System Specification
Type-A Document

Airbus A330/A340 Flight Control System

Contents

1.0 Introduction

This document is the Type-A part B document describing the requirements and design and construction of The Airbus A330/A340 Primary Flight Control System. Figure 1 gives an overview of the top-level functions of the system that are described in part A of the Type-A document.

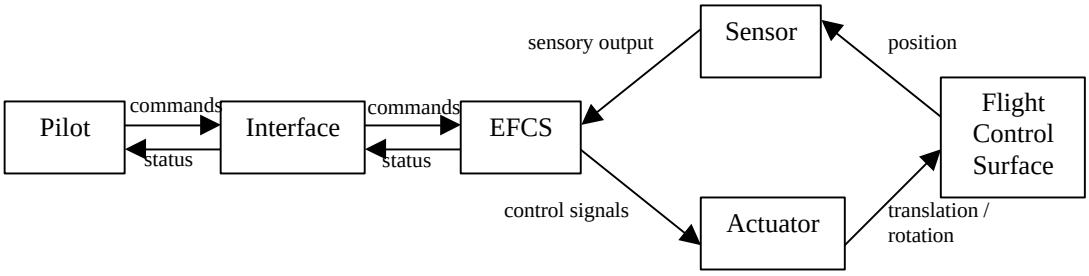

Figure 1 System top-level functions of the Flight Control System

2.0 Requirements

2.2 System Characteristics

2.2.1 Performance Characteristics

Since the Airbus A330/A340 is a very critical system, any failure in the flight control system can cause heavy casualties. So its performance is also critical. The performance characteristics of the flight control system can be summarized as follows:

- High fault tolerance in extreme environment conditions such as low temperatures and low pressures.
- Accurate and fast control so as to promptly react to dangerous conditions
- The system has to be robust. Redundancy of subsystems within the flight control system so that even if one subsystem fails another subsystem can take over without affecting safety of the airplane.
- Control within safe operating limits (limits in pitch, roll and yaw axes) to avoid stalls. See figure 2 for flight envelope protections.
- Real-time interface feedback and alarm of faults
- The system has to meet the FAR/JAR-25 large aeroplanes requirements

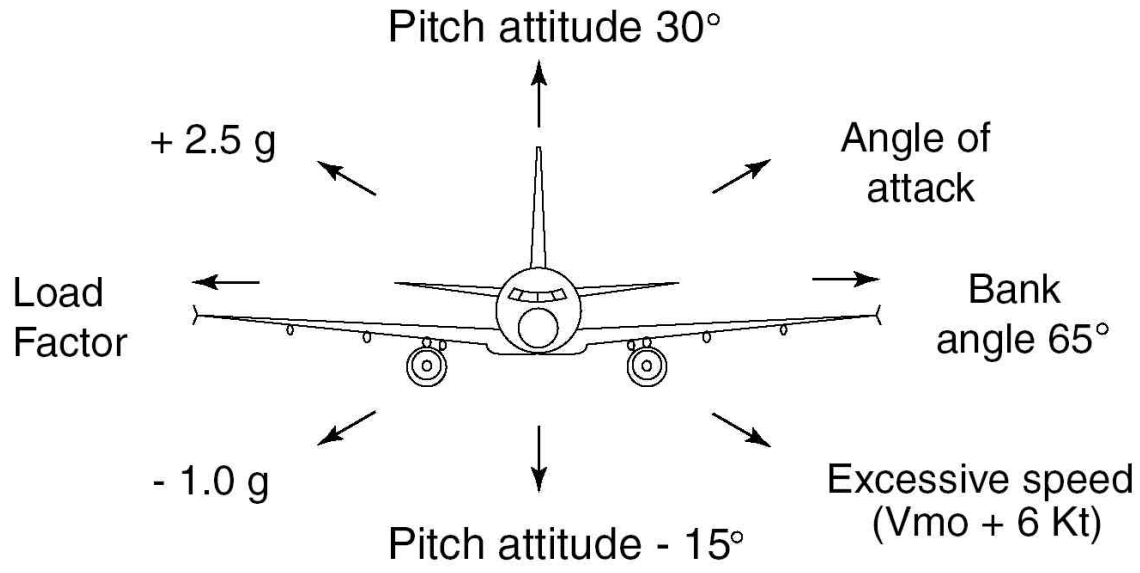

Figure 2 A330 flight envelope protections

2.2.2 Physical Characteristics

For the physical characteristics of the flight control system, the following issues should be considered:

- Size and weight of the electronic flight control system
- Layout of the interface and placement of other subsystems (EFCS)
- Power supply required by the system

- Size, weight, capacity and layout of the hydraulic supplies needed for the actuators

2.2.3 Effectiveness Requirements

There are certain effectiveness requirements to the system:

- Real-time operation of the flight control system
- High fault tolerance and redundancy
- Audio and visual alarms according to fault hierarchy (Critical faults should provide audio alarms and alarms should be acknowledged by pilot)
- Alerts of possible faults and hazards

2.2.4 Reliability

Reliability is a key issue for the flight control system. Reliability can be achieved by the following:

- Acceptable failure rate of the system (high mean time between failure-MBTF)
  By using a software tool high numbers of failure cases can be evaluated and would be useful in determining of the static dependencies.
- Multiple subsystems (redundancy)
  By the use of double or triple subsystems and for each subsystem different microprocessors. These subsystems are based on the command and monitoring computer architecture
- System must perform in extreme conditions
- The flight control laws have to be robust. This must be proven by the use of formal methods and simulation.

2.2.5 Maintainability

For the maintainability of the flight control system the following aspects need to be implemented:

- System modularity and accessibility for maintenance
- Preventative maintenance
  By the implementation of a good maintenance scheme and organization plan
- Maintenance frequency should be less than the Mean time between failure (MTBF). Reliability centered maintenance (RCM) should be implemented to achieve safety.
- Self and normal tests
- Log system of maintenance history

2.2.6 Usability

In order for the user to easily learn how to operate the flight control system, the interface must be firstly clearly visible and intuitive. Secondly the interface should be compatible with the A3XX range of aircraft. Finally the interface should minimise possible human error.

Figure 3: Cockpit of A330

2.2.7 Supportability

For the effective use of the system, support during its operation is essential which includes:

- Availability of spare parts
  Worldwide network of spare parts setup
- Experts for operation and maintenance
  Trainee programs for operation and maintenance
- Documentation of design and operation
- Pilot training
  Use of flight simulator for training in extreme situations that cannot be achieved otherwise

2.2.8 Transportability/Mobility

- Modular system
  For easy transportation of the flight control system between airports

2.2.9 Flexibility

- The system must be accessible to personnel for maintenance
- The system can be easily updated

2.3 Design and Construction

2.3.1 Electromagnetic Radiation

In designing the flight control system, the electromagnetic radiation should also be considered. The radiation must not affect communication between the control tower and the aircraft and also data communication associated with the fly by wire system. In particular the system must be especially protected against overvoltages and undervoltages, electromagnetic aggressions, and indirect effects of lightning.

2.3.2 Safety

- The use of preventative maintenance to reduce the chance of faults

- Fire safety
  The EFCS is housed in fireproof casing
  In case of fire in the system there has to be means to stop the fire (fire extinguisher, etc)
- Environmental implications
  The system must adapt to changes in the environment
- Warning and caution for the pilots are one of these categories
  - Red warning with continuous sound when an immediate action is necessary (for example, to reduce air speed)
  - Amber caution with a simple sound, such that the pilot is be informed although no immediate action is needed (for example, in case of loss of flight envelope protection an airplane speed should not be exceeded
  - Simple caution (no sound), such that no action is needed (for example, a loss of redundancy
- System must only be accessed and maintained by authorized people, not terrorists

2.3.3 Interchangeability

- Portability of control systems to all A3XX models of aircraft

2.3.4 Testability

- Every subsystem has to be testable. Failure test can be run at every point during system operation
- Self-testing system
  During the energization of the aircraft every computer runs it's self-test and tests its peripherals.
- Standard tests
  These test are conducted periodically so that the probability of the occurrence of an undesirable event remains sufficiently low (i.e. to fulfill [FAR/JAR 25] 25.1309 quantitative requirements)
- Log system
  From self tests, operation and maintenance

2.3.5 Economic Feasibility

The system is to be relatively cheap compared to other kinds of systems and this can be achieved by:

- Low flight costs are achievable by the preventative maintenance program with a small mean preventive maintenance time. The airplane will have a large operational availability and relatively few maintenance hours
- Fuel efficiency
  The system ensuring efficient flight which result in efficient fuel use
- Long lifecycle
  The system is designed to work for a long time by the system engineering approach. The system is modular, very reliable and good supported.