DOCUMENT
GSM-AUS-AASA-AFC

DOCUMENT TITLE
AUTOMATIC FLIGHT CONTROL SYSTEMS (CASA ATPL)

CHAPTER 1 – INTRODUCTION TO AUTOMATIC FLIGHT

Version 1.0
October 2014

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INTRODUCTION

The development of Automatic Flight

The first aircraft autopilot was developed by the Sperry Corporation in 1912. The autopilot connected a gyroscopic heading indicator and an attitude indicator to hydraulically operated flight controls. It permitted the aircraft to fly straight and level on a compass course without the pilot's attention, greatly reducing the pilot's workload.

Further development of the autopilot occurred over time and with the inclusion of radio navigation aids made automatic flight possible at night and in almost all weather conditions.

In 1947 a US Air Force C-54 made a transatlantic flight, which included take-off and landing, completely under the control of an autopilot. Autothrottle systems were also developed which could be used in conjunction with the autopilot system for almost fully automatic flight.

Fully automatic flight could not be achieved however, until aircraft were able to land safely with almost no visibility of the runway. With the introduction of the Instrument Landing System (ILS), safe approaches could be made to very low altitudes in IMC conditions by another system called the Flight Director.

The Flight Director allowed pilots to fly approaches manually, guided by indicators on their instruments to a point where the runway could be seen. By adding extra autopilots for redundancy and using the flight director and auto throttle simultaneously, safe fully automatic landings were finally achieved. This combination of systems has developed into what is referred to today as the Automatic Flight Control System (AFCS)

In modern aircraft the AFCS is not only operated by the pilot but also a Flight Management Computer, which is designed to manage the flight through the AFCS in the most efficient and economical manner.

Lastly, the introduction of Electronic Flight Instrument Systems (EFIS) allowed the situational information from the AFCS to be presented to the pilot in a condensed and user friendly manner.

<u>The function of the autopilot or automatic flight control system is to relieve the workload of the crew allowing them to concentrate on the management and monitoring of the flight.</u>

The AFCS allows a modern aircraft to operate and navigate without any manual flying from just after take-off to the end of the landing roll at destination.

Depending on the aircraft manufacturer the automatic system may be called the:

- Automatic Flight Control System (AFCS);
- Autopilot Flight Director System (AFDS); or
- Automatic Flight System (AFS).

Depending on the size and capability of an aircraft various levels of autopilot/AFCS are used.

Usually a light aircraft with manually operated flight controls will have a single simple autopilot provided to maintain a wings level condition and to follow a selected heading.

In medium transport aircraft the AFCS is more advanced, usually with a more sophisticated autopilot with automatic navigation capability.

A modern large transport aircraft has a complex AFCS and is capable of fully automatic vertical and lateral navigation along with full autoland, rollout guidance and go-around capabilities.

COMPONENTS OF AUTOFLIGHT SYSTEMS

All aircraft fitted with autopilot systems will include some or all of the components described below. A modern large transport aircraft AFCS typically includes the following sub systems:

- Multiple individual autopilots/flight control computers;
- Flight directors;
- Flight management system; and
- Autothrottle (autothrust) system; and
- Autotrim system.

Individual Autopilots (A/P)

Depending on the size and type, aircraft may be fitted with one, two or three individual autopilots. For most of the flight one autopilot will fly the aircraft leaving the other(s) as backup in case of failure. During automatic landings however, all autopilots are used in this critical phase of flight for safety through redundancy. In modern aircraft the autopilot operation is part of the overall task of the Flight Control Computers (FCCs).

Flight Directors (FD)

The flight director senses deviation from the planned flight path and presents this as a correction command to the pilot on the Attitude Indicator and the Navigational Display. In automatic flight systems these computed correction commands may be fed to the autopilot(s).

Flight Management System (FMS)

The flight management system is a complex digital system capable of controlling both the aircraft's flight path and thrust. Performance optimization allows the FMS to determine the best or most economical speed to fly. This is often called the ECON speed. This is based on the cost index, which is entered to give a weighting between speed and fuel efficiency.

Generally a cost index of 999 gives ECON speeds as fast as possible without consideration of fuel and a cost index of Zero gives maximum efficiency. ECON mode is used by most airliners.

The FMS receives a multitude of inputs from such components as the central air data computer, flight control computers, thrust management computers, pilot's controls and navigational sensors. When it is coupled to the AFCS by the pilot it becomes the manager of the AFCS and its outputs are to the autopilots, flight directors, flight control computers and the autothrottle system. In Airbus aircraft this is called the Flight Management and Guidance System (FMGS).

Autothrottle (A/T) System

The autothrottle (A/T) or autothrust A/THR), controls engine thrust to suit the phase of flight. This includes take-off, climb, cruise, descent/approach and landing or go around. All these systems of the AFCS will be discussed in greater detail in the following Chapters of this textbook.

Automatic Pitch Trim System

When the autopilot is engaged and maintaining pitch control using elevators, the automatic pitch trim system trims the horizontal stabiliser continuously to reduce drag. This also prevents large pitch deviations if the autopilot becomes disengaged.

SYSTEMS ASSOCIATED WITH AUTOFLIGHT

The large aircraft AFCS works in conjunction with and receives information from other systems associated with the automatic control of the aircraft such as:

- Yaw damper system;
- Mach trim and low speed stability system;
- The central air data computer;
- Radio altimeters;
- Engine thrust and fuel consumption;
- Navigational aids; and
- Symbol generators.

Yaw Damper System

Aircraft that have swept wings and operate at higher altitudes are typically fitted with a yaw damper system to prevent the onset of Dutch Roll.

<u>Yaw dampers are active all of the time with autopilots ON or OFF</u>.

Yaw dampers provide stabilization about the vertical axis and turn co-ordination in normal flight.

<u>Only during an autoland sequence using multiple autopilots does the autopilot takeover control of the aircraft's yaw axis</u>.

Mach Trim and Lowspeed Stability System

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, an independent system is provided and is called Mach Trim.

At low airspeeds another function of this system adjusts the horizontal stabilizer to improve the low speed handling characteristics of the aircraft. This is called low speed stability.

Both these functions are inhibited when autopilots are engaged as the AFCS has its own set of protections for high and low airspeeds.

Central Air Data Computer (CADC)

The central air data computer provides all the pressure related information derived from pitot and static sources for the AFCS. The computer is capable of computing IAS, TAS, Mach number, and pressure altitude. The information provided by air data computers is sometimes referred to as manometric data.

Radio Altimeters

During autoland operation of the AFCS, the radio altimeters provide accurate height above the ground values which trigger the sequencing of the autoland procedure.

Thrust and Fuel consumption

To operate the AFCS in the most economical manner this information is provided to the Flight Management System.

Navigational Aids

To laterally and vertically navigate the aircraft the appropriate radio aids are coupled to the AFCS through the Flight Management System.

Symbol Generators

In modern aircraft fitted with an Electronic Flight Instrument System (EFIS) the numerous different presentations that may be displayed require a component to generate the coloured symbols and digital information on the screens. This component is called the Symbol Generator.

SUMMARY

In the first chapters this textbook will discuss the basic functions and principles of operation of each of the components and systems mentioned.

In later chapters the components and operation of the B767 will be discussed in detail as an example of a large transport aircraft. Autoflight questions in CASA examinations are usually based on this aircraft.