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DOCUMENT
**GSM-AUS-AASA-AFC**

DOCUMENT TITLE
# AUTOMATIC FLIGHT CONTROL SYSTEMS (CASA ATPL)

# CHAPTER 6 – AUTOFLIGHT ASSOCIATED SYSTEMS

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## INTRODUCTION

There are a number of other systems fitted to the aircraft that are closely associated with manual and automatic flight control of the aircraft. In the context of this textbook the following systems are described:

- The Air Data Computer
- The radio altimeters
- The yaw damper system
- The automatic pitch trim system
- The high and low speed stability trim
- Symbol generators.

## THE AIR DATA COMPUTER

Conventional pressure or temperature sensitive flight instruments are used in light aircraft to display airspeed, altitude, rate and temperature.

Larger aircraft use an Air Data Computer centrally located in the aircraft to gather pressure and temperature information and convert it to analog and digital information to be used by the numerous aircraft systems as well as the flight instruments. ADCs are active whenever the aircraft is electrically powered.

Depending on the manufacturer the Air Data Computer (ADC) may also be referred to as the Central Air Data Computer (CADC). There are normally at least two fitted. An air data computer normally has three basic inputs:

- Dynamic (pitot) pressure
- Static pressure
- Total air temperature.

Modern aircraft also add aircraft Angle of Attack. Refer to figure 6-1.

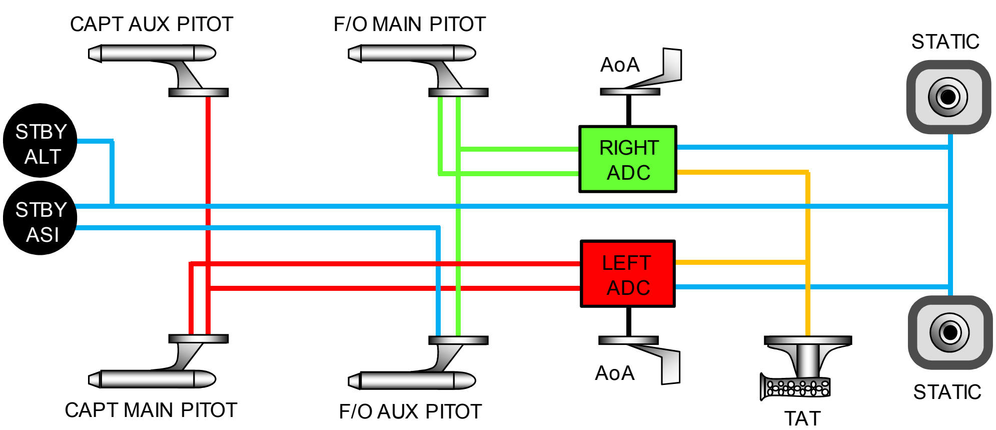



**Figure 6-1 Air Data Computer Inputs**

All of these inputs are duplicated to ensure accurate information is supplied to this critical piece of equipment.

From the inputs the air data computer calculates a large range of information outputs used by the AFCS and other aircraft systems. The outputs include:

- Barometric altitude for instruments and transponder
- Rate of altitude change
- Indicated airspeed, Mach No and true airspeed
- Maximum and minimum airspeeds
- Total and static air temperature.

Note that in older air data computers the transducers and other mechanisms were analog technology and the output information was often referred to as “manometric data”. Modern digital solid state air data computers are digital based technology.

The disadvantage of the ADC is that, unlike conventional pressure instruments, it requires power to operate, so a back-up system is provided, either by duplicate systems, alternate power supplies, or by simple standby pressure instruments for airspeed and altitude.

Systems that typically use the information supplied by the ADC are:

- The Flight Director System (FD)
- The Automatic Flight Control System (AFCS)
- The Autothrottle System (A/T)
- The Flight Management System (FMS)
- The transponders
- Airborne Collision Avoidance System (ACAS)
- The Ground Proximity Warning System (GPWS)
- The Flight Data Recorder (FDR)
- The yaw damper systems (YD).

## RADIO ALTIMETERS (RA)

The Radio Altimeters are an essential part of the autoland sequence and there will be one for each autopilot fitted. Radio altimeter height is used during the autoland sequence to trigger the mode and sub-mode changes. Radio altimeters normally become operational at approximately 2,500 ft RA.

Radio Altitude is displayed to the pilots on the EADIs on modern aircraft or on separate Radio Altitude Indicators on older types. The decision height for the ILS approach is set on the Radio Altimeter. Refer to Figure 6-2.

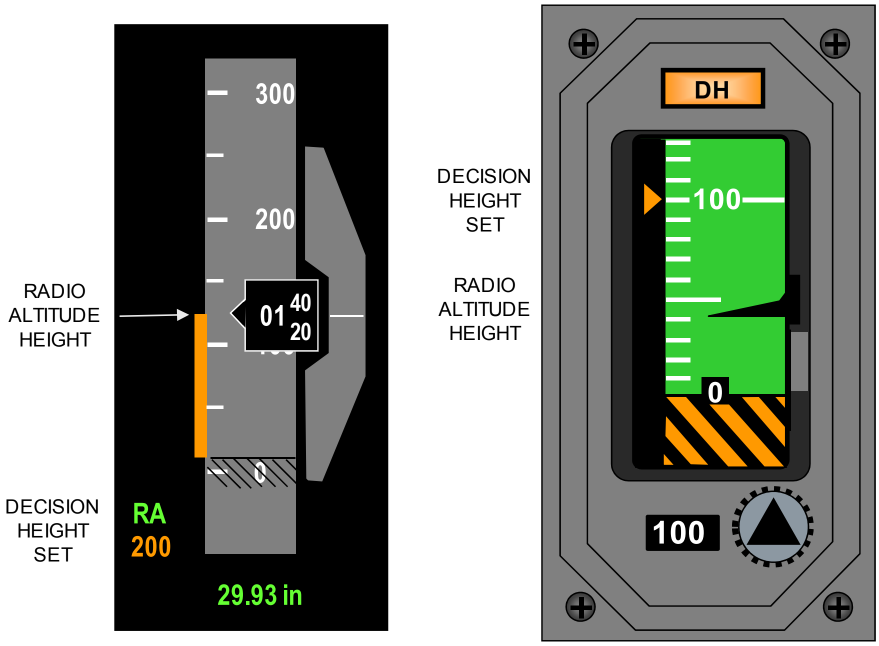



**Figure 6-2 Radio Altimeter presentations**

## THE YAW DAMPER SYSTEM

On aircraft with relatively straight wings any upset that produces yaw does not cause any appreciable roll. On high speed swept wing aircraft an upset causing yaw will also cause roll.

Depending on the aircraft this may result in a condition known as “Dutch Roll”. This can be counteracted by the use of a yaw damper system.

All high speed swept wing transport aircraft are fitted with a yaw damper system. The yaw damper is on all of the time and continuously corrects very small deviations in yaw to stop the development of Dutch Roll.

### Yaw Damper Controls

The ON/OFF control switches for yaw dampers are typically located on the overhead panel. Refer to Figure 6-3.

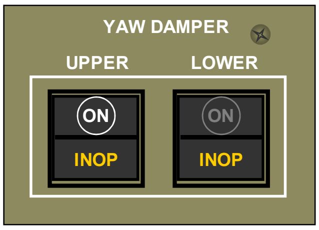



**Figure 6-3 Yaw Damper Controls**

### Yaw Damper Functions

The yaw dampers receive information from rate gyros or the Inertial Navigation System (INS) or Inertial Reference System (IRS and provide the following functions:

- Dutch roll damping, which is continuously operating throughout the flight;
- Turn coordination when the autopilot is OFF. This function is activated if a roll control wheel deflection is detected above a predetermined threshold; and
- Autopilot assistance in case of engine failure. This function is activated if the IRS detects a lateral acceleration which is above a predetermined threshold when the autopilot is engaged.

Typically yaw dampers will modify their operation considering roll inputs for turn co-ordination, airspeed and flap position for rudder deflection. The yaw damper computer controls movement of the rudder via the rudder actuator servo control unit. Refer to Figure 6-4.

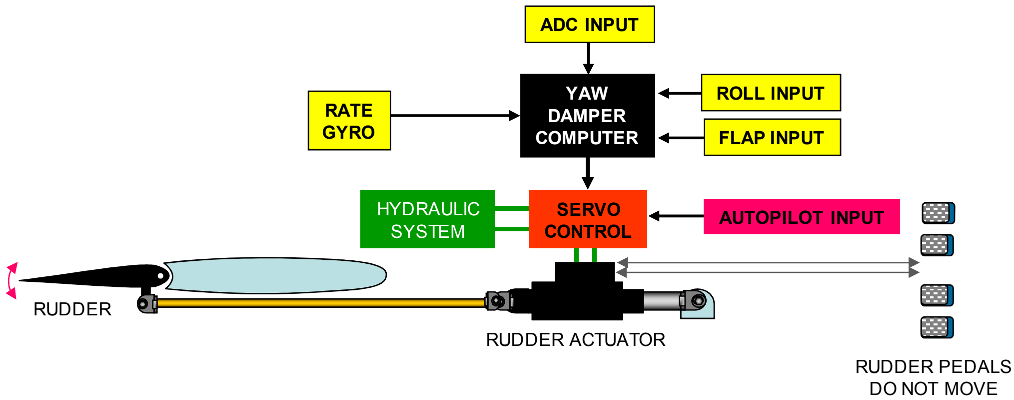



**Figure 6-4 Yaw Damper**

<u>In modern aircraft the rudder pedals DO NOT move when the yaw damper is operating as they are connected in a SERIES configuration</u>, however some older aircraft do connect yaw dampers in a parallel configuration which causes rudder pedals to move.

### Yaw Damper Operation

The yaw damper(s) are active anytime power is supplied to the aircraft and the switches ON.

Yaw dampers provide the functions described previously when the autopilot is engaged or disengaged. This means that in a three axis autopilot the yaw channel does not operate in normal flight as the yaw damper is sufficient for co-ordinated turns.

When an autoland is conducted and multiple autopilots are engaged the yaw axis of the autopilots become active and control the rudder for landing and rollout.

**Yaw Damper Failure**

A failure of the yaw damper system during flight will limit the altitude and speed of the aircraft. Refer to Figure 6-5. Large aircraft are typically fitted with two independent systems for redundancy.

**YAW DAMPER**

Condition: **The YAW DAMPER light illuminated indicates the yaw damper is disengaged.**

**YAW DAMPER switch . . . . . . . . . . . . . . . . . . . . . OFF then ON**

**If light remains illuminated:**

**YAW DAMPER switch . . . . . . . . . . . . . . . . . . . . . . . . . . .OFF**

**Avoid areas of predicted moderate or severe turbulence. If turbulence is encountered and passenger comfort becomes affected, reduce airspeed and/or descend to a lower altitude.**

**Do not exceed flaps 30 if the crosswind exceeds 30 knots.**

Figure 6-5 Yaw Damper Failure Checklist B737-800

## THE AUTOMATIC PITCH TRIM SYSTEM

### Introduction

When an autopilot is engaged it will initially maintain pitch attitude using the elevators.

As the aircraft develops an out of trim condition the autopilot will maintain the pitch attitude by more and more deflection of the elevator. This would eventually lead to an increase in drag caused by the excessive elevator deflection. Additionally, disengaging the autopilot in this situation would lead to a large deviation in flight path as the pilot would soon discover.

Therefore to maintain the elevator in the most streamlined position and to facilitate a smooth autopilot disengagement, the horizontal stabiliser is continuously adjusted by an Automatic Pitch Trim System commonly referred to as “autotrim”.

### Autotrim Operation

Automatic pitch trim is a sub-operation of the autopilot and is activated when an autopilot is engaged. There is no specific control switch for automatic pitch trim.

The engaged autopilot uses the aircraft's pitch trim system to continuously trim the horizontal stabiliser to maintain the elevator in the most streamlined position to reduce drag.

Autotrim movement is approximately half of the normal trim rate.

When the pilot operates the normal pitch trim switches on the control column or the alternate trim switches on the centre console both trim motors are operated simultaneously.

When an autopilot commands trim movement only one trim motor operates. This results in a trim movement of approximately half of the normal rate.

In single autopilot operation if the pilot operates the normal trim switches on the control column the autopilot will disengage. In multiple autopilot operation the normal trim switches are inhibited.

The alternate trim switches will override autopilot trim commands with any number of autopilots engaged and does not cause disengagement.

Pitch is the only trim is that is automatically controlled under autopilot operation. Refer to Figure 6-6.

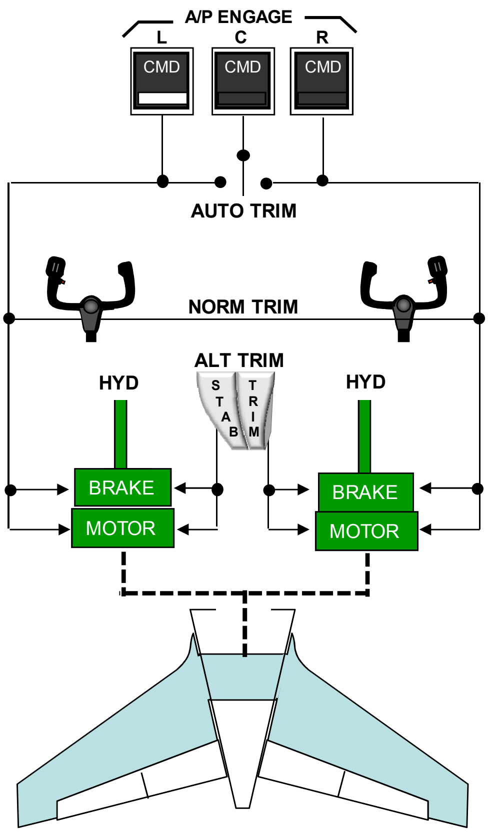



**Figure 6-6 Automatic Pitch Trim**

## STABILITY TRIM

### Introduction

When aircraft are operating at very high and very low airspeeds they become less stable.

At high Mach Nos a nose down tendency may occur and at low airspeeds avoidance of stalling is critical.

When autopilots are **NOT ENGAGED** a stability trim system automatically trims the horizontal stabiliser to improve the handling characteristics of the aircraft in the lower and higher speed ranges.

### High Speed Operation

Mach Tuck or "Tuck Under" may occur in aircraft flying at high subsonic speeds.

Due to a significant rearward movement of the Centre of Pressure the aircraft may develop an uncontrollable nose down motion. To correct this, the stability trim system adjusts the horizontal stabiliser.

If the pilot engages an autopilot or manually trims the aircraft, <u>stability trim is inhibited</u>.

### Low Speed Operation

As airspeed decreases the body angle or alpha angle, sensed by the Angle of Attack sensor, may become excessive. To improve the handling characteristics at high alpha the stability trim system adjusts the horizontal stabiliser.

If the pilot engages an autopilot or manually trims the aircraft, <u>stability trim is inhibited</u>.

When autopilots are engaged high and low speed protections are provided by the autopilot systems.

## SYMBOL GENERATORS

In modern aircraft the EADIs and the EHSIs are part of the Electronic Flight Instrument System (EFIS). The numerous different presentations that occur require a component to generate the symbols and information to be displayed. This component is called the Symbol Generator (SG) and there is typically three for redundancy. Refer to Figure 6-7.

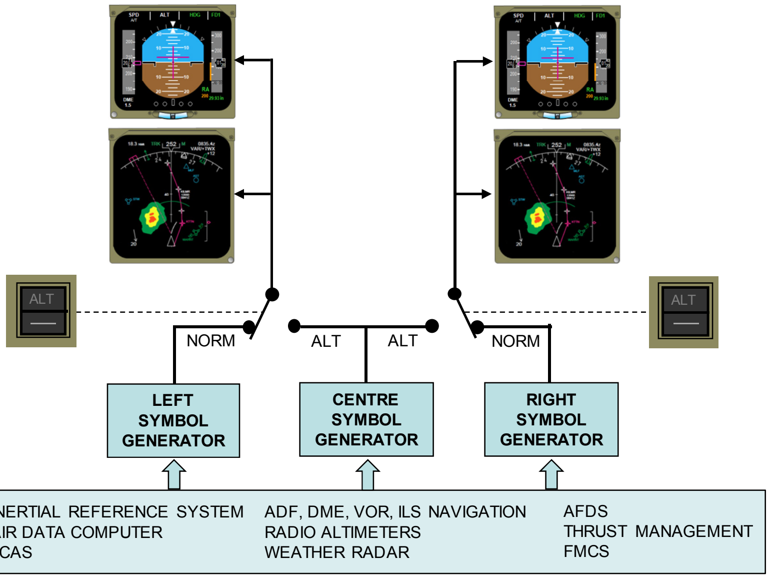
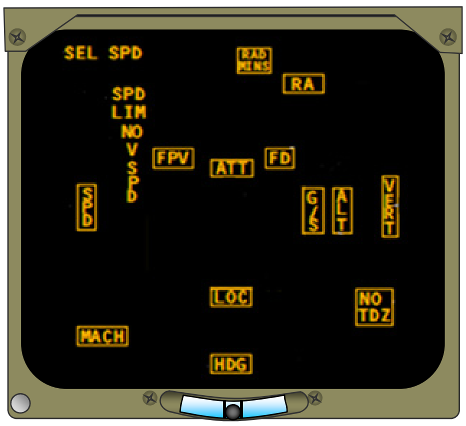



**Figure 6-7 Symbol Generators**

The symbol generators interface between the aircraft systems, the display screens and the EFIS control panels. They perform the main control functions of the EFIS, including system monitoring and generation of the digital and analogue displays for the EADI and EHSI screens.

### Failure Displays

When failures occur of the systems displayed on the screens they are annunciated. Failure flags replace the appropriate display to indicate source system failure, or lack of computed information. Refer to Figure 6-8.




ELECTRONIC ATTITUDE DIRECTION INDICATOR

**Figure 6-8 Failure Displays**