV commands a descent with the MCP altitude window above the current airplane altitude, the autopilot maintains the altitude at which VNAV was selected. When on an instrument approach using VNAV, selecting the missed approach altitude does not interfere with the VNAV descent.

- If VNAV is selected and VNAV commands a climb with the MCP altitude window below the current airplane altitude, the autopilot maintains the altitude at which VNAV is selected.
- With the VNAV ALT pitch mode engaged, the autothrottle operates in the speed (SPD) mode.
- With the VNAV PTH pitch mode engaged, the autothrottle operates in the following modes:
 - for climb or cruise operates in the speed (SPD) mode
 - for descent operates in the IDLE, HOLD, or speed (SPD) mode.
- VNAV pitch guidance is available with one engine inoperative.

VNAV is disengaged:

- by engaging TO/GA, FLCH SPD, V/S, FPA, ALT or G/S pitch mode
- if there is a dual FMC failure.

VNAV is disarmed by:

- pushing the VNAV switch a second time, or
- arming APP.

4 VNAV Light

Illuminated (green) - the VNAV mode is armed or engaged.

5 Flight Level Change (FLCH) Switch

Push –

- FLCH SPD is displayed on the PFD pitch flight mode annunciator as the pitch mode.
- If the IAS/MACH window is blank, the IAS/MACH window opens to the FMC target speed, if valid. If not valid, the IAS/MACH window opens to the current speed.
- When changing from TO/GA to FLCH:
 - if the current speed is greater than the IAS/MACH window speed, the IAS/MACH window speed changes to the current speed.
 - if the current speed is less than the IAS/MACH window speed, the IAS/MACH window speed does not change.
- The autothrottle activates:
 - for climb activates in THR mode; the thrust limit is CLB thrust
 - for descent activates in THR mode, followed by HOLD if the thrust levers reach idle.

6 Flight Level Change Light

Illuminated (green) – the flight level change mode is engaged.

Autopilot Flight Director Heading, Track, and Bank Angle Controls



1 Heading/Track (HDG/TRK) Reference Switch

Push – alternately changes the heading/track window, PFD, and ND selected heading/track references between heading and track. Also changes the PFD roll flight mode annunciator, if the HDG or TRK mode is engaged.

2 Heading/Track Window

Displays the selected heading or track.

The selected heading or track is displayed on the PFD and ND.

If approach is armed, the heading/track in the MCP window automatically changes to the selected ILS front course heading at LOC capture.

Displays 360 degrees when power is first applied.

3 Heading/Track Hold (HOLD) Switch

Push –

- selects heading hold (HDG HOLD) or track hold (TRK HOLD) as the roll mode
- displays HDG HOLD or TRK HOLD on the PFD roll flight mode annunciator
- the AFDS commands wings level and holds the heading or track established when wings level is established.

4 Heading/Track Hold Light

Illuminated (green) - the heading/track HOLD mode is engaged.

5 BANK LIMIT Selector (outer)

Rotate – sets the AFDS commanded bank limit when in the heading select (HDG SEL) or track select (TRK SEL) roll mode as follows:

- AUTO varies between 15 25 degrees, depending on TAS
- 5, 10, 15, 20 or 25 the selected value is the maximum, regardless of airspeed.

6 Heading/Track Selector (middle)

Rotate – sets heading or track in the heading/track window and on the PFDs and NDs.

7 Heading/Track Select (SEL) Switch (inner)

- selects heading select (HDG SEL) or track select (TRK SEL) as the roll mode
- displays HDG SEL or TRK SEL on the PFD roll flight mode annunciator
- the AFDS controls roll to fly the selected heading or track
- bank is limited by the bank limit selector.

Autopilot Flight Director Vertical Speed (V/S) and Flight Path Angle (FPA) Controls



1 Vertical Speed/Flight Path Angle (V/S – FPA) Window

Displays the selected vertical speed in 100 fpm increments or the selected flight path angle in 0.1 degree increments.

The display range is:

- V/S: -8000 to +6000 fpm
- FPA: -9.9 to +9.9 degrees.

Blank when the vertical speed (V/S) or flight path angle (FPA) pitch mode is not engaged.

The selected vertical speed is displayed on the PFD vertical speed indication.

The selected flight path angle is displayed on the PFD attitude indicator.

2 V/S – FPA Reference Switch

Push – alternately changes the vertical speed/flight path angle window and PFD references between vertical speed and flight path angle. Also changes the PFD pitch flight mode annunciator, if the V/S or FPA mode is engaged.

3 V/S – FPA Switch

Push –

- Engages vertical speed (V/S) or flight path angle (FPA) as the pitch mode.
- Displays V/S or FPA on the PFD pitch flight mode annunciator.
- Displays the current vertical speed or flight path angle in the vertical speed/flight path angle window.
- When the selected altitude is reached, the pitch mode changes to altitude (ALT).
- AFDS commands pitch to maintain the vertical speed or flight path angle displayed in the vertical speed/flight path angle window.
- If vertical speed or flight path angle is selected while in FLCH or VNAV, the autothrottle activates in speed (SPD) mode, if armed.

4 V/S – FPA Light

Illuminated (green) – the vertical speed/flight path angle mode is engaged.

5 V/S – FPA Selector

UP or DOWN – sets the vertical speed or flight path angle in the vertical speed/flight path angle window and on the PFDs.

Autopilot Flight Director Altitude Controls



1 Altitude Window

Displays the selected altitude.

The displayed altitude is the reference altitude for altitude alerting and level off. The altitude range is 0 to 50,000 feet. Displays 10,000 feet when power is first applied.

Displayed altitude transmitted to ATC when Eurocontrol-compliant transponder installed.

2 Altitude Increment Selector (outer)

AUTO –

- the altitude selector changes in 100 foot increments
- displays the selected BARO minimum as the selector passes through that altitude. If the BARO minimum is not a 10 foot increment, displays the next highest 10 foot increment.

1000 - the altitude selector changes in 1,000 foot increments.

3 Altitude Selector (inner)

Rotate – sets the altitude in the altitude window and on the PFD altitude indication display.

Push –

- During climb or descent with altitude constraints, each push deletes the next waypoint constraint between the airplane altitude and the altitude window.
- During climb with no altitude constraints, and the altitude window set above the FMC cruise altitude, the cruise altitude is changed to the altitude window value.
- During cruise:
 - with the altitude window set above or below FMC cruise altitude, the FMC cruise altitude resets to the altitude window altitude
 - if in VNAV PTH or VNAV ALT pitch mode, the airplane begins a climb or descent toward the altitude window altitude
 - within 50 NM of the top–of–descent (T/D) point, with the altitude window set below cruise altitude, the airplane initiates the descend now (DES NOW) feature.

4 Altitude HOLD Switch

Push –

- engages altitude (ALT) as the pitch mode
- ALT is displayed on the PFD pitch flight mode annunciator
- the AFDS commands pitch to maintain the altitude when the switch was pushed.

5 Altitude Hold Light

Illuminated (green) – the altitude hold mode is engaged.

Autopilot Flight Director Approach Mode Controls



1 Localizer (LOC) Switch

Push –

- arms, disarms, engages, or disengages localizer (LOC) as the roll mode
- displays LOC in white (armed) on the PFD roll flight mode annunciator before localizer capture
- displays LOC in green (engaged) on the PFD roll flight mode annunciator after localizer capture
- · arms the AFDS to capture and track inbound on the front course
- the capture point varies based on range and intercept angle
- localizer capture can occur when an intercept track angle is within 120 degrees of the localizer course.

The localizer mode can be disarmed before localizer capture by:

- pushing the localizer switch a second time, or
- selecting LNAV.

The localizer mode can be disengaged after localizer capture by:

- selecting a roll mode other than LNAV,
- pushing a TO/GA switch,
- · disengaging the autopilot and turning both flight director switches off, or
- pushing the localizer switch a second time above 1,500 feet radio altitude (reverts to the default roll mode).

2 Localizer Light

Illuminated (green) - the localizer mode is armed or engaged.

Approach (APP) Switch 3

Push -

- arms, disarms, engages, or disengages localizer (LOC) as the roll mode and glideslope (G/S) as the pitch mode
- displays LOC and G/S in white (armed) on the PFD roll and pitch flight mode annunciators prior to localizer and glideslope capture
- displays LOC and G/S in green (engaged) on the PFD roll and pitch flight mode annunciators after each one is captured
- the AFDS captures and tracks the localizer in the localizer (LOC) mode and captures the glideslope in the glideslope (G/S) mode upon interception
- localizer captures when the intercept track angle is within 120 degrees of the localizer course
- glideslope captures when the intercept track angle is within 80 degrees of the localizer course.

[Option – GS capture not inhibited before LOC capture] Glideslope can capture before localizer capture.

[Option – GS capture inhibited before LOC capture]

Glideslope capture is inhibited before localizer capture.

The approach mode can be disarmed with localizer and glideslope armed by selecting APP, LOC, LNAV, or VNAV.

The approach mode disengages:

• with localizer captured and glideslope armed, by selecting heading select (HDG SEL) or heading hold (HDG HOLD)

[Option – GS capture not inhibited before LOC capture]

- with glideslope captured and localizer armed, by selecting any other pitch mode except VNAV
- after localizer and/or glideslope are captured, by engaging TO/GA mode, or by disengaging the autopilot and turning both flight director switches off
- after localizer and/or glideslope are captured, by pushing the approach switch a second time above 1,500 feet radio altitude (AFDS reverts to default roll and pitch modes).

4 **Approach Light**

Illuminated (green) – the approach modes (LOC and G/S) are armed or engaged.

PFD Flight Mode Annunciations (FMAs)

- Note: When first engaged/activated, AFDS/autothrottle mode changes are emphasized for 10 seconds by a green box drawn around the mode. A change to the AFDS mode NO AUTOLAND is emphasized by an amber box.
- Note: An amber horizontal line is drawn through the appropriate ENGAGED pitch or roll mode when a flight mode fault is detected.



1 **Autothrottle Modes (Active)**

Displayed (green) -

- THR
- THR REF
- HOLD

2 **AFDS Roll Modes (Engaged)**

Displayed (green) -

- HDG HOLD
- HDG SEL
- LNAV
- LOC
- ROLLOUT

AFDS Roll Modes (Armed) 3

Displayed (white) -

- LOC
- ROLLOUT

IDLE SPD

٠

- TO/GA
- TRK SEL
- TRK HOLD
- ATT

• LNAV

4 AFDS Pitch Modes (Engaged)

Displayed (green) -

- TO/GA
- ALT
- V/S
- VNAV PTH
- VNAV SPD

- VNAV ALT
- G/S
- FLARE
- FLCH SPD
- FPA

VNAV

• LAND 3

5 AFDS Pitch Modes (Armed)

Displayed (white) -

- G/S
- FLARE

6 AFDS (Engaged)

Displayed (green) -

- FLT DIR
- A/P

Displayed (green with white triangles) – ▷LAND2⊲

Displayed (amber) – NO AUTOLAND.

Autopilot Disconnect Switch



1 Autopilot Disconnect Switches

First push (either switch) -

- disconnects the autopilot
- the master warning lights illuminate
- displays the EICAS warning message AUTOPILOT DISC
- sounds an aural warning
- if the autopilot automatically disconnects, resets the master warning lights, EICAS warning message, and the aural warning.

Second push – resets:

- the master warning lights
- EICAS warning message
- the aural warning.

TO/GA and Autothrottle Disconnect Switches



1 Takeoff/Go-around (TO/GA) Switches

On the ground:

Push –

• below 50 knots and flaps out of up, activates autothrottle in THR REF mode at thrust limit selected on THRUST LIMIT page. If not pushed below 50 knots, autothrottle operation is inhibited until reaching 400 feet altitude

• pushing either switch above 80 knots disarms LNAV and VNAV

In flight:

Push (after lift-off with takeoff thrust limit displayed) -

- removes takeoff derates
- activates autothrottle in THR REF mode
- disarms AFDS modes
- between 50 feet and 400 feet, selects TO/GA roll mode
- above 400 feet, selects TO/GA roll and pitch modes

Push (on approach with flaps out of up or glideslope captured) -

- activates autothrottle in THR mode with GA thrust limit displayed
- disarms AFDS modes
- selects TO/GA roll and pitch modes
- arms or engages LNAV if an LNAV path is available
- second push activates autothrottle in THR REF mode

2 Autothrottle Disconnect Switches

Push (either switch) -

- disconnects the autothrottle (both left and right)
- illuminates the master caution lights
- displays the EICAS message AUTOTHROTTLE DISC
- if the autothrottle automatically disconnects, resets the master caution lights and EICAS message.

Second push -

- resets the master caution lights and EICAS message
- the autothrottle remains armed.

Introduction

The automatic flight control system consists of the autopilot flight director system (AFDS) and the autothrottle system. Both the AFDS and the autothrottle are controlled using the mode control panel (MCP) and the FMC.

Normally, the AFDS and autothrottle are controlled automatically by the FMC to perform climb, cruise, descent, and approach flight path guidance.

Autopilot Flight Director System

The AFDS consists of three autopilot flight director computers (AFDCs) and the MCP.

The MCP provides control of the autopilot, flight director, altitude alert, and autothrottle systems. The MCP is used to select and activate AFDS modes, and establish altitudes, speeds, and climb/descent profiles.

The AFDCs provide control of the flight directors, and autopilot. Flight director information is displayed on the primary flight displays (PFDs). The AFDS does not have direct control of the flight control surfaces. The autopilot controls the elevators, ailerons, flaperons, and spoilers through the fly–by–wire flight control system. Autopilot rudder commands are added only during an autopilot approach and landing. The autopilot controls nose wheel steering during rollout after an automatic landing.

MCP Mode Selection

MCP mode switches are used to select automatic flight control and flight director modes. A light in the lower half of each switch illuminates to indicate that the mode is armed or engaged. Mode engagement is indicated by the PFD roll and pitch flight mode annunciations. Autothrottle modes are discussed later in this section.

Most modes engage with a single push. These modes include:

- flight level change (FLCH SPD)
- heading hold (HDG HOLD)
- track hold (TRK HOLD)
- heading select (HDG SEL)
- track select (TRK SEL)
- vertical speed (V/S)
- flight path angle (FPA)
- altitude hold (ALT).

Other modes arm or engage with a single push. These modes are:

- lateral navigation (LNAV)
- localizer (LOC)
- vertical navigation (VNAV)
- approach (APP).

Page 20

All modes except APP can be disengaged by selecting another mode. All modes can be disengaged by disconnecting the autopilot and turning both flight directors off. After localizer and glideslope capture, the localizer and glideslope modes can only be disengaged by disconnecting the autopilot and turning both flight directors off, engaging the go–around mode, or if above 1,500 feet radio altitude, by reselecting APP (roll and pitch will revert to default modes). The VNAV, LNAV, LOC and APP modes can be disarmed by pushing the mode switch a second time.

Desired target values can be selected on the MCP for:

- airspeed
- Mach
- heading

vertical speedflight path angle

heading

• altitude.

track

All of these parameters except vertical speed and flight path angle can be preselected prior to autopilot and/or flight director engagement.

Autopilot Engagement

The autopilot is engaged by pushing either of the two MCP autopilot engage switches.

Autopilot Disengagement

Normal autopilot disengagement is through either control wheel autopilot disconnect switch. The autopilots can also be disengaged by:

- the MCP autopilot disengage bar, or
- overriding with the control column, control wheel, or rudder pedals (pedals will only disengage the autopilots with LAND 2 or LAND 3 annunciated).

An automatic autopilot disconnect occurs for some failures detected by the autopilot. The EICAS warning message AUTOPILOT DISC is displayed if the autopilot is manually or automatically disconnected. Depending upon the system failure, it may be possible to re–engage an autopilot by pushing the autopilot engage switch.

Autopilot and Flight Director Mode Degradations

Autopilot

The autopilot system can detect the degradation of a specific autopilot mode. When an engaged mode degrades, the autopilot remains engaged in an attitude stabilizing mode based on inertial data. If the degradation persists, the condition is annunciated on the PFD by an amber line drawn through the affected flight mode annunciation. If the degradation continues, the EICAS caution message AUTOPILOT is displayed to indicate the autopilot is operating in a degraded mode. When the degradation is no longer present the annunciations clear, the autopilot resumes using the mode, and a green box is drawn around the affected flight mode annunciation on the PFD for 10 seconds.

Flight Director

When a specific flight director mode degrades, the flight director provides an attitude stabilizing command based on inertial data. If the degradation persists, the condition is annunciated by removal of the affected (pitch or roll) flight director bar. When the degradation is no longer present the flight director commands immediately return to view.

ILS Signal Interference Monitor

The autopilot flight director system (AFDS) can detect significant ILS signal interference due to service vehicles or aircraft. If localizer or glideslope signal interference is detected, the autopilot disregards the ILS signal and remains engaged in an attitude stabilizing mode based on inertial data. Most ILS signal interferences last only a short period of time, so there is no annunciation other than erratic movement of the ILS raw data during the time the interference is present. If the condition persists, the annunciations described above for Autopilot and Flight Director Mode Degradation are provided.

Flight Director Display

The flight director steering indications are normally displayed any time the related flight director switch is ON.

The steering indications are also displayed when the related flight director switch is OFF and a TO/GA switch is pushed, if airspeed is greater than 80 knots and the flaps are not retracted. In this case, the flight director display can be removed by cycling the respective flight director switch on and then off.

A flight director mode failure, in either pitch or roll, causes the respective steering bars to disappear. The stall and overspeed protection functions will also cause the pitch flight director bar to disappear.

IAS()MACH HDG () TRK V/S(C)FPA IAS HDG ^{v/s}-8888 88888 SEL BANK FMS L С R CDUs AFDC AFDC AFDC AFDS Flv-bv-Wire Flight Control System ACEs PFCs (Čhapter 9) PCUs FLIGHT CONTROL SURFACES

Autopilot Flight Director System Schematic

AFDS Status Annunciation

The following AFDS status annunciations are displayed just above the PFD attitude display:

- FLT DIR (the flight director is ON and the autopilots are not engaged)
- A/P (the autopilots are engaged)
- LAND 3 (three autopilots are engaged and operating normally for an automatic landing)

- LAND 2 (AFDS redundancy is reduced; in some cases, only two autopilots are available)
- NO AUTOLAND (the AFDS is unable to make an automatic landing).

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

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

An EICAS message is displayed for any fault which limits the capability of the automatic landing system. Aural alerts for EICAS messages not affecting safety of flight are inhibited until after touchdown. Changes in autoland status below 200 feet, other than a transition to NO AUTOLAND status, are inhibited.

AFDS Flight Mode Annunciations

The flight mode annunciations are displayed just above the PFD AFDS status annunciations. The mode annunciations, from left to right, are:

- autothrottle
- roll
- pitch.

Engaged or captured modes are shown at the top of the flight mode annunciator boxes in large green letters. Armed modes (except for TO/GA in the air) are shown in smaller white letters at the bottom of the flight mode annunciator boxes. Degradations of a specific mode while the autopilot is engaged are annunciated by an amber line drawn through the mode annunciations. A green box is drawn around the mode annunciation for 10 seconds when a mode first becomes active, and when the amber line through a degraded mode is removed.

Autothrottle Modes

The autothrottle modes are:

- THR The autothrottle applies thrust to maintain the vertical speed required by the pitch mode.
- THR REF Thrust is set to the selected thrust limit displayed on EICAS.
- IDLE Displayed while the autothrottle moves the thrust levers to idle; IDLE mode is followed by HOLD mode.
- HOLD The thrust lever autothrottle servos are inhibited. The pilot can set the thrust levers manually.
- SPD The autothrottle maintains the selected speed displayed on the PFD. Speed can be set by the MCP IAS/MACH selector or by the FMC, as shown on the CDU CLIMB, CRUISE, or DESCENT page. The autothrottle will not exceed the operating speed limits or the thrust limits displayed on the EICAS.

Roll Modes

The roll modes are:

LNAV –

- LNAV (armed) LNAV is armed to engage when parameters are met.
- LNAV (engaged) LNAV engages if above 50 feet, and within 2 1/2 NM of the active route leg. The AFDS follows the active leg displayed on the ND.

HDG –

- HDG SEL (engaged) The airplane is turning to, or is on the heading selected in the MCP heading/track window.
- HDG HOLD (engaged) The AFDS holds the present heading. If turning, the AFDS holds the heading reached after rolling wings level.

TRK –

- TRK SEL (engaged) The airplane is turning to, or is on the track selected in the MCP heading/track window.
- TRK HOLD (engaged) The AFDS holds the present track. If turning, the AFDS holds the track reached after rolling wings level.

[Option – ATT Hold Engage]

ATT – (engaged) – When the autopilot is first engaged or the flight director is first turned on in flight, the AFDS holds a bank angle between 5 and 30 degrees and will not roll to wings level. If the bank angle is less than 5 degrees, the AFDS returns to wings level (HDG HOLD or TRK HOLD). If the bank angle is greater than 30 degrees, the AFDS returns to 30 degrees of bank

LOC –

- LOC (armed) The AFDS captures the localizer when within range and within 120 degrees of the localizer track.
- LOC (engaged) The AFDS follows the selected localizer course.

TO/GA –

- On the ground, TO/GA annunciates by positioning either flight director switch ON when both flight directors are OFF, or by pushing either TO/GA switch with airspeed greater than 80 KTS. TO/GA roll guidance becomes active at lift-off.
- In flight, TO/GA is armed when flaps are out of up or glideslope is captured. There is no flight mode annunciation for TO/GA armed. TO/GA is activated in flight by pushing a TO/GA switch. The roll steering indication provides guidance to maintain the ground track present at mode engagement.

ROLLOUT -

- ROLLOUT (armed) Displayed below 1500 feet radio altitude and engages below 2 feet.
- ROLLOUT (engaged) After touchdown, the AFDS uses rudder and nosewheel steering to keep the airplane on the localizer centerline.

Pitch Modes

The pitch modes are:

TO/GA -

On the ground, TO/GA annunciates by positioning either flight director switch ON when both flight directors are OFF, or by pushing either TO/GA switch with airspeed greater than 80 knots. The flight director PFD pitch bar indicates an initial pitch of eight degrees up.

After takeoff, the AFDS commands a pitch attitude to maintain:

- a target speed of V2 plus 15 knots
- if current airspeed remains above the target speed for 5 seconds, the target airspeed is reset to current airspeed, to a maximum of V2 plus 25 knots
- the IAS/MACH window speed if the IAS/MACH window speed is changed to a speed greater than the target speed.
- **Note:** The AFDS uses the speed set in the IAS/MACH window prior to takeoff for V2.

In flight, TO/GA is armed when flaps are out of up or glideslope is captured.

When a go-around is initiated, the commanded speed is the MCP IAS/MACH window or current airspeed, whichever is higher, to a maximum of the IAS/MACH window speed plus 25 knots. GA displays as the thrust limit on the primary EICAS engine display.

VNAV -

VNAV is armed by pushing the VNAV switch (the switch bar is displayed and VNAV is annunciated on the PFD pitch mode annunciator in small white characters below the current pitch mode).

VNAV engages above 400 feet after takeoff, if armed. VNAV engages in the appropriate VNAV mode as required to maintain the current flight path:

- VNAV SPD (engaged) The AFDS maintains the FMC speed displayed on the PFD airspeed indicator and/or the CDU CLIMB or DESCENT pages. If speed intervention is selected, the MCP IAS/MACH selector is used to manually select the speed.
- VNAV PTH (engaged) The AFDS maintains FMC altitude or descent path with pitch commands. If the MCP altitude window is set to the current cruise altitude as the airplane approaches the top of descent, the CDU scratchpad message RESET MCP ALT displays.

- VNAV ALT (engaged) When a conflict occurs between the VNAV profile and the MCP altitude, the airplane levels and the pitch flight mode annunciation becomes VNAV ALT. VNAV ALT maintains altitude. To continue the climb or descent, change the MCP altitude and push the altitude selector or change the pitch mode.
- If an early descent is desired, FLCH, V/S, or FPA may be selected to descend below the VNAV descent path. If, during the decent, VNAV is armed and the airplane descent path subsequently intercepts the VNAV descent path, VNAV engages in VNAV PTH.

V/S (engaged) – Pushing the MCP VS/FPA switch, opens the vertical speed window to display the current vertical speed. Pitch commands maintain the rate of climb or descent selected in the VS/FPA window.

FPA (engaged) – Pushing the MCP VS/FPA switch opens the flight path angle window to display the current flight path angle. Pitch commands maintain the flight path angle selected in the VS/FPA window.

FLCH SPD (engaged) – Pushing the MCP FLCH switch opens IAS/MACH window (if blanked). Pitch commands maintain IAS/MACH window airspeed or Mach.

ALT (engaged) – Altitude hold mode is engaged by:

- pushing the MCP altitude HOLD switch, or
- capturing the selected altitude from a V/S, FPA, or FLCH climb or descent.

G/S (engaged) – The AFDS follows the ILS glideslope.

FLARE (armed) – During an autoland, FLARE is displayed below 1500 feet RA.

FLARE (engaged) – During an autoland, flare engages between 60 and 40 feet radio altitude. FLARE accomplishes the autoland flare maneuver so the AFDS can transition to the ROLLOUT mode.

Autothrottle System

The autothrottle system provides automatic thrust control from takeoff through landing.

Autothrottle operation is controlled from the MCP and the CDUs. The MCP provides mode and speed selection. The CDU provides FMC thrust reference mode selection. When the VNAV mode is selected, the FMC selects the autothrottle modes and target thrust values. Refer to Chapter 11, Flight Management, Navigation, for FMS and CDU operation.

The autothrottle can be operated without using the flight director or the autopilot. In this condition, the autothrottle operates in either the THR REF, SPD, HOLD or IDLE modes.

When the autothrottle is used during a manual landing, thrust reduces to IDLE at 25 feet radio altitude when the flight director is off or the pitch mode is V/S, FPA, G/S, or any VNAV mode (VNAV SPD, VNAV PTH, or VNAV ALT). The autothrottle does not automatically retard if the pitch mode is TO/GA or FLCH.

With the autothrottle armed, the autothrottle automatically activates if:

- no autopilot or flight director active, or
- an autopilot or flight director is in VNAV XXX, FPA, ALT, V/S, or G/S,

and:

- speed less than an FMC calculated value for one second
- thrust below reference thrust
- airplane altitude above 100 feet RA on approach, or airplane barometric altitude 400 feet above airport on takeoff.
- **Note:** During a descent in VNAV SPD, the autothrottle may activate in HOLD mode and will not support stall protection.

The EICAS advisory message AUTOTHROTTLE L or R is displayed when the respective autothrottle servo fails. If the autothrottle is active and only one autothrottle is armed, the PFD autothrottle flight mode annunciation displays L or R preceding the mode. For example, L SPD indicates only the left autothrottle is active in speed mode.

Autothrottle Thrust Lever Operation

The autothrottle system moves either or both thrust levers to provide speed or thrust control, depending on the active mode.

The thrust levers can be manually positioned without disconnecting the autothrottle. After manual positioning, the autothrottle system repositions the thrust levers to comply with the active mode. The autothrottle system does not reposition the thrust levers while in HOLD mode.

Autothrottle Disconnect

The autothrottle system can be disconnected manually by pushing either thrust lever autothrottle disconnect switch, except during conditions that cause the autothrottle to automatically activate. The autothrottle can also be disconnected manually by positioning both A/T ARM switches to OFF, or individually by positioning the left or right A/T ARM switch to OFF. Positioning one or both A/T ARM switches to OFF prevents activation of all autothrottle modes for the affected autothrottle.

Autothrottle disconnect occurs automatically:

- if a fault in the active autothrottle mode is detected
- when either reverse thrust lever is raised to reverse idle

- if the thrust levers are overridden during a manual landing, after the autothrottle has begun to retard the thrust levers to idle
- when both engines are shut down.

The EICAS caution message AUTOTHROTTLE DISC is displayed and an aural alert sounds when the autothrottle is manually or automatically disconnected. The EICAS caution message and aural alert are inhibited if the disconnect occurs because of reverse thrust.

Automatic Flight Operations

Automatic Flight Takeoff and Climb

Takeoff is a flight director only function of the takeoff/go–around (TO/GA) mode. The autopilot may be engaged after takeoff.

During preflight:

- With the autopilot disengaged and both flight director switches OFF, engagement of TO/GA roll and pitch mode occurs when the first flight director switch is positioned ON.
- The PFD displays FLT DIR as the AFDS status and TO/GA as the pitch and roll flight mode annunciations.
- The pitch command is a fixed attitude (about eight degrees up).
- The roll command is wings level.

During takeoff prior to lift-off:

- With speed less than 50 KIAS, pushing a TO/GA switch activates the autothrottle in the thrust reference (THR REF) mode. The thrust levers advance to the selected thrust limit. If the autothrottle is not active by 50 knots, it cannot be activated until above 400 feet.
- At 80 knots, the autothrottle mode annunciation changes to HOLD.
- With speed greater than 80 knots, pushing a TO/GA switch disarms LNAV and VNAV.
- During takeoff, the FMC records the barometric altitude as the airplane accelerates through 100 knots. This altitude is used to engage VNAV, enable autothrottle activation (if not active), command acceleration for flap retraction, and set climb thrust if an altitude has been selected. Radio altitude is used for engagement of LNAV.

At lift-off:

- The pitch command target speed is V2 + 15. If current airspeed remains above the target speed for 5 seconds, the target airspeed is reset to current airspeed (limited to a maximum of V2 + 25).
- If an engine failure occurs on the ground, the pitch command target speed at lift-off is V2 or airspeed at lift-off, whichever is greater.
- The roll command maintains ground track.

After lift–off:

- If an engine failure occurs, the pitch command target speed is:
 - V2, if airspeed is below V2
 - existing speed, if airspeed is between V2 and V2 + 15
 - V2 + 15, if airspeed is above V2 + 15.
- If a TO/GA switch is pushed:
 - takeoff derates are removed
 - the autothrottle activates in THR REF.
- At 50 feet radio altitude, LNAV engages, if armed. Roll commands bank to track the active route.
- At 400 feet above runway elevation, VNAV engages, if armed. Pitch commands the current airspeed. The autothrottle sets the selected reference thrust and annunciates THR REF.
- At acceleration height, pitch commands speed to 5 knots below takeoff flap placard speed. As flaps are retracted, pitch commands an acceleration to 5 knots below the placard speed of the commanded flap position.
- When flaps are up, pitch commands an acceleration to VNAV climb speed. VNAV climb speed is the greater of:
 - VREF + 80 knots, or
 - speed transition associated with origin airport
- At thrust reduction point (either an altitude or a flap position), the FMC changes the thrust limit to the armed climb limit (CLB, CLB 1, or CLB 2).

The TO/GA mode is terminated by selecting any other pitch and roll mode; automatic LNAV/VNAV engage terminates TO/GA mode.

Automatic Flight Takeoff Profile



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 FMS. Using LNAV and VNAV ensures the most economical operation.

Other roll modes available are:

- heading hold (HDG HOLD)
- heading select (HDG SEL)

Other pitch modes available are:

- altitude hold (ALT)
- flight level change (FLCH SPD)
- track hold (TRK HOLD)
- track select (TRK SEL).
- vertical speed (V/S)
- flight path angle (FPA).

Profile illustrations show the use of LNAV and VNAV.

Automatic Flight Approach and Landing

The AFDS provides autopilot guidance for ILS approaches.

[Option – GS capture not inhibited before LOC capture] Pushing the APP switch arms localizer in roll mode and glideslope in pitch mode. Either localizer or glideslope can be captured first.

[Option – GS capture inhibited before LOC capture]

Pushing the APP switch arms localizer in roll mode and glideslope in pitch mode. Glideslope capture is inhibited until the localizer is captured.

Pushing the LOC switch arms the AFDS for localizer tracking. Descent on the localizer can be accomplished using VNAV, V/S, FLCH, or FPA pitch modes. The localizer mode cannot capture if the intercept angle exceeds 120 degrees. All other non-ILS approaches can be flown using LNAV and VNAV modes, or HDG SEL, TRK SEL, V/S, or FPA modes.

With a command speed of VREF+5 knots and landing flaps, there is sufficient wind and gust protection available with the autothrottle active. The autothrottle adjusts thrust quickly when the airspeed decreases below the command speed. The autothrottle decreases thrust slowly when the airspeed is more than the command speed. In turbulence, the result is that the thrust average is higher than necessary to keep the command speed. This causes the speed average to be more than the command speed.

Runway Alignment

Runway alignment is a submode of the approach mode. With crosswinds, the crab angle is reduced at touchdown. Runway alignment also compensates for a single engine approach.

For crosswinds requiring more than 10 degrees of crab angle, runway alignment occurs at 500 feet AGL. A sideslip of 5 degrees is established to reduce the crab angle. This configuration is maintained until touchdown. The airplane lands with the upwind wing low.

For crosswinds requiring a crab angle of between 5 and 10 degrees, an initial alignment occurs at 500 feet AGL, followed by a second alignment at 200 feet AGL. The initial alignment initiates a sideslip to reduce the crab angle to 5 degrees. This configuration is maintained to 200 feet AGL, where a second sideslip alignment increases the sideslip to further reduce the touchdown crab angle.

For crosswinds requiring a crab angle of less than 5 degrees, no runway alignment occurs until 200 feet AGL, where a sideslip is introduced to align the airplane with the runway.

If an engine fails prior to the approach, the AFDS introduces a sideslip at 1,300 feet AGL. This establishes a wings level configuration. If an engine fails during the approach, the wings level configuration is established when the engine failure is detected.

In the event of moderate or strong crosswinds from the side opposite the failed engine, no wings level sideslip is commanded, since the airplane is already banked into the wind.

Flare

The flare mode brings the airplane to a smooth automatic landing touchdown. The flare mode is not intended for single autopilot or flight director only operation.

Flare is armed when LAND 3 or LAND 2 is annunciated on the PFDs. At approximately 50 feet radio altitude, the autopilots start the flare maneuver. FLARE replaces the G/S pitch flight mode annunciation.

During flare:

- between 25 and 50 feet radio altitude, the autothrottle begins retarding the thrust levers to idle
- the PFD autothrottle annunciation changes from SPD to IDLE
- at touchdown, the FLARE annunciation is no longer displayed, and the nose is lowered to the runway.

Rollout

Rollout provides localizer centerline rollout guidance. Rollout is armed when LAND 3 or LAND 2 is annunciated on the PFDs.

At less than two feet radio altitude, rollout engages. ROLLOUT replaces the LOC roll mode annunciation.

The autopilot controls the rudder and nose wheel steering to keep the airplane on the localizer centerline.

During rollout, the autothrottle IDLE mode remains active until the autothrottle is disconnected.

Rollout guidance continues until the autopilots are disengaged.



Automatic Flight Approach Profile

Go-Around

TO/GA is armed when flaps are out of UP or glideslope is captured. The thrust limit changes to GA when flaps are extended out of UP, flaps are extended to landing position, or glideslope is captured. The thrust limit is locked in GA when flaps are in landing position or glideslope is captured.

Pushing either TO/GA switch activates a go-around. The mode remains active even if the airplane touches down while executing the go-around.

When the flight director switches are not on, pushing either TO/GA switch displays the flight director bars.

The TO/GA switches are inhibited when on the ground and enabled again when in the air for a go–around or touch and go.

With the first push of either TO/GA switch:

- the PFDs display roll and pitch guidance to fly the go-around
- the autothrottle activates in thrust (THR) mode for a 2,000 FPM climb
- the AFDS increases pitch to hold the selected speed as thrust increases
- if current airspeed remains above the target speed for 5 seconds, the target airspeed is reset to current airspeed, (to a maximum of the IAS/MACH window speed plus 25 knots).

[LNAV auto-engage option - requires AIMS 05]

- if an LNAV path is available, LNAV automatically arms and engages:
 - above 50 feet radio altitude when autopilot is not engaged, or
 - above 200 feet radio altitude when autopilot is engaged.
- **Note:** During go-around from a LAND 2 or LAND 3 approach, automatic LNAV engagement causes disconnect of autopilot rudder control. If executing an engine out missed approach with TAC inoperative, manual rudder control may be required to prevent large roll and yaw excursions.

With the second push of either TO/GA switch:

• the autothrottle activates in the thrust reference (THR REF) mode for full go-around thrust.

TO/GA level-off:

- at the selected altitude, the AFDS pitch mode changes to altitude hold (ALT)
- if altitude is captured, or if V/S or FPA is engaged, MCP speed is automatically set to:
 - the flap placard speed minus 5 knots
 - 250 knots if flaps are up, or
 - a speed value entered in the IAS/Mach window after TO/GA was pushed

[no LNAV auto-engage]

• go-around remains the engaged roll mode until another mode is selected.

[LNAV auto-engage option - requires AIMS 05]

• go-around remains the engaged roll mode until LNAV automatically engages or another mode is selected.

TO/GA mode termination:

- below 400 feet radio altitude, the AFDS remains in the go-around pitch and roll mode unless:
 - the autopilot is disconnected and both flight directors are turned off, or
 - LNAV automatically engages (after automatic LNAV engagement, a different roll mode can be selected)
- above 400 feet radio altitude, select a different MCP pitch or roll mode.



Automatic Flight Go–Around Profile

Automatic Flight Windshear Recovery

The AFDS provides windshear recovery guidance by means of the normal go–around pitch and roll modes. Go–around is engaged by pushing a TO/GA switch. The AFDS commands a pitch–up of 15 degrees or slightly below the pitch limit, whichever is lower.

As rate of climb increases, the AFDS transitions from pitch to airspeed control. The target airspeed is IAS/MACH window airspeed or current airspeed,

whichever is greater when TO/GA is engaged. If current airspeed remains above the selected speed for 5 seconds, the selected airspeed is reset to current airspeed, (to a maximum of the IAS/MACH window speed plus 25 knots).

If the autopilot is not engaged when go-around is initiated, the pilot must fly the windshear recovery following the flight director commands. If the autothrottle is not armed, the thrust levers must be advanced manually.

Flight Envelope Protection

There are three forms of flight envelope protection in the autopilot:

- stall protection
- overspeed protection
- roll envelope bank angle protection.

An AUTOPILOT caution message and roll or pitch mode failures alert the pilot if the envelope is exceeded, and the autopilot prevents further envelope violations.

Refer to Chapter 9, Flight Controls, for a description of flight envelope protection.

Automatic Flight EICAS Messages

The following EICAS messages can be displayed.

Message	Level	Aural	Condition
AUTOPILOT	Caution	Beeper	Autopilot is operating in a degraded mode. Engaged roll and/or pitch mode may have failed, or the autopilot has entered envelope protection.
[Option - siren or wailer]			
AUTOPILOT DISC	Warning	Siren	Autopilot has disconnected.
AUTOTHROTTLE DISC	Caution	Beeper	Both autothrottles have disconnected.
AUTOTHROTTLE L, R	Advisory		Affected autothrottle is OFF or has failed.
NO AUTOLAND	Caution	Beeper	Autoland is not available.
	Advisory		Message is a caution if fault occurs after LAND 3 or LAND 2 is annunciated, or approach has been selected but does not engage by 600 AGL. Message is an advisory if fault occurs before LAND 3 or LAND 2 is annunciated.
NO LAND 3	Caution	Beeper	Autoland system does not have
	Advisory		redundancy for triple channel autoland.
			Message is a caution if fault occurs after LAND 3 is annunciated. Message is an advisory if fault occurs before LAND 3 is annunciated.