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**AUTOMATIC FLIGHT CONTROL SYSTEMS (CASA ATPL)**  
**CHAPTER 4 – AUTOTHROTTLE**

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<b>CONTENTS .....</b>	<b>PAGE</b>
<b>INTRODUCTION.....</b>	<b>3</b>
<b>B767 AUTOTHROTTLE .....</b>	<b>3</b>
<b>AUTOTHROTTLE MODES .....</b>	<b>6</b>
<b>B767 AUTOTHROTTLE MODES .....</b>	<b>11</b>
<b>TYPICAL USE OF AUTOTHROTTLE MODES .....</b>	<b>13</b>

## **INTRODUCTION**

The autothrottle is a full time system which provides automatic thrust control from the start of the take-off roll through climb, cruise, descent, approach and landing or go-around.

Autothrottle operation is controlled by the pilot and the Flight Management Computer (FMC) to achieve specific thrust settings or specific aircraft speeds.

A Thrust Management Computer controls the movement of the thrust levers or the engine thrust control. In Boeing aircraft the thrust levers move when the autothrottle is operating and in Airbus aircraft they do not.

Generally speaking the following statements apply to autothrottle systems:

- The autothrottle can be operated without using the flight director or autopilot systems.
- The autothrottle system cannot control reverse thrust operation.
- The autothrottle cannot automatically reduce thrust for an aborted take-off.
- The autothrottle can be overridden at any time by physically operating the thrust levers.
- Manually positioning the thrust levers does not disengage the autothrottle.

## **B767 AUTOTHROTTLE**

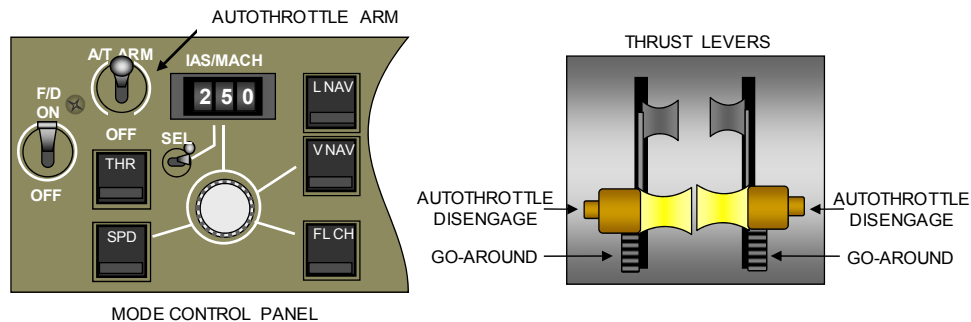
Because of the differences in autothrottle systems this Chapter will focus only on the system fitted to the Boeing 767. This is the recommended aircraft for study by the CASA syllabus.

The B767 autothrottle system consists of the following components and indications:

- Control switches on the Mode Control Panel (MCP)
- Control switches on the Thrust Levers
- A Thrust Mode Select Panel (TMSP)
- A section of the Flight Mode Annunciator (FMA) on both Electronic Attitude Direction Indicators (EADIs)
- An electrically operated servo system to operate the thrust levers
- Failure annunciators
- A single Thrust Management Computer (TMC).

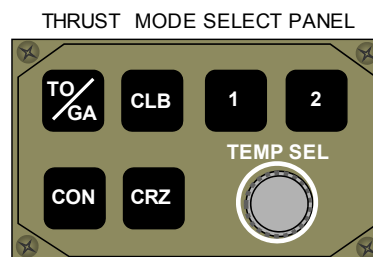
### Control Switches

The controlling switches for the autothrottle are located on the Mode Control Panel (MCP), and the thrust levers. Refer to Figure 4-1.



**Figure 4-1 Autothrottle Controls**

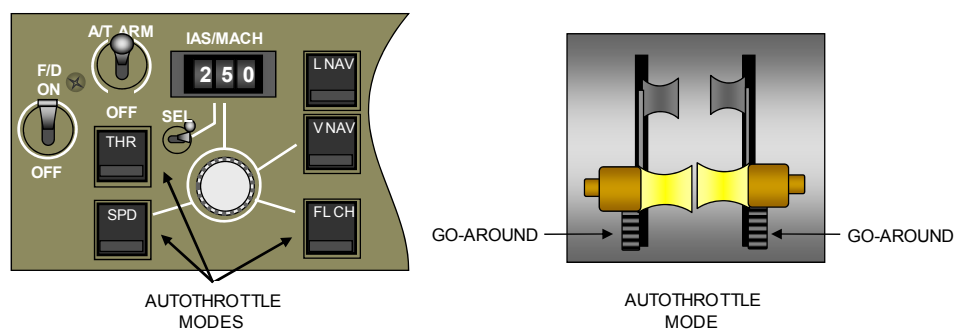
A Thrust Mode Select Panel located on the centre instrument panel allows selections of autothrottle reference thrust. Refer to Figure 4-2.



**Figure 4-2 Thrust Mode Select Panel**

### Autothrottle Engagement

The auto throttle arming switch, A/T ARM, only arms the autothrottle. To engage the autothrottle a selection of an autothrottle mode switch must be made. Refer to Figure 4-3.



**Figure 4-3 Autothrottle Mode Controls**

## Autothrottle Disengagement

The autothrottle can be disengaged manually by:

- Positioning the A/T ARM switch on the Mode Control Panel to OFF; or
- By pushing either autothrottle disengage switch on the thrust levers.

The autothrottle will disengage automatically when:

- A fault is detected in the operating mode; or
- Either reverse thrust lever is moved to the reverse idle position.

A manual or automatic disengagement will cause:

- An annunciator light to illuminate
- An EICAS caution message “AUTOTHROT DISC” to appear
- An aural beeper to sound.

If the autothrottle was disconnected by the disengage switches on the thrust levers a second push will cancel the cautions. Refer to Figure 4-4.



**Figure 4-4 Autothrottle Disengagement**

## AUTOTHROTTLE MODES

Similar to the autopilot the autothrottle system has modes of operation. The Thrust Management Computer (TMC) controls thrust based on data inputs of airspeed and engine thrust.

Depending on the mode that is engaged the thrust levers are set for **ENGINE THRUST**, **AIRCRAFT SPEED** or **PILOT CONTROL**.

### Engine Thrust

A reference thrust is selected by the pilot via the Flight Management System or a separate thrust mode select panel. When engaged the autothrottle will advance to and maintain the reference thrust. The reference thrust may be one of the following:

- Maximum take-off or go-around thrust
- Reduced take-off thrust
- Maximum climb thrust
- Reduced or derated climb thrust
- Cruise thrust; or
- Maximum continuous thrust.

The autothrottle will never go beyond the reference thrust or other maximum engine limitations such as EGT or RPM.

The autothrottle may decrease automatically from the reference thrust if a flap, gear or aircraft speed limit is reached.

Depending on the selection, the actual value of the reference thrust is determined by computation based on the current conditions of temperature, altitude, bleed air use and weight.

### Aircraft Speed

The pilot or the Flight Management System can select a reference speed for the aircraft. When engaged the autothrottle will advance or reduce thrust to maintain the reference speed.

The autothrottle will never advance beyond the current reference thrust or reduce below flight idle thrust.

The autothrottle may decrease automatically from the reference speed if a flap, gear or aircraft speed limit is reached.

## Pilot Control

As previously stated the pilot can always override the autothrottle when it is engaged. However, once the pilot removes his or her hands from the thrust levers the autothrottle will change the thrust attempting to satisfy the reference thrust or speed.

One particular mode of the autothrottle allows the pilot to have control of the thrust levers (if required) during take-off. The autothrottle is still engaged but it cannot move the thrust levers or change the thrust setting.

The autothrottle will remain this way until the pilot selects another autothrottle mode. It is referred to as “Thrust Hold”.

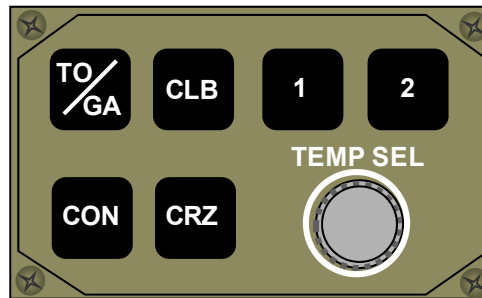
This mode automatically occurs at approximately 80 kts Ground Speed (GS) during the take-off roll. By the time 80 kts GS is reached the autothrottle will have set the take-off reference thrust.

This mode is designed so the pilot can have total control of the thrust levers. The pilot may have to abort, or make small adjustments to thrust settings. The autothrottle cannot interfere with the pilot settings.

### Thrust Mode Select Panel (TMSP)







The thrust mode select panel is located on the centre instrument panel. It is used to set the reference thrust for the autothrottle for the conditions of Take-off, Go-around, Climb, Cruise and Maximum Continuous Thrust.

Some selections are inhibited when VNAV is engaged. Refer to Figure 4-5 and 4-6.



**Figure 4-5 Thrust Mode Select Panel (TMSP)**

### Thrust Mode Selections

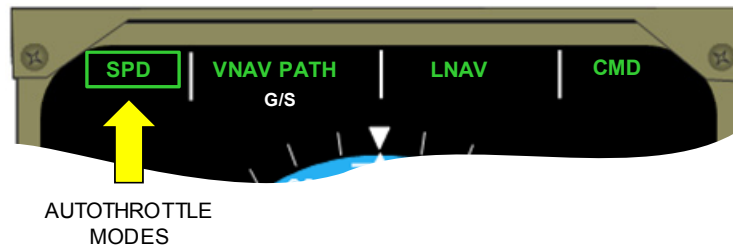
	On Ground - Selects take-off thrust limit which is the reference thrust.  In Flight - Selects go-around thrust limit which is the reference thrust.	With VNAV engaged GA selection is inhibited. Cancels selected assumed temperature and preselected CLB 1 or 2.
	Selects maximum climb thrust limit as the reference thrust.  Selects preselected derated 1 or 2 thrust as the reference thrust.	With VNAV engaged CLB selection is inhibited.
	Preselects one of two fixed derated climb thrusts. 8% and 16% derates.	Derated modes are inhibited above 12,500 ft
	Selects maximum cruise thrust as the reference thrust.	
	Selects maximum continuous thrust as the reference thrust.	With VNAV engaged CON selection is inhibited.
	Selects an assumed temperature reduced thrust for take-off as the reference thrust.  The selected temperature appears on the primary EICAS screen	Maximum of 25% assumed temperature reduced thrust

**Figure 4-6 Thrust Mode Select Panel**



### Mode Annunciator

Autothrottle engaged modes are displayed on the left hand side of the Electronic Attitude Direction Indicator (EADI) Flight Mode Annunciator (FMA). Mode changes are emphasized for 10 seconds with a green box. Refer to Figure 5-4.



**Figure 5-4 Flight Mode Annunciator**

### Thrust Lever Operation

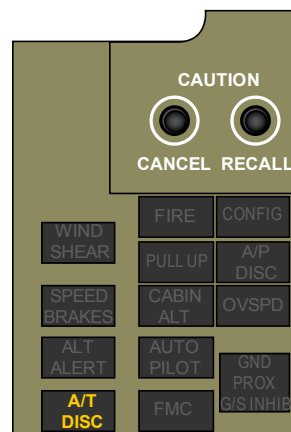
The autothrottle system, using electric motors, move both thrust levers together, maintaining their relative positions. The autothrottle can be overridden manually at any time by physically operating the thrust levers.

Manually positioning the thrust levers does not disengage the auto throttle.

Following manual positioning, the autothrottle system may reposition the thrust levers to comply with computed thrust requirements, except when in THR HOLD mode.

### Failure Annunciation

When a failure occurs the autothrottle system will automatically disconnect and illuminate the A/T DISC annunciator light on the discrete annunciator panel located on the forward instrument panel. An alert will also appear on the EICAS. This light also appears for any normal disconnect made by the pilot. Refer to Figure 5-5.



**Figure 5-5 Discrete Annunciator Panel**

### Thrust Management Computer (TMC)

The thrust management computer exercises primary control of the autothrottle system.

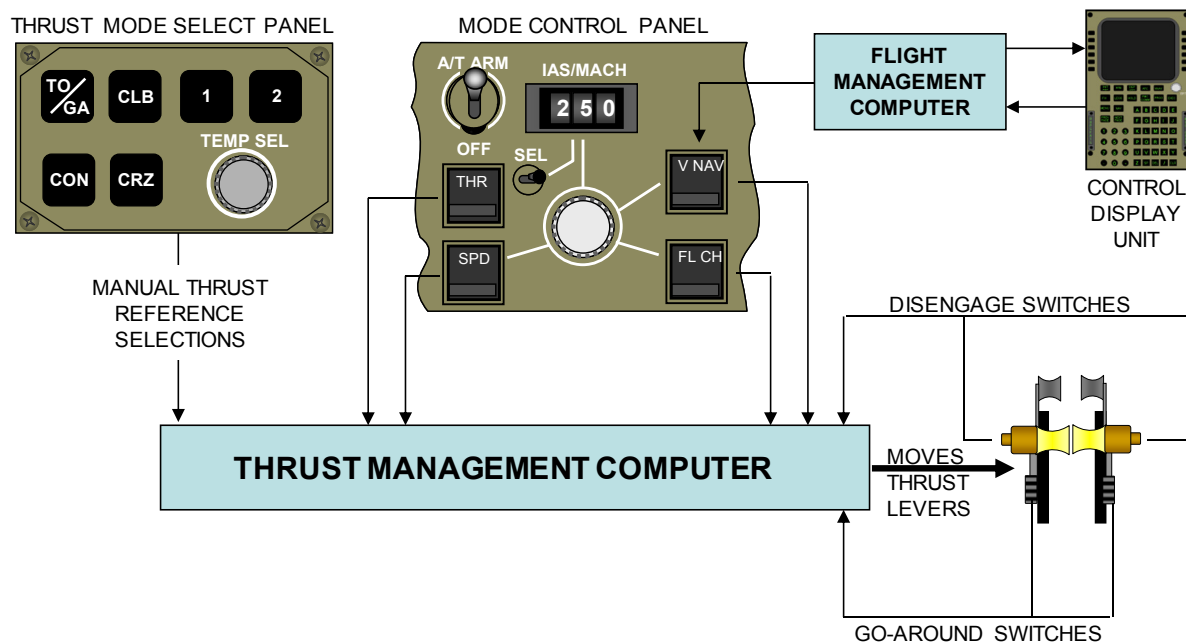
It operates the autothrottle in response to:

- Manual thrust reference selections made from the Thrust Mode Select Panel;
- Manual mode requests from the pilot made on the Mode Control Panel (MCP);
- Automatic mode requests from the Flight Management Computer (FMC) when VNAV mode is engaged; or
- A go-around request from the pilot made with the thrust lever switches.

The basic functions of the Thrust Management Computer (TMC) are to:

- Calculate thrust limits and thrust settings
- Follow thrust settings from the Flight Management Computer (FMC)
- Detect and transmit autothrottle failures
- Actuate the thrust levers.

Refer to Figure 5-6.



**Figure 5-6 B767 Autothrottle System**

## B767 AUTOTHROTTLE MODES

The B767 autothrottle system provides not only normal operating modes but some protection or limit modes as well. Refer to Figures 5-7 and 5-8.

### Autothrottle Normal Modes



Once ARMED the autothrottle can be ENGAGED in one of the following modes. Each EADI displays the ENGAGED mode.

SWITCH	ENGAGED MODE DISPLAYED	NORMAL OPERATION
	<b>EPR</b>	Autothrottle controlling to the selected reference thrust.
	<b>N1</b>	Depending on engines fitted there are three choices of switch names. RR and P&W use EPR, GE uses N1 and THR may be used for either.
	<b>THR</b>	All switches perform the same operation
	<b>SPD</b>	Autothrottle controlling thrust to maintain the speed selected in the speed window,
THRUST MANAGEMENT COMPUTER	<b>SPD</b>	VNAV mode engaged, the speed as programmed by the Flight Management Computer
	<b>FL CH</b>	Autothrottle controlling to a maximum of the selected mode reference thrust during climb and to a minimum N1 during descent
THRUST MANAGEMENT COMPUTER	<b>IDLE</b>	Autothrottle is reducing or has reduced thrust to flight idle. It may engage in a VNAV descent. It will engage when FLARE is engaged
 EITHER GO-AROUND SWITCH ON THE THRUST LEVERS	<b>GA</b>	Only becomes available when flap is away from UP or ILS glideslope is captured. Autothrottle controlling to a maximum of the go-around reference thrust to maintain a climb rate of at least 2000 fpm with GA displayed as the pitch mode If both Flight Directors and the autopilots are off the autothrottle controls to the GA reference thrust subject to flap and VMO limit speeds
> 80 KTS GS DURING TAKE-OFF or MANUAL POSITIONING OF THRUST LEVERS	<b>THR HOLD</b>	Thrust levers remain in their existing positions OR where manually placed.

**Figure 5-7 Normal Autothrottle Modes**

### Autothrottle Limit Modes

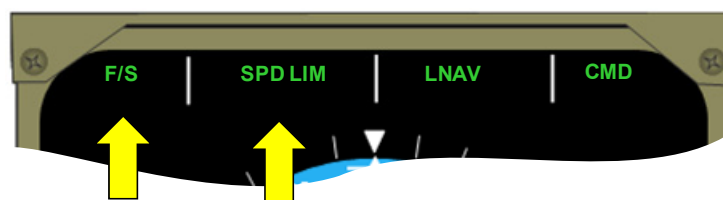
Flap placard speeds and maximum speed limits are automatically monitored by the AFDS and the Thrust Management Computer (TMC) in all AFDS modes except V/S pitch.

If a PITCH limit mode is displayed the limit speed becomes the new reference speed for the autothrottle system. The autothrottle status changes to F/S. Refer to Figure 5-8 and 5-9.

These modes will only occur if the autothrottle is ENGAGED.

NORMAL AUTOTHROTTLE REFERENCE	A/T STATUS DISPLAYED	PITCH LIMIT MODE DISPLAYED	LIMIT OPERATION
MCP selected speed OR FMC target speed	F/S	FLAP LIM	Current speed setting will exceed the speed limit for the flap position set. - New autothrottle reference speed.
	F/S	SPD LIM	Current speed setting will exceed the maximum speed limit for the aircraft. - New autothrottle reference speed.
			Current speed setting will exceed the maximum speed limit with gear down. - New autothrottle reference speed.
	F/S	ALPHA	Current speed setting is less than the minimum speed for alpha limit. - New autothrottle reference speed

**Figure 5-8 Autothrottle Limit Modes**



**Figure 5-9 Example display of Limit Mode**

## TYPICAL USE OF AUTOTHROTTLE MODES

### Introduction

The B767 has three autoflight systems:

- The flight director
- The autopilots
- The autothrottle.

Each of these may be operated alone or in conjunction with each system. It is normal to operate all three simultaneously except for take-off, when only the flight director and/or the autothrottle may be used. The autopilot cannot be used until the aircraft has reached a height of 400 ft RA.

The following are specific autothrottle modes however, if the autopilot and/or flight director is engaged, they will control the autothrottle to suit the pitch modes used by the FMC.

For any of the following modes to be activated the autothrottle must be ARMED.

### Take-off Mode

Take-offs may be conducted using reduced thrust or maximum thrust when conditions do not permit a reduced thrust take-off. Reduced thrust significantly increases engine life and is considered the normal option for take-off.

Reduced thrusts are calculated by using the assumed temperature control on the Thrust Mode Select Panel (TMSP). The reduced thrust value will be displayed on the EICAS display. Maximum thrust, if required is set by selecting TO/GA on the Thrust Mode Select Panel.

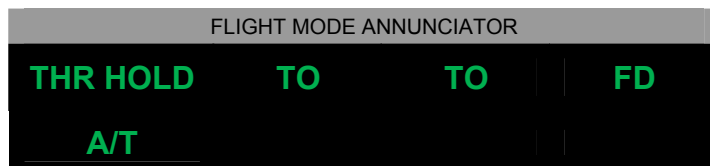
The autothrottle is ENGAGED by pressing the EPR, N1 or THR switch (whichever fitted).

The autothrottle status **A/T** and the engaged mode **N1** annunciates on the Flight Mode Annunciator (FMA).

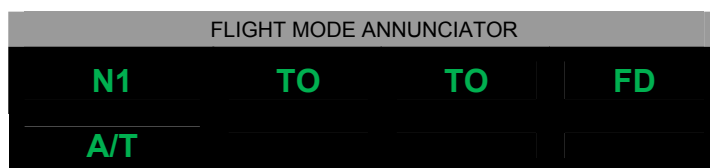
FLIGHT MODE ANNUNCIATOR			
<b>N1</b>	<b>TO</b>	<b>TO</b>	<b>FD</b>
<b>A/T</b>			

Typically the pilot will initiate the advance of the thrust levers manually and then engage by pressing N1. The throttles will advance to the reference thrust (either a reduced or maximum take-off thrust value), then adjust and maintain reference thrust until 80 kts Ground Speed (GS).

Above 80 kts GS, electrical power to the autothrottle motor is removed and the autothrottle mode changes to **THR HOLD**. (The THR HOLD mode is effectively autothrottle OFF). Any adjustments made by the pilot to the thrust levers will not be changed by the autothrottle.



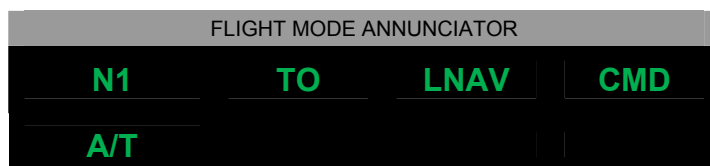
After take-off, if desired, the autothrottle can be reengaged by pressing the N1 switch. **N1** is displayed and the current thrust value is maintained.



### Climb Mode

Climb thrust is selected by the pilot on the Thrust Mode Select Panel (TMSP). This action reengages the autothrottle in climb mode and **N1** is displayed. Climb thrust is normally selected between 1000 – 1500 ft AAL.

The Thrust Mode Select Panel offers three values of climb thrust, Maximum, Derate 1 or Derate 2 allowing the pilot to select the most suitable for the circumstances. When the CLB button is pressed the autothrottles new reference thrust is activated. If a derated thrust has been selected first this will be the reference thrust. Derates gradually reduce and become non effective at higher altitudes. An autopilot will normally have been engaged by this time.



## Speed Mode

This mode can be engaged in two ways:

- By selecting an appropriate IAS or MACH in the speed window and pressing the SPD switch. This is an autothrottle mode and thrust will control speed.

FLIGHT MODE ANNUNCIATOR			
SPD	TO	LNAV	CMD
A/T			

- By pressing the VNAV switch which will use the speed programmed by the Flight Management Computer (FMC). VNAV is an autopilot pitch mode and the FMC will control speed by pitch (with a fixed thrust) or speed by thrust alone when the aircraft is level. (If the SPD switch (above) is pushed VNAV is deactivated).

FLIGHT MODE ANNUNCIATOR			
N1	VNAV SPD	LNAV	CMD
A/T			

Speed mode is normally used during climb, cruise, some parts of a descent and when established on final, to ensure VREF is attained. In this mode the autothrottle moves the thrust levers to achieve and maintain the desired aircraft speed within the boundaries of engine limitations.

## Flight Level Change Mode

In this mode the autopilot/flight director will begin a climb or descent using pitch for control of speed. The speed used is the speed current at the time the FL CH switch was pressed.

The autothrottle will set the required thrust limited by the climb thrust limit or the minimum thrust (idle) depending on whether the selected altitude is above or below the aircraft.

For altitude changes in ascent above approximately 6,000 FT maximum climb thrust is set.

If VNAV is engaged it will deactivate when FL CH is pushed.

FLIGHT MODE ANNUNCIATOR			
FL CH	SPD	LNAV	CMD
A/T	VNAV		

### Idle Mode

The pilot cannot select idle mode. It automatically occurs during the autoland sequence when FLARE becomes engaged. It also may engage automatically during a VNAV descent.



### Go-Around Mode

The go-around mode becomes ARMED for use only when flaps are selected or the ILS glideslope is captured.

When either go-around thrust lever switch is pushed the autothrottle sets go-around reference thrust until a satisfactory rate of climb is achieved, about 2,000 fpm. Thrust will automatically reduce to maintain 2,000 fpm at the current airspeed.

The go-around thrust lever switch is also the trigger for Flight Director and/or Autopilot pitch and roll mode go-around operation.

If armed the go-around autothrottle mode may be used for windshear recovery.

