DOCUMENT
GSM-AUS-AASA-AFC

DOCUMENT TITLE

AUTOMATIC FLIGHT CONTROL SYSTEMS (CASA ATPL)

CHAPTER 8 – AUTOFLIGHT OPERATION

Version 1.0
October 2014

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INTRODUCTION

This Chapter illustrates the operation of an automatic flight control system and the relationship of the Flight Directors, Autopilots and Autothrottle during a normal flight profile leading to an autoland. The example aircraft used is the B767.

PREPARATION FOR FLIGHT

During pre-flight the flight planned route and airways clearance will be entered into the Flight Management System (FMS) using the Control and Display Unit (CDU). This will provide route waypoints for automatic navigation and calculate the most economical climb cruise and descent profiles. Refer to Figure 8-1.

Figure 8-1 Control and Display Unit (CDU)

The Thrust Mode Select Panel (TMS) is used to set the thrust limit for take-off. Pushing T/O will provide the maximum limit, however a reduced thrust take-off limit may be computed by entering the assumed temperature with the TEMP SEL control which is shown in degrees Celsius on the EICAS primary display. The autothrottle cannot increase thrust above the limits selected on this panel. Refer to Figure 8-2.

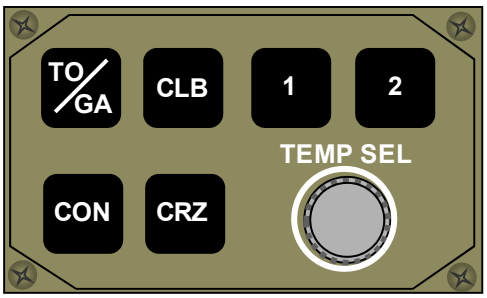


Figure 8-2 Thrust Mode Select Panel (TMS)

Mode Selections

Most of the Mode selections and other controls for the Flight Directors, Autopilots and Autothrottle are located on the Mode Control Panel. Refer to Figure 8-3.

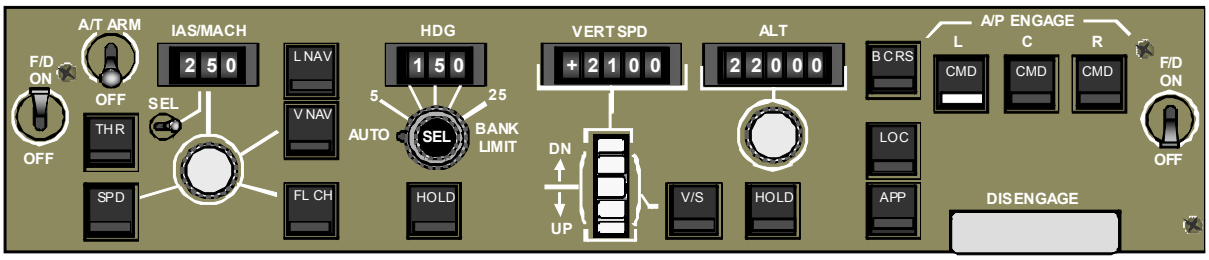


Figure 8-3 Mode Control Panel (MCP)

The Autopilots have disengage switches on the control columns and the Autothrottle has controls on the thrust levers. Refer to figure 8-4.

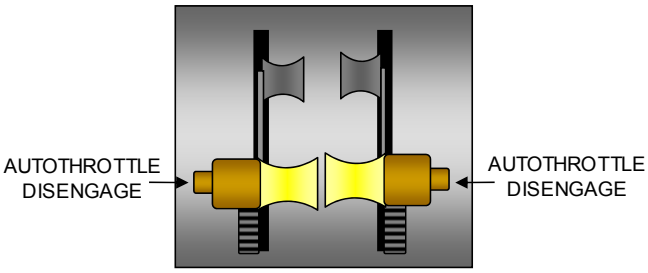


Figure 8-4 Thrust Levers

Mode and Status Indications

The Flight Director, Autopilot and Autothrottle modes are displayed on the Flight Mode Annunciator at the top of the EADI. Modes in green are ENGAGED and modes in white are ARMED. Refer to Figure 8-5

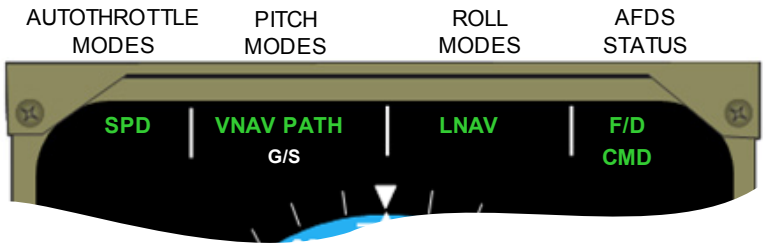


Figure 8-5 Electronic Attitude Direction Indicator (EADI)

During autoland the serviceability of the autoland systems is displayed. Refer to Figure 8-6.

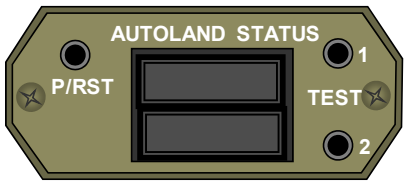
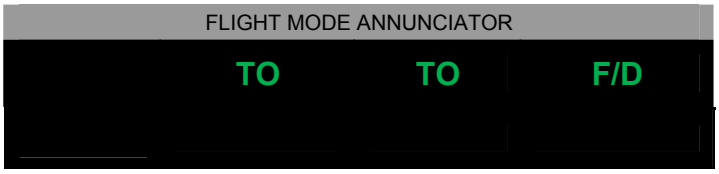


Figure 8-6 Autoland Status Annunciator (ASI)

LINEUP FOR TAKE-OFF

Flight Directors ON, Autothrottle ARMED, Autopilots OFF

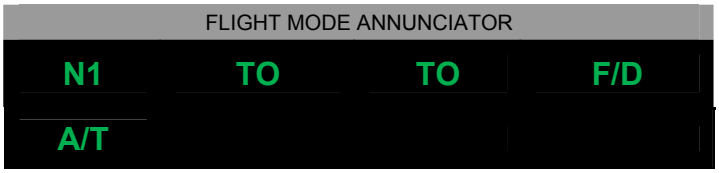
With Flight Directors ON the command bars will appear ready for the take-off. Pitch command bar at 8° nose up and roll command bar centred.



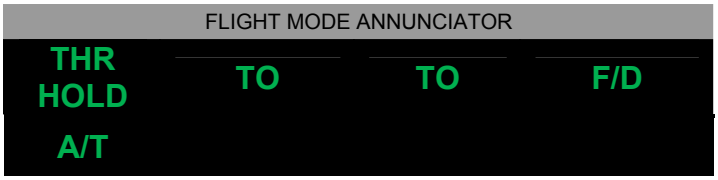
TAKE-OFF AND CLIMBOUT

Begin advancing the thrust levers ensuring an even engine response and;

PUSH N1 – autothrottle ENGAGES and advances thrust levers to reference (take-off) thrust.



At 80 kts autothrottle mode N1 changes to THR HOLD.



Aircraft is manually flown by the pilot following the Flight Director commands. At lift-off the pitch command bar will increase to about 17° nose up and the roll command bar will maintain ground track.

The aircraft must be manually flown following the Flight Director command bars until above 400 ft AGL at which time an autopilot may be engaged.

The autothrottle remains in THR HOLD until:

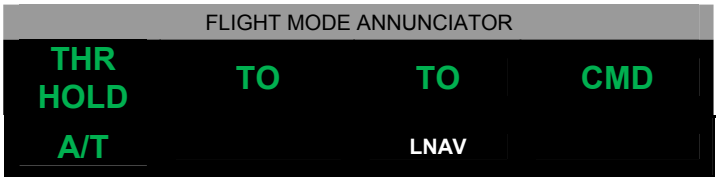
- A pitch mode is selected;
- An autothrottle mode is selected; or
- A thrust reference change is made.

The autothrottle then sets climb thrust or the selected reference thrust.

After 400 ft AGL an autopilot and other pitch and roll modes may be engaged.

PUSH A/P – the selected autopilot is in CMD and controlling the aircraft. Typically if the Captain is flying the LEFT autopilot is selected, the RIGHT if the F/O is flying.

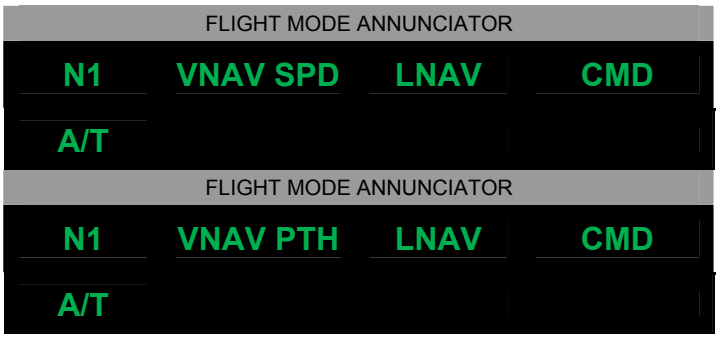
PUSH LNAV – LNAV mode is ARMED and is ready to intercept the first programmed track.



When the programmed track is intercepted LNAV ENGAGES and turns the aircraft.

By approximately 1000 ft the CLB selection should be made on the Thrust Mode Select Panel.

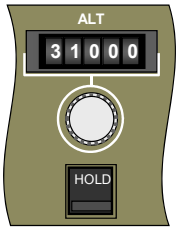
PUSH VNAV – VNAV allows the Flight Management Computer to take control of the climb profile using pitch and autothrottle. VNAV mode will automatically satisfy any climb restrictions entered into the FMC. VNAV will engage in and may alternate between either VNAV SPD or VNAV PTH.



- *If* **VNAV SPD** *displays the pitch mode follows a speed set by* the FMC and the A/T uses the thrust reference from the TMSP.
- *If* **VNAV PTH** *displays the pitch mode follows a vertical path created by the FMC and the A/T receives thrust adjustments from the FMC.*

CLIMB

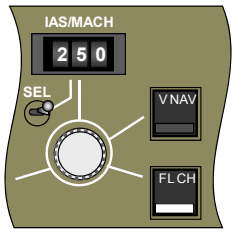
When clearance is given to cruise altitude the pilot sets the ALT window on the Mode Control Panel for altitude alerting and level off.



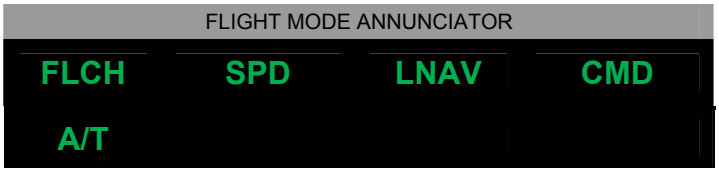
In **VNAV** the aircraft is climbing at the most economical profile of speed and thrust as determined by the Flight Management Computer and the selections made on the Thrust Mode Select Panel.

Variations to this profile may occur due to new ATC restrictions or climb requirements. In this case the pilot can take control from VNAV as follows:

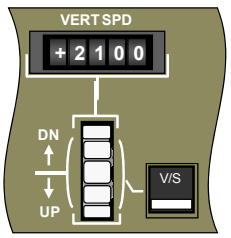
- To climb at a **specific speed.**



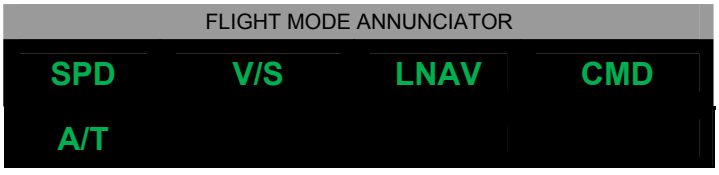
PUSH FLCH and set the speed required in the IAS/MACH window. This mode will ignore any speed or climb restraints that VNAV would have followed from the FMS.



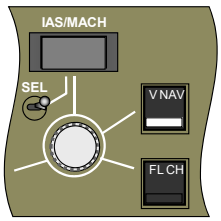
- To climb at a **specific rate of climb**.



PUSH V/S and set the rate of climb required in the VERT SPD window. This mode will ignore any speed or climb restraints that VNAV would have followed from the FMS.



To resume the **climb profile from the Flight Management Computer**



PUSH VNAV - VNAV allows the Flight Management System to take control of the climb profile using pitch and autothrottle. VNAV will engage in and may alternate between either VNAV SPD or VNAV PTH

FLIGHT MODE ANNUNCIATOR			
N1	VNAV SPD	LNAV	CMD
A/T			

The aircraft is approaching top of climb and the aircraft will capture the lowest altitude of the programmed FMS level or the level set in the MCP window. (Which should be the same).

CRUISE

Approaching the altitude level as described above, VNAV commands a level off.

ALT CAP will replace the VNAV mode.

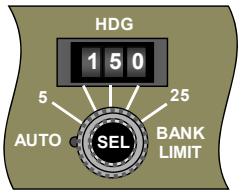
FLIGHT MODE ANNUNCIATOR			
SPD	ALT CAP	LNAV	CMD
A/T			

When stabilised at the programmed cruise altitude and the economical cruise speed is established **VNAV PTH** is displayed.

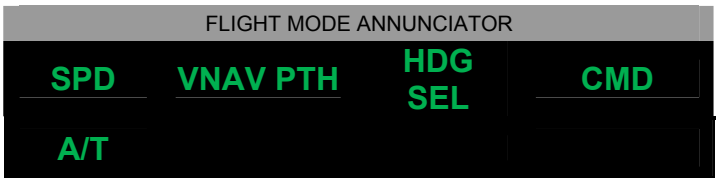
FLIGHT MODE ANNUNCIATOR			
SPD	VNAV PTH	LNAV	CMD
A/T			

Variations to the lateral route may occur due to new ATC restrictions or course change requirements. In this case the pilot can take control from LNAV as follows:

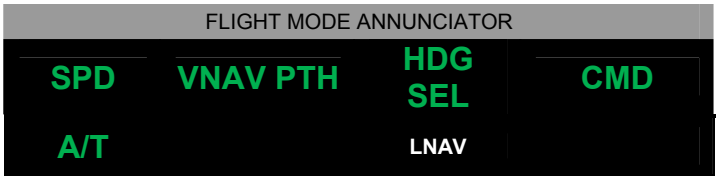
To deviate from the programmed track to a **specific heading**
SET the desired heading in the HEADING window.



PUSH HDG SEL– AFDS controls roll to acquire and then hold the heading shown in the window.



To resume **programmed track.**
SET an intercept heading in the HEADING window.
PUSH LNAV – LNAV is ARMED to capture.



LNAV will capture when with capture limits and turn the aircraft onto the programmed track

DESCENT

Assuming the expected approach is programmed into the FMS a descent clearance should be obtained before the actual descent point. The pilot sets the ALT window on the Mode Control Panel for descent altitude.

At the programmed descent point the throttles will close and VNAV commands a descent.

The standard VNAV descent path is calculated on passing over waypoints complying with altitude restrictions, using idle thrust, speed brakes retracted, an appropriate speed and windspeeds that decrease with altitude.

If unexpected headwinds occur the autothrottle will advance thrust to maintain target speed on the descent path.

If unexpected tailwinds occur a message is displayed, “DRAG REQUIRED” at which time the pilot should deploy speed brake manually.

APPROACH CAPABILITY

The B767 Autopilot system provides automatic flying of the following types of approach:

- Precision approaches to ILS Cat I, Cat II, Cat IIIA and Cat IIIB weather minimums; or
- Non-precision approaches using LNAV and VNAV, LOC or B/CRS.

The B767 Flight Director system provides steering commands for manual flying of:

- Precision approaches to ILS Cat I and Cat II weather minimums; or
- Non-precision approaches using LNAV and VNAV, LOC or B/CRS.

The B767 Autothrottle system provides thrust control for all of the above conditions.

NOTE

A normal part of an approach procedure is to set the missed approach altitude in the MCP altitude window as the aircraft passes over the outer marker. This does not affect the autoland sequence but will be used as the target height in the go-around sequence if performed.

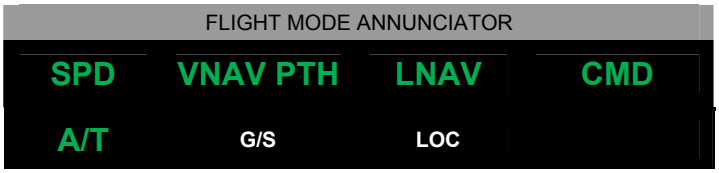
If a non-precision approach is conducted VNAV mode will fly the aircraft to a point 50 feet above the approach end of the runway. At some point on the VNAV path the pilot should have taken control from the autopilot to land the aircraft.

If VNAV is still engaged at 50 feet the autopilot will automatically begin a climb to the missed approach altitude using climb thrust.

If a precision approach is conducted VNAV mode is disengaged by pushing the APP switch.

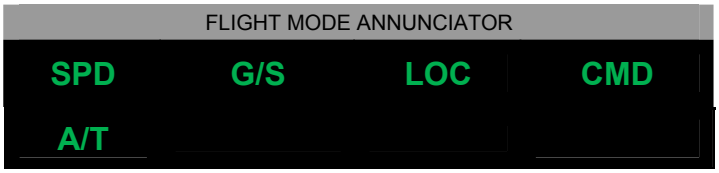
APPROACH

PUSH APP – this prepares the aircraft to intercept the ILS localizer and glideslope beams.
LOC mode is ARMED
G/S mode is ARMED
Remaining A/Ps ARMED

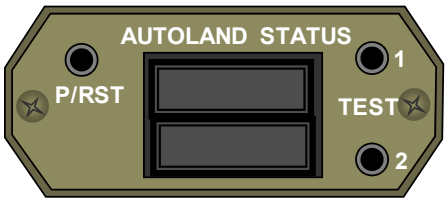


The localizer is captured, LNAV mode disengaged and LOC mode becomes engaged – aircraft turns towards threshold - altitude is maintained.

The glideslope is captured, VNAV mode is disengaged and G/S mode becomes engaged – descent begins to the threshold.



Remaining A/Ps ARMED – For the autopilots to ENGAGE the G/S and LOC must be captured and the aircraft to be below 1500 FT Radio Altitude.



AUTO LANDING

Autoland Submodes

There are three submodes that occur during an autolanding. They are:

- Runway Alignment and Asymmetric Thrust Compensation
- Flare
- Rollout.

Runway Alignment and Asymmetric Thrust Compensation

The AFDS controls the rudder during the autoland sequence and will slip the aircraft to reduce the crab angle in crosswind conditions. It will also compensate for engine-out asymmetric thrust conditions. This sub mode is not displayed to the pilot.

Flare

The flare submode brings the aircraft to a smooth automatic landing touchdown at a rate of two feet per second. This submode is displayed when armed and engaged.

Rollout

The rollout submode provides centreline steering after touchdown using rudder and nosewheel steering. This submode is displayed when armed and engaged.

These submodes are multi-autopilot modes designed as part of the autoland sequence. They are not intended for a single autopilot, or flight director only operation. The following diagram illustrates the vertical profile the aircraft will follow for the autoland sequence. Refer to Figure 8-7.

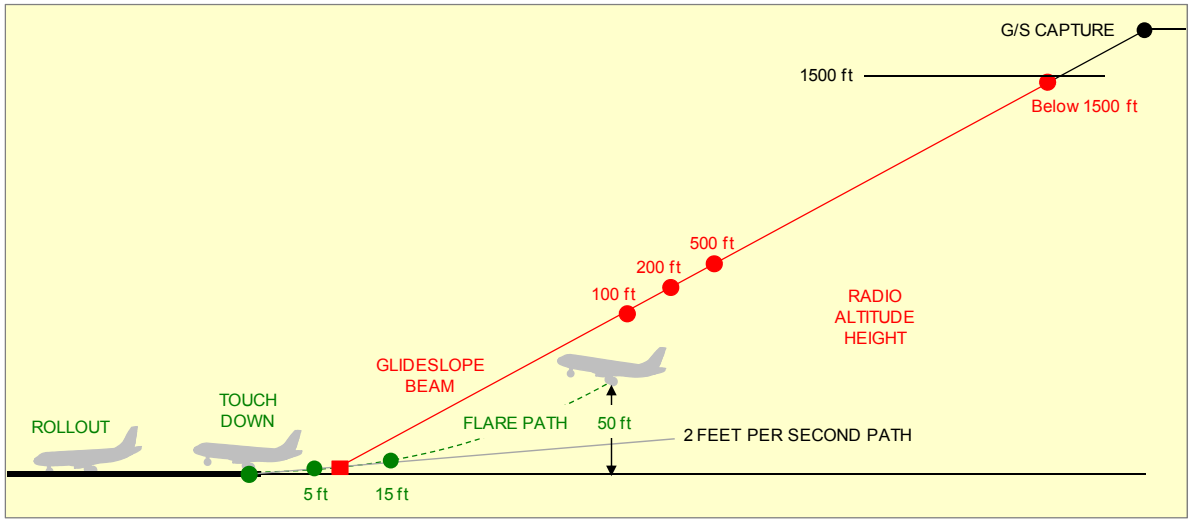
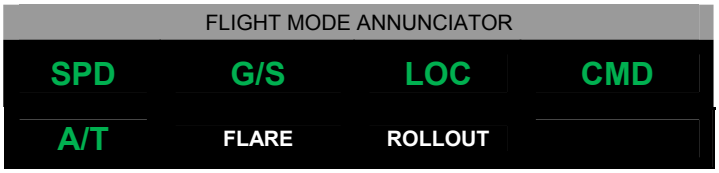
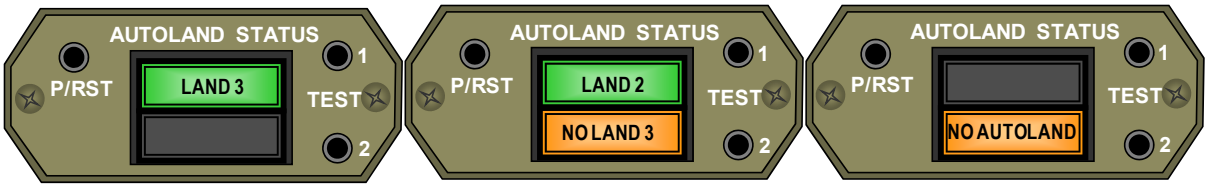


Figure 8-7 Autoland Vertical Profile

Once the aircraft is below 1500 FT radio altitude – the aircraft prepares to autoland.
FLARE mode is ARMED
ROLLOUT mode is ARMED



Remaining A/Ps, if serviceable, become ENGAGED. Autopilot status is displayed to the pilots.



1. **LAND 3**. - three autopilots engaged and operating normally for an automatic landing – a Fail Operational system.
2. **LAND 2**. - AFDS redundancy reduced, only two autopilots are available so **NO LAND 3** is displayed. – a Fail Passive System.

With LAND 3 or LAND 2 displayed the A/P takes control of the rudder.

LAND 3 or LAND 2 must be displayed to engage the next submodes, FLARE and ROLLOUT.

3. **NO AUTOLAND** – AFDS is unable to make an automatic landing.

If NO AUTOLAND is displayed a manual landing will have to be made by the pilot using Category II weather minima or the pilot may choose to divert to an alternate airfield.

If at anytime the NO AUTOLAND is displayed during the approach a go-around may be performed using the single autopilot or flight director only.

At 500 FT Radio Altitude

The runway alignment and asymmetric thrust compensation submode becomes engaged – it is not displayed to the pilot.

This submode provides two functions:

- To reduce the crab angle before touchdown caused by crosswind on the approach
- Automatic rudder compensation for an asymmetric thrust condition should an engine failure occur.

At 200 FT Radio Altitude

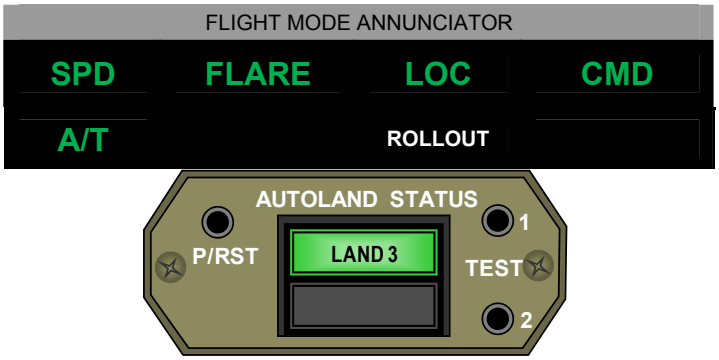
The display of NO LAND 3 is inhibited however, NO AUTOLAND can still be displayed.

100 FT Radio Altitude (LAND 2 only)

If LAND 2 is displayed (fail passive) the autotrim system trims the aircraft nose up in preparation for flare. The elevators maintain the glideslope. There is no display to the pilot.

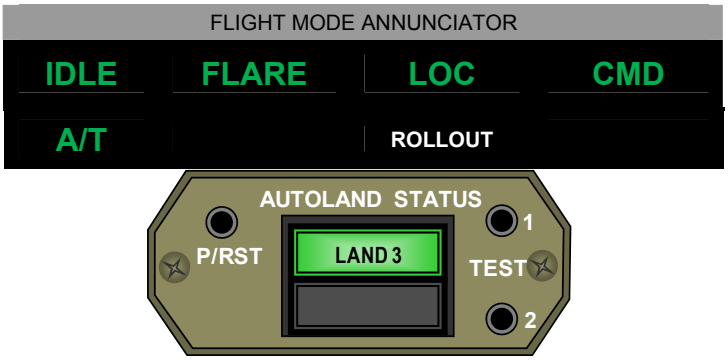
At approximately 50 FT Radio Altitude

The FLARE submode becomes engaged – G/S mode is disengaged.



At approximately 15 FT Radio Altitude

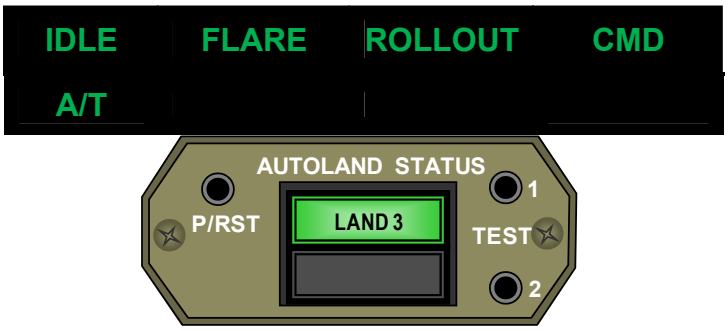
The IDLE mode becomes active – SPD is disengaged and thrust is reduced to IDLE.



At approximately 5 FT Radio Altitude

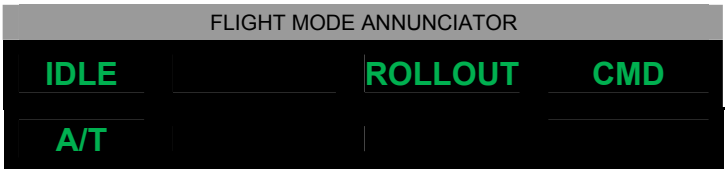
The ROLLOUT mode becomes engaged - LOC mode is disengaged.

If any slip exists due to runway alignment submode, wings are levelled

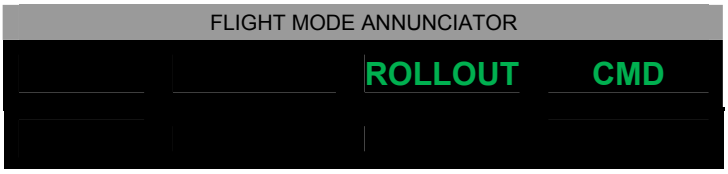


At touchdown

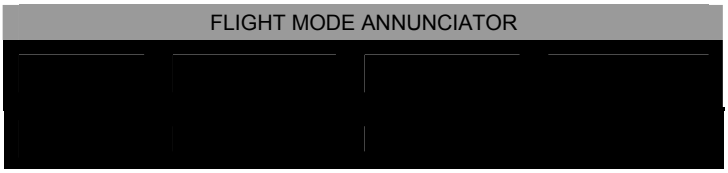
FLARE disappears.



The A/T maintains idle until disengaged. Selecting reverse thrust will automatically disengage the A/T.



The AFDS maintains the localiser centreline by autopilot control of the rudder and nosewheel steering until the aircraft comes to a complete stop or the A/Ps are disengaged.



GO-AROUND

A fully automatic GA is a pitch mode, a roll mode and an autothrottle mode. The go-around mode can only be activated if it is ARMED. The GA mode is not displayed when ARMED.

The GA mode:

- Is ARMED when the glideslope is captured OR anytime the flaps are not UP
- Is DISARMED at 2 seconds after the aircraft has passed through 5 feet radio altitude
- Is ENGAGED by pressing either GA button located on the thrust levers
- Will remain ENGAGED even if the aircraft touches down during the go-around manoeuvre.

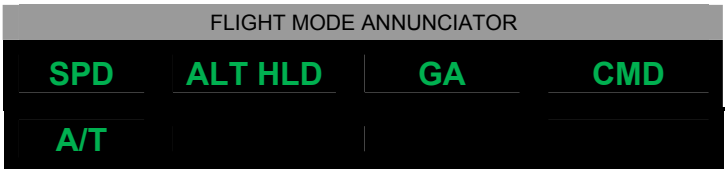
PUSH GA SWITCH - either switch (on the thrust levers).

The Thrust Management Computer (TMC) changes its maximum thrust reference to GA thrust.

Thrust is increased to establish a climb rate of 2,000 feet per minute at the speed described next. At the selected level off altitude, the autothrottle mode changes to **SPD**.

Pitch is increased to hold the highest of the existing speed or the speed shown in the MCP speed window. Approaching the level off altitude the pitch mode changes to **ALT CAP** and then to **ALT HOLD** when captured.

Roll maintains the current ground track. At the selected level off altitude It will remain as the roll mode until another roll mode is selected. All three autopilots are still ENGAGED.



Terminating the GA Mode

When the aircraft has levelled off at the selected altitude, the pilot can terminate the GA mode by selecting other appropriate pitch and roll AFDS modes. This will automatically cease multi-autopilot operation resulting in single autopilot only operation.

NOTE

If the multi-autopilot go-around was compensating for an asymmetric thrust condition, when terminated, the rudder will revert to the trimmed position unless the pilot is ready to apply the required force to maintain the existing rudder position.

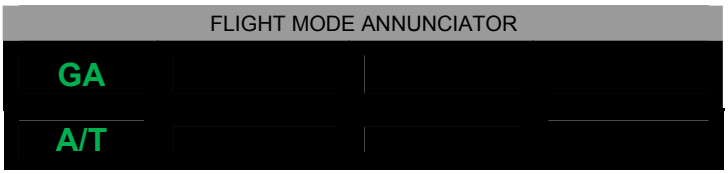
The GA mode may be terminated early by the pilot and depending on the aircraft's radio altitude the following actions are required. Refer to Figure 8-8.

Terminating GA below 400 ft RA

DISENGAGE - autopilots

TURN OFF - both Flight Directors.

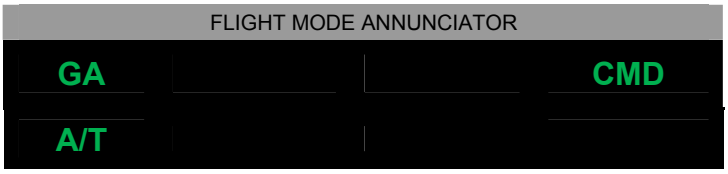
Fly the aircraft manually. If the flaps are still in the landing range (25 or 30) the autothrottle will remain ENGAGED and increase thrust to GA reference thrust unless it is disengaged. It will reduce thrust if a flap limit speed is reached.



Terminating GA above 400 ft RA

SELECT - a different roll or pitch mode.

All autopilots, except the first one that was placed in CMD will disengage. Single autopilot will follow new selected mode(s).



Refer to Figure 8-8.

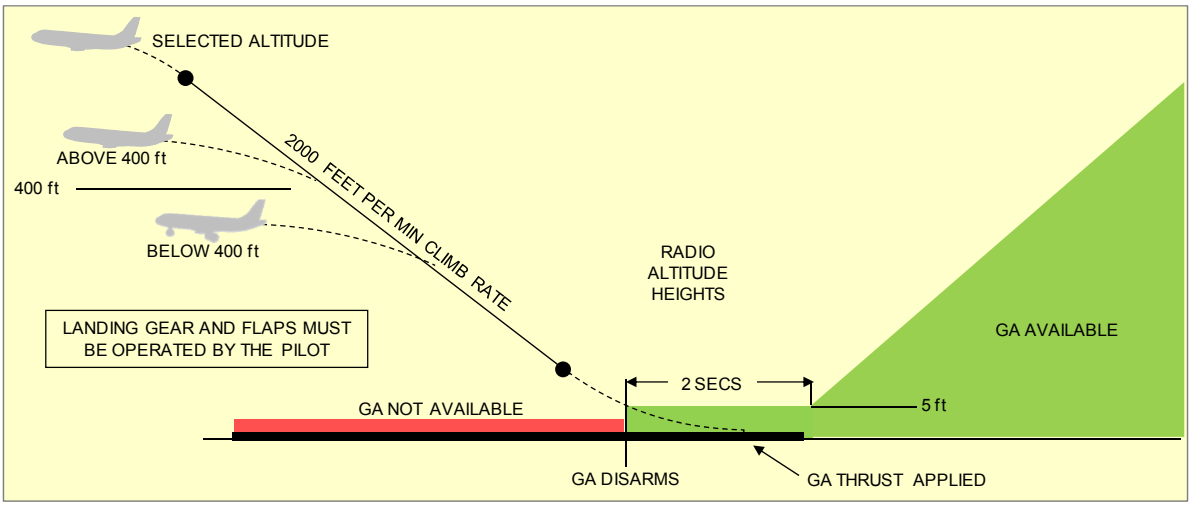


Figure 8-8 Go-around Vertical Profile