Flight Controls

A350 XWB

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Overview

The A350 has fly-by-wire flight controls.

The flight controls can be divided into two categories:

- The **primary flight controls** which control the aircraft according to the three axes (Roll, Pitch and Yaw) and fulfill the auxiliary functions (speedbrakes, ground spoilers,…)
- The **slats and flaps** which fulfill the high-lift function.

The A350 flight controls system benefits from evolutions introduced on the A380:

- Integration of the Flight Guidance (FG) and Flight Envelope (FE) functions in the Primary Flight Computers (PRIMs)
- Replacement of all mechanical backup controls by electrical backup controls
- Addition of a new pitch trim switch which replaces the trim wheels
- Introduction of active stability for longitudinal and lateral axes
- Introduction of Electro-Hydrostatic Actuators (EHAs) and Electro Backup Hydraulic Actuators (refer to *Actuators*).

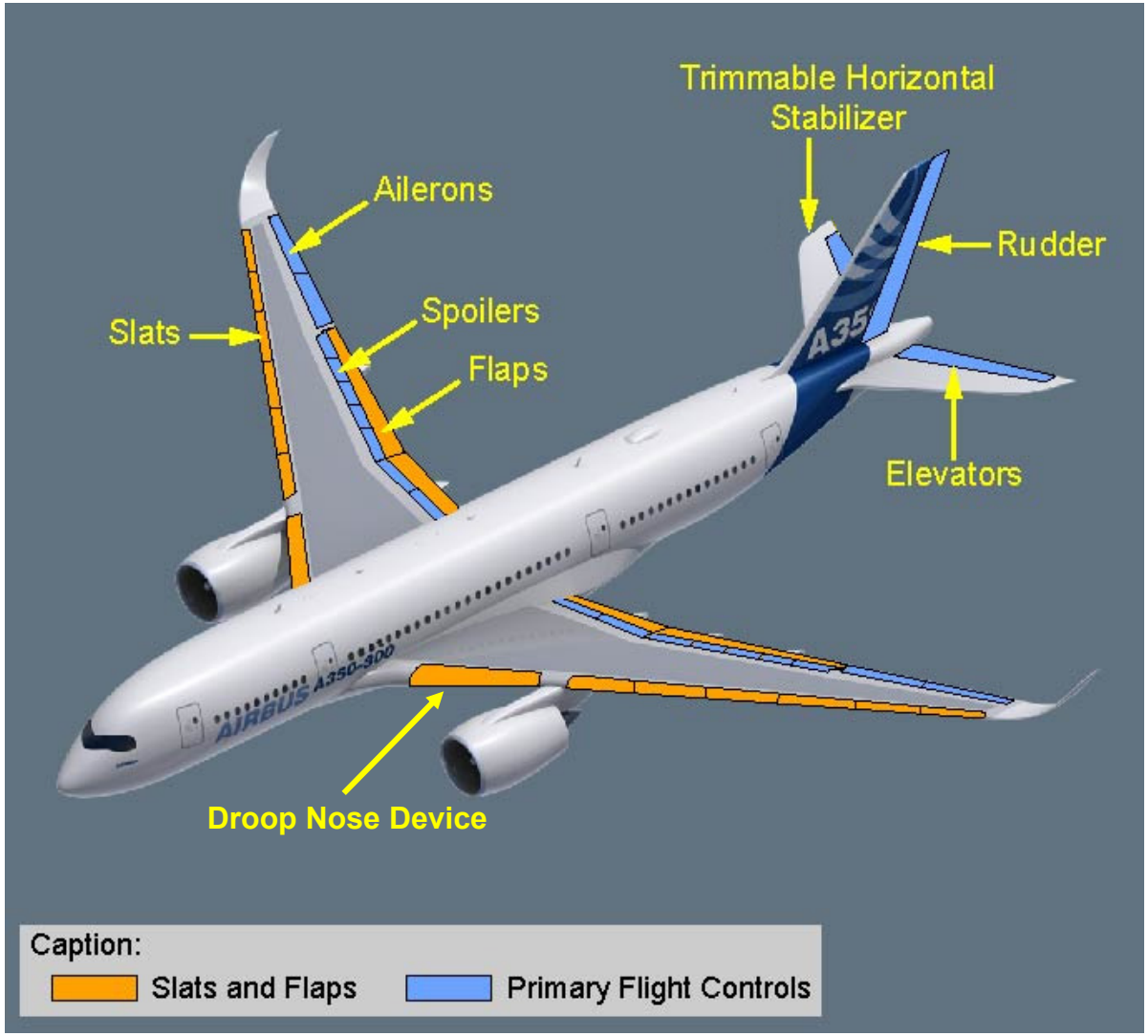
Control Surfaces

The A350 has:

- 4 ailerons
- 14 spoilers
- 2 elevators and 1 Trimmable Horizontal Stabilizer (THS)
- 1 rudder
- 12 slats, 4 Adaptive Dropped Hinge Flaps and 2 Droop Nose Devices.

The A350 has two independent hydraulic circuits and two independent electrical circuits which power the flight controls surfaces. For more information refer to *Power supply for the Actuators and Control Surfaces*

Control Surfaces



System Architecture

The flight controls system has:

- Flight deck controls
  - Sidesticks
  - Rudder pedals
  - Rudder trim selector
  - Pitch trim switch
  - Speed brake lever

  The relation between the flight crew input on the sidestick and the aircraft response is called a Control Law.
  There are three control laws:
  - The normal law
  - The alternate law
  - The direct law.

- Three **Primary Flight Computers (PRIMs)**.
  Each PRIM can provide aircraft control under normal, direct or alternate law. The PRIMs perform the
  - Control of flight controls
  - Flight Guidance (FG), A/THR and AP/FD functions
  - Flight Envelope (FE) function

- Three **Secondary Flight Computers (SECs)**. The SECs can provide complete aircraft control in direct law only.

  The computers receive inputs from the pilot controls or from the Auto Flight System. These inputs are transformed into control surfaces commands which are electrically transmitted to actuators.

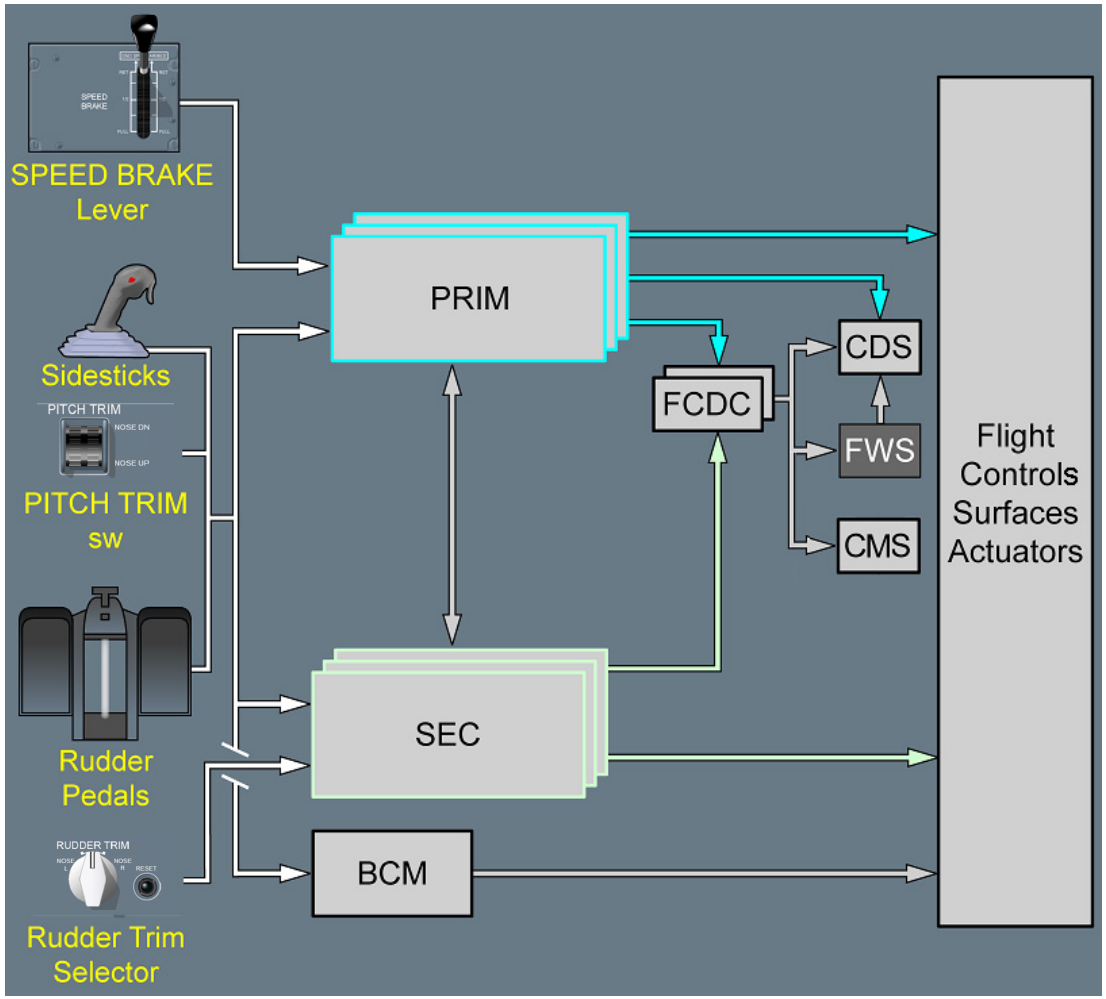
The A350 has:

- Two **Flight Control Data Concentrators (FCDCs)** which acquire data from PRIMs and SECs and send them to the:
  - Control and Display System (CDS)
  - Flight Warning System (FWS)
  - Centralized Maintenance System (CMS)

- An **Electrical Backup System** (Backup Control Module – BCM) that controls the aircraft in the case of failure of all PRIMs and all SECs (For more information, refer to ***Backup System***)

- Flight Control Surfaces and Actuators.

Flight Controls Architecture



Operations

The PRIMs and SECs compute the flight controls orders.

Each of these computers can perform two functions:

- The computation function:
  - Converts inputs that come from the flight crew or FG into orders, and computes corresponding surface deflections that are sent to the other computers
  - Compares the aircraft response with the objective to check if its orders are fulfilled.

- The execution function:
  - Commands the surfaces actuation
  - Monitors the surface deflection.

One of the three PRIMs is the master. The master PRIM computes the flight controls orders and transmits them to the other computers. Then, each operative PRIM and SEC activates its respective control surfaces accordingly.

If a malfunction is detected on the master PRIM, the master PRIM transfers the computation function to another PRIM. The master PRIM continues to perform the execution function, depending on the malfunction.

If all the PRIMs are lost, each SEC performs the computation and execution functions. There is no master SEC.

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Actuators

The A350 has three types of actuators:

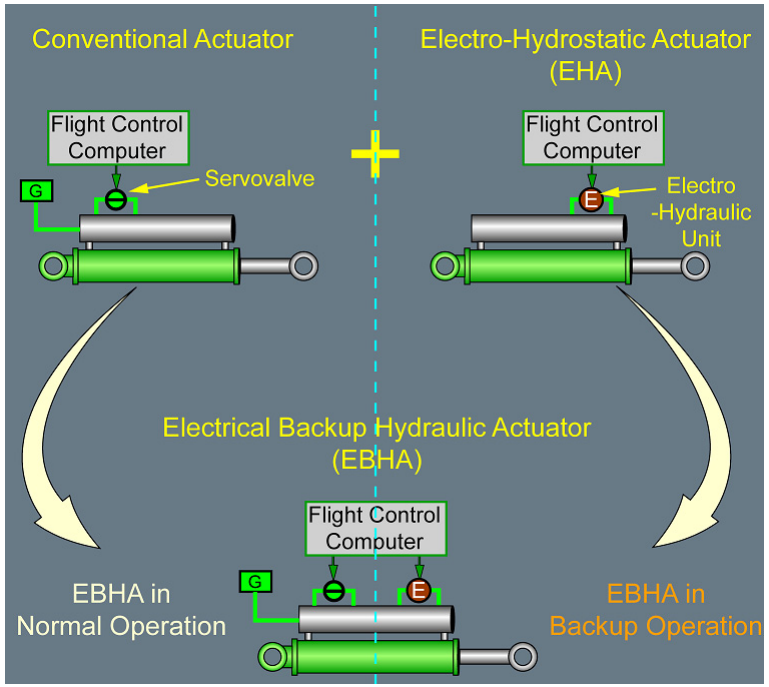
- **Conventional actuators** that include:
  - One actuator
  - One hydraulic block connected to one hydraulic power supply of the aircraft
  - One servovalve that receives orders from the flight controls computers and controls the translation direction of the actuator rod.

  A conventional servocontrol cannot operate if there is no hydraulic supply.

- **Electro-Hydrostatic Actuators (EHAs)** that include:
  - One actuator
  - One hydraulic block
  - One electro-hydraulic generation system that receives orders from the flight controls computers. The rotation direction and the speed of the electro-hydraulic generation system determine the translation direction and speed of the actuator rod.

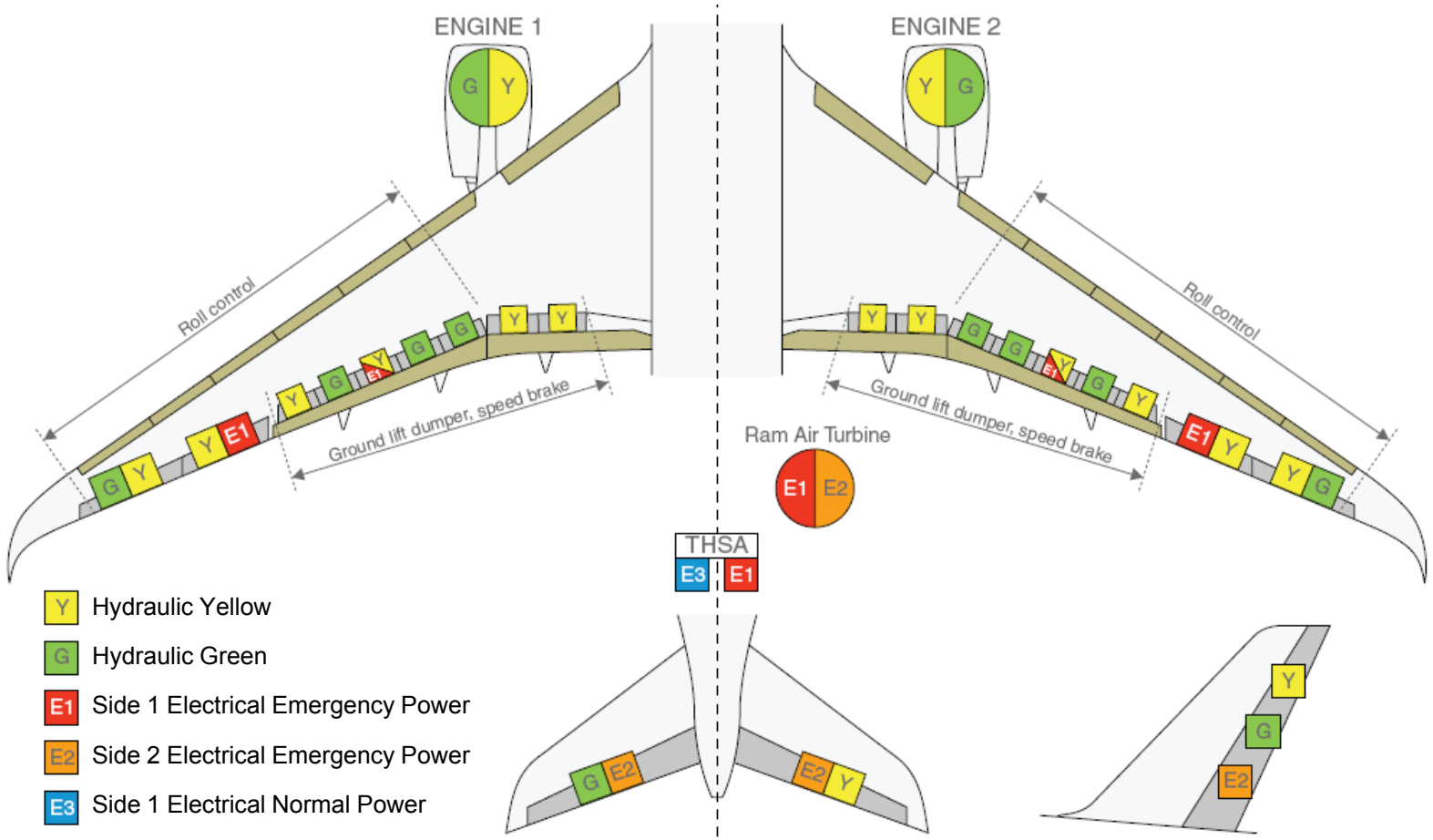
  In flight, EHAs are fully isolated from the hydraulic power supplies of the aircraft. An EHA can operate when there is no hydraulic supply, but needs an electrical supply.

- **Electrical Backup Hydraulic Actuators (EBHAs)** that are a combination of a conventional servocontrol and an EHA.
  In normal mode, they operate as conventional actuators. If there is a hydraulic failure, they operate as EHAs.



Note: The YELLOW or the GREEN hydraulic circuit supplies the actuators (refer to next page).

Power Supply for the Actuators and Control Surfaces



Primary Functions

Lateral Control (Roll+Yaw)

The following surfaces provide lateral control:

- The two pairs of ailerons (Inboard and Outboard)
- Spoilers 3 to 7
- The rudder.

Lateral orders are sent by:

- The sidesticks, to the PRIMs and SECs
- The rudder pedals and pedal feel and trim unit, to the PRIMs and SECs
- The rudder trim control panel, to the SECs only
- The autopilot, to the PRIMs only.

Pitch Control

The following surfaces provide pitch control:

- The elevators for short-term actions
- The Trimmable Horizontal Stabilizer (THS) for long-term actions.

Pitch orders are sent by:

- The sidesticks, to the PRIMs and the SECs
- The pitch trim control switches, to the PRIMs and the SECs (only active on ground or in direct law)
- The autopilot, to the PRIMs only.

Auxiliary Functions (1/2)

Speedbrake Function

The objective of the speedbrake function is to increase the drag of the aircraft with an acceptable buffet for passenger comfort.

A speedbrake demand deflects all the spoilers. The roll command has priority over the speedbrake command.

An automatic retraction is provided, when one of the following conditions is fulfilled:

- Angle-of-Attack (AOA) protection is active
- Load factor is lower than 0.3 g in normal or alternate law
- A go-around is initiated.

Spoilers are lost in symmetrical pairs in the case of a failure.

Ground Spoilers Function

The objective of the ground spoiler function is to:

- Stick the aircraft to the ground and reduce the risk of bounce at touchdown
- Increase the efficiency of the brakes
- Decelerate the aircraft.

The ground spoilers function orders the deflection of all the spoilers.

Auxiliary Functions (2/2)

Aileron Droop Function

The objective of the aileron droop function is to increase the high lift function performed by the slats and flaps.

The **inboard ailerons** droop downwards when the flaps are extended. They continue to perform the roll function.

Load Alleviation Function

The objective of the load alleviation function is to reduce structure fatigue and static loads on the wing during manoeuvres, turbulence and gust. This function is available in normal law only.

Differential Flap Setting and Variable Camber

The Differential Flap Setting and Variable Camber enable to optimize the loads and drag on the wings.

Small flaps deflections (4° maximum) either symmetrically or asymmetrically, enable to automatically :

- Optimize the wing camber to reduce wing loads and drag
- Perform an optimized Lateral Trim function.

An **Electrical Backup System** controls the aircraft in the case of the failure of:

- All the PRIMs and all SECs, or
- The electrical power supply of the PRIMs and the SECs.

The electrical backup system is totally segregated from the normal flight controls system and has:

- A Backup Power Supply (BPS)

  The BPS is an electrical generator that is activated in the case of computer or electrical generation failure. The yellow hydraulic circuit supplies the BPS.

- A Backup Control Module (BCM)

  The BCM controls and monitors:
  - The inboard ailerons
  - The elevators
  - The rudder

The direct control laws apply whenever the electrical backup system is active, with the following features:

- Pitch motion damping
- Yaw damping
- Direct roll.

Architecture