FlightFactor aero

A350 XWB

# A350-900 Advanced for X-Plane 10&11

## Flight Deck and Systems Briefing for Simmers

v1.4.x feb2017

# *A350-900*
# *Flight Deck and Systems Briefing for Simmers*

Make sure you read though this brochure before starting to use the model. The brochure contains all the information you need to effectively fly the plane and fully enjoy this simulation.



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applicable for version v1.1x

# Model Set-up

A350 XWB

# Model Set-up

## Introduction

Welcome to FlightFactor.aero ™ Airbus a350 Advanced. Our team is glad to present this first in our new line of products which should suit the beginner simmer as well as an experienced one. This is brochure to help you use the model.

This model is produced by FlightFactor.aero ™ in cooperation with QualityPart AviationCenter (qpac). To provide you a most realistic easy to use flight experience.

This model provides a very realistic simulation of most of the aircraft systems, especially with respect to Fly-by-wire and autopilot functionality. But also most of the aircraft system, such as electrics, hydraulics, fuel are simulated; this includes a complete sensor model for the aircraft state measurement of speed, attitude, altitude, etc. The model includes a real in-depth ECAM system with messaging and procedures, 18 screens to monitor the flight parameters and systems' operation. OIS will give you excess to options screens, wright and fuel setup, cabin announcements and much more. Most of the screens are available for pop-up.

The a350 joystick on-screen touch system is implemented fully on this model as well. Two function MCDUs are present in the cockpit, an old style fully functional MCDU which provides control of the FGMS and a graphical type MFD which gives excess to standby systems, surveillance and most FMS functions (this system will be updated soon).

The model also includes a funny functional interactive airbus style checklist which will monitor your every move and provide helpful guidance as to what to do at all stages of the flight.
The model also includes a very detailed 3D model both exterior and interior of the aircraft, a stunning detailed cockpit and many effect which are the hallmark of FlightFactor models.

## Model Classification

FlightFactor currently classifies its model lines in three categories. Ultra, Professional and Advanced.

Ultra These are models for professional training where each aircraft system has been modeled from inner circuitry upwards. These models simulate not only the way the aircraft's systems work, but the interworking of the systems themselves, down to electronic response times and communication between different pieces of software in the plane. Currently we do not offer any such simulations to the wide X-Plane community.

Professional  This is a line of products which is most popular on the X-Plane market. These models offer the user the opportunity to learn about the real aircraft systems and experience the full range of interaction with the plane, including hundreds of failures, emergency procedures and full navigation using a fully functional FMS system with a custom database including SIDs/STARs and full complexity of model navigation. These models require patience and knowledge from the users. Currently we offer the officially licensed Boeing 757 and Boeing 777 series available on x-plane.org

Advanced This is a new line of product which we offer X-Plane users gives you the opportunity to experience the full range of capabilities of the real plane without the need to invest too much time into learning the systems. The idea behind the advance models is to give inexperience users the opportunity to fly a complex plane right away. Basically the advanced models are the same as Professional, but with emergency procedures, failures and some interworking of the systems removed. Also, the navigation system on the advanced models is simpler and uses the native X-Plane database rather than a custom one.

The current model is classified as Advanced and is suitable for both the experienced and novice user.

**Note** thought an Advanced model is not as complicated to use as the Professional, it still requires learning and training. We urge you to read though this brochure carefully and to property prepare for you flying experience.

# Model Set-up

## The Team

Pavel Krupnyakov – aeronautical engineering
Marius Hoppmann – sound engineering
Pierre Lavaux – sound engineering
Richard Kulver – 3D design and textuting

Torsten Liesk – FBW, Autopilot and Navigation programming
Roman Berezin – general programmer, 3D designer, project manager

We thank all the testers for their great contribution

We also thank Pavel Pronov and Ahmed Akram Ahmadi for locating and compiling sounds.

## Installation

With the download/DVD you should have received a key number, which is to be used to register the model. You will be asked for the key upon first usage of the model. The key is supported for X-Plane 10 (starting at 10.30). The key will work twice for the same computer. If you require an extra key, please contact the support.

To install the model, extract it into a folder of your choice. We suggest that the folder name contains no non-unicode characters. The folder also must not be a system folder.

Upon first usage a window prompting you for your key will appear. Copy the key from your confirmation email and paste/type it into the window. Press automatic installation. Only if the computer running the sim has no internet connection, use the manual registration.

## Troubleshooting

On some Mac-Computers, the plugin can not be recognized if the overall path to the plugin is too long. If the aircraft instrument panel looks screwed up on startup, although you left the plugin where it belongs, this is most likely what happened.

To rectify this issue, reduce the name of the Aircraft to “a350”. That normally does the job.

## Support

If you are having trouble with the aircraft you can use our support system.

Support system: http://flightfactor.aero/ticket/

Please note, that if some of the following conditions are not met in your message, it might not be answered.

1. All questions regarding the links to file downloads, extra airport downloads or redownload of any content produced by FligthFactor, are to be addressed to the store where you bought the products. This email is for technical support only. (if you bought the product at x-plane.org you should address your link/download questions to sales@x-plane.org)

2. When sending us a question regarding activation, reactivation or reinstallation you must include your key number (it's a 34 character long sequence found on the button of the confirmation email you received from the store upon purchase of the product (e.g. XX-XXXXXX-XXXXXX…..)).

3. For any technical problem always include a recent log (this is an automatically generated log.txt file located in your main XP folder). Always remember to load the plane just before sending the log, as this file is created each time you load the aircraft.

4. All users should make sure they have java runtime installed on their machines and that JAR extension is associated with this programme

5. Windows users should make sure they have Microsoft C++ redistributable installed

6. All questions are to be addressed in English, German or Russian

## Joystick and shortcuts

For the use of this aircraft, you should have a joystick that has a **yaw axis** available. If you don’t have a yaw axis on your joystick, you can choose to deflect the nose wheel with the roll axis.

For an optimal flight experience with this aircraft, we also recommend to have at least these features assigned to joystick buttons:

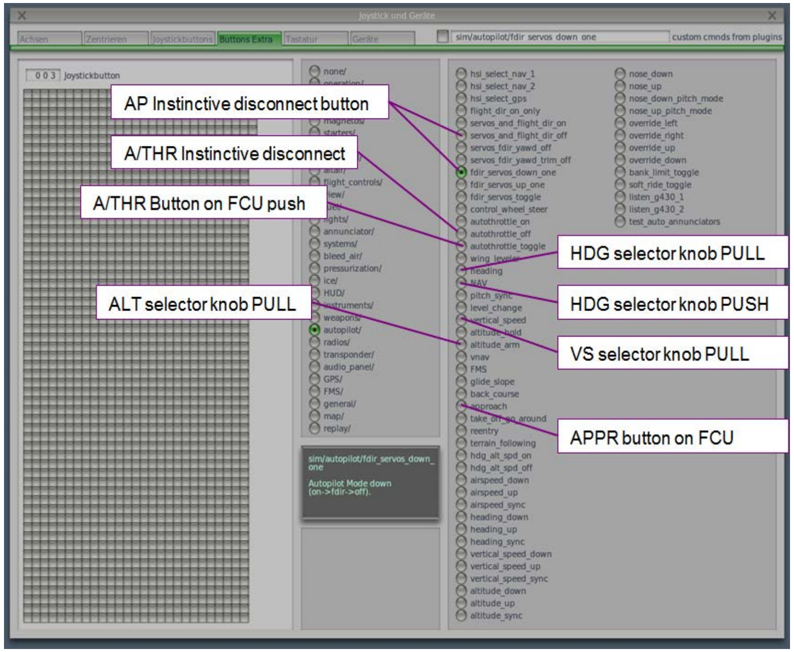
Autopilot instinctive disconnect (it is different from pressing the button on the FCU!)

Regular brakes hold and, if possible maximum brakes hold (unless you have brake pedals)

Reverse thrust toggle (unless you have dedicated reverse levers)

All other commands can also be done via keyboard commands if no more joystick buttons are available. The buttons above should be on the joystick, because these features are on the actual flight controls in the real aircraft, and the pilot can use them without taking his hands of the controls. All other commands, such as gear, flaps, spoilers are commands for which in real life you need to take one of your hands of the controls. (OK, in real life you got a co-pilot for those.)

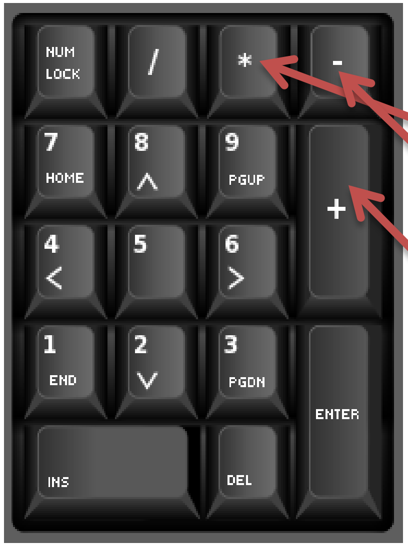
Most of the native X-Plane commands work well with this aircraft too. However for all autopilot related features, only the commands shown in the figure below are mapped to the respective plugin commands:




The a350 is equipped with a graphics interface MFD (Multi Functional display). In the real plane, the pilots use the roller, check buttons and a mouse like joystick to move a cursor on the screens. To imitate this we have connected all these function onto the checklist roller and check button on the pedestal and strongly suggest you define shortcut keys for these. This will expedite your manipulation of the MFD, checklist and the OIS.

## Joystick and shortcuts

These buttons will change the target of your manipulation. Pressing each will focus the target on a specific screen and a small not CAPT will appear in the corner.




We suggest using the numpad to set the custom keys for the three most important MFD functions.

click - 1-sim/click

pointer up - 1-sim/pointerUP

pointer down - 1-sim/pointerDN

The roller will allow you to scroll those all the available push click zones on a focused screen. Use the check button (above the roller) to click on items.

## Using the MFD and OIS

The MFD and OIS use the above-mentioned point + click system. If you popup the screens you can use your mouse and keyboard to enter values, pushbutton and manipulate everything else on the screens. Every time you pop-up a screen a note will appear on the top left "PRESS KEY OF KEY INPUT" if you click once anywhere on the popuped screen the note will change to "KEY INPUT IN PROGRESS", which means you keyboard is now locked onto this srceen and all input from the keyboard is interpreted as input to the screen. Click with you mouse anywhere outside the screen to unlock the keyboard and return to the original setting.

The screens are made up of input elements such as button, bullets, input fields. Most of these are straightforward to use, by clicking them. Here are some notes that might help you with specific things:

In some cases, a button or bullet will be nonoperational, it will turn grey and will not except input.

Menus: when clicking on a menu the click zones are reassigned and you can only manipulate within a menu. Click on the top of the menu again to close the menu down and return to full page control again.

Fields: the field will display the current value of the field until you click on the field and activate the input. At that moment the field value will change to the default value (usually something like ---- which means 4 characters). Some fields will except numerical values only, some will except the decimal point or any alpha numeric input. The default value usually means that you should enter the same number of characters as there are dashes, but this is not always true. For a flight level for example you will see --- appear as default. You can enter 150, 050 or 50.

The field input will stop automatically if you fill-in the entire field. You can hit ESC key on your keyboard at any time to delete everything and return to the previous value. Use BACKSPACE key to clear the last character. Use ENTER key to stop the input and use the value you entered.

At any point you can use the build in keyboard which duplicate all the key relevant keys. Use the Click as ENTER

## Using the MFD and OIS

If you are not using the popup function you can still use your keyboard to enter values in the fields on the MFD. When the window is active and non popuped, you can hit the Click to start entering a value in a field. At that moment you will see a message on the button left of you screen “PRESS FOR KEY INPUT”. Clicking on the message will lock your keyboard and except key input into the field. The message will read “PRESS TO END INPUT” now.

Another way is to set the popup+click option to off and use direct clicking. In this case, you will be able to click on field directly with you mouse, but the pop-up option will no longer be available.

## Using the MFD and OIS

The folder CHARTS contains user's charts files in PDF and common images format. You can also use subfolders in order to structurize your charts files. Make sure the name of the pdf has no more than 5 latters. We suggest simply using the code of the airport.

# Model Set-up

## Options

The options page on the OIS gives you the ability to set some parameters of the sim. At any point, you can restore the default settings. If you want the current setting so load automatically every time you load the model, press SAVE CURRENT to save the current configuration. Here are some non-self-explanatory options.

Time flow – some things like loading the plane require time. This options sets the flow of time.

Difficulty level – set the level of realism in terms of mistake you can make

Structural limits – should the plane brake when the real one would

Auto Pause will cause the sim to pause automatically in the specified cases

MFD Control – wheel + popup will allow you to popup the windows of the MFD, OIS, and Checklist and click with you mouse. When non-popedup you can use the built-in wheel and click system. If you choose the touch screen option you will be able to directly click the screens with you mouse but will not be able to pop them up.


Mouse wheel – manipulate will allow you to manipulate most knobs with the mouse wheel

Auto-helper – will help you with ground equipment

# General

A350 XWB

## General

The A350 is a twin engine subsonic aircraft designed for commercial transportation of passengers and cargo.

There are three members in the A350 XWB family:

•The A350-800 (276 passengers in a 2 class cabin arrangement)

•The A350-900 (315 passengers in a 2 class cabin arrangement)

•The A350-1000 (369 passengers in a 2 class cabin arrangement).

When dependent on the aircraft model, this brochure describes the A350-900.

The A350 has two high-bypass turbofan engines mounted underneath the wings. Its cockpit is designed for operation by a crew of two pilots.

All the A350 variants have the same type rating.

The A350 also shares high degree of commonality with other Airbus aircraft.

## Certification Basis

Airbus designs and builds the aircraft according to Airworthiness Requirements from the European Aviation Safety Agency (EASA) requirements:

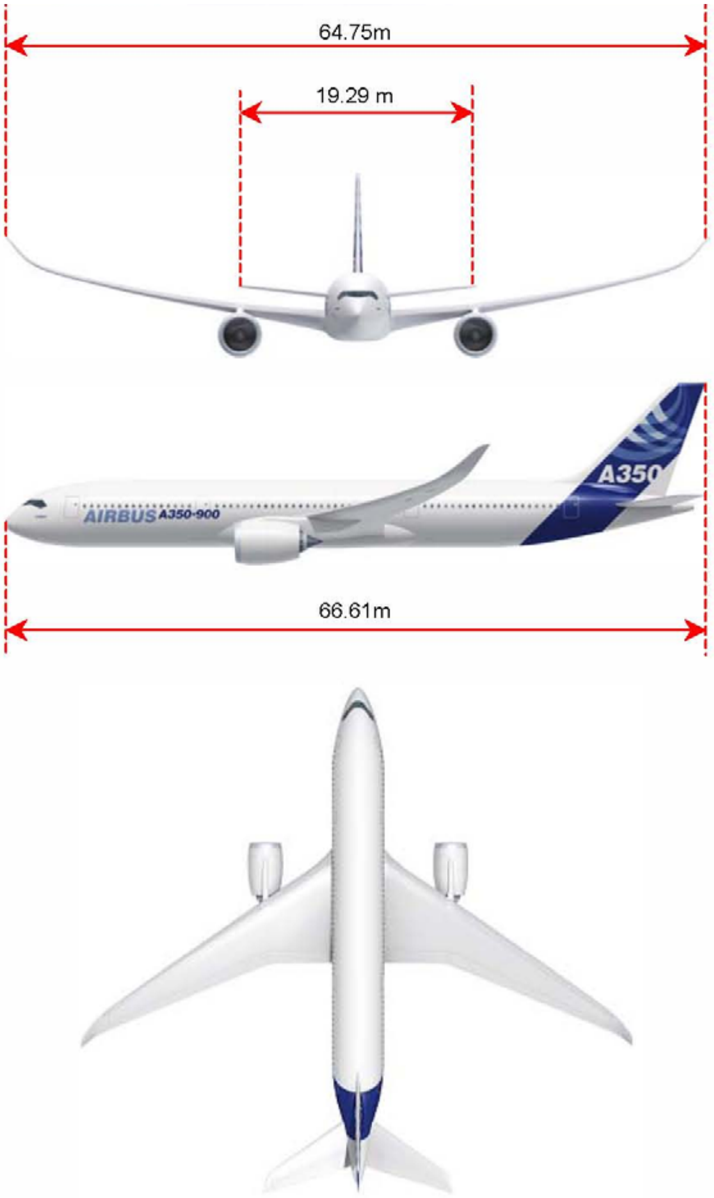
• CS 25 amendment 4
• CS AWO dated October 2003.

A350 XWB

## Dimensions

The A350 Family presents the current following main dimensions still under review:

| | A350-900 |
|---|---|
| Wing span | 64.75 m (212 ft 5.2 in) |
| Wing area | 442.9 m² (4767.3 ft²) |
| Sweep (25% chord, mid-wing) | 31.9° |
| Fuselage length | 65.26 m (214 ft 1.3 in) |
| Fuselage cross-section (constant part) | 6.09 m (239 in) height<br>5.96 m (234 in) width |
| Horizontal tail plane area | 82.7 m² (890.2 ft²) |
| Horizontal tail plane span | 19.29 m (63 ft 3.4 in) |
| Vertical tail plane area | 51 m² (549 ft²) |
| Overall height | 17.05 m (56 ft) |

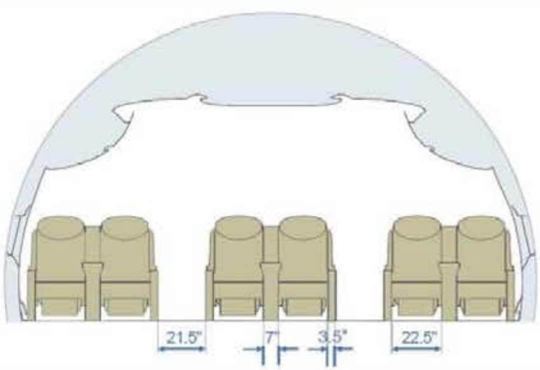


A350 XWB

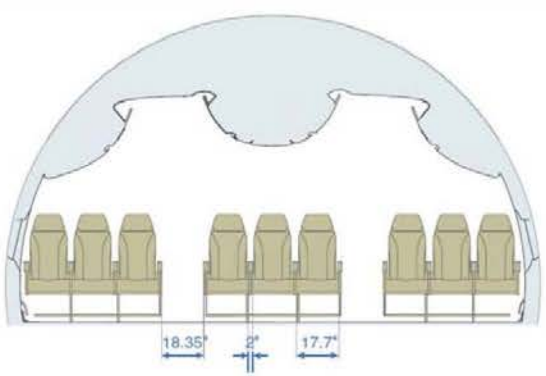
## Typical Cabin Layout

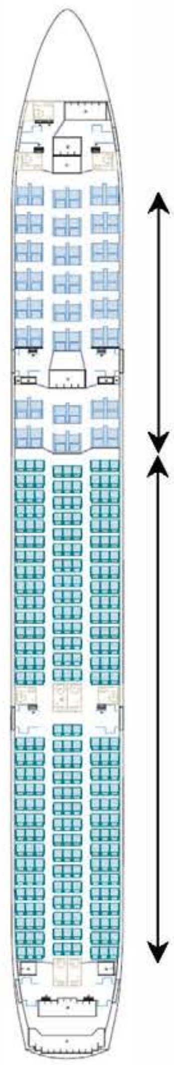
The typical cabin layout is 315 seats. The passenger seating layout may vary according to the Operator's requirements.

### Business/First Class




### Economy Class

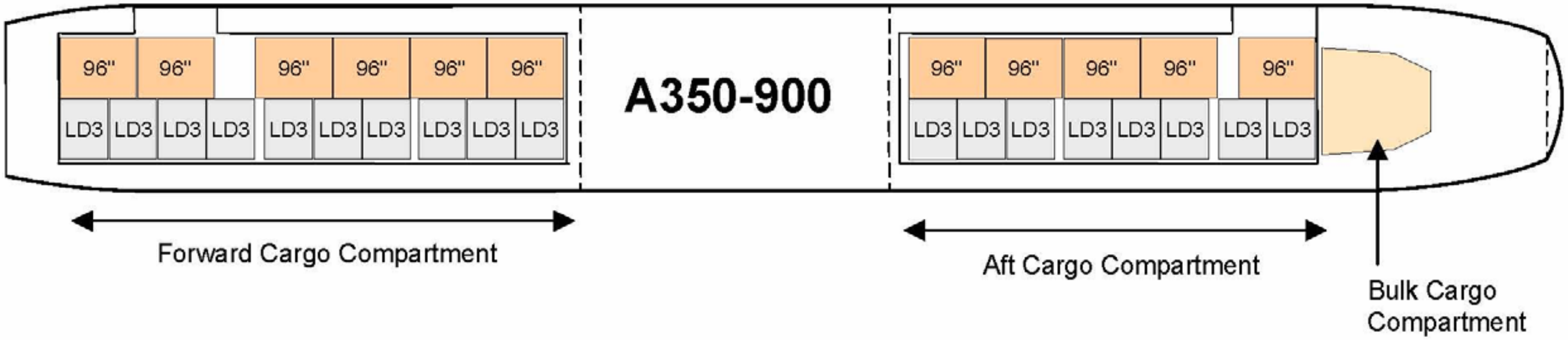


## Cargo Hold Capacity

The A350 has the following lower deck cargo compartments:

- Forward cargo compartment (20 LD3 or 6 pallets 96")
- Aft cargo compartment (16 LD3 or 5 pallets 96")
- Bulk cargo compartment (400 ft$^3$).



# General

## 1. Design Weights

| | A350-900 |
|---|---|
| MTW (taxi) | 268 900 kg |
| MTOW | 268 000 kg |
| MLW | 205 000 kg |
| MZFW | 192 000 kg |

## 2. Design Speeds

| | |
|---|---|
| $V_{MO}$ | 340 kt CAS |
| $M_{MO}$ | 0.89 |
| $V_D$ | 375 kt CAS |
| $M_D$ | 0.96 |
| $V_{LO}$ | 250 kt CAS<br>250 kt CAS (gravity extension) |
| $V_{LE}$ | 250 kt CAS |
| $M_{LO}$ | 0.55 |
| $M_{LE}$ | 0.55 |

## 3. Slats and Flaps Design Speed

| Lever Pos. | Configuration | Flight Phase | DND(°) | Slats (°) | Flaps (°) | |
|---|---|---|---|---|---|---|
| | | | | | Inboard | Outboard |
| 0 | Clean | CLB/CRZ/HOLD | 0 | 0 | 0 | 0 |
| 1 | 1 | HOLD | 16.7 | 18 | 0 | 0 + TBD |
| | 1+F | TO | 16.7 | 18 | 13 | 13 + TBD |
| 2 | 2 | TO/APP | 16.7 | 18 | 20 | 20 + TBD |
| 3 | 3 | TO/APP/LDG | 16.7 | 18 | 28 | 28 + TBD |
| | 3+S | LDG | 25 (TBC) | 27 (TBC) | TBD | TBD |
| Full | Full | LDG | 25 | 27 | 37.5 | 37.5 - TBD |

*Note: DND stands for Droop Nose Device.*

## 4. Fuel Capacity

| | | USABLE FUEL (Fuel Specific Density: 0.799 kg/L) | | | |
|---|---|---|---|---|---|
| | | Left Wing Tank | Center Tank | Right Wing Tank | TOTAL |
| VOLUME | Liters | 31 333 | 75 334 | 31 333 | 138 000 |
| | US Gal | 8 277 | 19 901 | 8 277 | 36 455 |
| WEIGHT | Kg | 25 035 | 60 190 | 25 035 | 110 260 |
| | Lbs | 55 265 | 132 870 | 55 265 | 243 400 |

## 5. Pavement Strength

| Main Landing Gear Gear tires (radial) | ACN | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Flexible Pavement | | | | Rigid Pavement | | | |
| | Cat A | Cat B | Cat C | Cat D | Cat A | Cat B | Cat C | Cat D |
| 1400 x 530R23 40PR | 56 | 61 | 71 | 95 | 48 | 55 | 65 | 76 |

*Note: The Nose Landing Gear is equipped with 2 radial 1 270 x 455 x R22 tires.*

## General

The Rolls Royce Trent XWB engines power the A350-900.

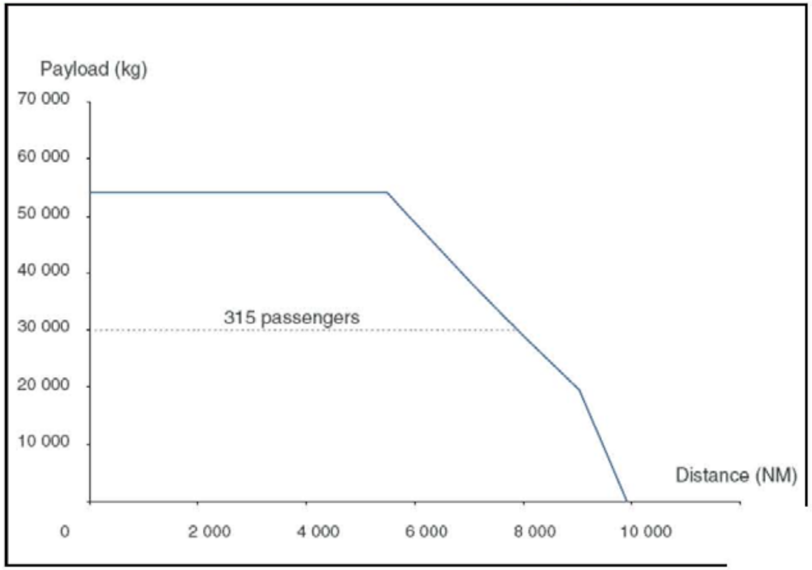
| Engine type | Thrust ratings (Maxi takeoff at MSL) |
|---|---|
| RR Trent XWB - 84 | 84,000 lbs |

## Payload / Range calculations

The following payload range calculations have been performed using the A350 Family standard layouts presented page 1.6 and Airbus standard operating rules described below:

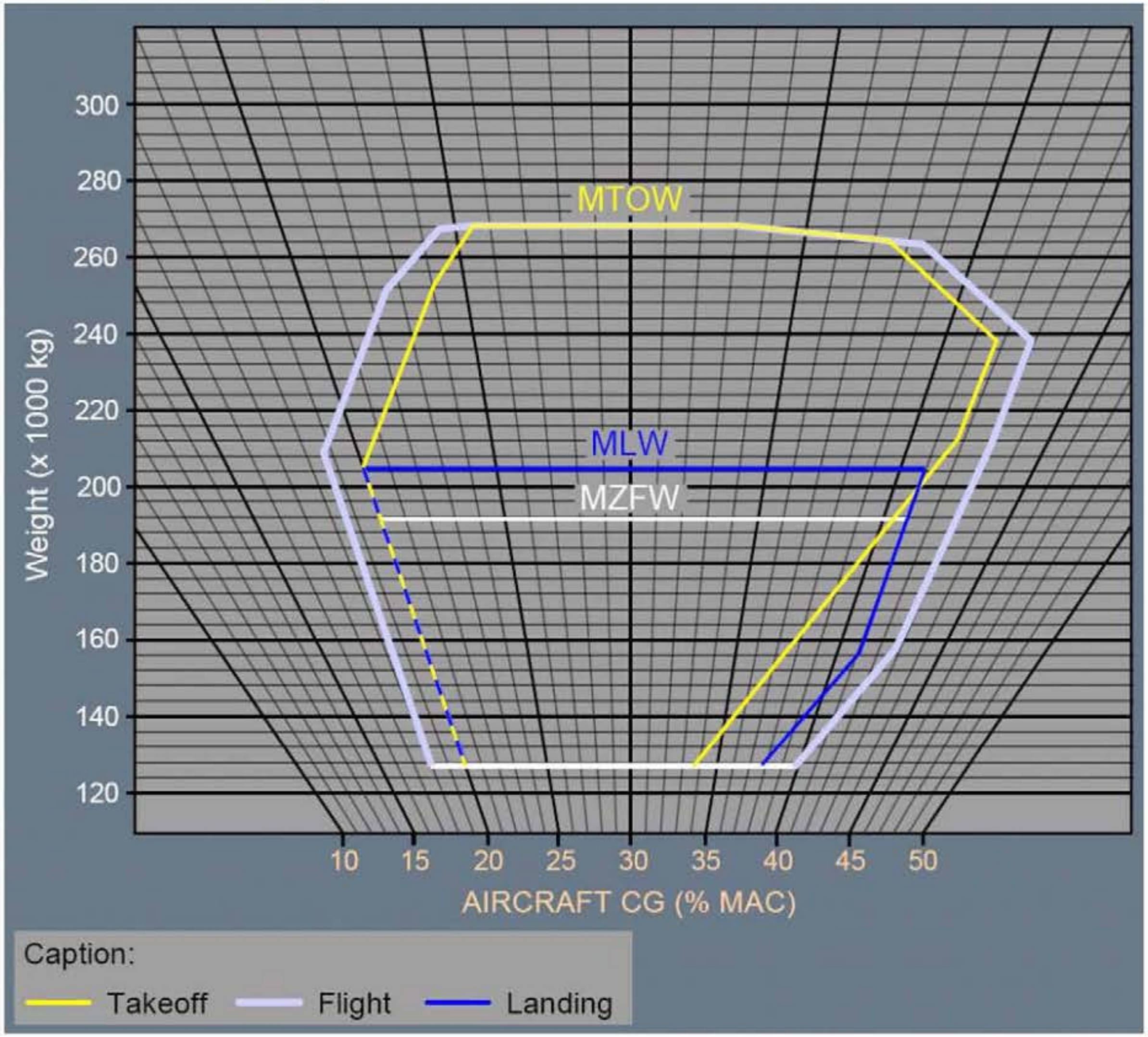
- Typical international reserves
- Nominal fuel flow
- Standard temperature conditions
- Payload: 95 kg per passenger including luggage
- Fuel density: 0.803 kg/l
- Mach: 0.85.

Payload Range Diagram (RR Trent Engine)



# General

Weight & Balance Graph



# Flight Deck Layout

A350 XWB

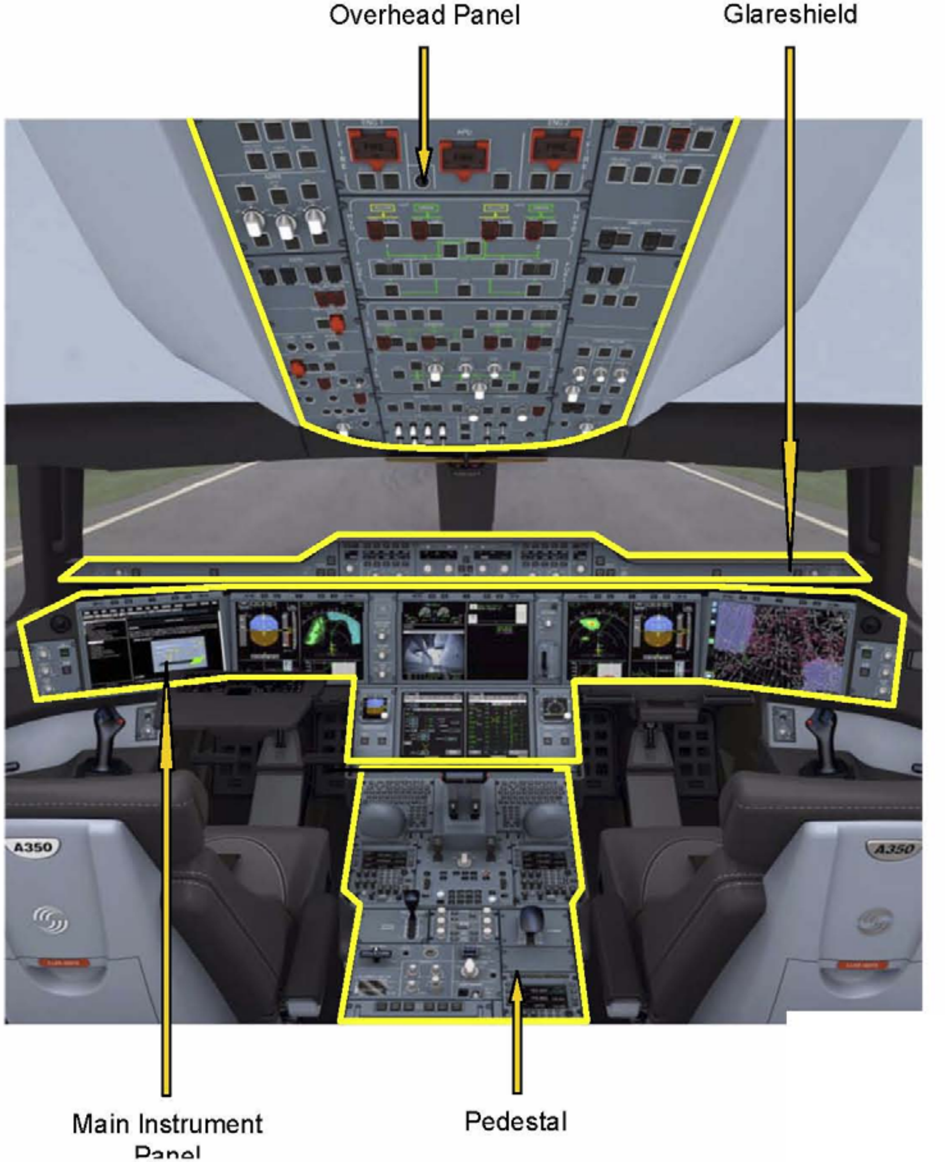
# Flight Deck Layout

A350 XWB

## Cockpit Views

The cockpit includes:

- The following instrument panels:
  - Overhead panel
  - Main instruments panel
  - Glareshield
  - Pedestal
- The Captain and First Officer lateral consoles that each have:
  - One sidestick
  - One steering handwheel
  - One oxygen mask
  - A stowed laptop
- An Onboard Maintenance Terminal (OMT) for maintenance staff
- A third occupant console with an oxygen mask
- A fourth occupant console with an oxygen mask.

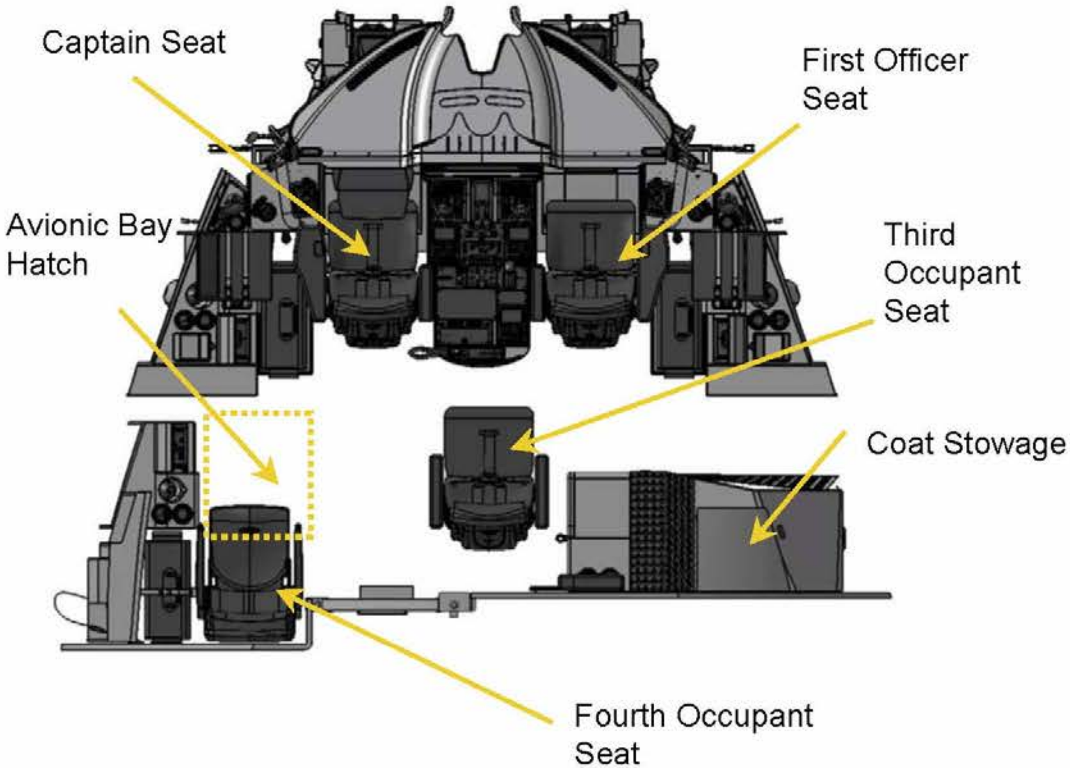


# Flight Deck Layout

## Overview

The A350 cockpit has:

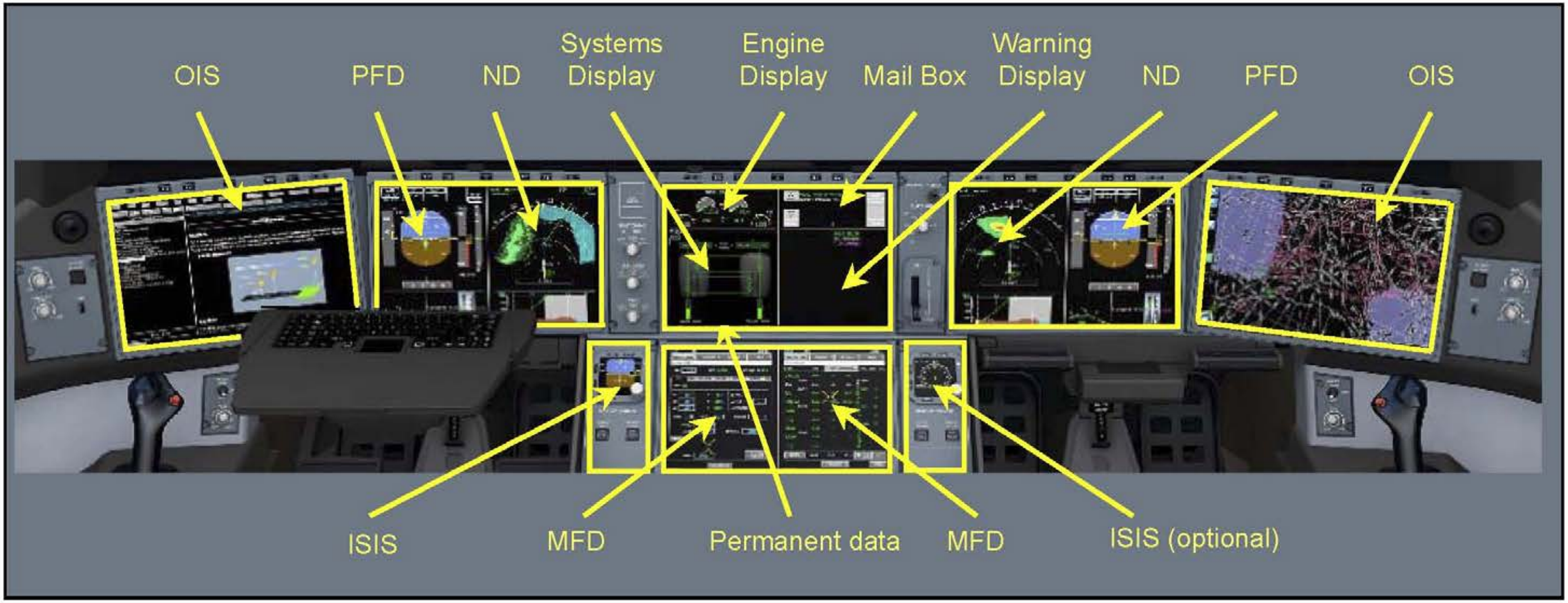
- A Captain seat
- A First Officer seat
- A third occupant seat
- A fourth occupant seat (*optional*)



# Flight Deck Layout

A350 XWB

## Main Instrument Panels




| | |
|---|---|
| **PFD: Primary Flight Display** | **MFD: Multi-Function Display** |
| **ND: Navigation Display** | **ISIS: Integrated Standby Information System** |

# Flight Deck Layout

## Glareshield

The glareshield has:

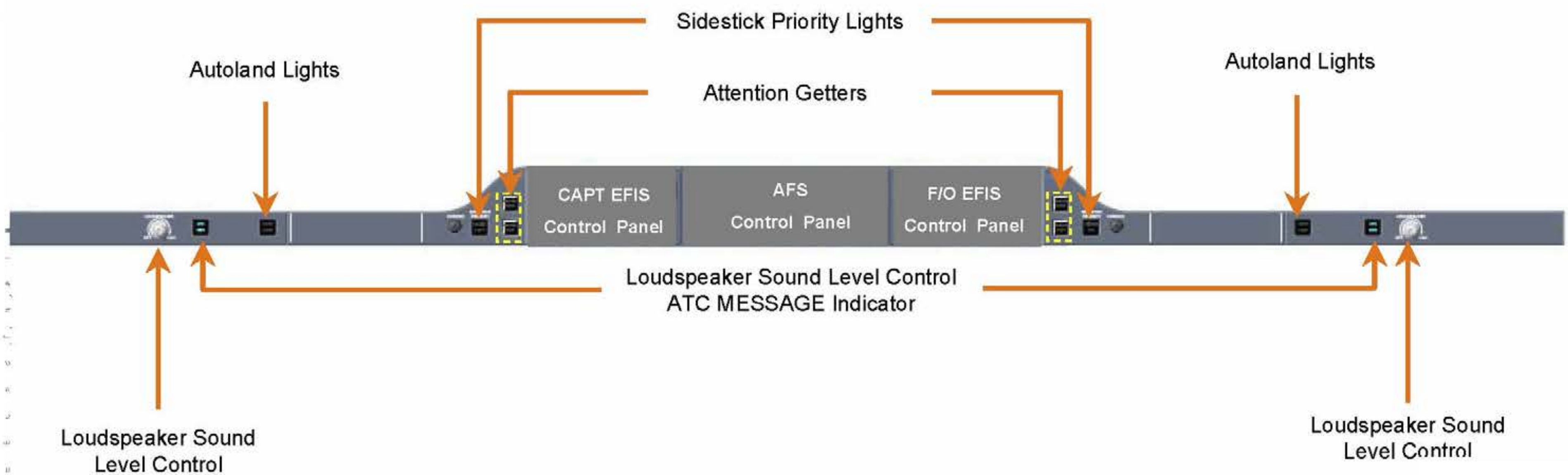
- One **Flight Control Unit (FCU)** with:
  - Two **EFIS Control Panels (EFIS CP)**
    Each EFIS CP is used to select the display on the onside PFD and ND, and to change the barometer settings.
  - One **Auto Flight System Control Panel (AFS CP)**
    The AFS CP is the main interface with the Flight Guidance (FG) system.

- Two panels with:
  - Attention getters: Master warning and master caution lights
  - Sidestick priority lights
  - Autoland lights.

- Two panels with:
  - Loudspeaker sound level controls
  - ATC MESSAGE indicators.

# Flight Deck Layout

## GLARESHIELD



## Pedestal

The central pedestal includes:

- Two **Keyboard and Cursor Control Units (KCCUs)**

  Each KCCU enables the crew to interface with the MFD, ND and the OIS.

- Three **Radio Management Panel (RMPs)**

  The RMPs can be used:

  - To tune all radio communications
  - To enter the squawk code
  - As a backup for radio navigation
  - To adjust the volume for communication and NAVAID identification

- One **SURV Control Panel**

  The SURV Control Panel is used to interface with the SURVeillance (SURV) functions of the aircraft:

  - Terrain Awareness and Warning System (TAWS)
  - Weather radar
  - Traffic Collision Avoidance System (TCAS)

- One **ECAM Control Panel (ECP)**

  The ECP is the interface with the ECAM.

- **Thrust levers and engine master levers**

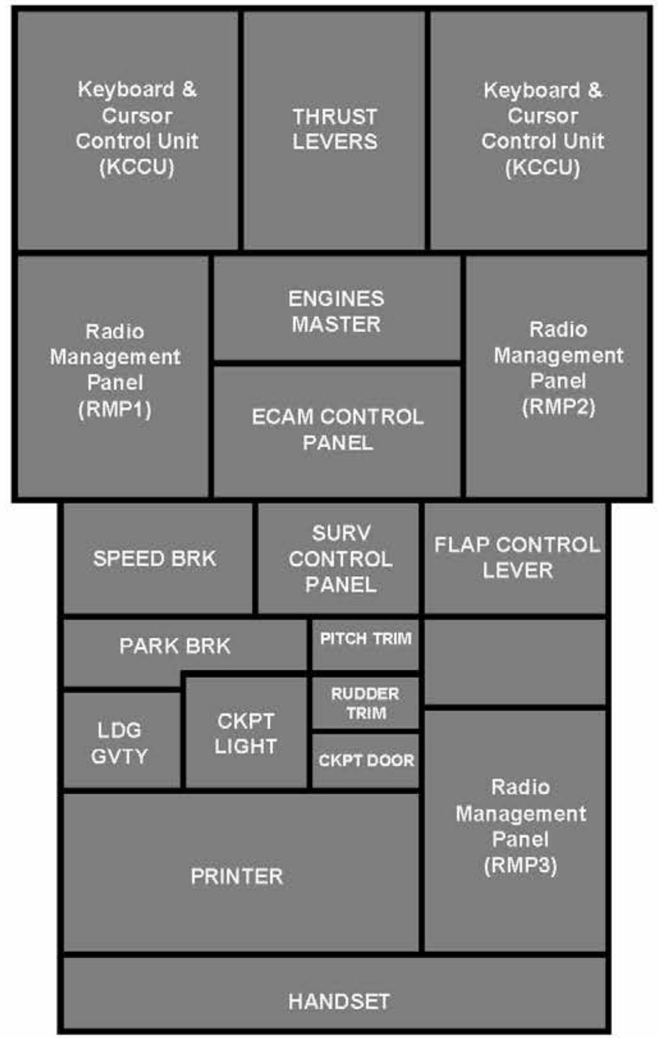
- The following panels for the flight controls:

  - Pitch trim and rudder trim panels
  - Speed brake lever and flaps/slats lever
  - Parking brake panel.

- The handset

# Flight Deck Layout

## PEDESTAL



# Flight Deck Layout

## Overhead Panel

Both pilots can reach all the controls on the overhead panel.

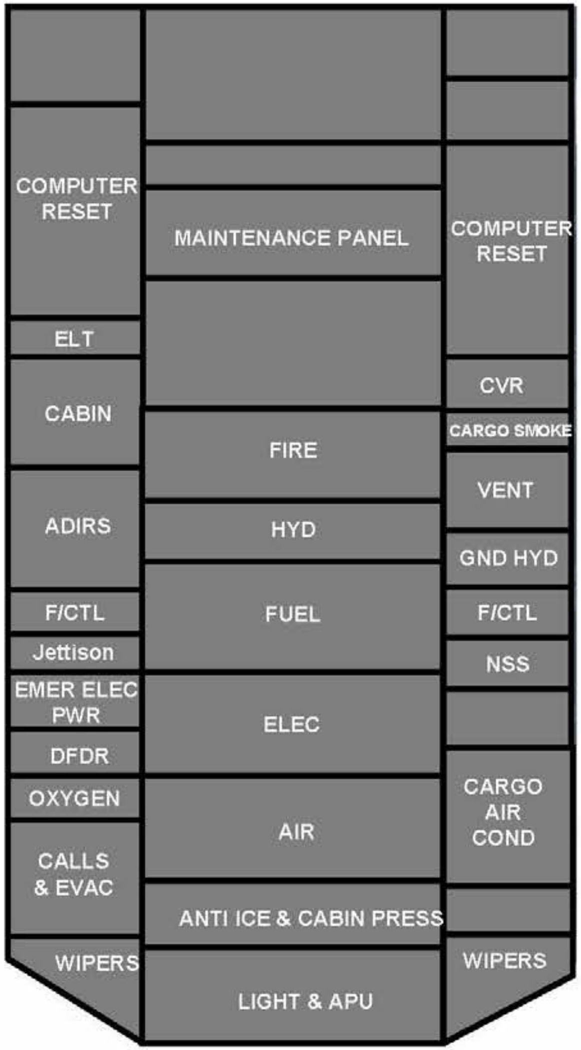
The overhead panel includes the system controls and is organized in three main rows:

- One center row for primary systems organized in a logical way
- Two lateral rows for other systems.

The pushbutton philosophy is identical to previous Airbus aircraft.

# Flight Deck Layout

## OVERHEAD PANEL



# Flight Planning

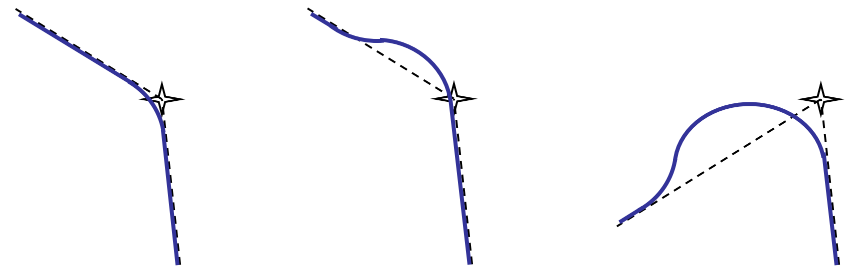
## General

The flight planning tool of this model is based on the standard X-Plane FMC. However, it has a couple of additions to it that I would like to present here and it has a completely reworked interface for flight-plan editing as described below.

In X-Plane's default FMC, you can only set waypoints (Either radio-navaids, airports, fixes or an arbitrary set of coordinates) and assign altitudes to these. In X-Plane's VNAV mode, the airplane then flies in straight lines between the waypoints with a vertical speed that makes the aircraft reach the altitude of the next waypoint at the same time it reaches the waypoint.

For the A350, we have extended this system by a few features to make it more realistic. The first feature is the definition of overfly waypoints. In real life, most waypoints are flyby waypoints, meaning the aircraft initiates the turn before reaching the waypoint in order to swing into the next leg without overshoot. However, especially in SIDs/STARs you often find overfly waypoints. At overfly waypoints, the aircraft stays on the track until it reaches the waypoint. The turn into the next leg is only initiated, once the waypoint has actually been passed.

Fly-by waypoints with very strong changes in track direction can also lead to overshoot of the next leg, as the aircraft initiates the turn at the earliest 7NM before the waypoint.



Regular Fly-by waypoint

Overfly waypoint

Fly-by waypoint with pointy angle

The second added feature is that altitude constraints can be classified as "at", "at or above", and "at or below" constraints.

During the climb phase, the aircraft levels off at "at" and "at or below" constraints, until the associated waypoint is passed. "At or above" constraints have no impact on the flight profile. In real life, the aircraft will warn you, if a "at or above" constraint will not be met, but it is up to the pilot to take proper action to meet the constraint.

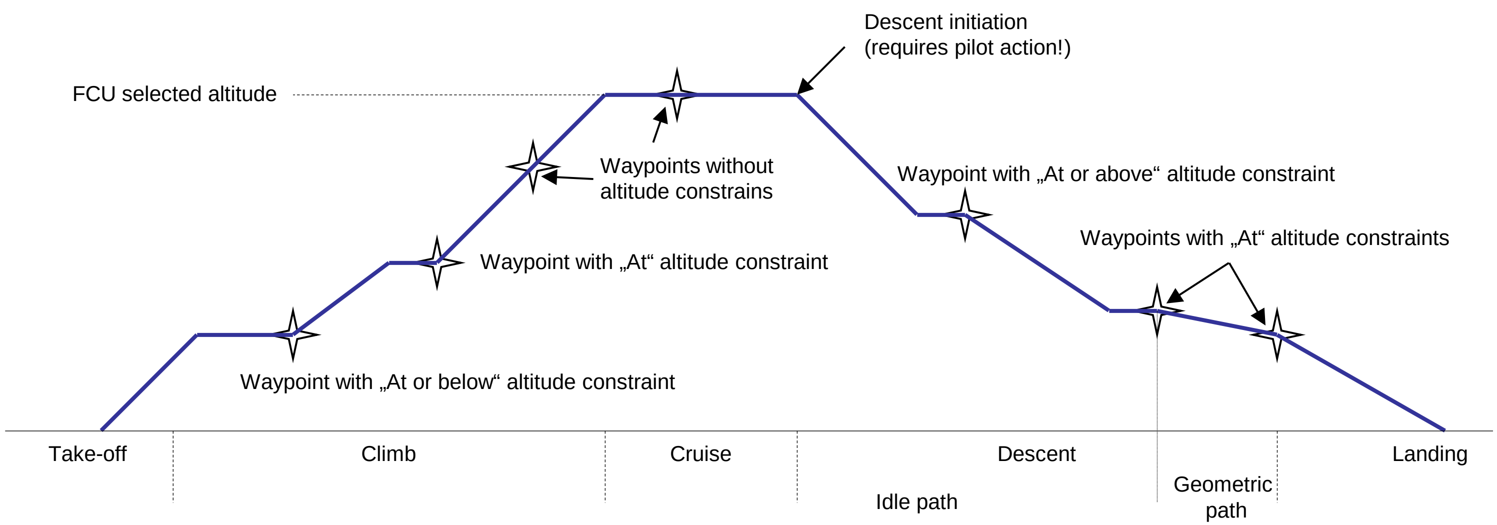
# Flight Planning

During the descent, the aircraft levels off at “at” and “at or above” constraints. Analogously to the climb phase, there is no algorithm in place yet that ensures that the aircraft descends fast enough to reach the constraint when reaching the waypoint. Hence, “at or below” waypoints are ineffective during descent. In contrast to the climb phase, there are differences between “at” and “at or above” waypoints during the descent. When flying to or from a waypoint with an “at or above” constraint, the aircraft will perform a idle descent, i.e. the engines will be at idle, and the autopilot adjusts the descent rate to maintain the desired airspeed. When the aircraft is flying between two waypoints that each have a “at” altitude constraint, the aircraft will fly a geometric path that connects both waypoints on a constant slope.

Pay attention not define these slopes too steep, otherwise the aircraft will build up undesired speed during the geometric path segment, as the engines cannot produce less thrust than idle!

Use the speedbrakes, if necessary!

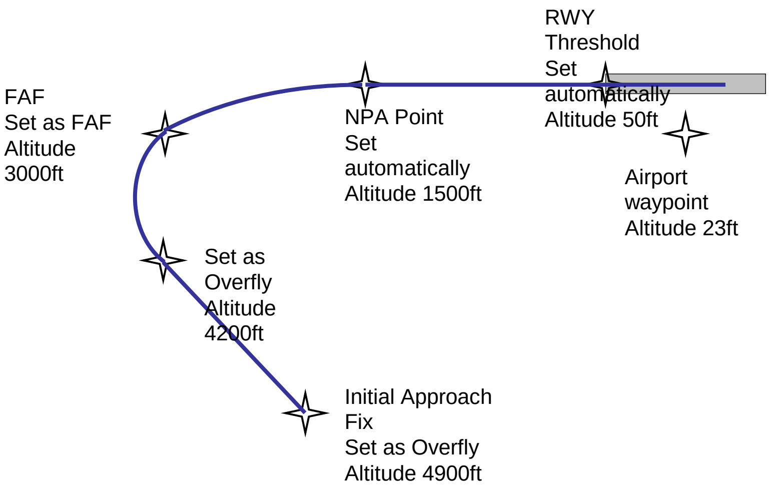
The third added feature is the definition of Non-Precision Approaches. To achieve a valid Non-Precision approach, the following structure needs to be observed.



# Flight Planning

The NPA section has to end with two waypoints, a Lat/Lon Waypoint defining the coordinates of the runway threshold with the altitude of this waypoint set to the runway threshold altitude plus 50 feet. This waypoint must be followed by an “airport” waypoint representing the destination airport. For the airport waypoint enter the airport elevation as altitude.

Before the waypoint representing the runway threshold, enter all waypoints of the Non-Precision-Approach up to the Final Approach Fix, including altitude information. At the FAF-waypoint, select “Set FAF” in the Flight management computer. All subsequent waypoints will be configured correctly for the Non-precision approach.




If you are programming a complex RNAV approach that includes a well-defined path before the FAF, set all the waypoints from the start of the RNAV approach to the FAF as “overfly” waypoints. Make sure to assign the correct altitude information for each waypoint, so that the computer can fly the correct geometric path during the descent. During the RNAV approach the altitude of the next waypoint must never be above the altitude of the previous waypoint.

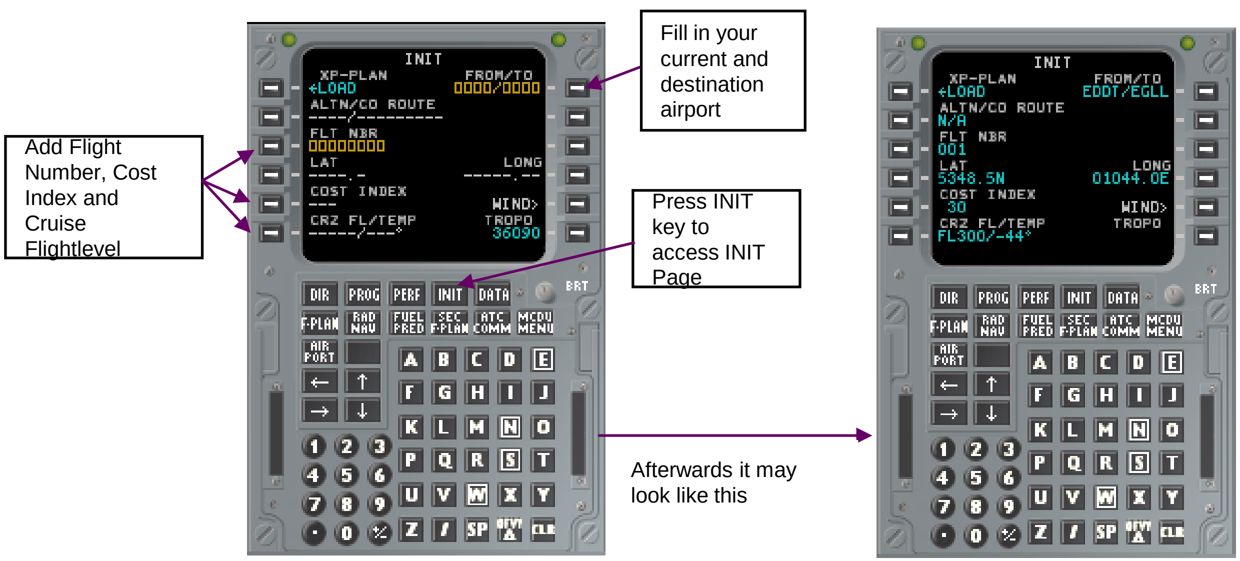
# Flight Planning

## Flight Planning Interface

The MCDUs provide the interface to plan your flight and use the additional features described above. The first step in flight planning is to fill the “INIT” (Initialization) page of the MCDU. To access the page, press the “INIT” key on the MCDU that you want to use for flight planning. The first thing you have to do is to type your current airport ICAO code and your destination airport ICAO code into the scratchpad (separated by a slash) and then put it by the upper right Line Select key (LSK) to its place. After that it is possible to indicate the Flight Number, the Cost Index and the cruise flight level you are planning to use.

The Cost Index denotes the ideal balance between performance and fuel consumption. When you plan a flight you have to decide between a high performance, which means a higher number of flights in a term, and a high cost efficiency regarding your fuel consumption. So if you have a low CI, you have low time-related costs and high costs of fuel, and the other way around.

One aspect to consider: The cruise flight level must be greater than the acceleration height and must be adapted to the total length of the flight, i.e. on a 50 NM flight you cannot reach FL390.



# Flight Planning

You can access the flight planning page by clicking the “F-PLAN” button. You will see the selected departure and destination airports as the first and last waypoint of your flight plan, separated by a “discontinuity”. The discontinuity has been inserted automatically, as we have not yet defined how to get from one airport to the other.

In order to add waypoints to your route, you have to type in the name of the waypoint into the scratchpad and insert it into the flight plan by clicking the left LSK of the waypoint, **before** which you want to insert the waypoint. (Note: Clicking the LSK left of a discontinuity will insert the waypoint before the discontinuity.)

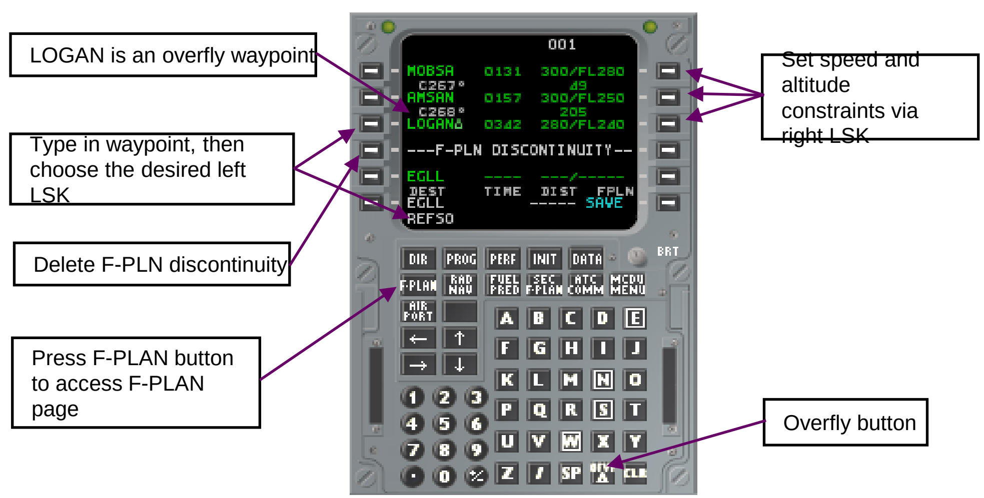
If you want to delete a waypoint click on CLR (“CLR” appears in the scratchpad) and then click the left LSK of this waypoint. Alternatively, you can also insert a waypoint that already exists further down in the flight plan. In this case, all intermediate waypoints will be skipped (including discontinuities).

Apart from entering of waypoints by name you can also enter the waypoints by Latitude/Longitude, or by Place/Bearing/Distance, e.g. HAM/310/13 stands for a waypoint located 13NM from VOR Hamburg (HAM) in a direction of 310 degrees.

The syntax for Lat/Lon waypoint is DDMM.MX/DDDMM.MY with X being either N or S, and Y being either W or E. A valid Lat/Lon waypoint is e.g. given by 5310.2N/01045.6E for 53degrees, 10.2 minutes north, and 10 degrees 45.6 minutes east. You can also skip the decimals of the minutes, if not needed: 5310N/01045E gives the waypoint 53 degrees 10 minutes north and 10 degrees 45 minutes east.

Through the left LSK you can also define overflies: Just click on the overfly button and the triangle will be displayed in the scratchpad. After that choose the desired left LSK and the corresponding waypoint will be set as overfly waypoint. To delete the overfly flag, perform the same action again!

Before starting your flight, you should delete all flight plan discontinuities, as you won’t have a complete path to your destination otherwise. To delete them you have two options: Either you use the CLR button to delete the discontinuity (as with waypoints) or you insert a waypoint that already exists after the discontinuity at a waypoint before the discontinuity.



The model supports speed and altitude constraints for waypoints. These are defined using the right LSK of the waypoint with the constraint. For speed constraints you have to enter it into the scratchpad and then put it to its desired place via the right LSK. For altitude constraints consider to set a slash in front of your requested altitude. Needless to say you can add both together, i.e. for a speed constraint of 250 and an altitude constraint of 3000 just type 250/03000 into scratchpad and take it with the appropriate right LSK to the desired place. Constraints with zero value delete the entry.

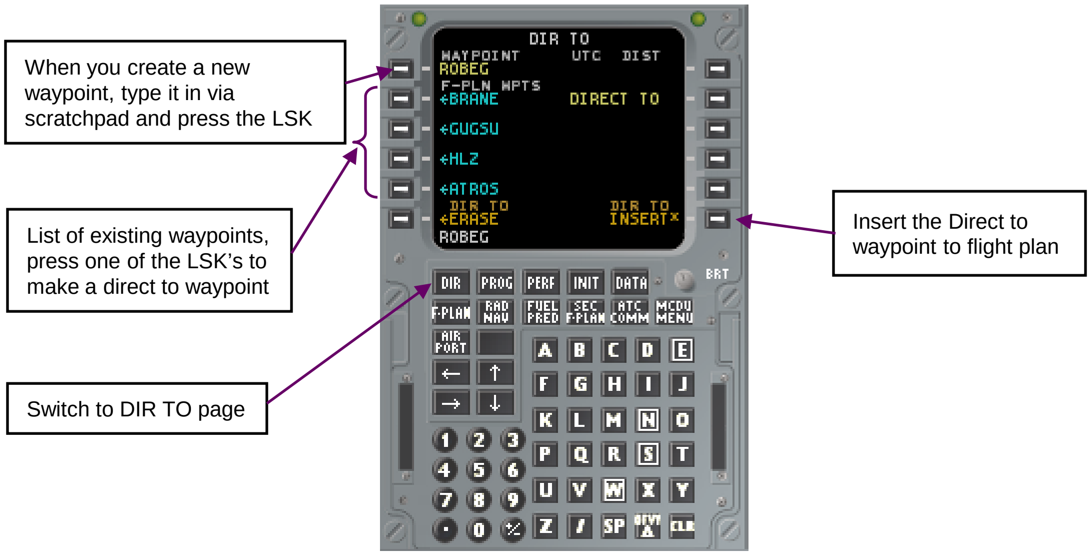
Regarding altitude constraints you have the possibility to choose between At, At or above and At or below constraints. For entering an At constraint, just type in altitude or FL and select the proper right LSK of the desired waypoint. For an At or above constraint, enter altitude or FL preceded or followed by “+” sign. For an At or below constraint, enter altitude or FL preceded or followed by “-“ sign.

As the A350 is using the X-Plane FMS for flight plan storage, the altitude constraint types, the overfly flags etc are coded into the last digit of the altitude information of the waypoint. This coding leads to the following restrictions for the altitude data in each waypoint: You can only enter the altitude rounded to the nearest 10 feet. For altitudes above 20000feet, you are only allowed to enter altitudes rounded to the nearest 100 feet. Only airport waypoints can receive the exact airport elevation as altitude value.

With most flight plans imported from Goodway, the plugin should understand that the altitude values are Goodway values and will round them to comply with the rules above. Under some rare circumstances it can occur that all values provided by Goodway can be interpreted as valid flag codings. Then you will receive a flight plan with apparently random selections of overfly flags and “At”, “At or above” and “At or below” constraints. For this reason we highly recommend that you verify the extra features carefully after importing a Goodway flight plan. Once you verified and set all the flags correctly, saving the flight plan will give you a valid flight plan that will retain these settings upon loading.

## Direct To Function

It is also possible to make a direct to on the DIR TO page; to access this page, click on the DIR page key. There are two options to perform a DIR TO: You can enter a waypoint which you want to fly to directly via scratchpad and press the left LSK 1, after that insert it to the flight route, thus creating a new waypoint. If the direct to waypoint did not previously exist in the flight plan, it will be followed by a "flight plan discontinuity" and then the previous "TO" waypoint.



## Performance Data Entry

The MCDUs are the strategic interface between crew and FMGC. The MCDU allows entering data needed for some of the advanced features of the a350. These data are the take-off speeds V1, VR, and V2, the Flex Temperature in Degrees Celsius as well as the thrust reduction altitude, the acceleration altitude and the transition altitude, all these settings are available on PERF page, the cruise altitude you can choose on Initialize page.

The flex temperature determines how much to reduce the thrust for a flex take-off. The logic behind the flex temperature is as follows: In principle, jet engines produce less thrust at higher ambient air temperatures due to the reduction in air density and the limit on the maximum turbine entry temperature. However, up to a certain temperature, modern jet-engines are flat-rated. That means they produce the same thrust for all temperatures up to the flat-rated temperature. Above the flat-rated temperature, the turbine entry temperature becomes the limiting factor and the thrust drops significantly as the ambient temperature increases further.

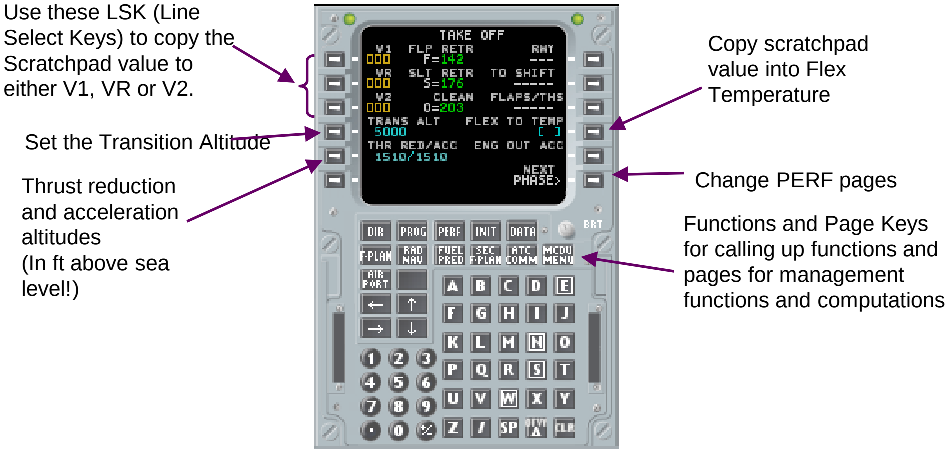
The flex temperature is now used to express how much thrust I want to have during my flex takeoff. For a flex temperature of *x*°C the engine will produce that amount of thrust, that it can produce maximally if the outside air temperature was *x*°C. This leads to the following consequences:

- The FLEX temperature must not be less than the Outside Air Temperature

- For FLEX temperatures that are below the flat-rated temperature of the engine, the engine will produce TOGA thrust even during a FLEX takeoff.

The flat-rated temperature of the engine depends on the airport altitude. For higher altitudes the flatrated temperature decreases.

To have properly reduced thrust during take-off, choose a flex temperature about 10-20°C above the flat-rated temperature. Unfortunately, I cannot provide data here on how to compute V1/VR/V2 and the associated FLEX temperature depending on runway length, wind and weight.



Thrust reduction and acceleration altitudes are important for the time immediately after take-off and the transition into the “climb” phase. The Thrust reduction altitude determines at which altitude the aircraft will request from the pilot to retard the thrust levers from the TOGA or the FLEX detent into the CL detent (LVR CLB flashing in the first column of the Flight Mode Annunciator). The acceleration altitude determines at which altitude the autopilot switches from the SRS into the (OP) CLB mode leading to an increase in speed target to allow for flap/slat retraction. When passing the acceleration altitude, the autopilot system switches from the “take-off” to the “climb” phase.

It is also important to enter a cruise altitude so that the aircraft enters the cruise mode upon leveling off at an altitude that is equal or greater than the cruise altitude entered in the MCDU. Only, if the AP switches to cruise mode, the speed profile during the descent will be correct ensuring that the speed is less than 250 knots upon passing through 10.000 feet.

There are several Performance pages, one page for every flight phase, that means for Take Off, Climb, Cruise, Descent, Approach and Go Around. After filling the Take Off page you can check all other pages by clicking the lower LSK.

To modify the values just type the desired value into the scratchpad and then press the corresponding line select key. After that the data will be uploaded into the desired field. An error message can appear, if the data is out of range or the format is incorrect. For correcting just clear it with CLR an type it again into the scratchpad. If you want to enter an altitude or a flight level you have to regard one rule: An entry of an altitude requires at least four digits, an entry with less digits is taken as a flight level. If the altitude should be under 1000, a zero is required in front of the altitude, i.e. the altitude should be 700, you have to enter 0700. Flight level can be entered with or without FL.

Note: Only values indicated in the colour “cyan” or indicated by a red box can be modified.

# Auto Flight

A350 XWB

# Auto Flight

## General

This section gives a quick rundown on the "must-knows" about the Airbus Auto Flight System. It has no guarantee for completeness or correctness. In the original Airbus Flight Crew Operating Manual, this section is over 100 pages long. These few pages here can hence not get remotely close to the comprehensiveness of the official manuals.

The ideal starting point to understand the Airbus Auto Flight System is to forget <u>everything</u> that you knew about the X-Plane Auto Pilot. Start on this section with an open and virgin mind and you will understand it easily.

## Auto Thrust System

Experience with the previous V0.9.x releases of this aircraft has shown that the users struggle most with the Auto Thrust system. Again, this system is quite different from the A/THR systems that you have encountered in X-Plane so far.

The basic philosophy of the system is that pilot inputs on the thrust levers always have priority over the Auto Thrust inputs. If a thrust reduction is needed, the pilot can pull the thrust levers back and reduce the amount of thrust produced, no matter whether the A/THR system is active or not. Unless the pilot pulls the levers all the way into idle, the A/THR will remain active. But it will be limited in how much thrust it may produce.

If the pilot decides that he needs more thrust (e.g. evasive maneuvers, go around), he can push the thrust levers forward of the CL detent and the engines will immediately produce the respective increased thrust. In this case, the Auto-Thrust system changes from active to armed and the thrust lever position commands the desired thrust. When the evasive maneuver is finished, moving the thrust levers back into the CL detent will reactivate the A/THR and it will continue its operation normally.

## Auto vs. Armed Auto Thrust

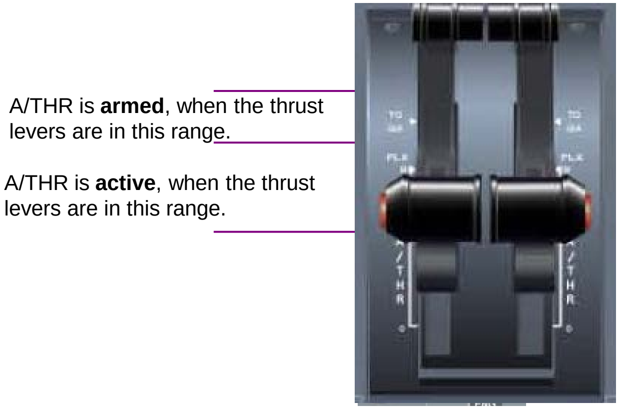
For the newbie one of the more confusing features is the differentiation between Active and Armed auto-thrust. In both bases, the green light on the A/THR button on the FCU is lit up; but only if the A/THR is active, does it control the engine thrust. Whether A/THR is active or armed can be seen on the FMA.

Whether the Auto Thrust System is active or armed depends solely on the thrust lever position.

- A/THR is armed if: The green light on the A/THR button is lit, and the thrust levers are forward of the CL detent. (If you are flying with one engine out, if the live thrust lever is forward of the MCT detent.) Thrust is determined by the Thrust lever position.
- A/THR is active if: The green light on the A/THR button is lit, and the thrust levers are both in the CL detent or below. (Flying with one engine out, if the live thrust lever is in the MCT detent or below.) Thrust is determined by the A/THR system.

The Auto Thrust System goes from armed to active, when both thrust levers are placed in the A/THR active range. (At or below the CL detent, or if one engine is out, at or below the MCT detent.)

Analogously, the Auto Thrust System goes from active back to armed, when both thrust levers are placed above the CL detent, or if one thrust lever is placed above the MCT detent.



## Thrust Limitation

As discussed in the previous chapter, the position of the thrust levers determines whether the A/THR system is armed or active. This does not yet explain the effect of the thrust lever position within the active range.

The thrust lever position determines the maximum thrust that the A/THR may command. This means:

- If A/THR is active and the thrust levers are in the CL detent, the A/THR can command thrusts from idle to Maximum Climb thrust. (This is the default for flights with active A/THR.)
- If you have A/THR active, and your thrust levers are in idle, then the A/THR can only command thrust from idle to idle.

This logic dictates that ideally the thrust levers should be in the CL detent during a flight with A/THR active, as this gives the auto thrust system the maximum possible authority. For flights with one engine out, the live thrust lever should be in the MCT detent for the same reason.

If the thrust levers are below the CL detent, the warning “AUTO FLT: ATHR LIMITED” appears in the ECAM informing the pilot that the A/THR is limited in its authority. Furthermore, the command “LVR CLB” flashes in the first column of the FMA, requesting from the pilot to move the levers into the CL detent.

If one lever is correctly in the CL detent and the other lever is not, the warning “LVR ASYM” is displayed in the first column of the FMA in amber.

## Thrust Limitation

The engagement of the system can be done in three different fashions:

- On take-off: When the thrust levers are placed in the FLX or the TOGA detent, the A/THR system is automatically armed. It becomes active, when the thrust levers are placed in the CL detent at thrust reduction altitude.
- On go around: A go around is initiated by moving both thrust levers into the TOGA detent during an approach with Slats or Flaps extended. This automatically arms the A/THR system, which becomes active as soon as the thrust levers are moved into the CL detent at thrust reduction altitude.
- In flight: If the A/THR is off in flight, you can engage it at any time, by pressing the A/THR button on the FCU. If the thrust levers are in the active range, the A/THR system will become active, otherwise it will become armed.

Auto thrust system disengagement can be done as standard disconnection or non-standard disconnection. There are two standard disconnection methods:

- Moving the thrust levers into idle disconnects the auto-thrust. This is normally used during the flare at landing.

- Pressing the “Instinctive disconnect buttons” on the thrust levers disconnects the auto-thrust. The pressing of these buttons is mapped to the standard X-Plane command: sim/autopilot/autothrottle_off

There is one implemented non-standard disconnection method:

- Pressing the A/THR button on the FCU also disconnects the Auto-Thrust, if the Auto-Thrust was armed or active before. As this is a non-standard disconnection method, it triggers an ECAM caution.

## Auto Thrust Active Mode

The Auto-Thrust can operate in a variety of modes, which depend on the active vertical guidance mode of the AP/FD (Auto Pilot/Flight Director). There are two fundamentally different modes in which the Auto Thrust System may operate. In speed mode, the Auto Thrust System adapts the engine thrust to maintain a given Speed or Mach target. In thrust mode, the Auto Thrust System commands a constant thrust, and the speed is maintained by the AP/FD by adapting the aircraft pitch.

## Speed Modes

There are two speed modes: In the mode SPEED, the Auto Thrust System maintains a given IAS target. In the mode MACH, it maintains a given MACH target.

These modes are active, if
- The AP/FD system is off. I.e. both APs and both FDs are switched off.

- The AP/FD system operates in one of the following modes
  - Vertical Speed (V/S)
  - Altitude and Altitude Capture modes (ALT, ALT CST, ALT CRZ, ALT*, ALT CST*)
  - Descent with the geometric descent path (DES)
  - Glide Slope and Glide Slope Capture (G/S, G/S*)
  - Final mode (FINAL, FINAL APP)

The system determines the difference between SPEED and MACH mode based on the type of speed target. (IAS in kts, versus a Mach number.)

## Thrust Modes

There are three thrust modes: Thrust Climb (THR CLB), Thrust Idle (THR IDLE) and Thrust Flare, which is currently identical with thrust idle. These modes are active, if the AP/FD is in the following modes:

- Climb modes (CLB/OP CLB): THR CLB
- Descent modes (OP DES and DES with idle path) : THR IDLE
- Flare during an autoland: (Mode FLARE): THR IDLE

In these modes, the A/THR command a fixed engine thrust and the speed is maintained by the respective AP/FD mode. In one engine out operation, the THR CLB mode is replaced by the THR MCT mode.

## Managed and Selected Speed

Independent of the mode that the A/THR operates in, you can choose to fly with a managed or a selected speed target.

The managed speed target considers automatically the speed evolution during climb and descent, including the 250 knots speed limit below FL100/10000ft. It also calculates an optimized speed profile during the approach allowing for flap extension without slowing down too early. Autoland is recommended to be flown with managed speed target only, as the managed speed includes features such as ground speed mini and wind compensation, that are hard to implement flying with selected speed.

To switch between selected and managed speed, you need to push or pull the speed selector knob on the FCU. The key philosophy with Airbus is that pushing means, you push the aircraft away from you (revert to managed mode). With pulling, you pull the aircraft towards you, and get control over this parameter. (Selected mode.)

## Auto Pilot Modes

On the FBW-family of Airbus aircraft the Auto Flight system is often also referred to as AP/FD which stands for Auto Pilot / Flight Director. The system is normally active throughout the entire flight, no matter whether you fly manually or let the auto pilot do the job. In normal operation, the Flight Directors are never turned off, except during the last 400ft of a non-precision (non-rnp) approach.

In manual flight, the pilot follows the Flight director commands, if the autopilot is engaged the flight director commands are followed by the AP.

We recommend for people who want to fly manually to try following the flight director. After months of tuning, keeping the bars in the middle has become really smooth now.


Concerning the guidance that the AP/FD provides, there are two fundamentally different possibilities available, selected guidance and managed guidance.

**Selected guidance** is normally used for short term changes to the flight path, e.g. during ATC radar vectoring or weather related deviations from the flight plan. In selected guidance, the AP/FD follows flight path targets provided on the Flight Control Unit (FCU). For lateral guidance these targets are predefined headings, for vertical guidance it can be a new altitude target as well as vertical speed targets.

**Managed guidance** provides automatic flight along the flight plan programmed in the FMS. The target for lateral guidance in this case is provided by the Flight Management and Guidance Computer (FMGC), the respective window on the FCU shows dashes only. For vertical guidance, the pilot still chooses the desired final altitude target on the FCU, but the FMGC ensures that altitude constraints and geometric descent paths defined in the flight path are met. For managed modes, you cannot select a vertical speed. The respective window in the FCU shows dashes.

The control of the AP/FD system is done primarily via the Flight Control Unit. The selector knobs on the unit can be used to set the selected targets. Pushing or pulling the selector knobs as well as pressing the push buttons on the FCU is used to select the desired mode of the AP/FD system.

The basic Airbus philosophy about pushing or pulling is the following:

When you **push** a selector knob on the FCU, you push the aircraft away from you towards the FMGC. I.e. you hand the aircraft over to the FMGC and engage **managed mode**.

When you **pull** a selector knob on the FCU, you pull the aircraft away from the FMGC towards you. You engage **selected mode** and gain control over the target of this mode.

To implement the distinguishing between pushing and pulling the selector knob, we have implemented two click zones at each of the FCU selector knobs.

## Lateral Guidance Modes

The lateral guidance modes guide the horizontal trajectory of the aircraft. The following list gives a quick overview of the modes implemented, what guidance they provide and how they are engaged.

- **RWY mode:** The runway mode is engaged automatically when the pilot sets the thrust levers into the FLX or the TOGA detent during the take-off run. The mode splits into two submodes:

    - The RWY mode that provides guidance during the take-off run to maintain the runway middle. This mode provides guidance only, if the ILS/LOC for the departure runway is tuned in Nav1 when you commence the take-off run. If the correct ILS or LOC is not tuned, the mode will become active but remain passive in the background.
    - The RWY TRK guidance activates after lift-off when the aircraft passes through 30ft RALT. (Unless NAV mode engages.) This submode provides guidance to maintain the track that the aircraft was flying at mode engagement.

- **NAV mode:** If you have a flight plan for your flight programmed into the FMC, you can use the NAV mode to guide the aircraft automatically along the flight plan. If you did not use “HDG preselect” for take-off, the NAV mode will engage automatically when the aircraft passes through30ft.

- Make sure that the waypoint displayed on the FMC is the TO-waypoint of the flight plan leg you want to intercept.
- Make sure that the aircraft flies a track that actually intercepts this flight plan leg
- Push the HDG Selector button. (Click zone slightly above the HDG selector knob.)

Upon pushing the heading selector button, the AP/FD verifies whether the current track of the aircraft intersects the flight plan leg that corresponds to the waypoint displayed in the FMC. If it detects an intersection, the waypoint displayed in the FMC becomes the active TO-waypoint, and the NAV mode is armed. (NAV appears in blue in the second line of the FMA and the white circle next to the heading window in the FCU lights up.)

As soon as the aircraft is sufficiently close to the current leg, the NAV mode activates and the AP/FD will guide the aircraft to intercept the leg smoothly. The Heading window in the FCU now shows dashes.

**HDG mode:** At any point during the flight (except in LAND mode), you can pull the heading selector knob (click on the knob) to engage the heading mode. The AP/FD will then follow the heading indicated in the heading window on the FCU.

**GA TRK:** This mode is similar to the RWY TRK mode, with the difference that it engages during a Go Around. A go around is initiated by moving the thrust levers into the TOGA detent, when the slats/flaps are extended and the aircraft is in the air or has been on the ground less than 30s. The GA TRK mode guides the aircraft along the track it was flying at mode engagement. From GA TRK you can revert to HDG mode by pulling the Heading selector knob or to NAV mode by pushing the heading selector knob. You cannot revert directly to an approach mode from GA TRK.

***Approach modes:***
The AP provides two different approach modes, depending on the type of the approach available. If a Non-precision Approach is defined in the Flight Plan (See Section 3), and the aircraft is already in the Non-Precision Approach part pressing the APPR button will arm the

**APP NAV mode:** The APP NAV mode is very similar to the NAV mode and guides the aircraft along the path of the Non-precision approach of the flight plan. The APP NAV mode is armed by pressing the APPR button on the FCU while the aircraft is in the NPA segment of the flight plan. If the NAV mode is active when pressing the APPR button, the APP NAV mode will engage immediately.

If no FAF point is defined in the flight plan before the next airport, and a ILS or a LOC is tuned in the Nav 1 receiver, you can engage the

**LOC mode:** If a LOC is tuned in Nav1, pressing the LOC button on the FCU will arm the LOC mode. If an ILS is tuned you can use either the LOC or the APPR button on the FCU to arm the LOC mode. The difference between the LOC and the APPR button is that the LOC buttons arms only the lateral LOC mode, whereas the APPR button also arms the vertical G/S mode. Hence, the APPR button works only, if the navaid tuned in Nav1 is an ILS.
The LOC mode goes from armed to active, when the aircraft approaches the Localizer-beam. It then turns the aircraft onto the localizer and maintains the localizer.

## Vertical Guidance Modes

The vertical guidance modes control the vertical flight path profile of the aircraft. There is a large variety of modes available, that I will quickly introduce here:

**SRS mode:** The Speed Reference System mode guides the aircraft during take-off, initial climb and after a Go-Around. It command the aircraft pitch in order to maintain a speed target that is slightly above the current stall speed allowing for a quick gain in altitude. The pitch-up command is limited to 18 degrees nose up, so that with a light aircraft and a lot of thrust, the speed will stabilize above the speed target.

The SRS mode automatically reverts to the CLB or the OP CLB mode when reaching the acceleration altitude. If the FCU selected altitude or a Flight Plan Altitude constraint is below the acceleration altitude, the SRS mode will revert to the ALT capture or the ALT CST capture mode upon approaching the respective altitude.

**CLIMB and DESCENT modes:** Altitude changes are normally done using either one of the CLIMB modes (CLB, OP CLB, EXP CLB) for achieving a higher altitude or one of the DESCENT modes (DES, OP DES, EXP DES). These modes have all in common that they are so-called pitch modes. (Except for the DES mode, when it follows a geometric path) In a pitch mode, the A/THR system commands a constant thrust level and the aircraft pitch is adjusted to maintain the aircraft speed.

<u>The fundamental difference between the CLIMB and the DESCENT modes is the amount of thrust commanded by the A/THR system.</u> The AP/FD the modes perform more or less the same task in CLIMB and DESCENT modes: It adjusts the pitch to maintain the aircraft speed target. <u>If you are flying with manual thrust this means:</u> If you engage a CLIMB mode and command idle thrust on the engines, the aircraft will descend! Vice versa if you engage a Descent mode and leave the engines at a high thrust setting, the aircraft will climb! This shows the importance of the correct interaction between the A/THR and the AP/FD systems.

**OP CLB and OP DES:** The open climb and descent modes are considered the selected modes for flight level change. They are engaged by pulling the ALT selector knob on the FCU with an FCU selected altitude that is above (OP CLB) or below (OP DES) the current aircraft altitude. The aircraft will initiate a climb or a descent to the new selected altitude without considering any altitude constraints given in a flight plan. In the case of OP CLB, the A/THR commands Maximum Climb thrust or – if the thrust levers are below the CL detent the thrust limit given by the thrust levers. In the case of OP DES, the A/THR commands Idle thrust, independent of the thrust lever position. (Attention: If A/THR is <u>active</u> only, of course, see section 6.1)

**CLB and DES:** The CLB and DES modes are the managed modes for flight level changes. They are engaged by pushing the ALT selector knob on the FCU with an FCU selected altitude that is above (OP CLB) or below (OP DES) the current aircraft altitude. In contrast to the OPEN Modes, these modes level off at Altitude constraints defined in the flight plan, until the waypoint with the constraint is sequenced. After sequencing the waypoint the mode CLB or DES is resumed until the next altitude constraint or the FCU selected altitude is reached.

CLB and DES can only be activated, if the lateral guidance is in mode NAV or APP NAV. With other lateral guidance modes, OP CLB and OP DES will be engaged instead.

**ALTITUDE modes:** There is a variety of different Altitude capture and Altitude maintain modes depending on the circumstances:

**ALT and ALT* mode:** The Altitude (ALT) and the Altitude Capture (ALT*) modes engage automatically, when the aircraft approaches the FCU selected altitude and one of the climb or descent modes is active or the VS mode is active. Upon approaching the altitude target, the ALT* mode engages and guides the aircraft to a level off when the selected altitude is reached. Upon reaching the Altitude, the ALT mode engages.

**ALT CRZ mode:** This mode is practically identical with the ALT mode, only that the FCU selected Altitude has to be at or above the Cruise Altitude defined in the MCDU. Engagement of the ALT CRZ mode also engages the Cruise Phase for the Autopilot and marks the end of the Climb Phase.

**ALT CST and ALT CST* mode:** The Altitude Constraint (ALT CST) or Altitude Constraint capture (ALT CST*) mode engages, when the aircraft approaches a relevant altitude constraint in the flight plan and is either in mode CLB or DES. Upon approaching the Altitude Constraint, the ALT CST* mode engages and the previously active mode (CLB or DES) becomes armed. The ALT CST* mode guides the aircraft to ensure smooth level off upon reaching the altitude constraint. When the constraint is reached, the ALT CST mode engages. Once the waypoint with the constraint is sequenced, the aircraft automatically resumes its climb or descent towards the FCU selected altitude.

**Vertical Speed mode:** The Vertical Speed mode is rarely used on the Airbus. One of the possible uses is if you get an ATC clearance that demands an explicit vertical speed. Another use is ILS glide-slope capture from above, in which case you use the VS mode to ensure that your rate of descent is high enough to catch the glide slope before reaching the airport. Non-precision approaches could also require the use of this mode, if the flight plan does not provide vertical guidance.

For a normal, correctly planned flight without ATC clearances, you should not need this mode except during approach!!

**Approach modes:** Analogously to the lateral guidance, the vertical modes during the approach depend on the approach type defined in the FMC. If the approach for the next airport in the FMC contains a FAF and the aircraft is in the Non-Precision Approach Part of the Flight Plan, pressing the APPR button will arm the

- **FINAL mode:** In final mode the aircraft is guided along the vertical flight path defined in the Flight Plan. For this guidance to work correctly, two items are of highest importance:
  - The NPA approach defined in the FMC ends with the runway threshold and the FMC altitude information at the Threshold waypoint corresponds to the threshold elevation +30 feet.
  - The altimeter setting corresponds to the QNH of the destination airport.

<u>The guidance in the mode is purely based on the barometric altimeter information. If your altimeter is set wrong or the runway threshold height is defined wrong, the AP will fly the aircraft into the ground! (And it’s not the plugins fault!)</u> The final mode engages automatically after passing the Final Approach Fix (FAF). Once the final mode engaged, you should set the FCU selected altitude to the Go-around altitude.

If the flight plan contains no Non-precision part for the next airport and an ILS is tuned in Nav1, pressing the APPR button on the FCU will arm the

**Glideslope mode:** The glideslope (G/S) and the glideslope capture (G/S*) mode guide the aircraft along the glide slope of the ILS. The G/S* mode ensures a smooth transition during glideslope capture and is automatically followed by the G/S mode, once the Glideslope is sufficiently well captured.

<u>If you are above the glide slope and not descending fast enough to capture the glide slope, the mode will disarm.</u> The APPR button light will extinguish, and the LOC button lights up instead.

## Combined Modes

The guidance during the approach is frequently done in combined modes, as the approach requires a good synchronization between lateral and vertical guidance.

The **FINAL APP mode** during non-precision approaches is a combined mode that covers lateral and vertical guidance. <u>Attention:</u> This mode does not perform an Autoland, you have to disconnect the autopilot latest 200ft above ground and fly the rest manually. (In real life, this is often 400ft AGL!)

The ILS approach modes LOC and GS revert to the **LAND mode** when descending through 400ft AGL. When performing an Autoland, the LAND mode is followed by the FLARE mode at around 30ft AGL and then the ROLL OUT mode upon touch down. These modes work purely on ILS data basis. Especially with custom scenery, the ILS is often not aligned correctly with the runway, in these cases the aircraft will land, where the ILS beam guides it to. It does not know, where the runway is!

For **LAND mode**, the only way to get out of this mode is by initiating a **go-around**! **To initiate a go-around,** push the thrust levers into the TOGA detent. If you are high enough, you can retard them back into the CL detent immediately as soon as the SRS and the GA TRK guidance modes are engaged on the FMA.

# Fly by Wire System

A350 XWB

This section gives a brief overview over the functionality that the fly-by-wire system provides. On the A350, the fly by wire will remain in Normal law throughout the entire flight, independent of system failures. The degenerated Alternate Law and Direct Law are not implemented in the freeware version.

## Flight Controls Behaviour

**Roll axis:** For lateral control, the sidestick deflection represents a roll rate demand. For neutral sidestick, the desired roll rate is 0 and the aircraft maintains its bank angle. A maximum lateral deflection of the side stick corresponds to a commanded roll rate of 15 degrees/second.

**Pitch axis:** The pitch axis control law is a so-called C*-law which is a mix between load factor demand and pitch rate demand. At high speeds, it is primarily a load factor demand, at low speeds primarily a pitch rate demand. Neutral side-stick corresponds to a load factor of 1g (compensated for pitch and roll up to 33° roll angle) and a pitch rate of 0deg/s. That means with neutral side stick the aircraft maintains its pitch angle and its flight path angle.

- A fully aft stick represents a desired load factor of +2.5g for a clean wing and +2g for flaps/slats extended. A fully forward stick represents a desired load factor of –1g for clean wing and 0g for flaps/slats extended.

- The corresponding pitch rate demands at lower speeds are the result of a too complex algorithm for a quick introduction here. You'll just need to get a feel for it by flying a lot. The key rule at speeds below maneuver speed is that a fully aft stick always corresponds to the creation of the maximum feasible amount of lift, and the pitch rate generated is in accordance with this.

- During the flare for landing, the FBW system introduces a gradually increasing nose-down input so that the pilot needs to apply backstick pressure to keep the nose up. This simulates the landing of a conventional aircraft.

**Yaw axis:** The Fly-by-wire system has a integrated yaw damper. You will not need to use the rudder at any stage in flight except for take-off, flare and rollout. The yaw damper cannot be switched on or off separately.

## Flight Envelope Protection

The second important task of the fly-by-wire system is the protection of the flight envelope. This feature ensures that the pilot cannot lose control over the aircraft and that the aircraft cannot by structurally overloaded.

**Attitude protection:** In order to avoid that the aircraft can get into abnormal attitudes, the fly-by-wire system does not permit pitch attitudes above 30 degree nose up or below 15 degrees nose down. The roll angle is limited to bank angles below 67 degrees. For bank angles between 33 and 67 degrees, the system levels the wings automatically when the stick is neutral until the bank angle is less than 33 degrees. To maintain 67 degree bank you need to keep the stick laterally fully deflected.

**Load factor protection:** As discussed above, the fly-by-wire system does not allow g-loads in excess of –1g/2.5g for clean wings and 0g/2g for flaps/slats extended. This protection is to ensure the structural integrity of the aircraft.

**High Speed Protection:** When the aircraft speed exceeds VMO/MMO (350kts/M0.84), the fly-by-wire system automatically introduces a pitch up moment in order to reduce the aircraft speed. This is coupled with the spiral dive protection. When the high speed protection is active, the maximum permissible bank angle is reduced to 45 degrees and with the side stick neutral, the system will fully level the wings.

**High Angle of Attack Protection:** The high angle of attack protection activates, when the actual angle of attack of the aircraft exceeds the activation limit “Alpha Prot”. The side stick now commands a desired angle of attack. Neutral side stick corresponds to the angle Alpha Prot, fully aft stick corresponds to the maximum permissible angle of attack, providing the maximum possible amount of lift. The E/WD will display a warning: ALPHA PROT and the Autopilot disconnects. For deactivation make sure you are fast enough and push the stick slightly forward to reduce the angle of attack below Alpha Prot.

**Low speed protection:** The low-speed protection is also triggered by a too high angle of attack. If the angle of attack exceeds the Alpha Floor limit (which is higher than the Alpha Prot limit), the A/THR system engages and commands TOGA thrust in order to provide a quick increase in speed or available climb performance. (Don’t forget: This event is triggered either because you fly too slow or because you pull strongly on the stick.)

The engagement of Alpha Floor is displayed in the first column of the FMA with the message A.FLOOR. When the angle of attack drops below the alpha floor limit, the A/THR mode changes from A.FLOOR to TOGA LK indicating that TOGA thrust is locked on the engines. Once TOGA LK appears in the FMA, you can deactivate this protection by disconnecting the A/THR system. (E.g. pull the thrust levers to idle or any other A/THR disconnect method.)

# Air System

# Air System

The A350 air system has the following subsystems:

- **Bleed Air System**
  - Engine Bleed Air System
  - Auxiliary Power Unit (APU) Bleed Air Supply
  - Ground Air Supply
  - Overheat Detection System.
- **Air Conditioning System**
  - Air Generation System
  - Temperature Control System
  - Cooling System
  - Conditioned Service Air Supply.
- **Ventilation Control System**
- **Cabin Pressure Control System**

# Air System

## Overview

The bleed air system consists of:

- An Engine Bleed Air System
- An Auxiliary Power Unit (APU) Bleed Air Supply
- A Conditioned Service Air Supply
- A distribution system
- An Overheat Detection System.

The bleed air system supplies air to the following systems:

- Air conditioning and pressurization systems
- Wing and engine ice protection system
- Engine starting systems
- Service air such as pack bay ventilation system
- Fuel Tank Inerting System.

The air sources are:

- The engines
- The Auxiliary Power Unit (APU)
- A HP ground supply source.

In normal conditions, the bleed air system operation is totally automatic.

If necessary, pushbuttons (pb) are available on the overhead panel to select the available source and to give the crew the possibility to override the automatic operations.

## System Description

### Engine Bleed Air System

The Engine Bleed Air System supplies the consumer systems with the required airflow at regulated pressure and temperature levels, in the complete range of aircraft operations and environmental conditions.

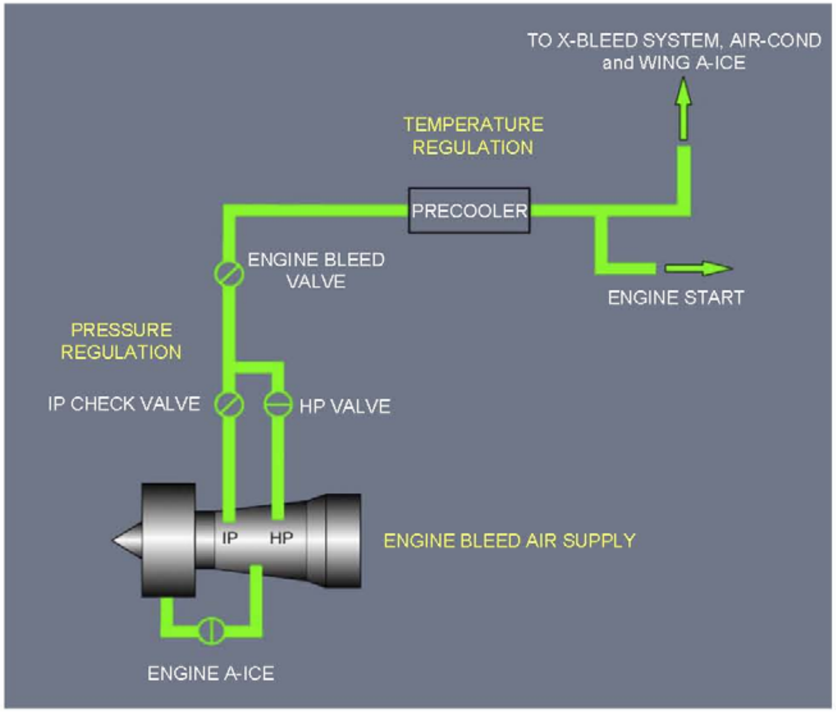
Engine bleed air usually comes from the **Intermediate Pressure (IP)** stage of the engine compressor via the Intermediate Pressure Check Valve.

At low engine thrust settings, the pressure of the IP stage is not sufficiently high thus the **High Pressure (HP) stage** of the compressor provides bleed air via the HP valve.

For each engine:

- The **engine bleed valve** automatically regulates the delivered bleed pressure. This valve can also close and isolate its applicable engine bleed
- A **Precooler** regulates the bleed air temperature.

<u>Note</u>: *One **Crossbleed Valve** interconnects the LH and RH bleed supply systems.*



# Air System

## APU Bleed Air Supply

The APU can supply bleed air to the bleed air system via the APU bleed valve:

- On ground, without any restriction
- In flight, up to 22,500 ft.

## Ground Air Supply

There are two **High Pressure (HP) Ground Connectors.** Thus two HP ground sources can be connected to the HP ground connectors to supply bleed air to the bleed air system.

# Air System

A350 XWB

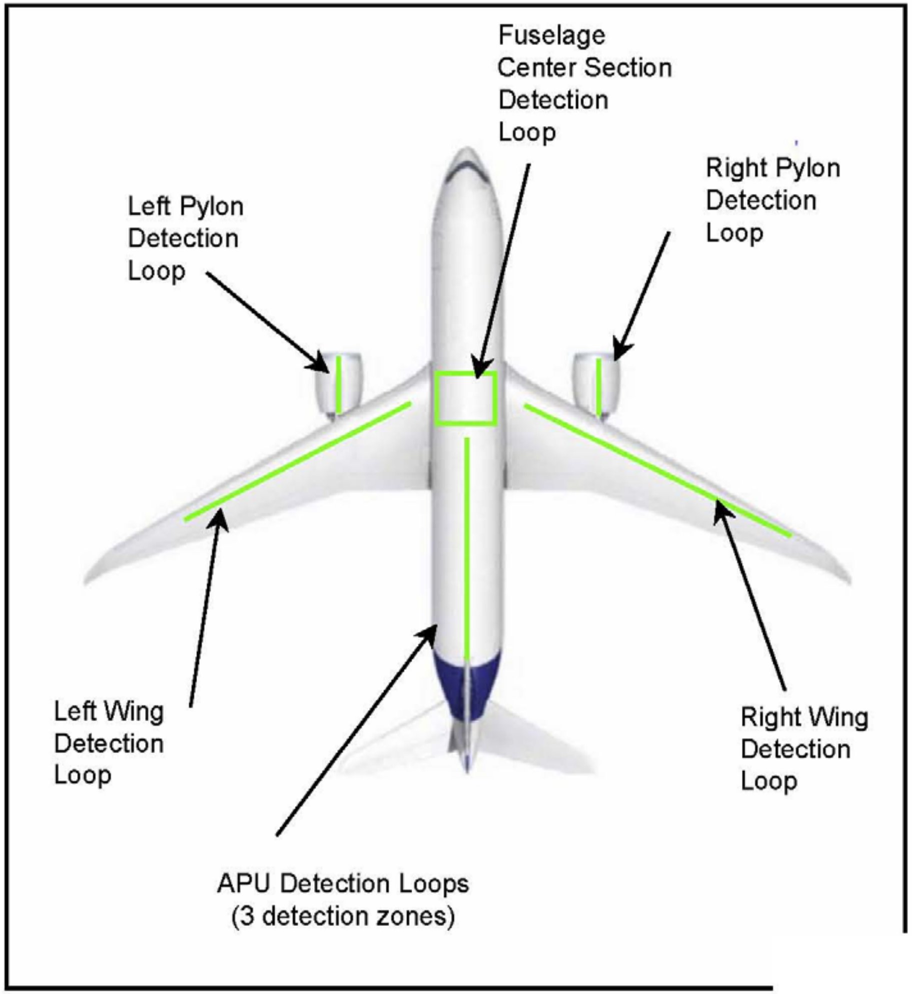
## Overheat Detection System

The overheat detection system includes a leak localization function for the **hot air ducts** in the following areas:

- The engine pylon
- Wings and fuselage center section
- APU hot air system in the fuselage.

When a sensor is exposed to hot air or any overheat condition:

- **A visual and aural overheat alert** is triggered in the cockpit if the temperature reaches the temperature limit for the corresponding aircraft zone
- The system will **automatically** send closure commands to the affected systems in order to prevent any damage to the aircraft structure and components.



# Air System



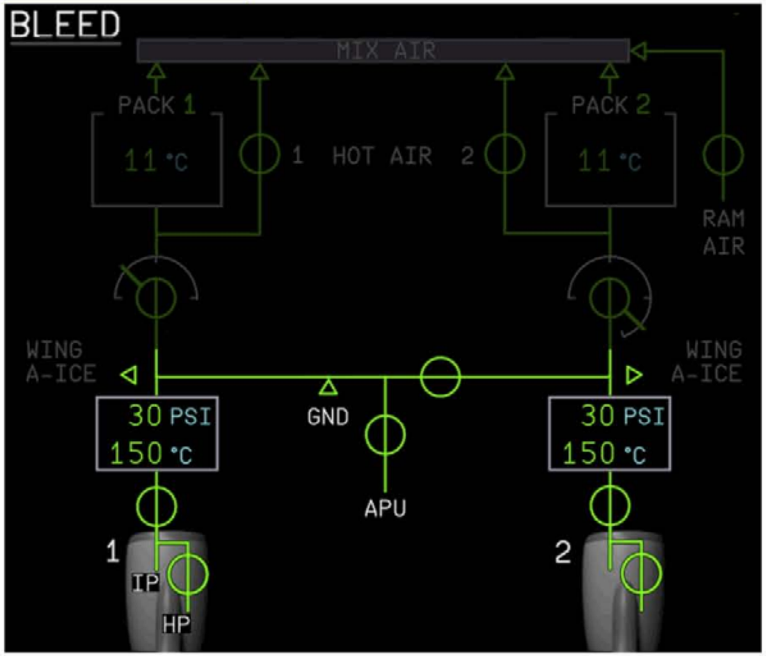
## Cockpit View

A350 XWB

## Controls and Indicators

AIR Panel


BLEED SD Page



## Overview

The Air Conditioning System is fully automatic. This system provides continuous air renewal and maintains a constant selected temperature in the cockpit, cabin zones, and crew rest compartments.

The Air Conditioning System has:

- An Air Condition Generation System
- A Temperature Control System
- A Cooling System.

Air from the air-conditioning system is also used for cargo ventilation:

- The bulk cargo compartment has a ventilation and a temperature control system
- The forward lower deck cargo compartments has an optional ventilation and temperature control system (refer to *Ventilation Control System*).
- The aft lower deck cargo compartments has an optional ventilation system (refer to *Ventilation Control System*).

.

# Air System

## System Description

### The Air Conditioning Generation System

The bleed air system supplies two packs, with air coming from the engines, the APU, or the ground air connectors. There are four recirculation fans that recycle cabin and cockpit air to the Mixer Unit via two premixers.

### The packs

The packs provide cold air by cooling hot bleed air. There are two packs which operate automatically and independently of each other.

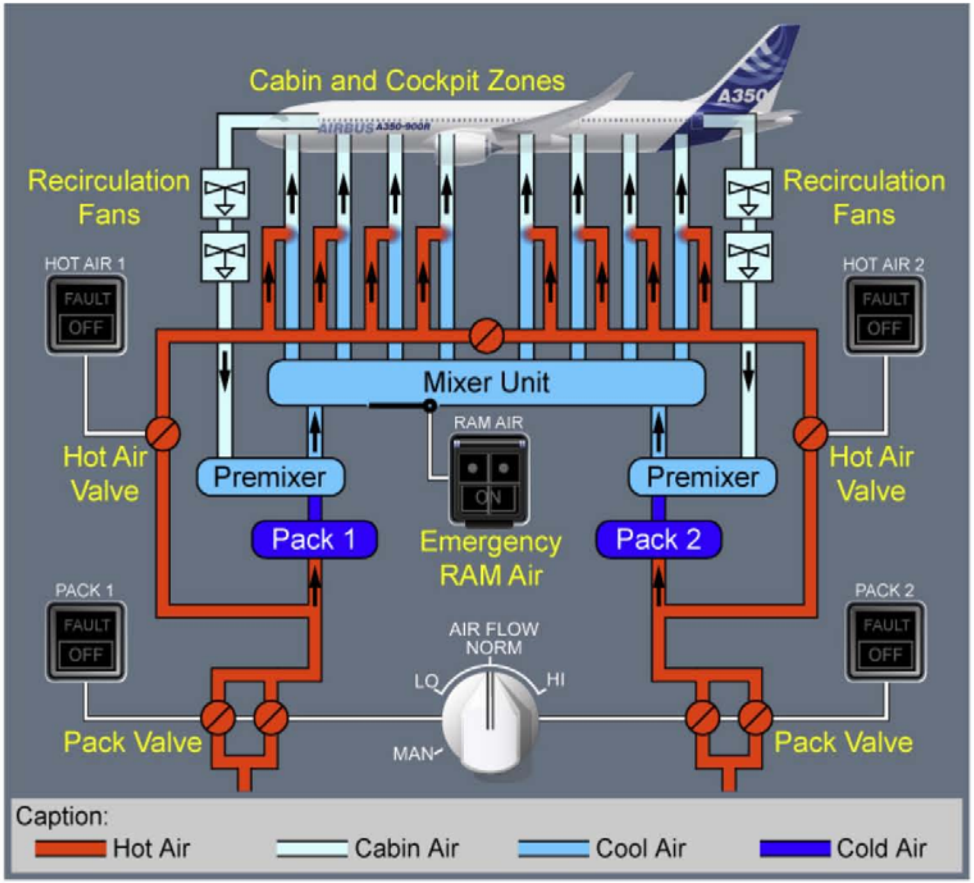
### Emergency RAM Air

One Emergency RAM Air Inlet ventilate the cockpit and cabin if both packs fail.

The RAM AIR pb on the AIR panel activates the emergency RAM air. When set to *ON*, air from outside the aircraft flows through the Emergency RAM Air Inlet directly to the Mixer Unit.

### Ground Air Supply

There are two Low Pressure (LP) Ground Connectors directly connected to the Mixer Unit. Two LP ground sources can be connected to the LP ground connectors to supply conditioned air to the Air Conditioning System when the packs are off.




*Note: Ducts for the bulk, forward cargo and crew rest compartments are not indicated (for clarity reasons.)*

# Air System

A350 XWB

## The Temperature Control System (TCS)

The Temperature Control System controls the temperature of the different zones within the flight deck and the 7 cabin zones. The system adjusts the temperature according to the demand, by adding hot air from the bleed system to air from the Mixer Unit. The hot air is added via two hot-air valves.

The flight crew controls the temperature in the cabin and cockpit. Moreover the cabin crew can adjust or directly control the temperature in each cabin zone.

Some air from the cabin is recycled into the bulk cargo compartment for ventilation and temperature regulation (temperature regulation is optional for the forward and aft cargo compartments).

If necessary, to obtain the desired temperature:

- An electrical heater can heat the air that flows into the **bulk cargo compartment**
- Air from a trim air pipe can heat the air from the Mixer Unit that flows into the **forward cargo compartment** (optional).

## The Supplemental Cooling System

In addition to the air conditioning system, a supplemental cooling system provides cooling capacity for galley trolley compartments and other optional cooling applications.

## Conditioned Service Air Supply

The Conditioned Service Air Supply is an Engine Bleed Air driven system which has the following objectives:

- To cool down the bleed air supplied by the Bleed Air System for air conditioning
- To reduce the Ozone content via the ozone converter
- To supply the Inert gas Generation System (IGGS) for fuel tank inerting.

## Cockpit View

# Air System

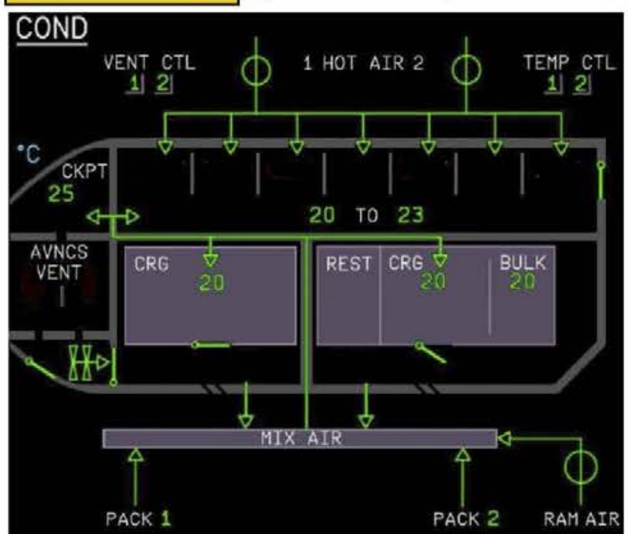
## Controls and Indicators

AIR Panel


CARGO AIR COND Panel


COND SD Page

(all options active)




CRUISE SD Page

# Air System

## Overview

The aircraft has a fully automatic ventilation system that ventilates:

- The forward avionics compartment
- The cockpit and cabin zones
- The IFE bay
- The pack bays
- Lower deck bulk cargo compartment

The ventilation of the forward and aft cargo compartments is optional.

In addition, the lower deck bulk cargo compartment has a temperature adjustable heating system.

# Air System

## Cockpit Ventilation

A mix of outside and recirculated air supplies the cockpit.
The following air outlets are in the cockpit:

- Windshield air outlets (RH and LH)
- Individual air outlets (CAPT and F/O)
- Foot air outlets (CAPT and F/O)
- Lateral windows air outlet (RH and LH)
- A third individual air outlet
- A fourth individual air outlet.

In addition, there are two ceiling diffusers (RH and LH).

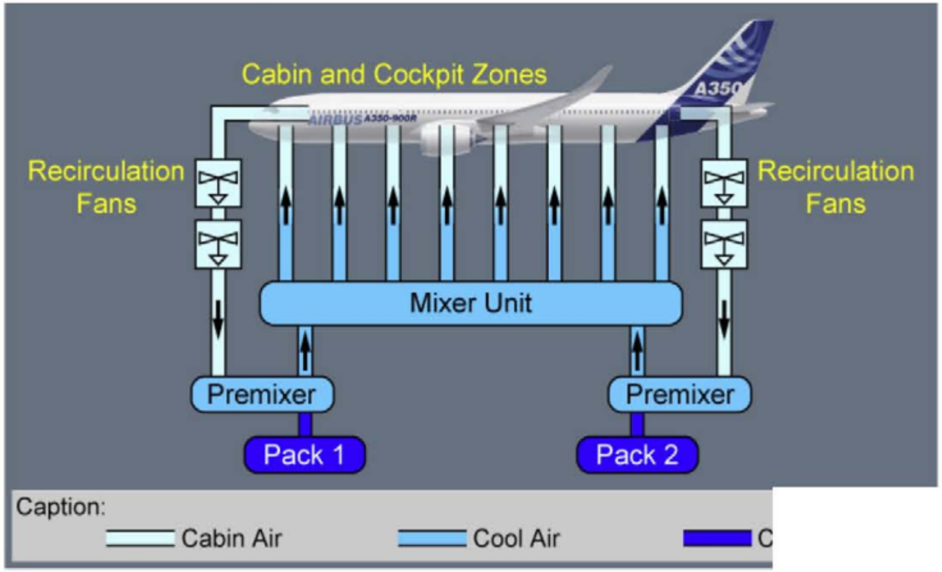
## Cabin Ventilation

Fresh air from the air generation system (Pack 1 & 2) is mixed with recirculated air from the cabin into the Premixers 1 & 2 and then sent to the Mixer Unit (refer to *Air Generation System architecture*).

The recirculated air is supplied through two recirculation circuits (LH and RH) which have each two filters (FWD and AFT) and two fans.

The Mixer Unit provides air in the 7 cabin temperature zones.

Cabin Ventilation



# Air System

## Cockpit View

## System Description

The Cabin Pressure Control System has:

- Two electrically actuated **Outflow Valves** which are in the forward and aft aircraft lower skin.
- Two **Outflow Valve Control Units,** which control the Outflow Valves, based on:
  - Measurement of the current cabin pressure
  - Computation of the target cabin pressure
- A separate **Semi Automatic Control Unit** (SACU) which provides a semi automatic pressure control.

The operation of the Cabin Pressure Control System is:

- Fully automatic under normal operating conditions
- Semi-automatic under abnormal operating conditions.

There are two semi-automatic pressurization modes:

- **Cabin altitude manual pressurization mode**: The flight crew selects the cabin altitude target. The cabin altitude will change automatically until the cabin altitude target is reached
- **Vertical speed manual pressurization mode**:

  If the cabin vertical speed is selected, the cabin altitude will change in accordance with the selected vertical speed until the cabin altitude target is reached.

In addition, to protect the aircraft from structural damage, there are:

- One **Overpressure Relief Valve** that provides the positive and negative relief function in case of excessive positive or negative differential pressure
- Two **Negative Relief Valves** that provide the negative relief function in case of negative differential pressure conditions.

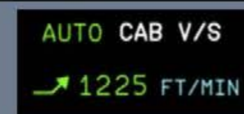
# Air System

## Cockpit View

A350 XWB

## Controls and Indicators

CABIN PRESS Panel


| | In automatic mode (digital indicators) | In manual mode (analogical indicators) |
|---|---|---|
| Cabin Altitude |   |   |
| Cabin V/S |   |   |

CABIN PRESS SD Page


CRUISE SD Page

# Communications

# Communications

## General

The communication system enables:

- **Internal communication** between the:
  - Captain
  - First Officer
  - Third and fourth occupant
  - Cabin crew
  - Ground crew
  - Passengers (for cockpit or cabin announcements).

  Internal communication is possible via the cockpit, cabin and service interphones, and the Passenger Address (PA).

- **External communication** in voice and data mode via the VHF, HF and Satellite Communication (SATCOM) systems.

The aircraft has:

- Three Very High Frequency (VHF) voice and data transceivers with a 8.33 kHz channel spacing
- One High Frequency (HF) transceiver voice and data capable. This transceiver enables to handle long-range communication (that includes polar routes). A second optional transceiver is available
- One SATCOM system
- One SELCAL system.

# Communications

## Radio and Audio Management

The flight crew interfaces with the communication system via:

- **Communication tools**:
  - Four cockpit loudspeakers
  - Three hand microphones
  - Three boomsets
  - One handset
  - Oxygen mask microphones
  - Two sidestick "Push-To-Talk" sw
  - Two glareshield PTT pushbutton (optional).

- **Three Radio Management Panels (RMPs):**
  - RMP 1 (Captain)
  - RMP 2 (First Officer), and
  - RMP 3 (third occupant)

The three RMPs are on the pedestal.

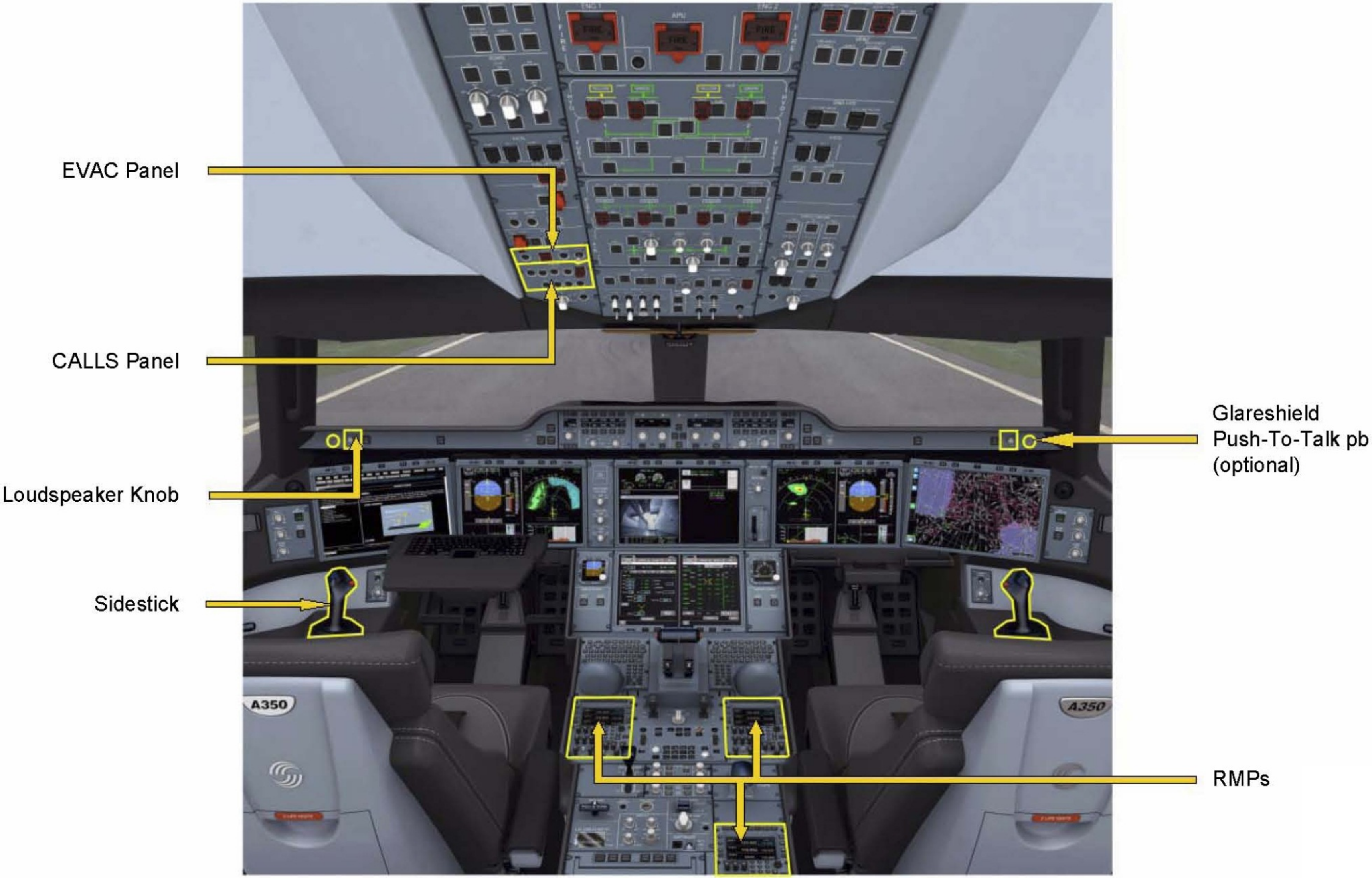
On each RMP the flight crew can:

- Select the type of communication (radio communication, SATCOM, interphones) in transmission and/or reception mode(s)
- Tune HF and VHF frequencies (up to five frequencies in standby)
- Dial SATCOM Telephone (TEL) numbers
- Select voice or data mode
- Monitor and change data
- Enter the squawk (SQWK) code
- Adjust the volume for voice communication and NAVAID identification.
- Load the ATC COM CPDLC frequencies.

- **One CALLS panel** to generate visual and aural call indications
- **One EVAC panel** to initiate evacuation of the aircraft
- **One ELT panel** to activate the Emergency Locator Transmitter.

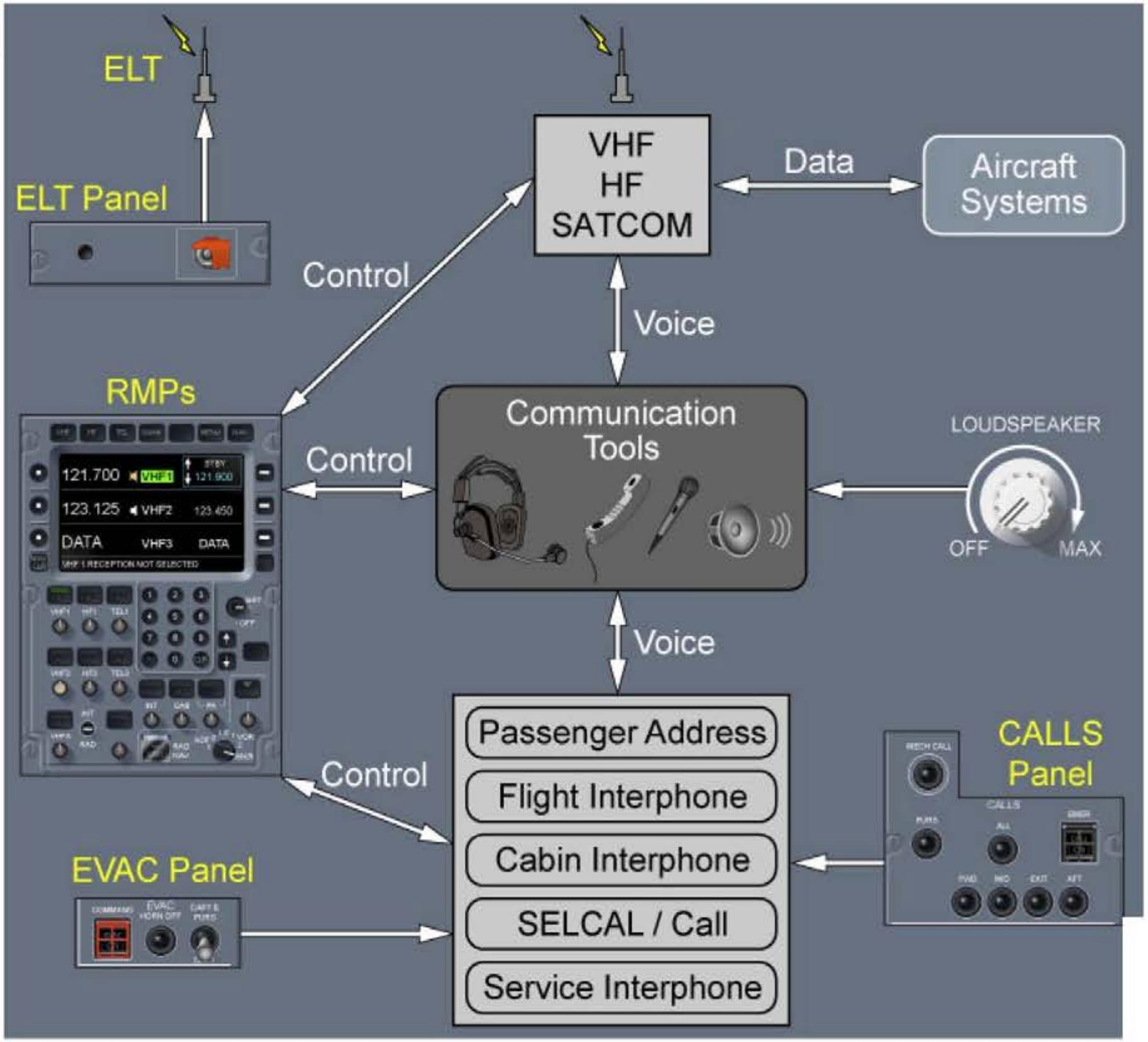
# Communications

## Cockpit View

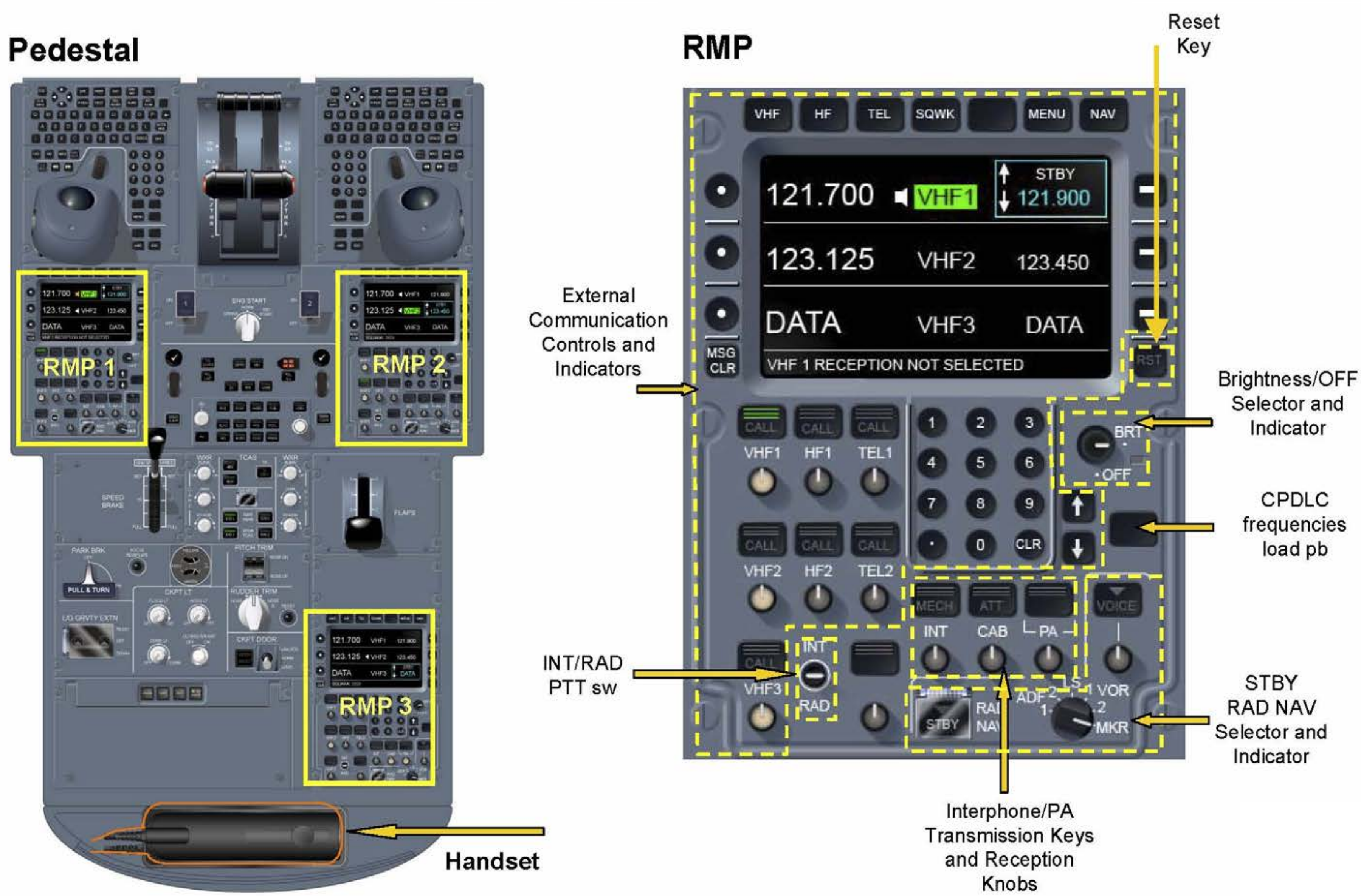


## Communication System Architecture

Communication System Architecture



# Communications



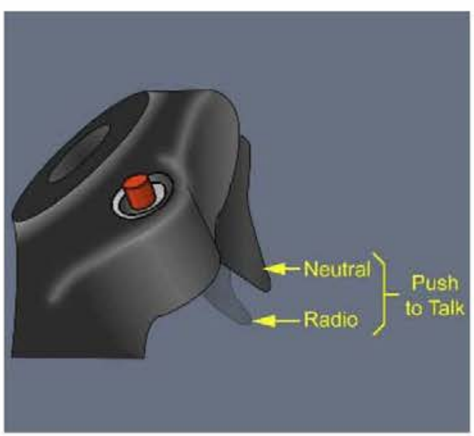
# Communications

CALLS Panel


EVAC Panel


ELT Panel

Sidestick




Glareshield Push-To-Talk pb


Loudspeaker Knob

# Electrical System

A350 XWB

# Electrical System

## Overview

The A350 electrical system has three types of power sources:

- The engine generators (two per engine)
- The APU generator
- The emergency generator driven by the RAT.

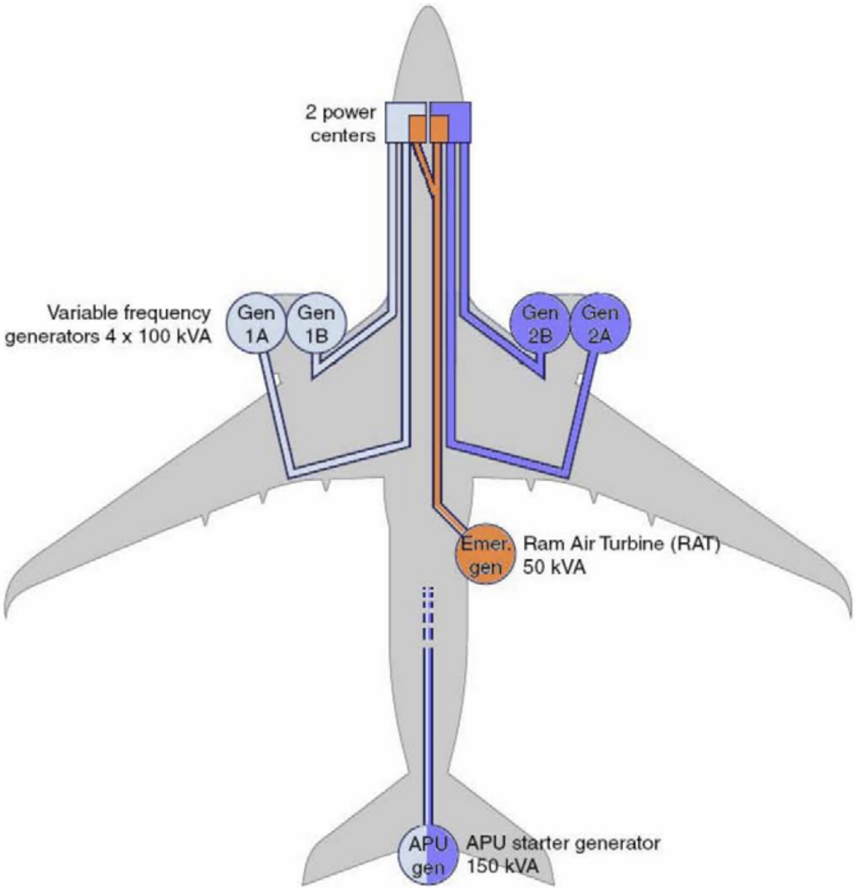
The A350 has three networks:

- 230 V Alternating Current network
- 115 V Alternating Current network
- 28 V Direct Current network

Each network has a normal and an emergency electrical distribution.

Two Electrical Power Distribution Centres manage the power distribution for normal and emergency operations.

The A350 electrical generation and distribution are designed to support ETOPS with diversion time up to **350 minutes.**



# Electrical System

## AC Power Generation

**AC main generation**

Four engine-driven generators are the main generators of AC Power. Each engine drives two main generators. Each main generator supplies 230 V AC at a variable frequency and a normal power of 100 kVA to the 230 V AC network. Then the Auto Transfer Units (ATUs) convert the 230 V AC into 115 V AC to supply the 115 V AC network.

**AC auxiliary generation**

The APU drives an auxiliary AC starter generator.
The APU generator supplies 230 V AC at a constant frequency of 400 Hz and a normal power of 150 kVA.
On ground, the APU can power the entire electrical network for normal operations.
In flight if one or more main generators fail, the APU generator can takeover the failed main generator(s).

**External Power**

On ground, it is possible to connect two Ground Power Units (GPU) to the aircraft through two external power connectors (however, one GPU is sufficient to provide electrical power to the aircraft). The GPU supplies 115 VAC and a normal power of 90kVA.

**AC emergency generation**

A drop out **Ram Air Turbine (RAT)** drives one AC generator to supply essential systems if all generators fail.

## DC Power Generation

**DC main generation**

The 230 V AC network supplies the 28 V DC network via four Transformer/Rectifiers Units (TRUs): TR 1, TR 2, TR EMER 1 and TR EMER 2.

**Batteries DC generation**

Four identical Lithium-Ion batteries are connected to the 28 V DC network in order to:

- Ensure the No Break Power Transfer function
- Provide standby DC power
- Provide DC power on ground if AC power is not available .

Two out of the four batteries can provide temporary supply in an emergency configuration.

# Electrical System

## Electrical Power Distribution

The electrical network supplies the aircraft systems with three voltages via the following networks:

**230 V AC Network (Normal and Emergency)**
This network supplies large power consumers (e.g. fans, compressors, pumps) and has:
- Four AC busbars (AC 1A, AC 1B, AC 2A, and AC 2B)
- Two AC emergency busbars (EMER AC 1 and EMER AC 2).

**115 V AC Network (Normal and Emergency)**
This network supplies commercial loads such as galley equipment and has:
- Four AC busbars (AC 1A, AC 1B, AC 2A and AC 2B)
- Two AC emergency busbars (Emer AC 1 and Emer AC 2).

**28 V DC Network (Normal and Emergency)**
This network supplies DC consumers and has:
- Two DC busbars (DC 1 and DC 2)
- Two DC emergency busbars (Emer DC 1 and Emer DC 2).

**Auto Transformer Units (ATUs)**
The 230 V AC network supplies the 115 V AC Network busbars via the Auto Transformer Units.

When the generators and the APU are not operating, the ATU enable to convert the 115 V AC that comes from the GPU into 230 V AC.

**Transformer/Rectifier Units (TRUs)**
The 230 V AC network supplies the DC busbars via the Transformer/Rectifier Units.

**BUS TIE contactors**
The BUS TIE contactors operate automatically to enable any reconfiguration by segregating/connecting:
- The AC busbars to/from each other and
- The DC 1 and DC 2 busbars to/from each other.

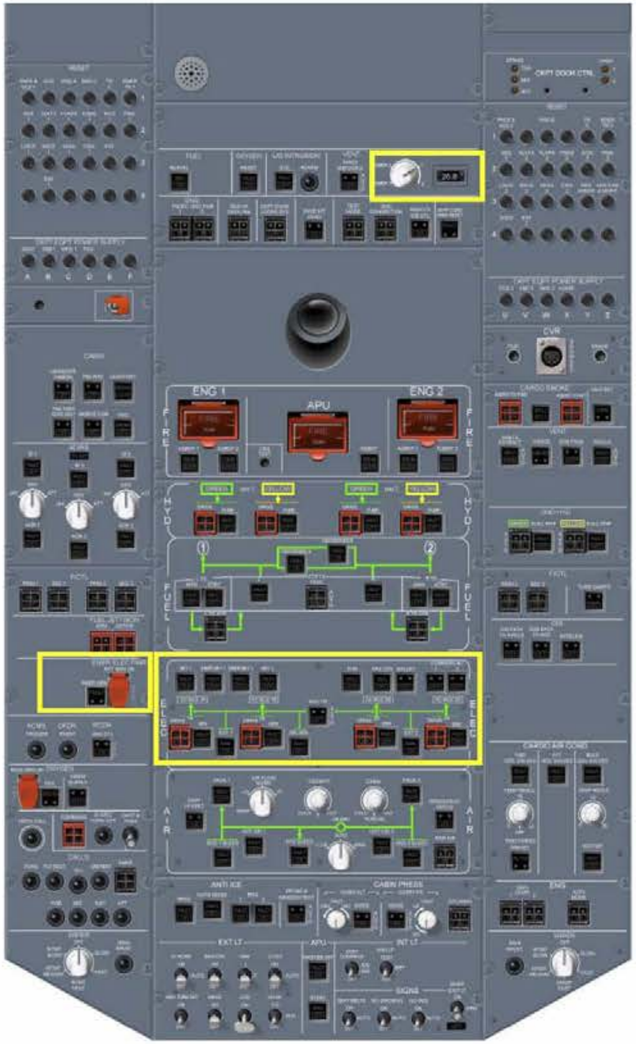
# Electrical System

## Cockpit View

# Electrical System

A350 XWB

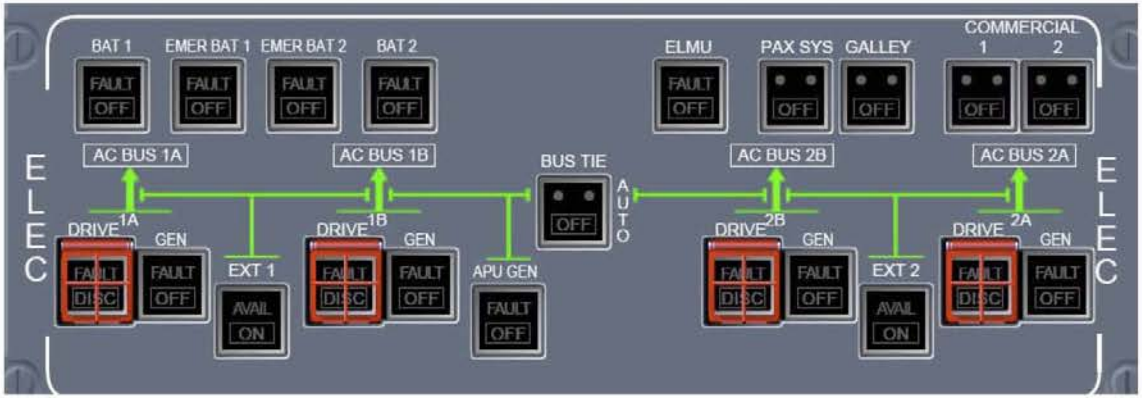
## Overhead Panel



EMER ELEC PWR


BATT CHECK Panel


ELEC Panel



FlightFactor aero

# Fire and Smoke

A350 XWB

# Fire and Smoke

## Overview

The A350 has a:

- **Fire and overheat detection system** for:
  - The engines
  - The APU compartment
  - The Main Landing Gear (MLG) bay

- **Smoke detection system** for:
  - The avionics bay
  - The cargo compartments
  - The lavatories
  - The flight crew rest compartment
  - The overhead cabin crew rest compartment
  - In-Flight Entertainment center

- **Fire extinguishing system** for:
  - The engines
  - The APU area
  - The cargo compartments
  - The lavatories.

*Note:*
*The fire extinguishing system standard satisfies 180 minutes ETOPS requirements. Additional optional equipment enables up to 350 minutes ETOPS capability.*

In addition, the aircraft has portable fire extinguishers in the cockpit and in the cabin areas.

## Engine Protection

### General

Each engine has:

- A Fire Detection System (FDS) that
  - Monitors all sensitive zones
  - Provides the flight crew with aural and visual alerts (via the FWS)
- Two extinguisher bottles

### Fire Detection

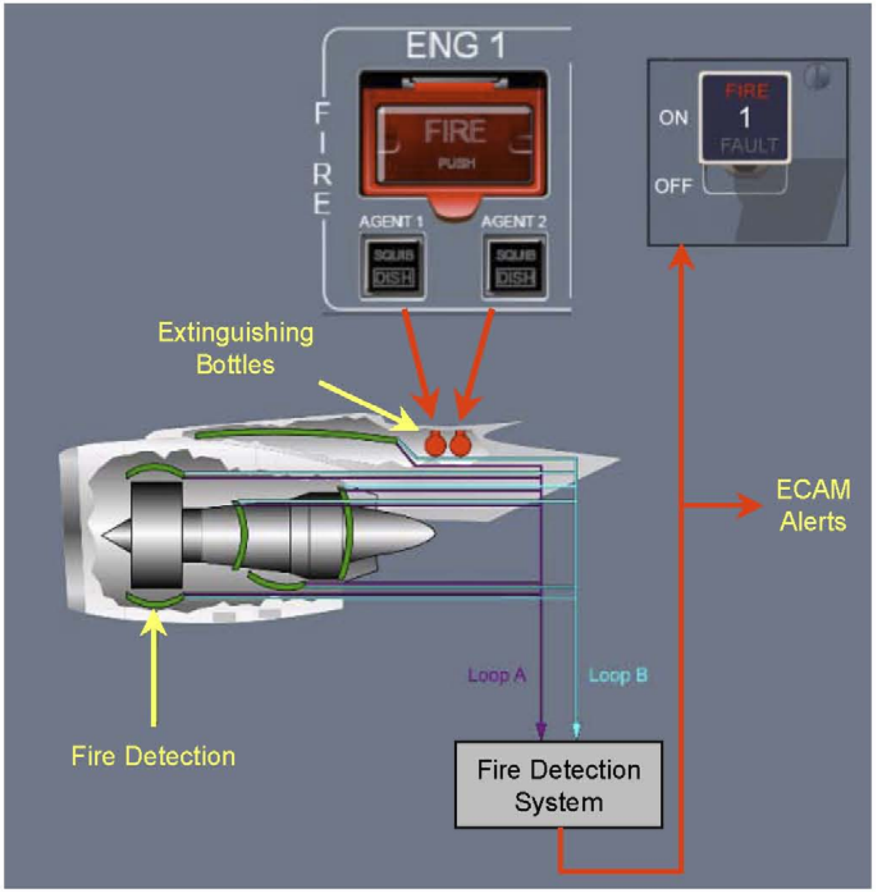
The fire detection system uses two identical and segregated loops (A and B) to monitor the sensitive zones of the engine. The Flight Warning System (FWS) alerts the fight crew if a fire is detected.

### Engine Isolation & Fire Extinguishing

In case of engine fire, the flight crew can isolate and extinguish the fire from the ENG FIRE panel in the cockpit.

The fire extinguisher agent is discharged in the engine nacelle.

Engine Fire Protection



# Fire and Smoke

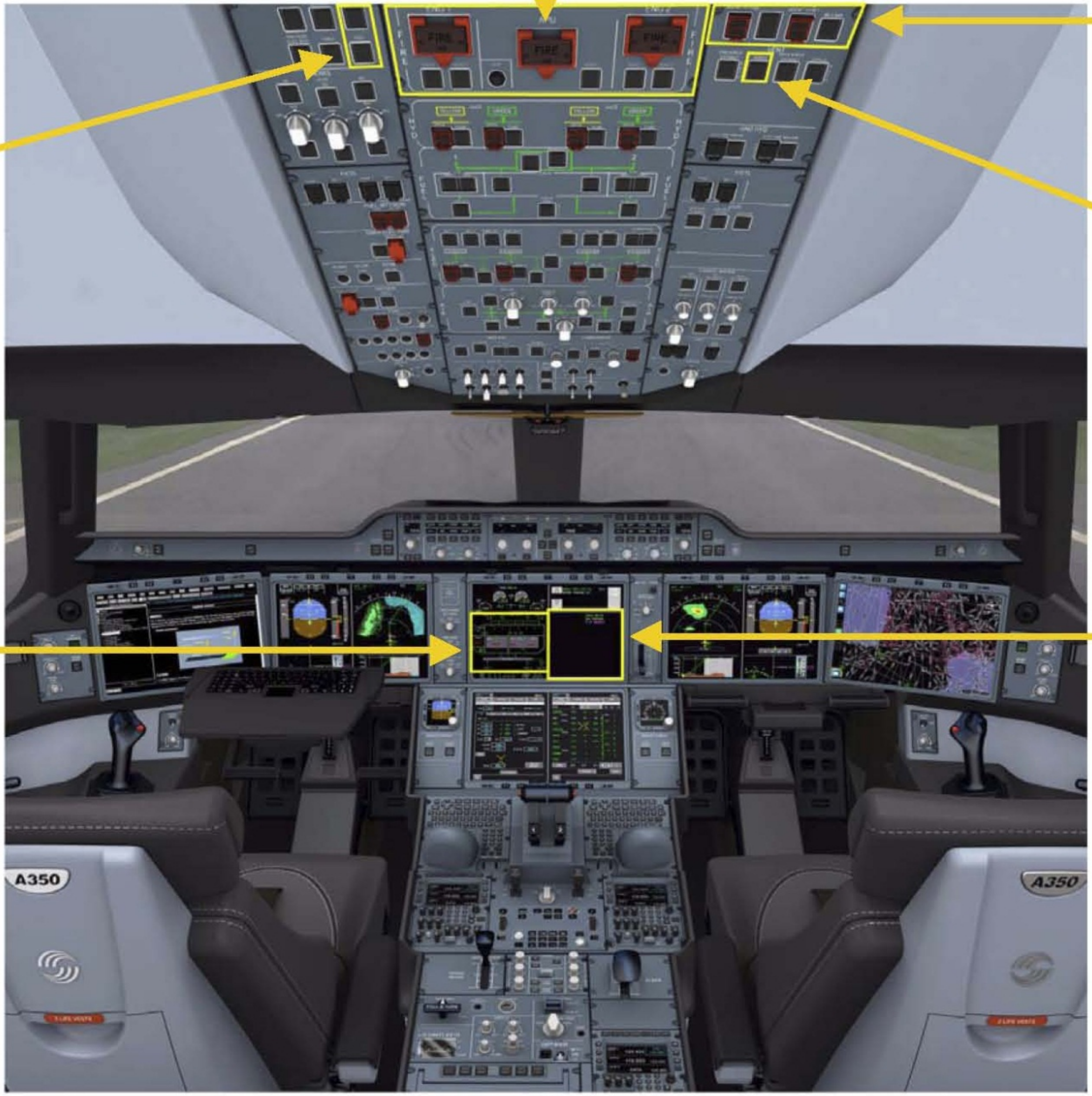
## Cockpit View

FIRE Panel

SMOKE Panel

LAVATORY SMOKE Light and IFEC SMOKE Light on CABIN Panel

AVNCS SMOKE Light on VENT Panel



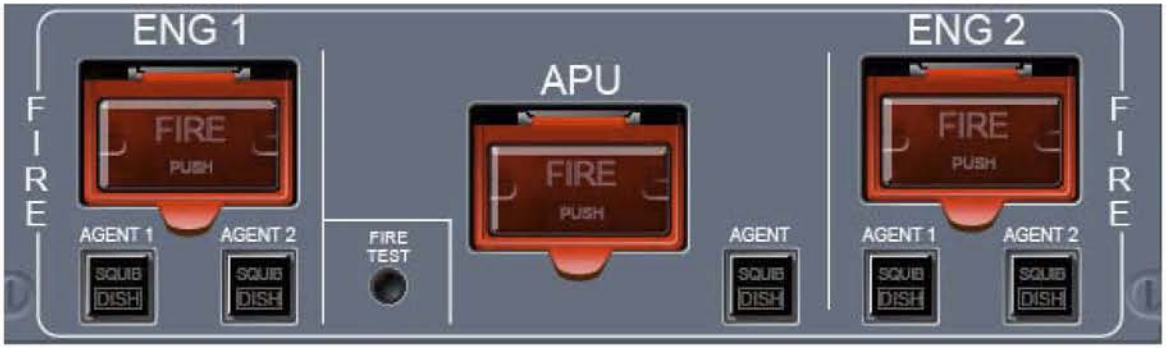
COND SD Page

Warning Display

# Fire and Smoke

## Controls

FIRE Panel




LAVATORY SMOKE Light and IFEC SMOKE Light on CABIN Panel

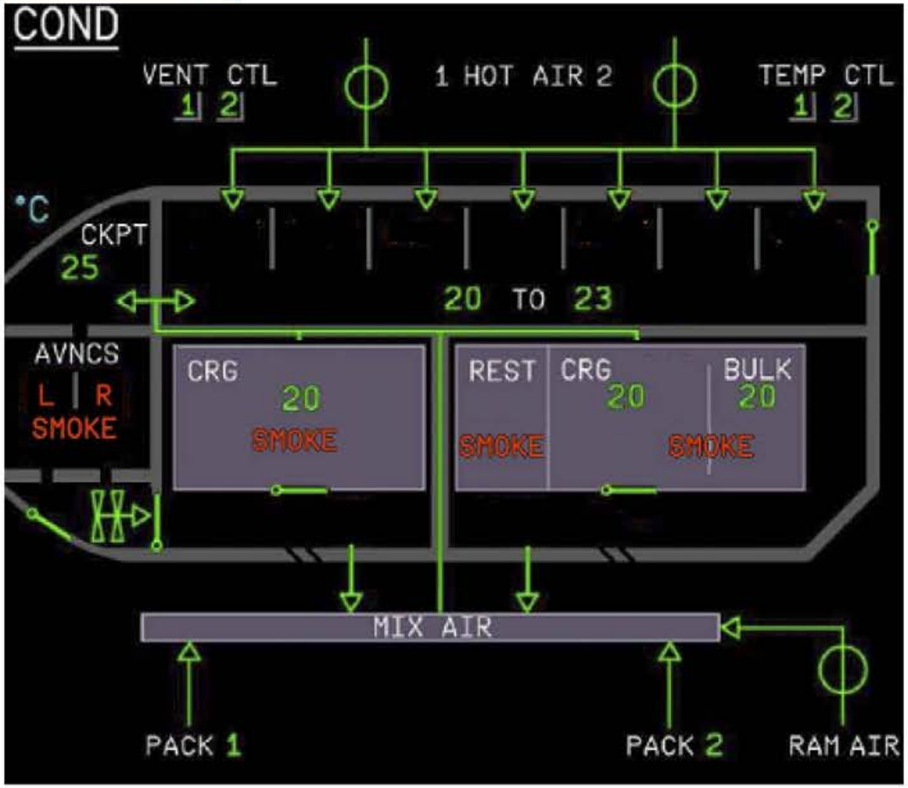

SMOKE Panel


AVNCS SMOKE Light on VENT Panel

# Fire and Smoke

## Indicators

COND SD Page



# Flight Controls

A350 XWB

# Flight Controls

## 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
- 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:

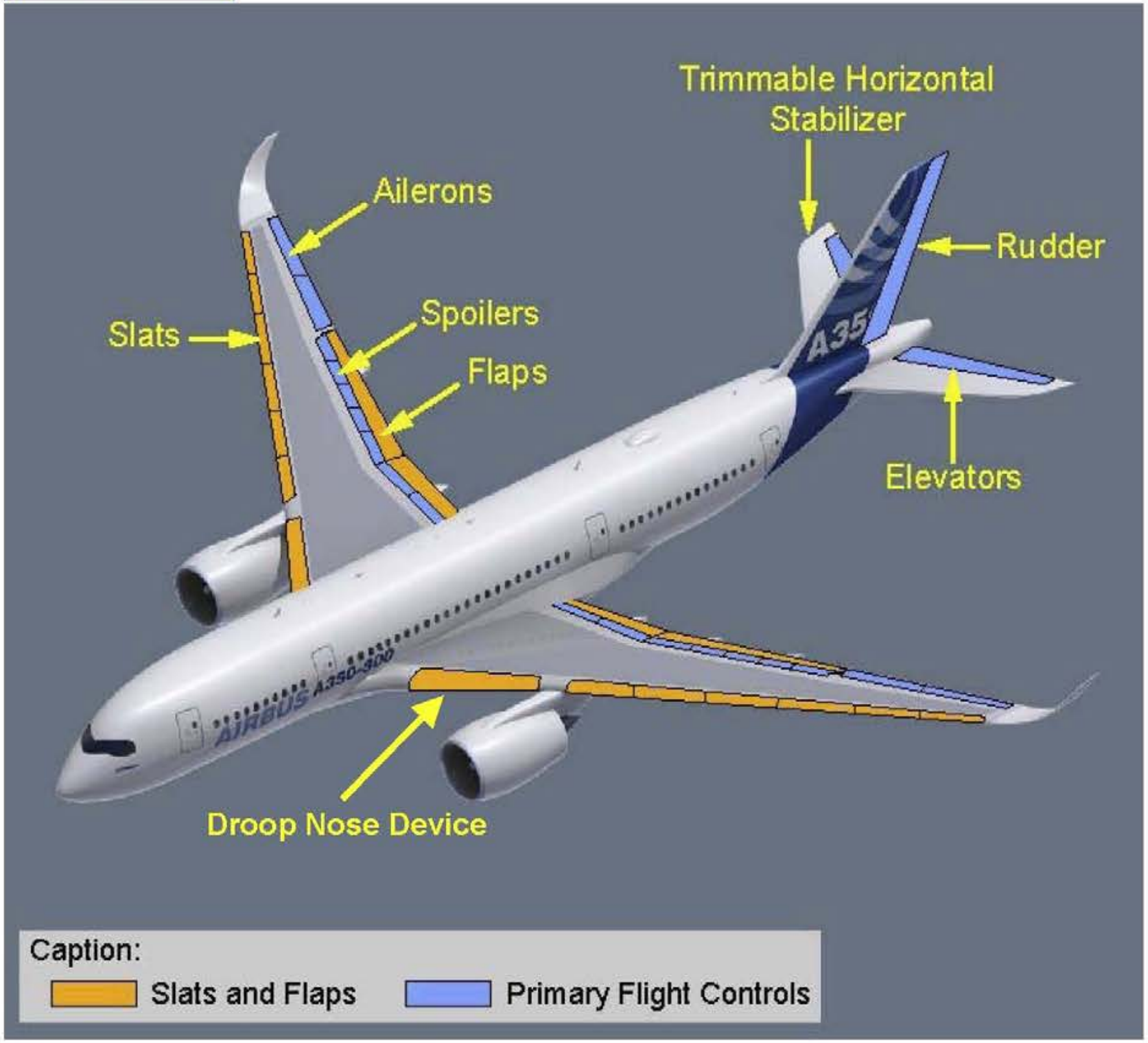
- 4 ailerons
- 14 spoilers
- 2 elevators and 1 Trimmable Horizontal Stabilizer (THS)
- 1 rudder
- 12 slats, 4 Adaptive Dropped Hinge Flaps and 2 Droop Nose Devices.

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*

# Flight Controls

Control Surfaces



## System Architecture

The flight control 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 side-stick 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 complete aircraft control under normal, direct or alternate law. The PRIMs perform the
  - Control of flight controls
  - Flight Guidance (FG) and Autothrust (A/THR) 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:

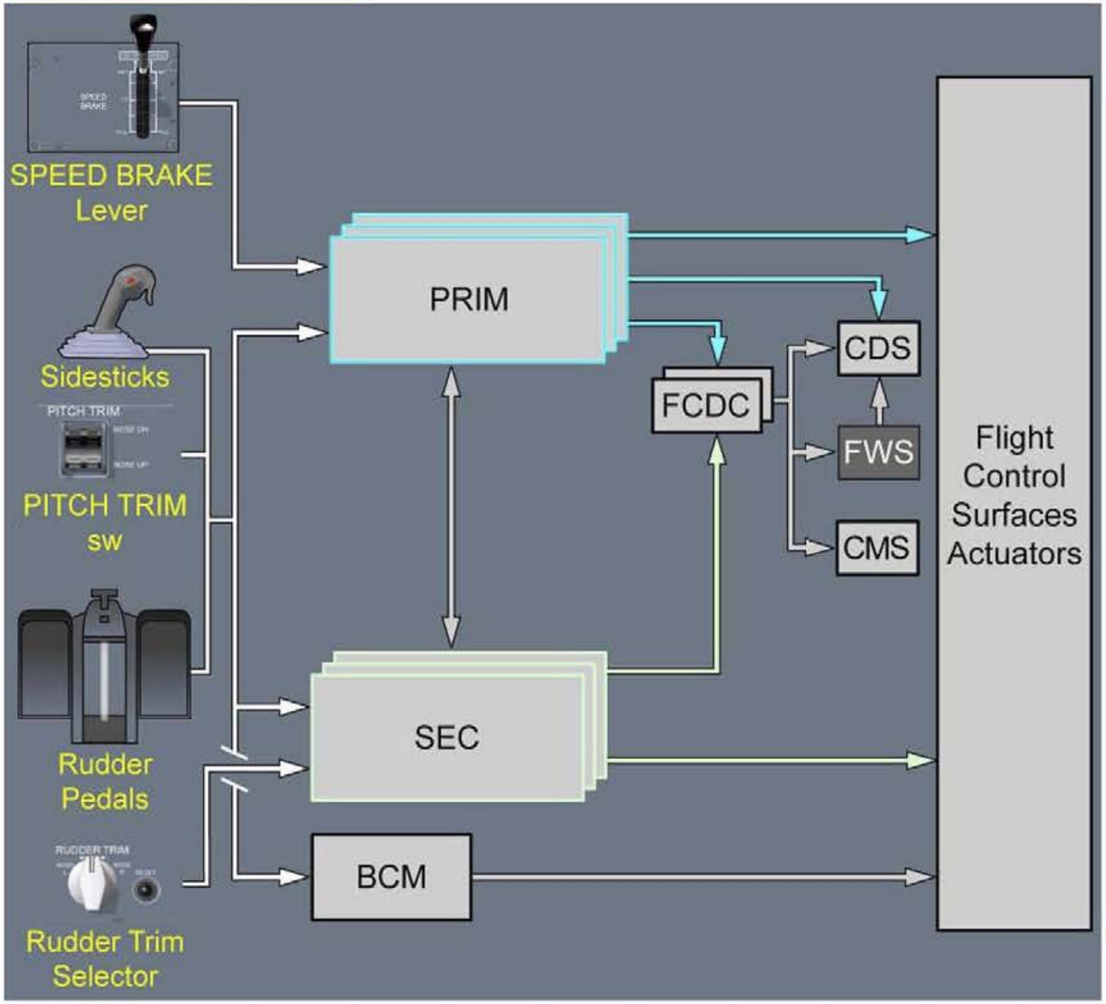
- Two **Flight Control Data Concentrators (FCDCs)** which acquire data from PRIMs and SECs and send them to the:
  - Control and Display System (CDS)
  - Flight Warning System (FWS)
  - Centralized Maintenance System (CMS)

- 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

Flight Controls Architecture



## Operations

The PRIMs and SECs compute the flight control. 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.

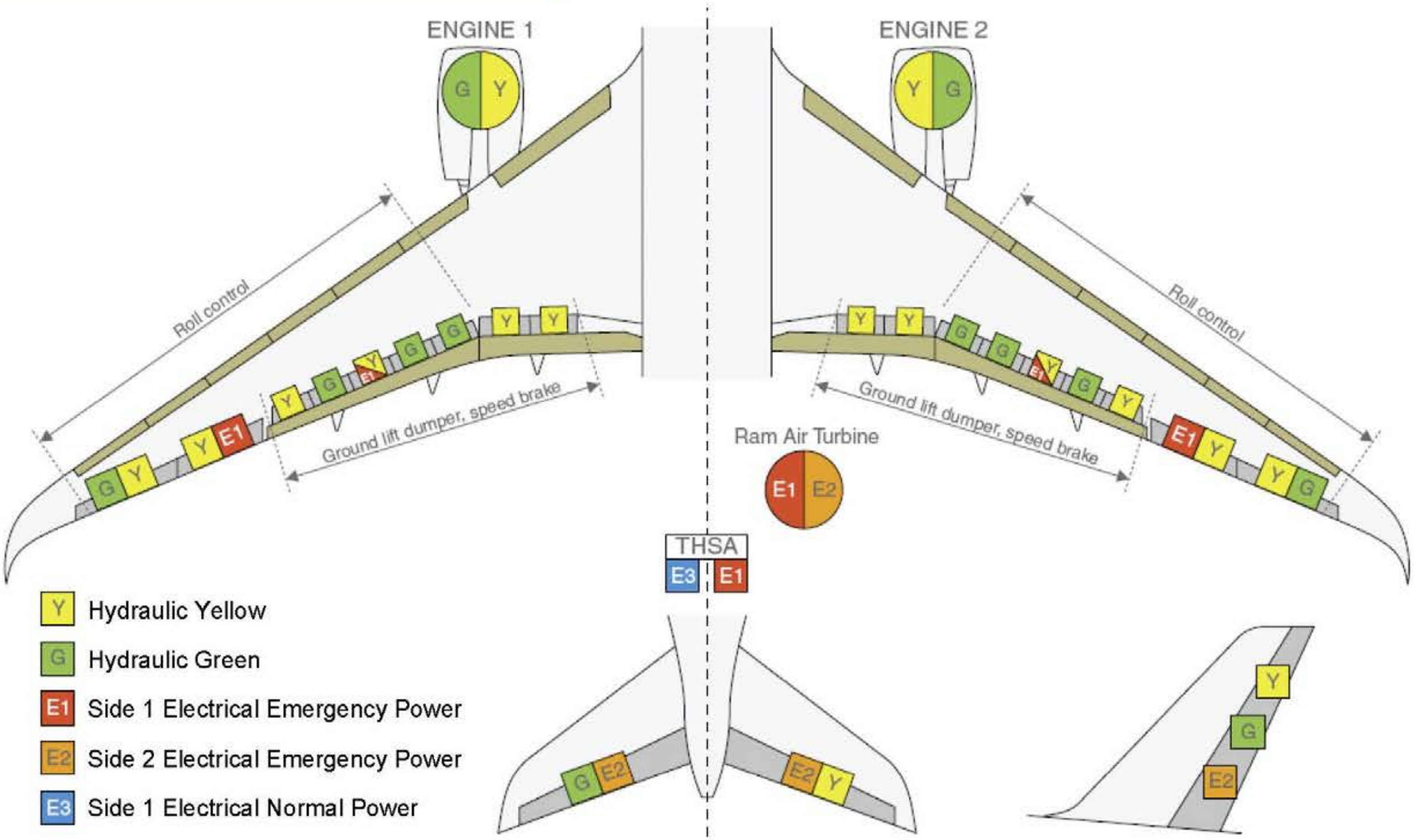
One of the three PRIMs is the master. The master PRIM computes the flight control orders and transmits them to the other computers. Then, each operative PRIM and SEC activates its respective control surfaces accordingly.

If a malfunction is detected, 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.

# Flight Controls

A350 XWB

Power Supply for the Actuators and Control Surfaces



# Flight Controls

## 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 deflectior the spoilers.

## Actuators

The A350 has three types of actuators:

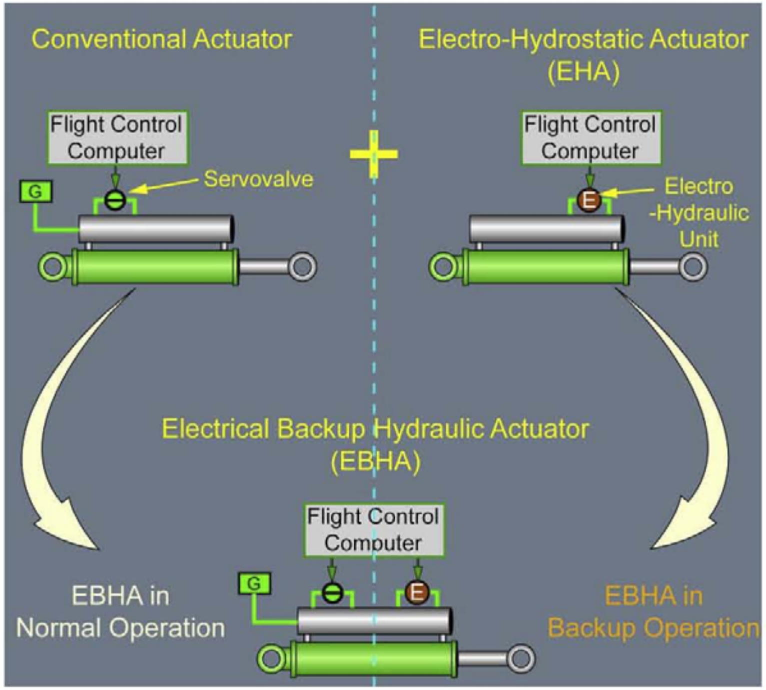
- **Conventional actuators** that include:
  - One actuator
  - One hydraulic block connected to one hydraulic power supply of the aircraft
  - One servo-valve that receives orders from the flight control computers and controls the translation direction of the actuator rod.

  A conventional servo-control 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 control 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 servo-control 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 cir supplies the actuators (refer to next page).*

# Flight Controls

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 control 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.

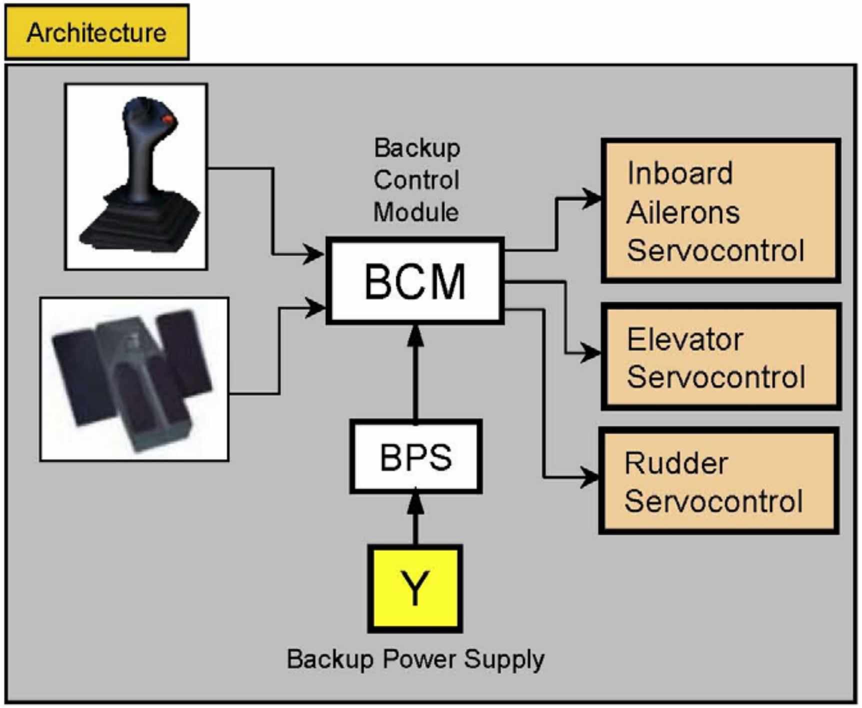
- A Backup Control Module (BCM)

  The BCM controls and monitors:

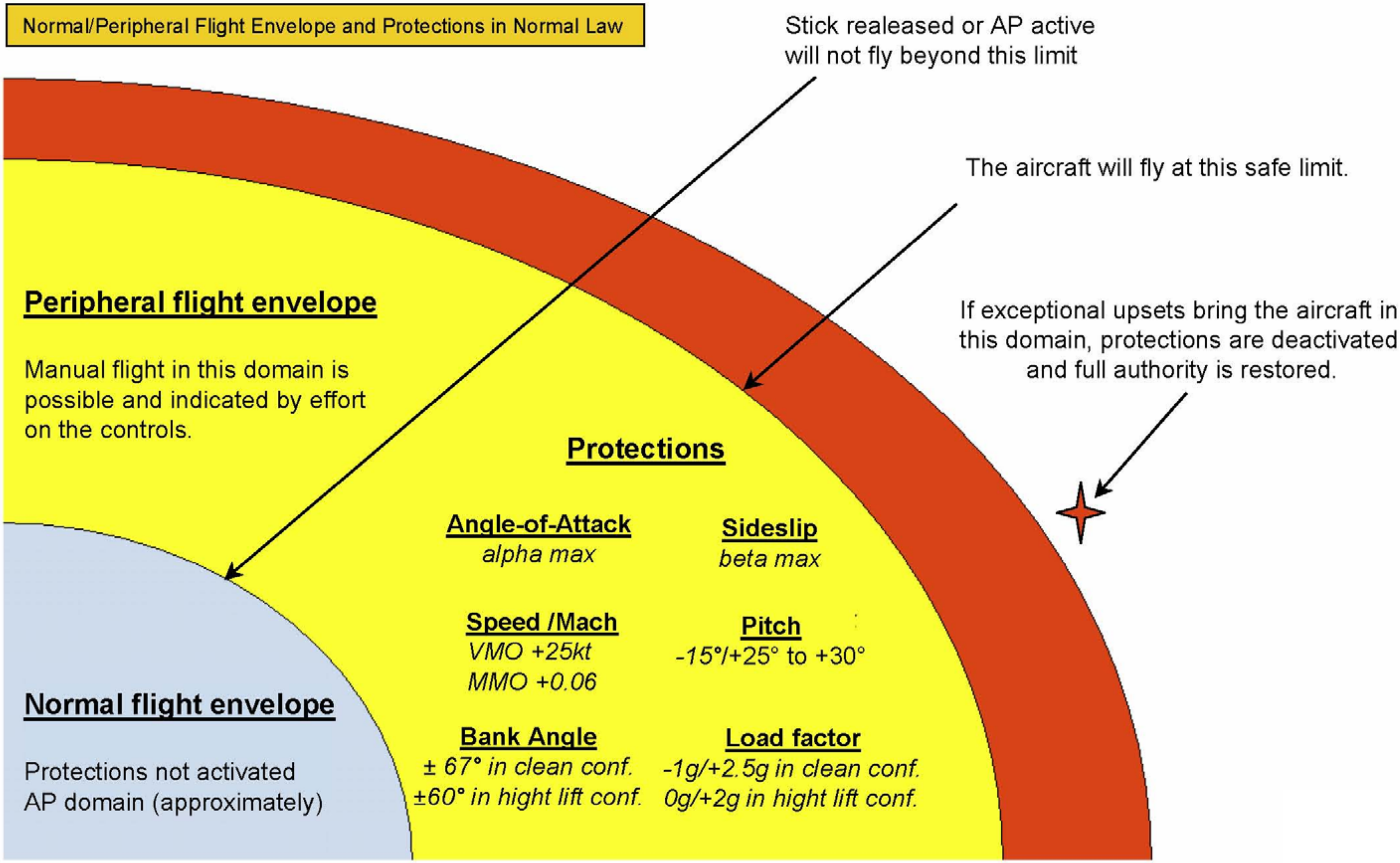
  - The inboard ailerons
  - The elevators
  - The rudder

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

- Pitch motion damping
- Yaw damping
- Direct roll.



# Flight Controls



# Flight Controls

## Protections

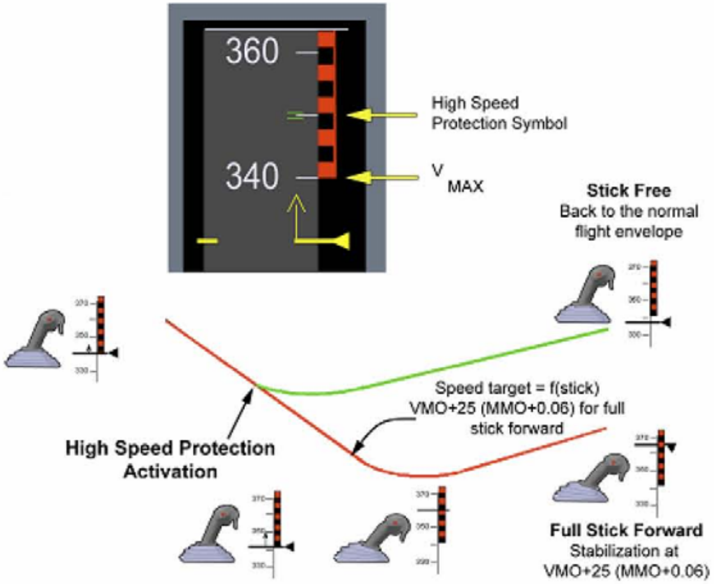
### High Speed Protection

Objective:

- To limit the possible speed/Mach excursions beyond VMO/MMO whatever stick input
- To cause no interference with flight at VMO/MMO.

Features:

- Pilot nose down authority is reduced and progressive elevator up is applied to stabilize the aircraft at VMO+25kt (MMO+0.06) if full forward stick is maintained.



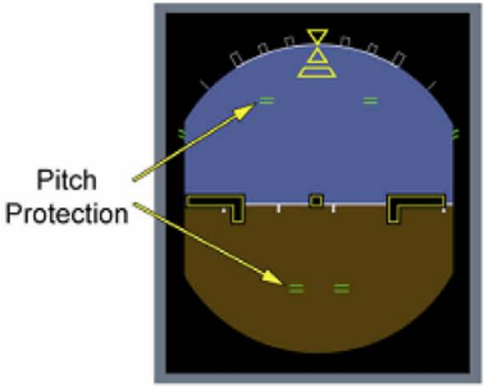

### Pitch Attitude Protection

Objective:

- To enhance the effectiveness of the Angle-of-Attack (AOA) and high speed protections in extreme conditions.

Features:

- Pitch limitation to:
  - -15° / +30° at high aircraft speed
  - -15° / +25° at low aircraft speed.



# Flight Controls

**Angle-of-Attack (AOA) Protection**

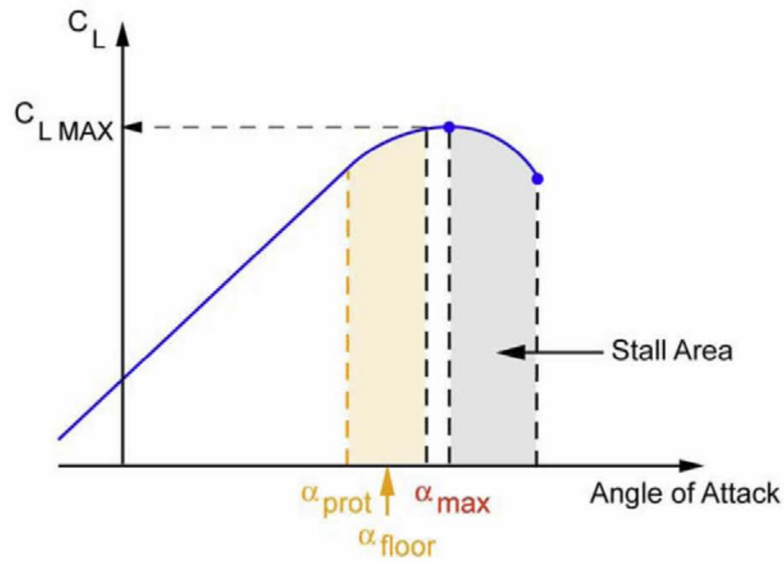
Objective:

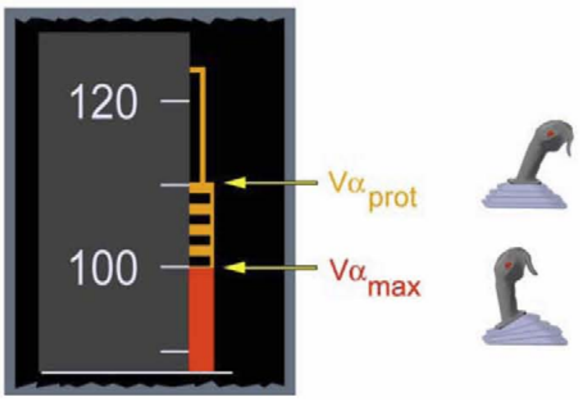
- To protect the aircraft against stall in dynamic maneuvers or gusts
- To ensure safe flight and good handling characteristics at high angle of attack
- To cause no interference with normal operating speeds and maneuvers.

Features:

- The angle of attack is limited to
  - $\alpha_{prot}$ with neutral stick
  - $\alpha_{max}$ with full back stick.

  When reaching $\alpha_{floor}$ ($\alpha_{prot} < \alpha_{floor} < \alpha_{max}$), TO GA thrust is automatically applied.
- Speedbrakes retraction
- Deactivation, as soon as the sidestick deflection commands a smaller angle of attack than $\alpha_{prot}$.



## Normal Law

Lateral Control Laws

### Lateral Ground Control Law

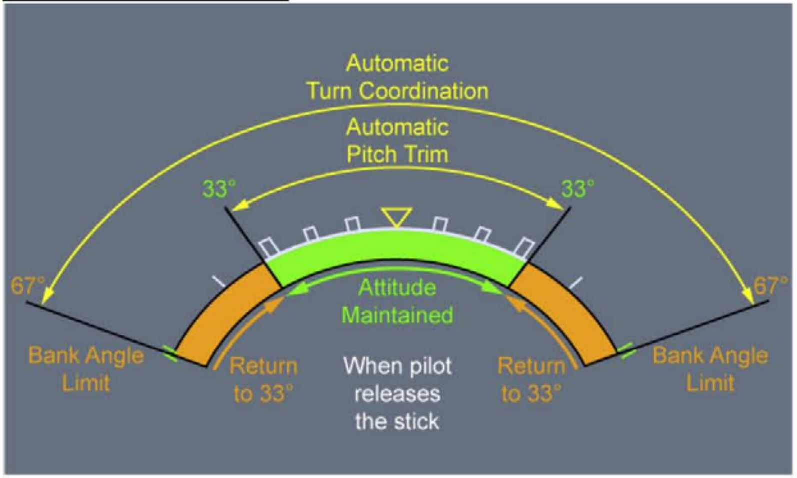
Objective:

- To facilitate aircraft handling on ground.

Features:

- The lateral ground law is a full authority control law in roll and yaw, with some yaw damping. However, for small sidestick deflections, the lateral ground control law helps the pilot to keep a small bank angle using only the ailerons. In particular, when the sidestick is at neutral, the law will aim at keeping the wing level

Lateral Normal Law




### Lateral Normal Law

Objective:

- To control the roll and yaw axes of the aircraft through roll rate and sideslip demands.

Features:

- A sidestick deflection results in a roll rate demand with turn coordination.

  Neutral spiral stability up to 33° bank:
  - Automatic pitch trim
  - The bank angle is maintained when the sidestick is at neutral

  Positive spiral stability restored above 33° bank:
  - No automatic pitch trim
  - The bank angle returns to 33° if the sidestick is at neutral
- Bank angle limitation to:
  - 67° in clean configuration
  - 60° in high lift configuration
  - 45° when the high speed or Angle-of-Attack (AOA) protection is active
- A pedal deflection results in a proportional sideslip and bank angle. In the case of an engine failure, the law provides a sideslip and bank angle to indicate the engine failure, as on a conventional aircraft
- Yaw rate feedback for stabilization.

# Flight Controls

## Alternate Law

### Longitudinal Control Laws

The pitch control is similar to the pitch control in normal law (refer to *normal law*).

### Lateral Control Laws

Depending on the failure:

The roll and yaw control is similar to the roll and yaw control in normal law (refer to *normal law*), or the roll and yaw control is almost a direct control, similar to the roll and yaw control of a conventional aircraft.

- **Roll Direct Law**
  Features:
  - Linear roll response with respect to roll order
  - Sufficient but not excessive roll order deflections (or authority) to provide adequate efficiency.
- **Yaw Alternate Law**
  Features:
  - Linear yaw response with respect to yaw order
  - Dutch roll damping
  - Turn coordination

### Protections

Protections are indicated as lost.

Depending on the failure, some protections may still be available. However, these protections are degraded, and are therefore indicated as lost.

## Direct Law

### Longitudinal Control Laws

The direct law is the lowest level of flight control computers

In direct law, there is a direct relationship between the sidestick position and the elevator position.

- **Pitch Direct Law**
  - No autotrim
  - Pitch rate feedback for stabilization
  - Aircraft behavior adequate to perform landing and sufficient authority to compensate airbrake extension/retraction, thrust variation or slats/flaps movements.

### Lateral Control Laws

Roll direct law & Yaw Alternate law.

### Protections

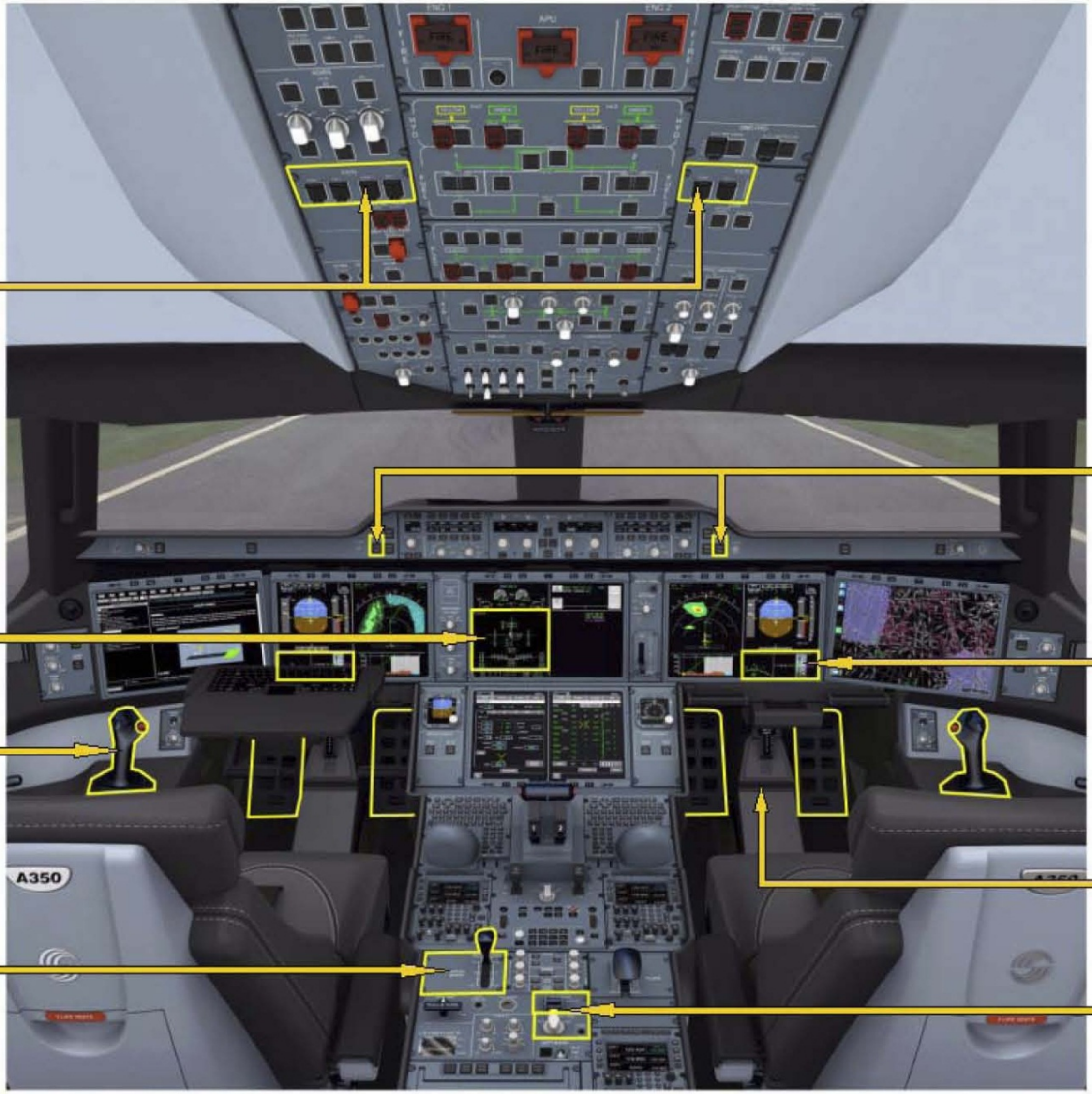
All protections are lost.

A conventional aural stall warning ($\alpha > \alpha_{sw}$) and an overspeed warning replace the protections in normal law.

Note: $\alpha_{sw}$ *stands for stall warning angle of attack.*

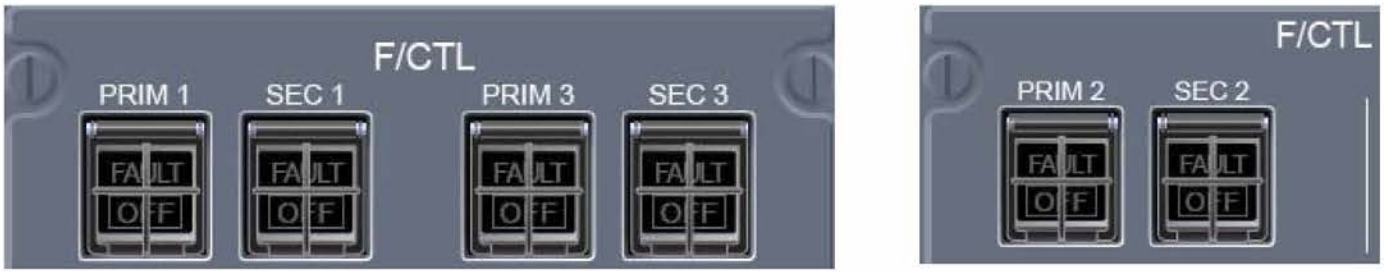
# Flight Controls

## Cockpit View

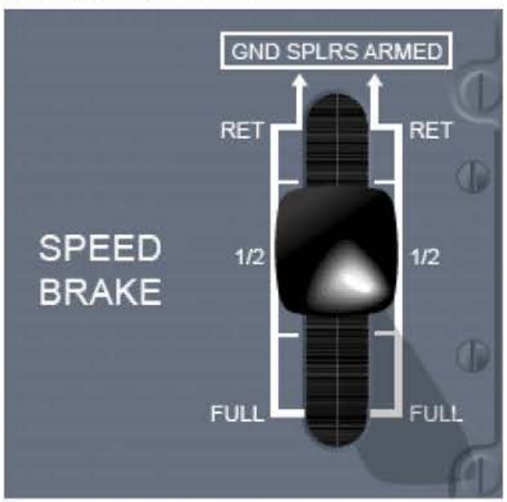


# Flight Controls

F/CTL Overhead Panels




SPEED BRAKE Lever




PITCH TRIM & RUDDER TRIM Panel

## Sidestick and Priority Logic

Normal Operation:
Only one sidestick is deflected


The Captain and First Officer inputs are algebraically summed. The maximum resulting input is limited to a full deflection input of a single sidestick.


+

**« DUAL INPUT »**
**Aural Message**

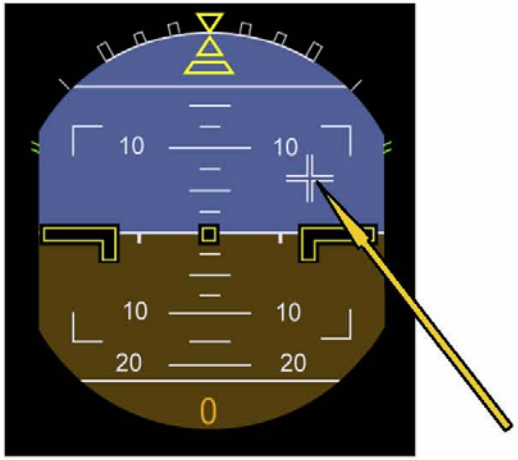
The Captain presses his sidestick pushbutton, while the First Officer moves his sidestick.
The Captain gains the priority.


+

**« PRIORITY LEFT »**
**Aural Message**

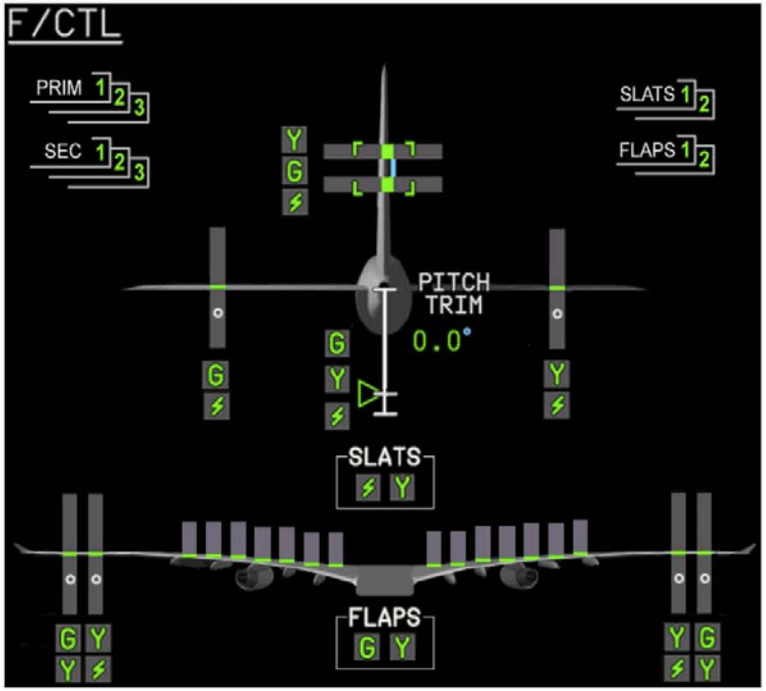
# Flight Controls

PFD: Sidestick Indicator




Sidestick Indicator *(displayed on ground only not in flight).*

F/CTL SD Page




PFD: Slats/Flaps Spoilers and Pitch Trim Display

## General

The basic functions of the slats/flaps system are to:
- Control and monitor slats and flaps movement
- Provide status and failure information of the high lift system to other systems and to the flight crew.

The A350 has the following surfaces that provide lift augmentation :
- 12 slats
- 4 flaps
- 2 droop nose devices.

The Adaptive Dropped Hinge Flaps (ADHF) is a mechanism that combines flaps and spoilers motion to improve the aerodynamic of the wing.

Slats are electrically and hydraulically-actuated.
Flaps are hydraulically-actuated.

High Lift Surfaces

**ADHF function**

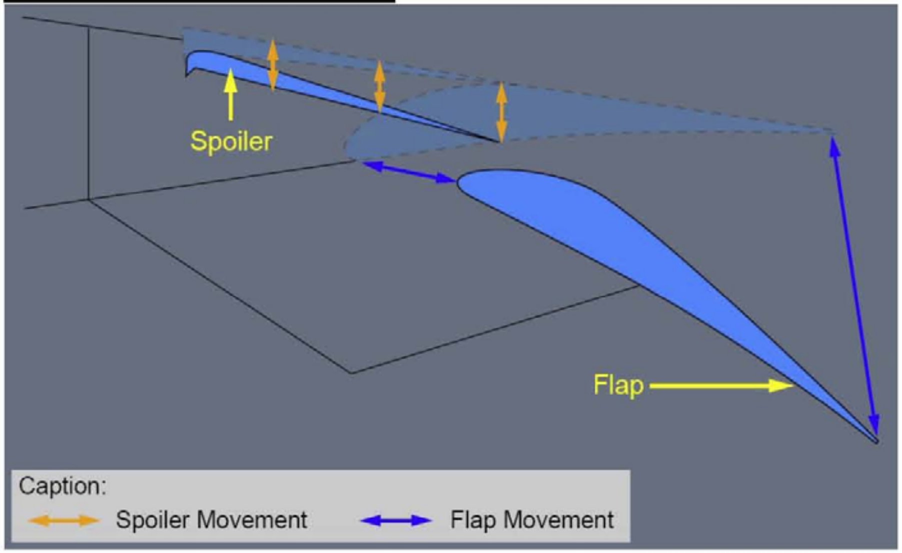
When flaps are extended, the spoiler actuator controls the gap between the spoiler trailing edge and the flap to an optimum value.

This function enables:

- In take off configuration to get a permanent optimum Lift over Drag ratio for better climb performance or maximal take off weight
- In landing configuration to get a maximum lift (CLmax ) for a low approach speed

The ADHF function does not require any pilot action except flap lever selection as usual.

Adaptive Dropped Hinge Flap



## Slats/Flaps Control and Motion

**Two Slat/Flap Control Computers (SFCCs)** control and monitor the High-Lift System. Each SFCC has two independent channels, a SLAT and a FLAP channel:

- SFCC 1 (FLAP 1 and SLAT 1 channels)
- SFCC 2 (FLAP 2 and SLAT 2 channels)

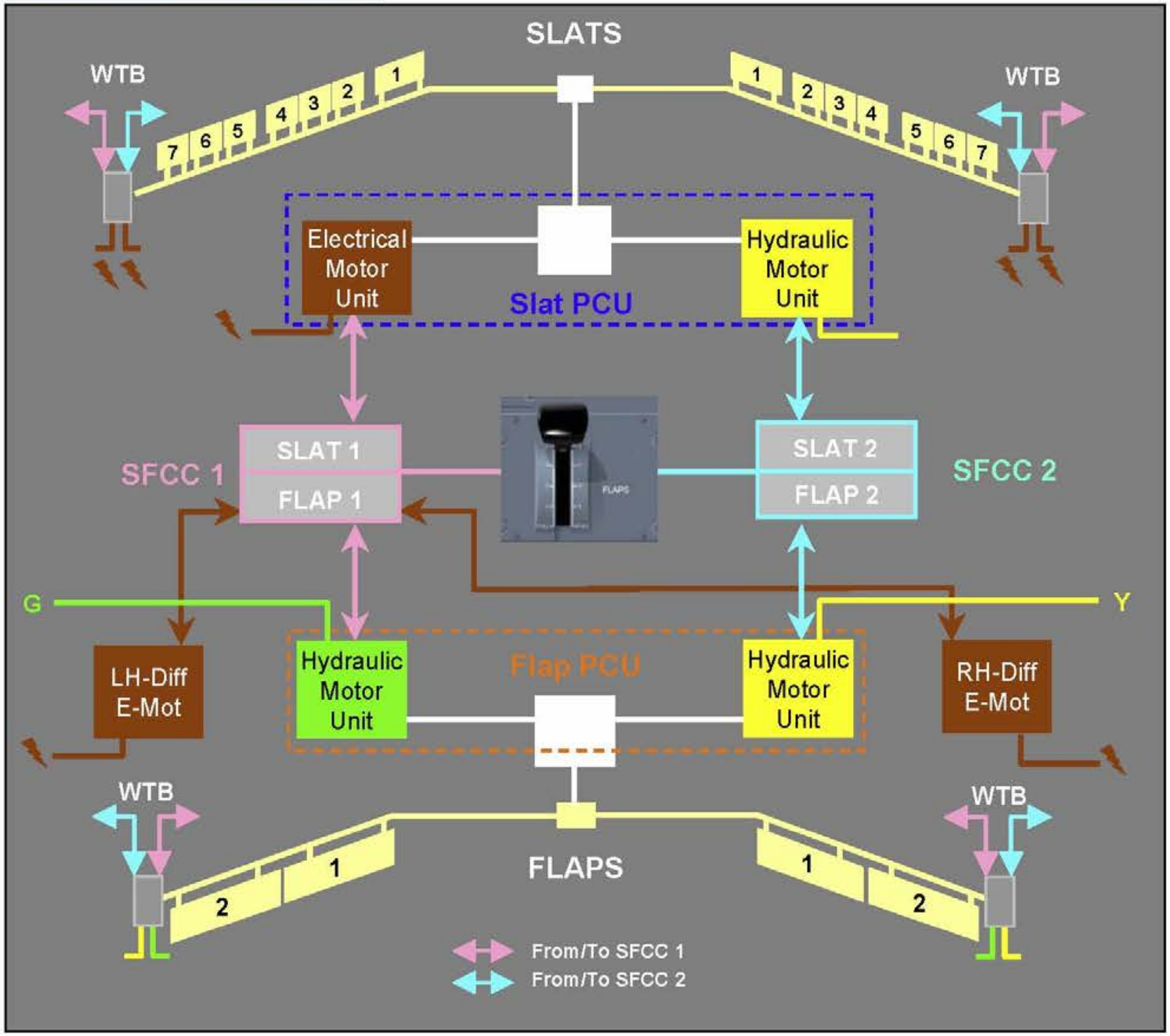
**Two Power Control Unit (PCUs)** power the system:

- **The Flap PCU** which drives the FLAP 1 & 2 systems. This PCU has two identical hydraulic motors:
  - The LH hydraulic motor
  - The RH hydraulic motor

  The GREEN hydraulic circuit supply the LH motor and the YELLOW hydraulic circuit the RH motor
- **The slat PCU** which drives the SLAT 1 & 2 systems. This PCU has an electric motor and a hydraulic motor:
  - The 230 VAC EMER 1 electrical circuit supplies the electrical motor
  - The YELLOW hydraulic circuit supplies the hydraulic motor.

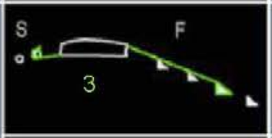
# Flight Controls

Slats/Flaps System Achitecture



# Flight Controls

## Slats/Flaps Configurations

| FLAPS Lever Position | Configuration on ECAM | Maximum Speed | Flight Phase |
|---|---|---|---|
| 0 |  | VMO/MMO | Cruise |
| 1 |  | TBD | Holding |
| |  | TBD | Takeoff/ Approach |
| 2 |  | TBD | Takeoff/ Approach |
| 3 |  | TBD | Takeoff/ Approach/ Landing |
| |  | TBD | Landing |
| FULL |  | TBD | Landing |

## Automatic Functions

### Flap Load Relief Function

The flaps load relief function retracts the flaps to the next retracted flaps position if the current speed exceeds the VFE. This limits the loads on the flaps. The FLRS is available in position 2, 3, or FULL only.

### Slats/Flaps Cruise Balk Function

If the lever is inadvertently moved from 0 to 1 during cruise, the slats/flaps cruise balk function will maintain the slats and flaps in their fully retracted position. This function prevents excessive loads on the flaps.

Nevertheless if the lever is inadvertently moved to 2, 3 or full during cruise, the slats and flaps will extend.

### Slats Speed Balk Function

The slat speed balk function inhibits slats retraction to zero if the speed is too low.

When the speed reaches an appropriate value, the slats retraction inhibition stops.

### Slats Alpha Lock Function

The slat alpha lock function inhibits slats retraction to zero if there is an excessive Angle-of-Attack (AOA).

When the angle of attack reaches an appropriate value, the slats retraction inhibition stops.

### Auto Slat Function

The auto slat function enables automatic extension of slats if there is an excessive Angle-of-Attack (AOA). The slats return to their initial selected setting as soon a the angle of attack has been restored to a safe level.

### Flap Deployment in Cruise Function

A small flap deployment in cruise function enables:

- Wing camber control
- Differential flap setting loads and drag control
- Lateral trim.

The function is active when the flaps lever is in position 0.

## Automatic Functions

### Differential Flap Setting and Variable Camber

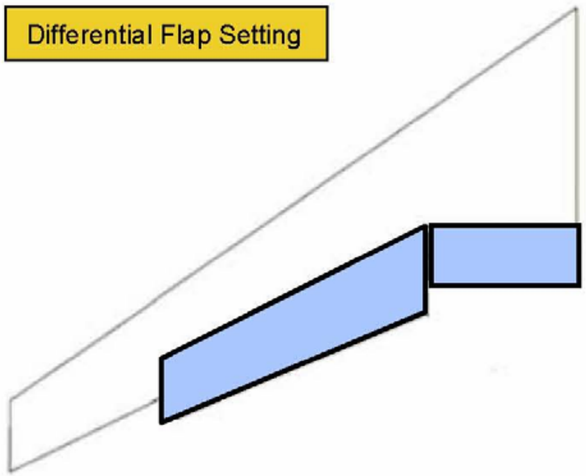
The Differential Flap Setting (DFS) performs small flaps deflections (4° maximum) either symmetrically or differentially.

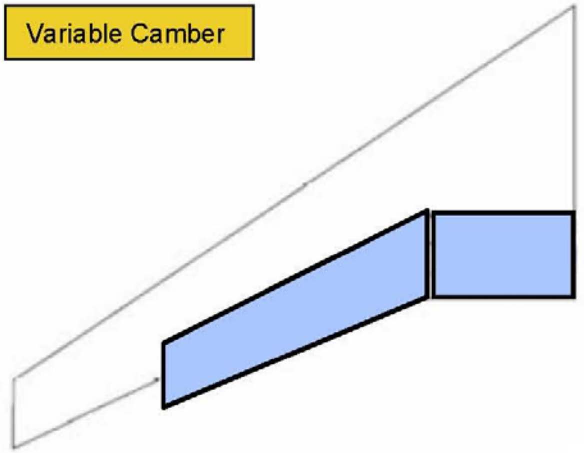
The variable camber adapts slightly the flaps deflection (in or out) during the cruise.

These two functions enable to:

- Optimize load (mainly wing root bending moment) at high weight
- Minimize drag in cruise
- Perform an optimized Lateral Trim function.

*<u>Note</u>:*
*When the DFS performs a differential deflection, the outer flaps only are a deflected differentially.*




### Wing Tip Brakes (WTB)

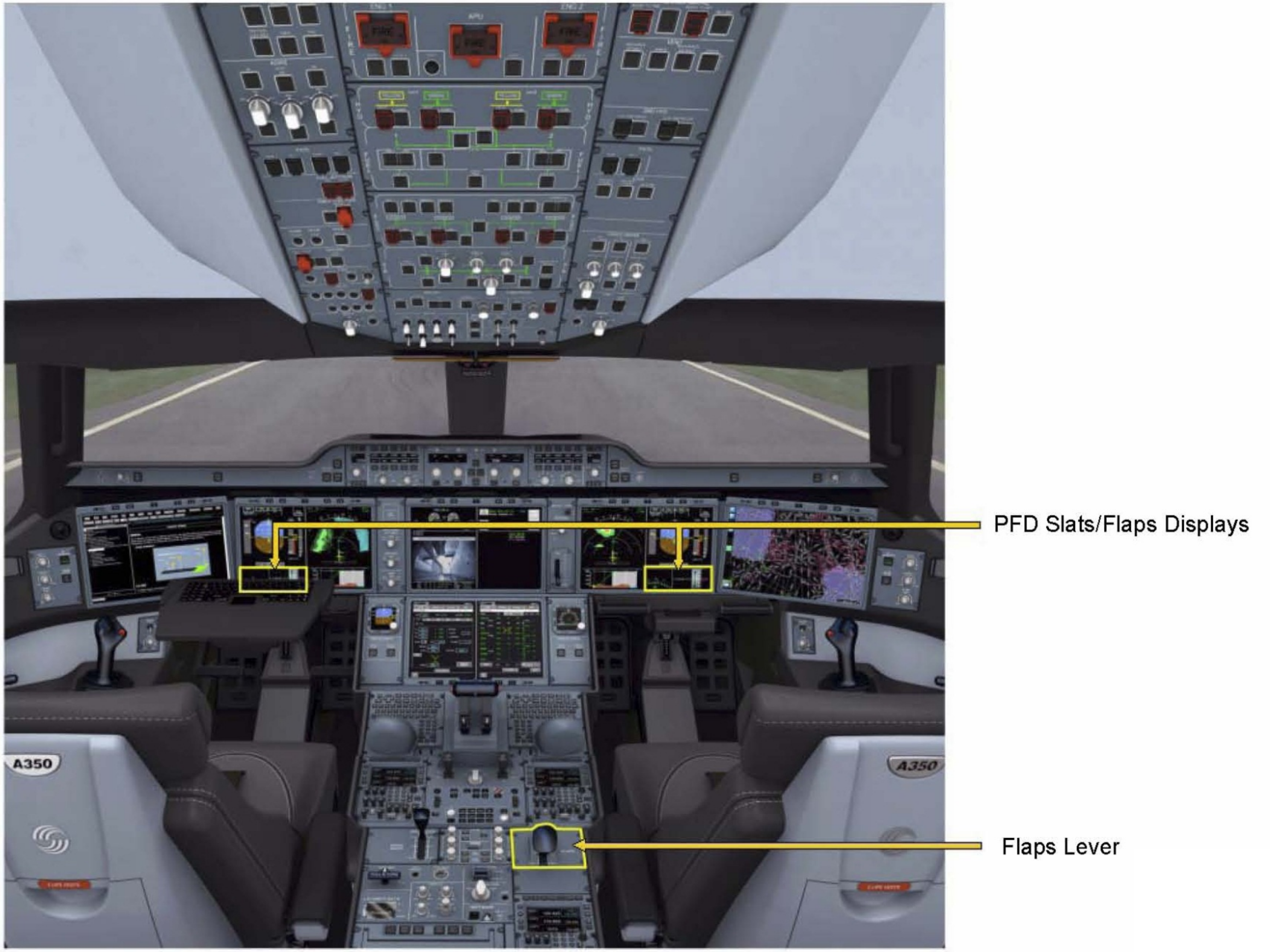
The Wing Tip Brakes WTBs mechanically lock the slats and flaps, in case of runaway, overspeed, or asymmetry.

If locked, the WTBs cannot be unlocked in flight.

# Flight Controls

A350 XWB

## Cockpit View



## Flaps Lever

The FLAPS lever controls both the slats and the flaps at the same time. This lever is on the pedestal.

There are five FLAPS lever positions.

## Override Mechanism

The FLAPS lever includes an override mechanism that is used if the FLAPS lever is jammed. The override mechanism allows to extend the slats/flaps by one step (e.g. from 0 to 1, from 3 to FULL).

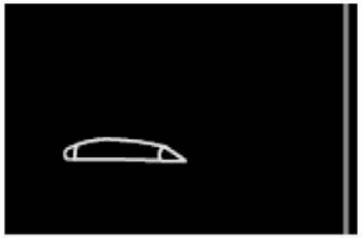
To use the override mechanism, the flight crew moves the lever one step with a strong force, without pulling the lever out of detent.

Flaps Lever

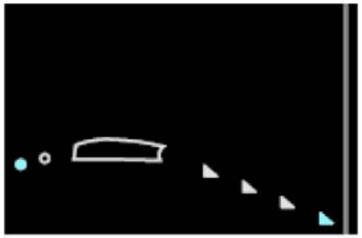
## Slats/Flaps Display

The slats/flaps display appears on the bottom left-hand side of the PFD displays.

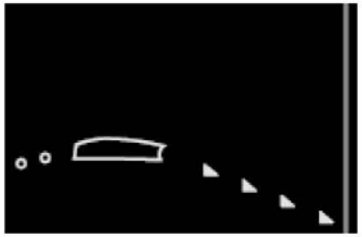
- Slats/Flaps Position Indexes



The slats and flaps are fully retracted.

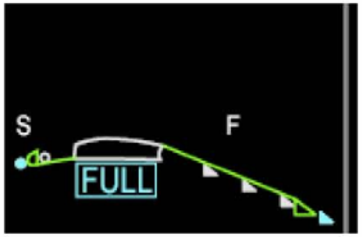


The blue point Indicates the selected slats position. The blue triangle Indicates the selected flaps position.



The dots indicate the slats positions that can be selected.

The triangles indicate the flaps positions that can be selected.



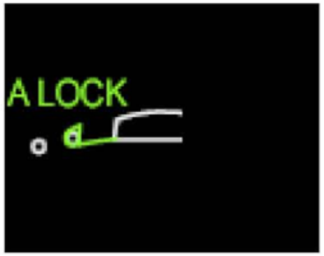

The slats/flaps move to the selected position.

# Flight Controls

## Slats/Flaps Display

- Slats Position and Messages


Position of the slats.

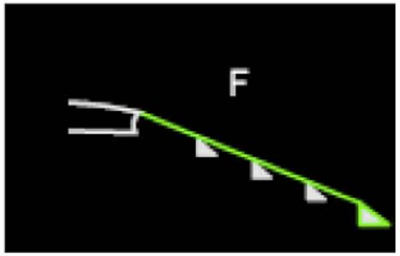



The slat alpha/speed lock function is active. The indication pulses.


The slats are failed.

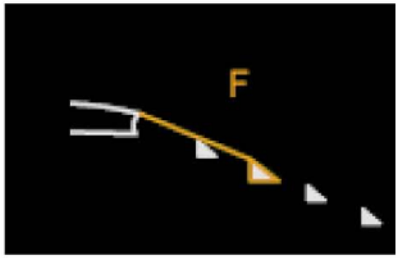

Wing-tip brakes are applied to the slats.

- Flaps Position and Messages

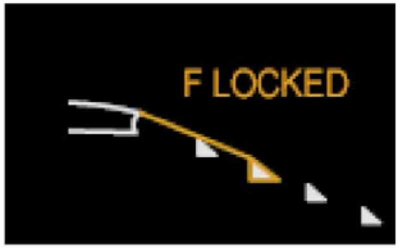



Position of the flaps.


The Flap Load Relief Function is active. The indication pulses.




The flaps are failed.




Wing-tip brakes are applied to the flaps.

# Fuel System

A350 XWB

# Fuel System

## Overview

The fuel system:

- Stores fuel
- Monitors the quantity and temperature of fuel in each tank
- Controls fuel transfers, in order to:
  - Supply fuel to the engines and to the Auxiliary Power Unit
  - Control refueling and defueling
  - Enable fuel jettison (optional), if necessary.

## Fuel Tank Arrangement and Quantity

### Fuel Tank Arrangement

The fuel is stored in three tanks:

- The left wing tank
- The center tank
- The right wing tank

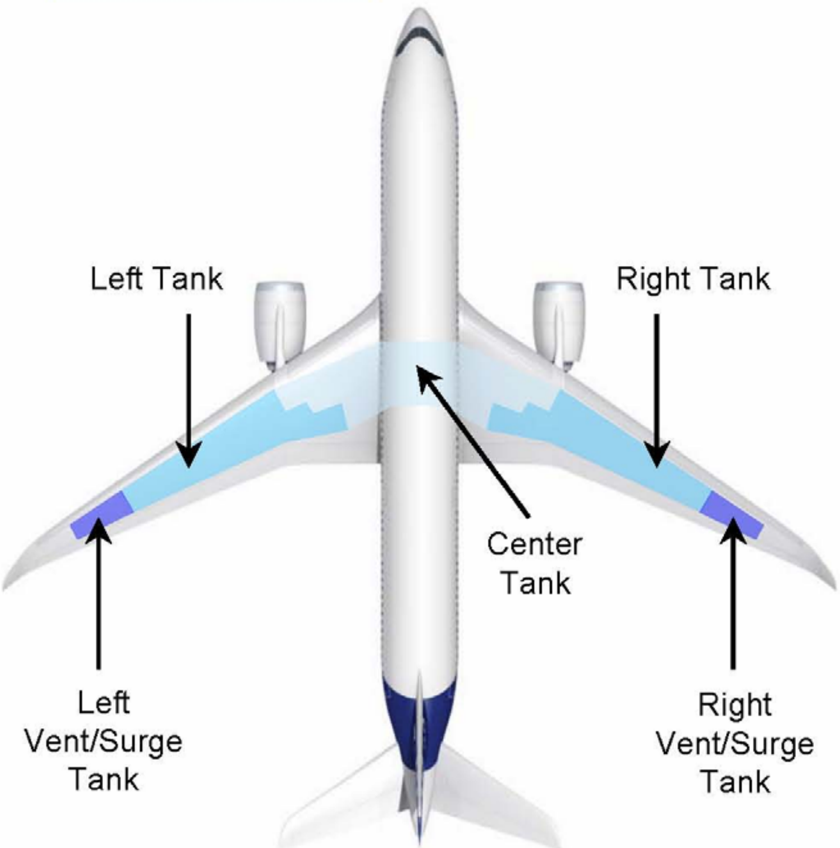
The wing tanks and the center tank directly feed the engines and/or the APU (refer to ***Engine Feed***).

In addition, the A350 has two vent/surge tanks which:

- Connect each tank to the outside atmosphere to:
  - Limit the differential pressure between the tanks and the atmosphere, and
  - Maintain the pressure within structural limits.

- Temporarily collect fuel that may overflow from any fuel tank during operation.

# Fuel System




**Fuel Tank Quantity**

| | | USABLE FUEL (Fuel Specific Density: 0.799 kg/L) | | | |
|---|---|---|---|---|---|
| | | Left Wing Tank | Center Tank | Right Wing Tank | TOTAL |
| VOLUME | Liters | 31 333 | 75 334 | 31 333 | 138 000 |
| | US Gal | 8 277 | 19 901 | 8 277 | 36 455 |
| WEIGHT | Kg | 25 035 | 60 190 | 25 035 | 110 260 |
| | Lbs | 55 265 | 132 870 | 55 265 | 243 400 |

# Fuel System

## System Architecture

The A350 has a feed gallery and the following feed pumps and valves:

**• Wing Tank Pumps and Center Tank Pumps**

Each wing tank has two feed pumps:

- One main wing tank pump
- One standby wing tank pump

The center tank has two feed pumps:

- The left center tank pump
- The right center tank pump

Each feed pump is directly connected to its related engine via the feed gallery.

The center tank pumps are designed to produce more pressure than the wing tank pumps, and therefore preferentially supply fuel to the engines.

**• APU Pump**

There is an APU pump at the rear of the center tank. This pump automatically starts to provide pressurised fuel to the APU if the pressure from the engine feed pumps is too low.

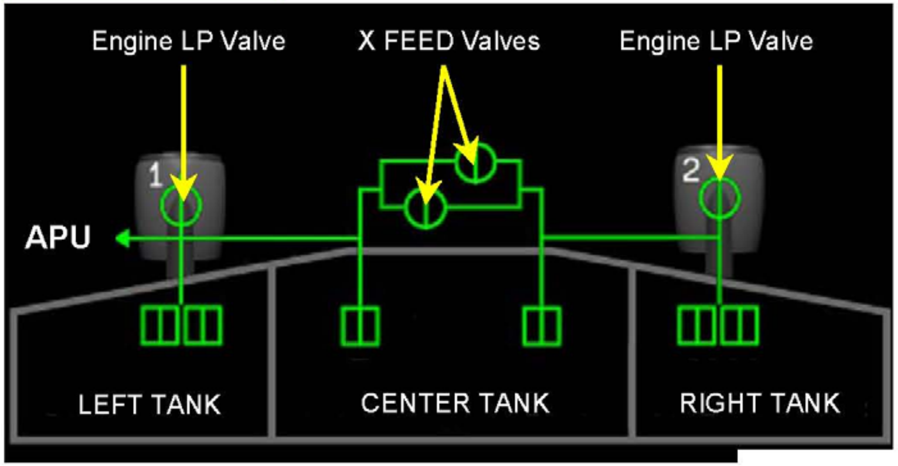
**• Crossfeed Valves (X FEED)**

The two X FEED valves and the feed gallery enable to feed any engine from any tank. This architecture maximizes fuel availability in case of feed pumps failure and enables correction for any lateral imbalance.

**• Engine Low-Pressure Valves**

Each engine has a Low Pressure (LP) valve that can stop the flow of fuel to the engine.

System Architecture




*Note: the APU pump is not displayed on this drawin*

## Engine and APU Feed

### Engine Feed

Normal operations:

The center tank feeds directly the engines via the feed gallery. When the center tank is empty, the wing tanks feed the engines.

*Note: during takeoff, only the wing tanks feed the engines.*

The wing tank pumps feed the engine of the same side via the feed gallery. If necessary, the wing tank pumps can feed the engine of the opposite side:

- Directly via the crossfeed valves and the feed gallery
- Indirectly via the center tank

Abnormal operations:

If a center tank pump fails, the opening of the crossfeed valves enables to maintain fuel supply from the center tank to both engines via the remaining center tank pump. A single center tank pump will maintain sufficient pressure and flow to maintain the fuel supply to both engines.

If both the main and the standby pumps in the same tank fail, gravity feed can supply fuel to the related engine when flying below fuel gravity ceiling.

If fuel is not available from one wing main or standby pump, the wing main or standby pump of the opposite will feed both engine via the crossfeed valves.

If a main wing tank pump fails, the corresponding standby wing tank pump automatically takes over.

If one engine has failed, a manual transfer from wing tank to center tank enables to make the fuel available for the remaining engine.

### APU Feed

The following pumps can feed the APU:

- Any LH pump (wing or tank pumps)
- Any RH pump (wing or tank pumps) via the crossfeed valves
- The APU feed pump, that automatically starts to provide pressurised fuel to the APU if the pressure from the engine feed pumps is too low.

# Fuel System

## Fuel Quantity and Management System

Two Fuel Quantity and Management Systems (FQMS) permanently monitor the fuel quantity and temperature. In addition, the FQMS controls:

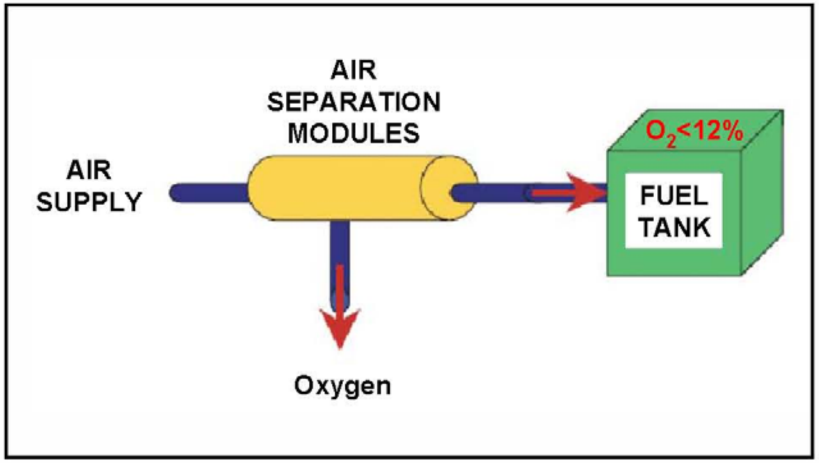
- Ground operations: Refueling and defueling
- Fuel jettison.

## Fuel Tank Inerting System

The objective of this system is to feed the fuel tanks with inert air while fuel is consumed in order to provide a full-time flammability protection in the fuel tanks.

Its design does not require any pilot action.

The system consists in passing pressurized conditioned air through a molecular filter. The filter separates the oxygen and safely exhausts it overboard. The remaining oxygen depleted air is fed in to the fuel tanks to replace ambient air, making the atmosphere in the fuel tank non-flammable.



A350 XWB

## Refuel/Defuel

In normal operations, the FQMS fully controls the refuelling. This automatic refuel can be initiated from the external refuel panel.

Manual refuel is also possible from the external refuel panel, if necessary (e.g. failure cases). In this case, an operator controls the refuelling.

The aircraft has one refuel coupling and can have a second optional one.

The refuel performance to refuel full fuel is typically:

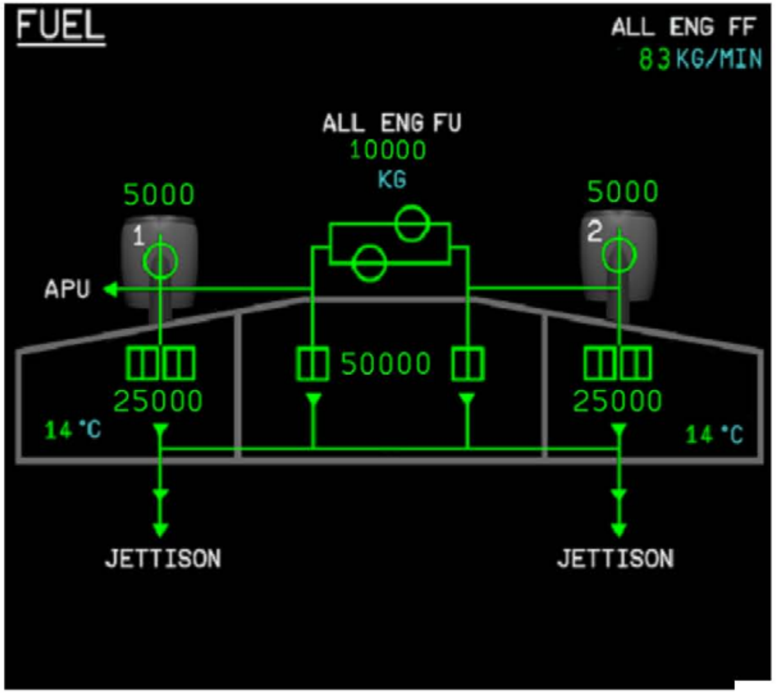
- Approximately 45 minutes, with one refuel coupling
- Approximately 35 minutes, with two couplings

Defueling may be necessary for maintenance reasons. Defueling is manually controlled via the FQMS, using the external refuel panel. The discharged fuel is collected via the refuel couplings.

## Fuel Jettison (optional)

To rapidly reduce the aircraft fuel weight, the jettison system can be used to discharge fuel overboard. The output rate is approximately 60 t (132400 lbs) per hour.

FUEL SD Page



# Fuel System

## Cockpit View

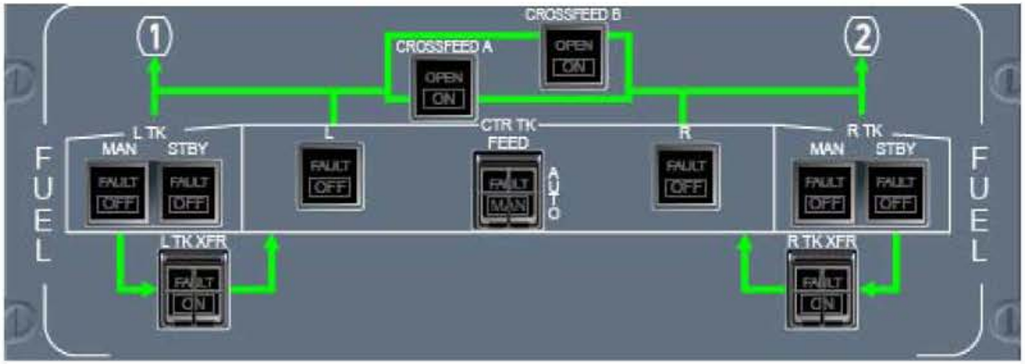
FUEL JETTISON Panel
(optional)

FUEL Panel

FUEL SD Page or
CRUISE SD Page

# Fuel System

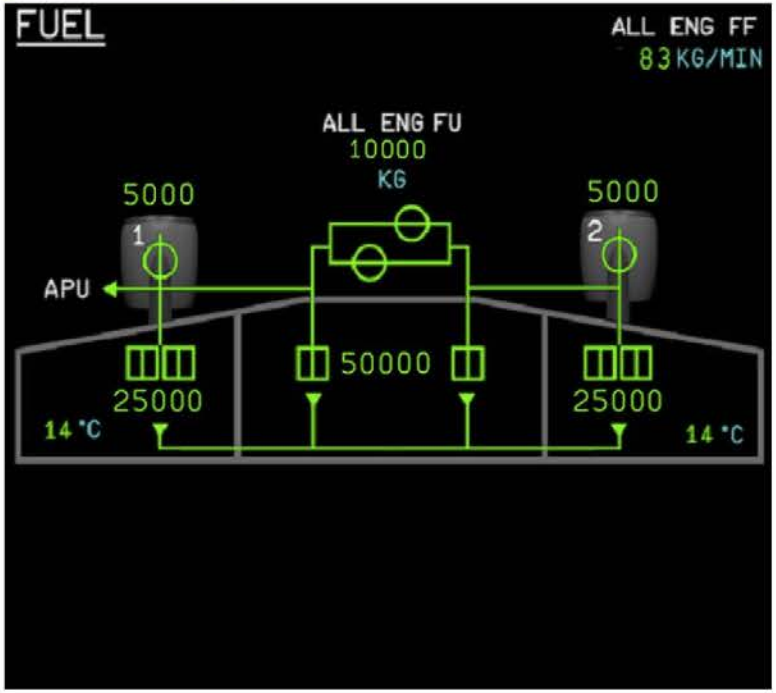
FUEL Panel




FUEL JETTISON Panel
*(optional)*

# Fuel System

FUEL SD Page




CRUISE SD Page


Permanent Data

# Hydraulic System

# Hydraulic System

## General

The A350 hydraulic system has two independent hydraulic circuits:

- The YELLOW hydraulic circuit
- The GREEN hydraulic circuit

The 2H/2E (two hydraulic circuits/two electrical circuits) architecture provides a redundancy on flight controls (use of electro-hydraulic actuators). Thus, this architecture enables to control the aircraft via the sidestick and pedals without any hydraulic supply.

The two hydraulic systems operate continuously and power the flight controls, the landing gear system and the cargo doors at a nominal pressure of **5000 psi** (like the A380) instead of 3000 psi on previous Airbus aircrafts.

If one or both hydraulic systems fail, the following backups remain available:

- For flight controls: the Electrical-Hydrostatic Actuators (EHAs)
- For braking: the independent: hydraulic accumulators
- For steering: the Automatic Differential Braking (ADB) and the hydraulic accumulators.

## Hydraulic Generation

The hydraulic power generation system provides hydraulic consumers with the required amount of hydraulic flow and pressure to ensure:

- Primary and secondary flight control operation
- Landing gear retraction/extension and associated doors closure/opening
- Wheel brake operation
- Nose Wheel Steering.

Each circuit has:

- One hydraulic reservoir
- Two Engine Driven Pump (EDP)
- One Electric Motor Pump (EMP)
- One accumulator
- Two Fire Shutoff Valves (FSOV)
- One cooling system
- A Hydraulic System Monitoring Unit (HSMU).

# Hydraulic System

## Hydraulic Generation

### Engine Driven Pumps

Four Engine-Driven Pumps (EDP) pressurize the hydraulic system. On each engine there are two EDPs, one pressurizes the GREEN hydraulic circuit and the other pressurizes the YELLOW hydraulic circuit. Thus if an engine fails, the remaining engine can still pressurize both hydraulic circuits.

### Electric Motor Pump

One Electric Motor Pump (EMP) per hydraulic system can provide hydraulic pressure on ground only, when all engines are off. For example, the EMP of the YELLOW circuit operates automatically for cargo door actuation.

### Fire Shut-Off Valves (FSOVs)

There are two fire shut-off valves per engine. The closure of the fire shut-off valves prevents hydraulic fluid from flowing into the pump and thus to sustain a fire.

### Cooling System

Both hydraulic circuits have a cooling system, that prevent overheat and degradation of hydraulic fluid.

This cooling system has two fuel/hydraulic Heat Exchangers (HHX) per circuit (one per EDP). The HHX are submerged in the Wing Tanks.

### The Hydraulic System Monitoring Unit

The HSMU monitors and/or controls:

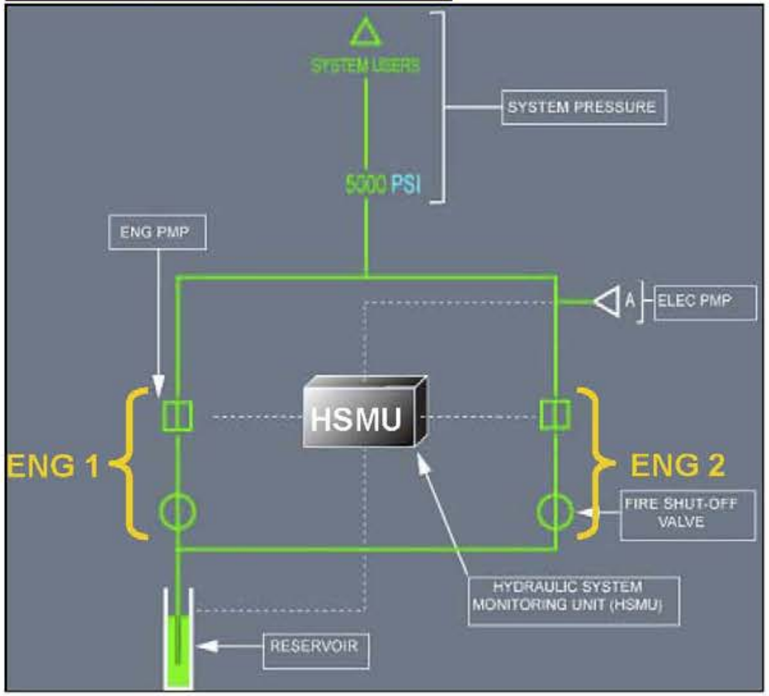
- The pump and reservoir pressure
- The reservoir and case drain line temperature
- The position of the FSOVs
- The EMP, its start-up and shutdown.
- The depressurization of the EDPs
- Hydraulic Heat Exchanger (HHX) control
- FSOV closure

# Hydraulic System

A350 XWB

## Hydraulic Generation

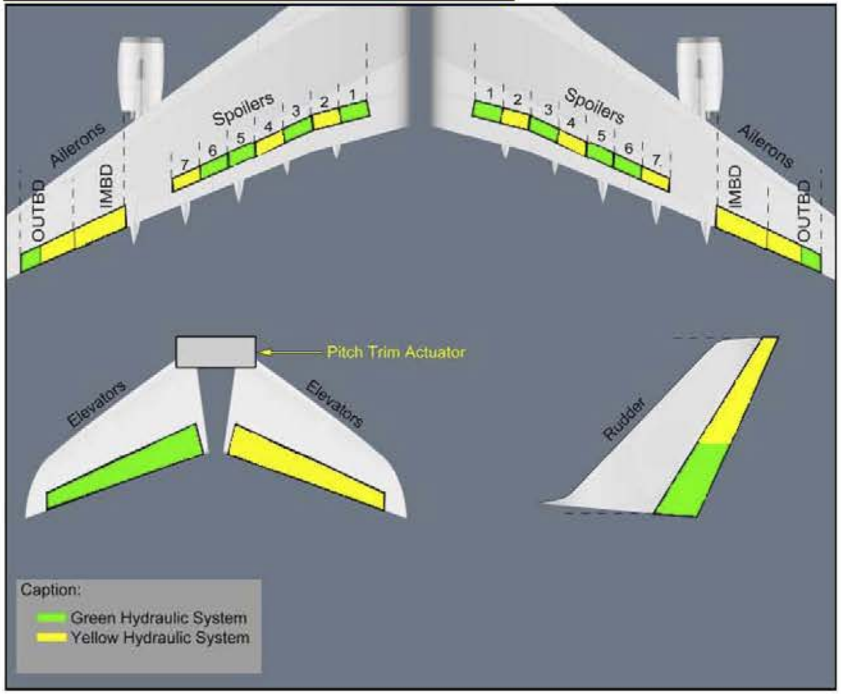
GREEN HYD circuit Architecture




Note: Similar architecture applies to YELLOW hydraulic circuit

## Hydraulic Distribution

Hydraulic Distribution for Flight Controls

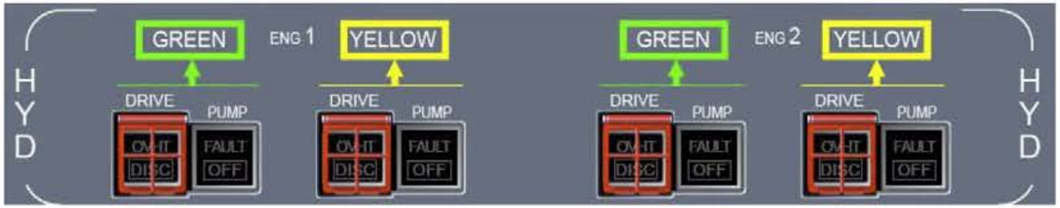



Note: For L/G, Brakes and Steering hydraulic distribution, refer to ***Landing Gear***.

### Cockpit View

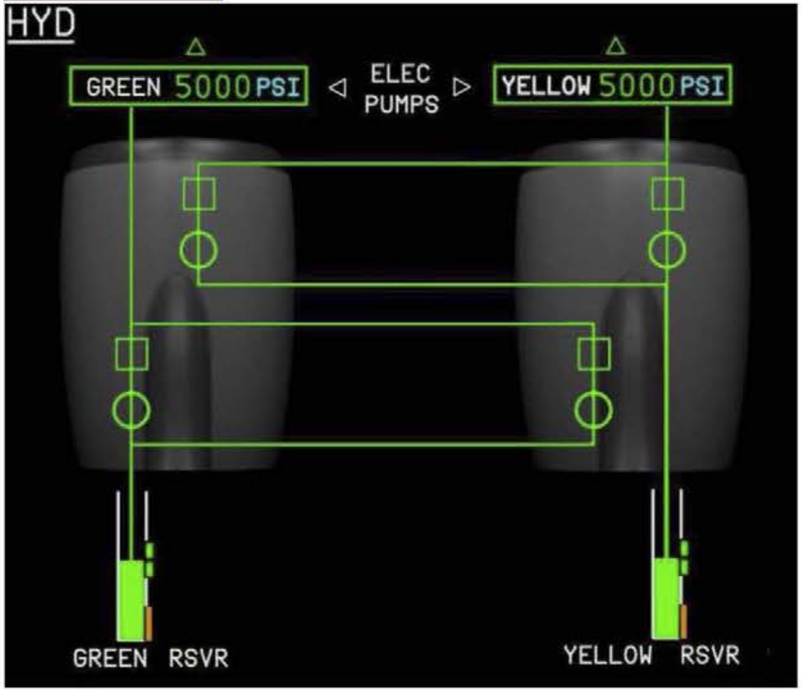
# Hydraulic System

HYD Panel




GND HYD Panel


HYD SD Page



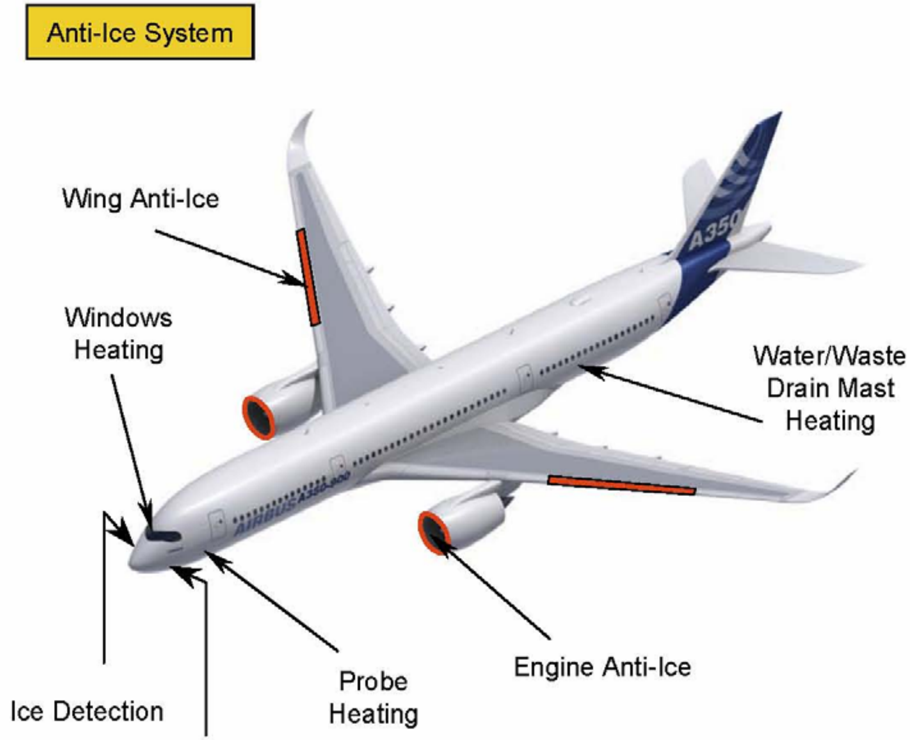
# Ice and Rain

A350 XWB

## Overview

The ice protection system enables operation of the aircraft in icing conditions with no restrictions.
The system protects the sensitive areas of the aircraft against ice by the use of:

- **Electrical power for**:
  - Probe heating
  - Cockpit windows heating
  - Water/Waste drain mast heating.
- **Hot bleed air for**:
  - Engine anti-ice
  - Wing anti-ice



# Ice and Rain

## System Description

### Probe Heating

The following probes are electrically heated:

- Static probes
- Pitot, TAT, AOA probes
- Side slip angle probes
- Standby probes.

### Engine anti-ice

Each engine has its own anti-ice system. An anti-ice valve on each engine enables the flow of hot air to prevent ice accretion on the nacelle air intake.

### Wing Anti-Ice

Hot air from the bleed air system can be used to prevent ice accretion on slats 3, 4, and 5. Wing anti-ice is inhibited on ground and during takeoff until takeoff thrust reduction

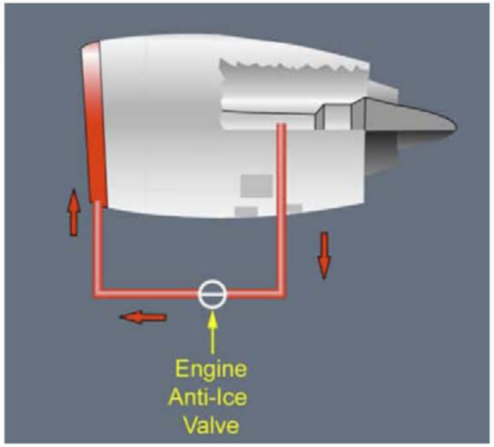
### Cockpit Windows heating

The cockpit windows are electrically-heated for icing prevention and for defogging.

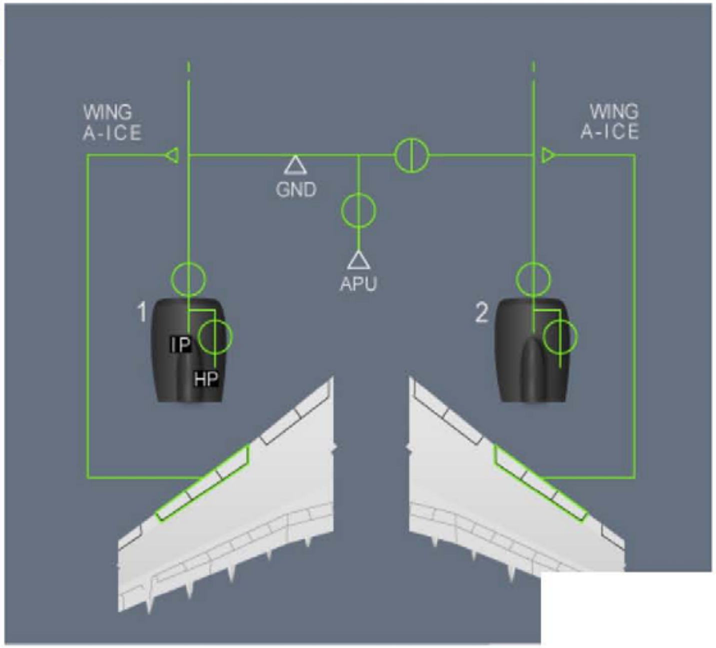
### Water/Waste Anti-Ice

The water lines are automatically heated to prevent water from freezing.

Engine Anti-Ice




Wing Anti-Ice

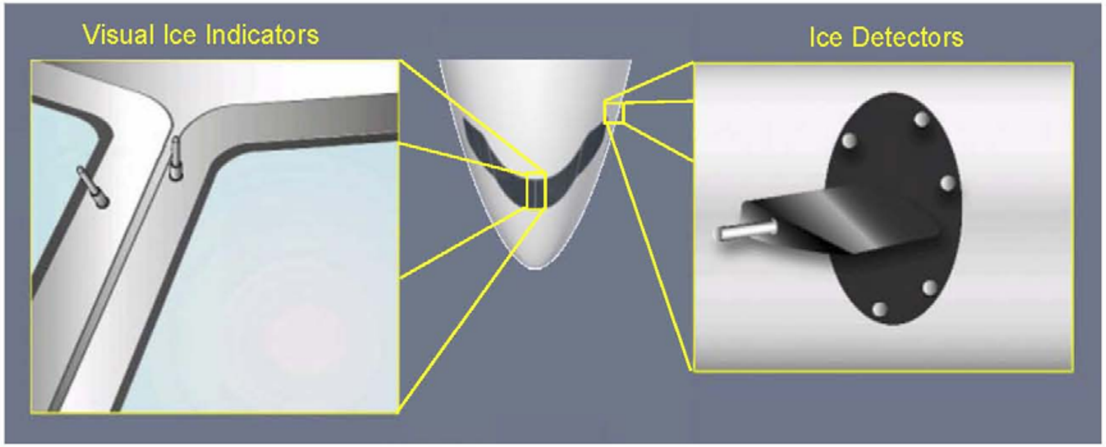


# Ice and Rain

### Ice Detection

The ice detection system has two ice detectors that measure ice accretion. If icing or severe icing conditions exist, the ice detectors provide this information to the flight crew. There is one ice detector on each side of the fuselage, next to each fixed cockpit side window.

Two visual ice indicators provide the flight crew with a visual backup of the ice detection system. These visual indicators can be illuminated.

# Ice and Rain

## General

The use of electric windshield wipers and a rain repellent system maintain a clear vision through the front windshields in case of rain.

## System Description

**Wipers**

Each captain and first officer windshield has a two-speed electric wiper. A WIPER selector with a slow and fast speed setting controls its assigned wipers.

The flight crew can use the wipers during taxi, takeoff, holding, approach and landing.

**Rain Repellent**

A rain repellent fluid can be sprayed on the surface of the windshields to improve visibility in moderate to heavy rain conditions.

# Ice and Rain

## Cockpit View

ANTI ICE Panel and
PROBE & WINDOW HEAT pb

WIPER selectors &
RAIN RPLNT pbs

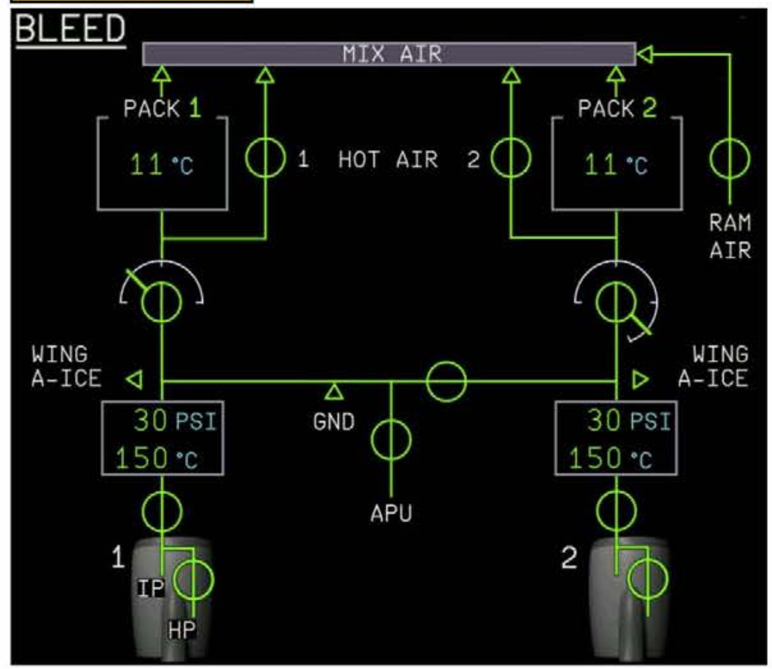
BLEED SD Page

# Ice and Rain

ANTI ICE Panel and PROBE & WINDOW HEAT pb


WIPER selector & RAIN RPLNT pb


BLEED SD Page



# Display System

A350 XWB

### Architecture

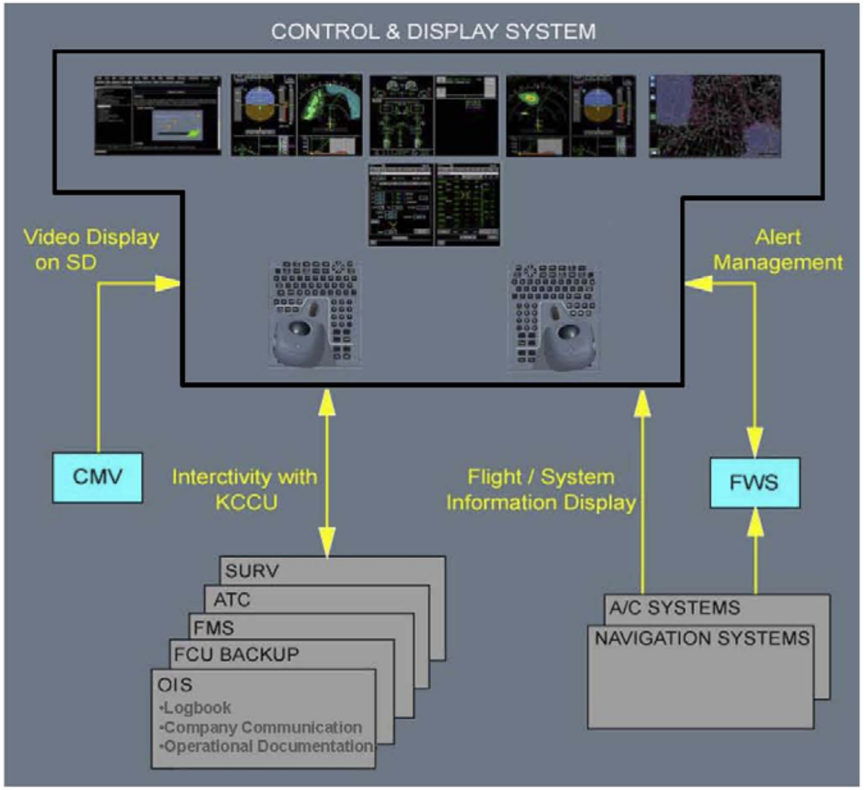
Each DU has a built-in calculator able to process all the available displays and functions.

The DUs receive flight and system information from :

- Various aircraft systems
- Flight Warning System (FWS)
- Navigation systems
- Concentrator and Multiplexer for Video (CMV)
- Surveillance (SURV)
- Flight Management System (FMS)
- Air Traffic Control (ATC) Communication system
- Full Authority Digital Engine Controls (FADECs)
- Primary flight computers (PRIMs)
- Onboard Information System (OIS): Logbook, Company Communication, Operational Documentation and Applications.

The DUs also provide interface and control through the KCCUs, for the following functions:

- Flight Management System (FMS)
- Air Traffic Control (ATC COM)
- SURVeillance (SURV)
- Flight Control Unit (FCU) backup
- Onboard Information System (OIS)



# Display System

## System Description

The Control Display System has 6 identical interchangeable 30 cm x 20 cm (12” x 8”) Liquid Crystal Display Units (DUs) and associated control panels.

The 6 DUs are referred to as (from left to right):

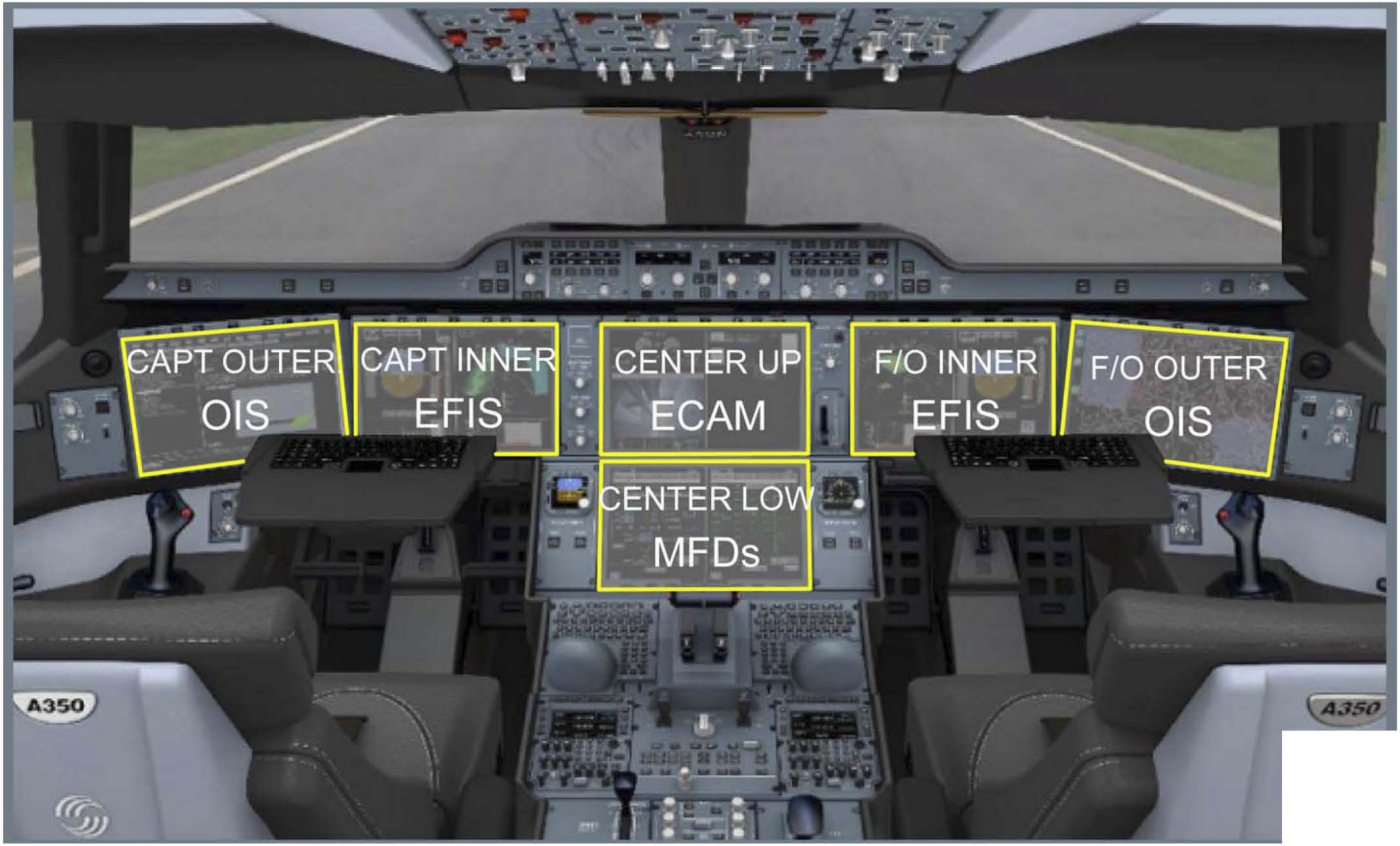
- Captain Outer DU
- Captain Inner DU
- Center Upper DU
- Center Lower DU
- First Officer Inner DU
- First Officer Outer DU

In normal operation, the configuration is the following:

- The Outer DUs display the OIS
- The Inner DUs display the EFIS
    - PFD
    - ND
- The Center Upper DU displays the ECAM and the mailbox
    - ED
    - SD
    - Permanent data
    - Mailbox
    - WD
- The Center Lower DU displays the MFD

# Display System

## Cockpit View

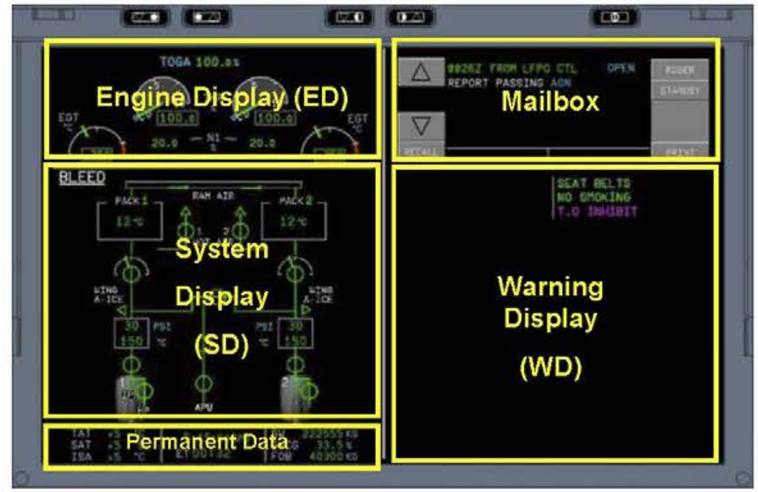


# Display System

## Controls & Indicators

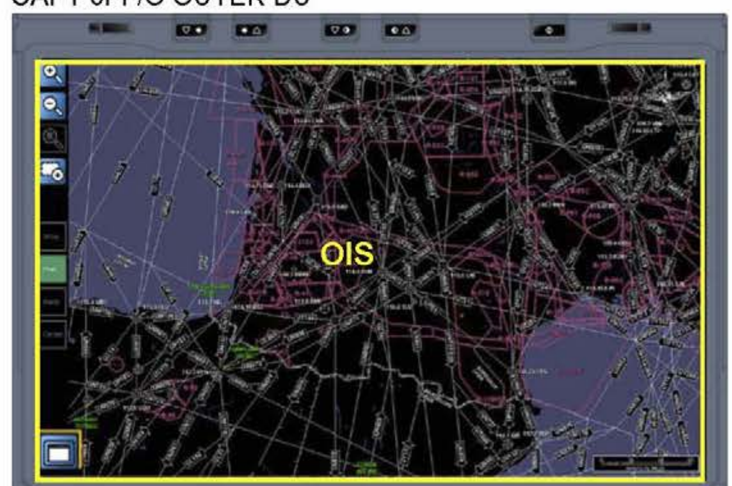
CAPT or F/O INNER DU


CENTER UPPER DU




CENTER LOWER DU

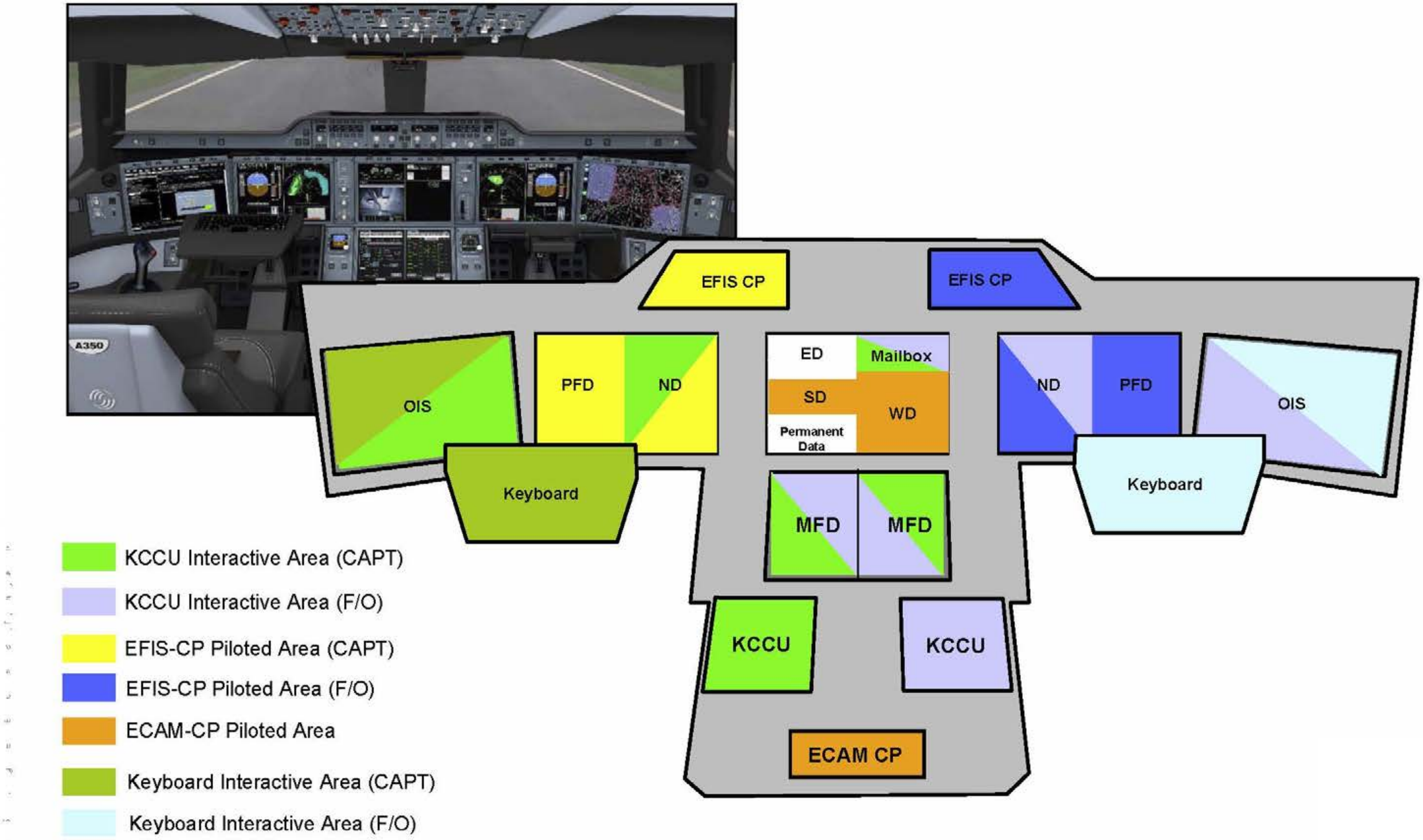

CAPT or F/O OUTER DU



# Display System

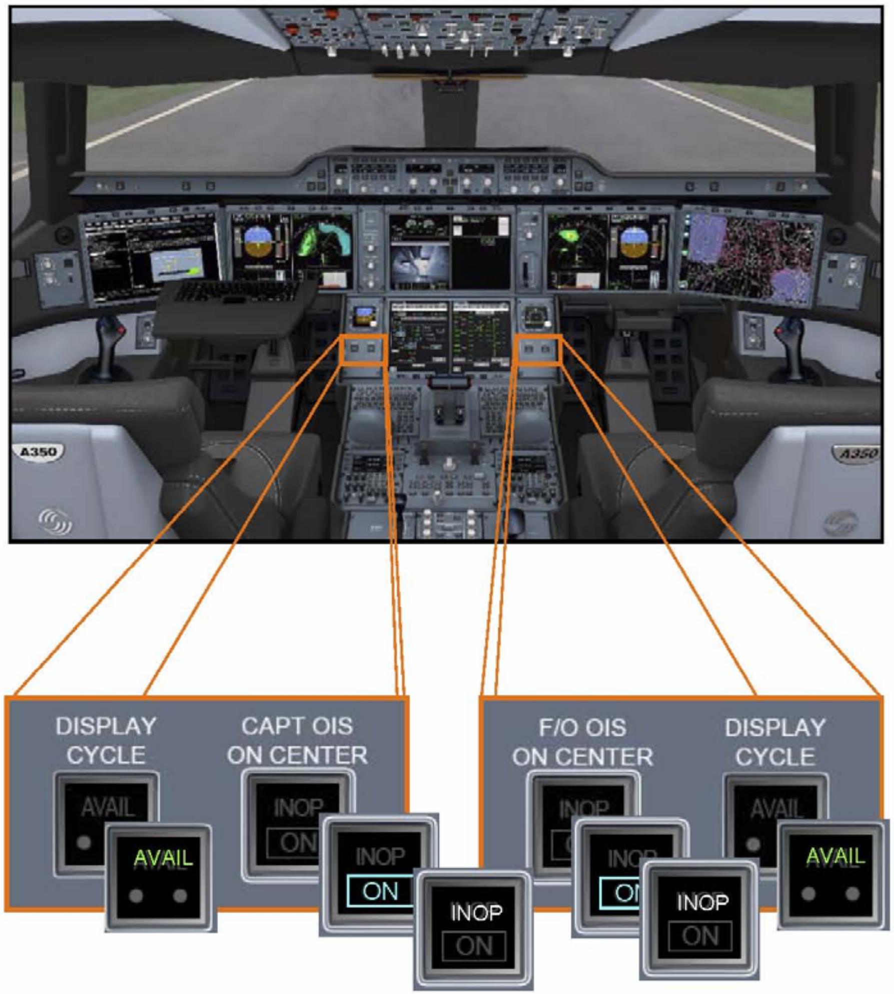
A350 XWB

## Controls and Display Interactivity



# Display System

## Display Reconfiguration:




Each pushbutton, dedicated to DU reconfiguration, clearly indicates the reconfiguration status and capabilities.

Each DU has a built-in calculator able to process all the available displays and functions:

- EFIS
- ECAM
- Mailbox
- MFD
- OIS

Thus, DU reconfigurations enable the flight crew to display the relevant information, either in the case of a DU failure or in normal operations for operational purpose. There are two types of reconfigurations:

- **Automatic reconfiguration**: the CDS reconfigures the display units in order to display, by order of priority, the following formats:
  - ED
  - PFD/ND
  - MFD
  - OIS
- **Manual reconfiguration**: the flight crew reconfigures the display according to opertional needs in normal operations or in the case of a DU failure.

For manual reconfiguration, the flight crew uses:

- The **CAPT (F/O) OIS ON CENTER pbs** enables to display the OIS on the center lower DU,
- The **DISPLAY CYCLE pbs** enables to choose, through a cyclic process, which display is selected on the remaining DUs.

## Display Reconfiguration: Display Capabilities

The A350 CDS has been designed to allow the dispatch in the following cases:

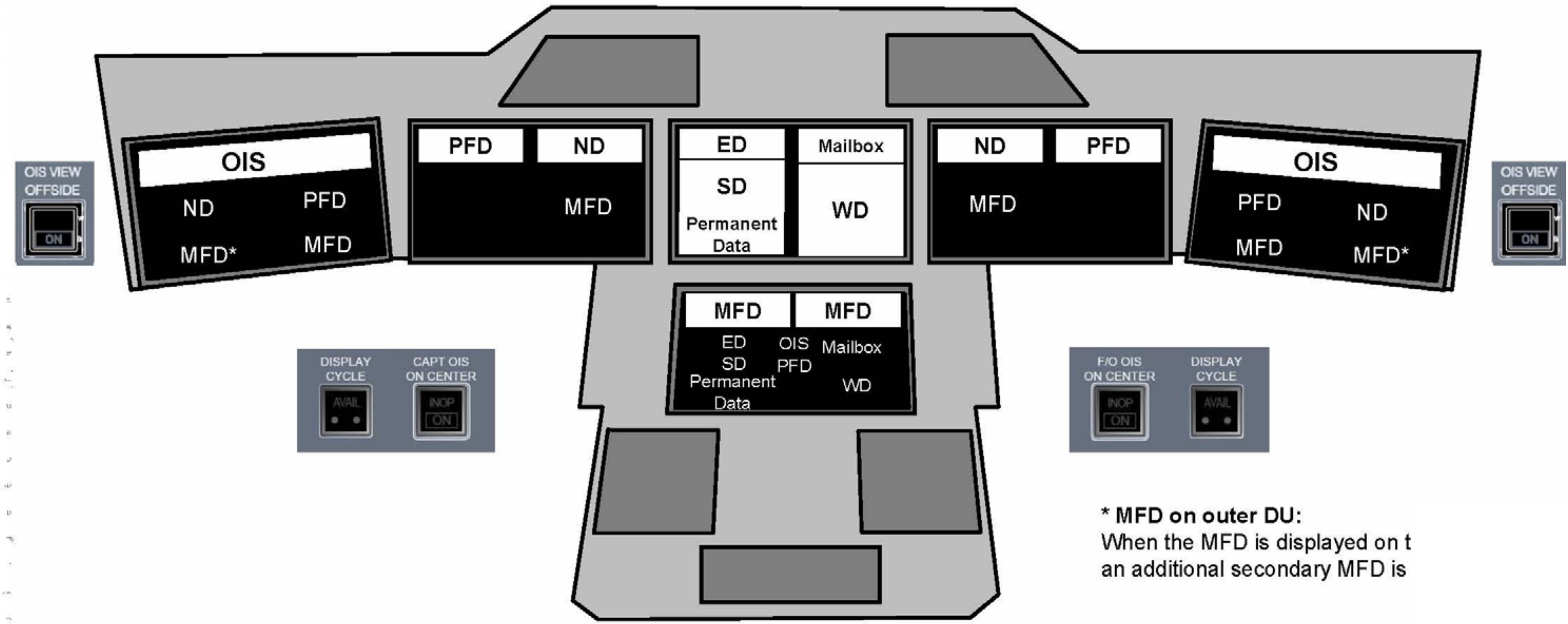
- One DU inoperative (regardless of which one)
- The two outer DUs inoperative

*Note: there are two laptops available that can be used to display the OIS.*

The following illustrates all the display capabilities for each DU:

**Caption:**

| | |
|---|---|
| XXX (white box) | Display in Normal Configuration |
| XXX (black box) | Display capabilities for Reconfigurations |



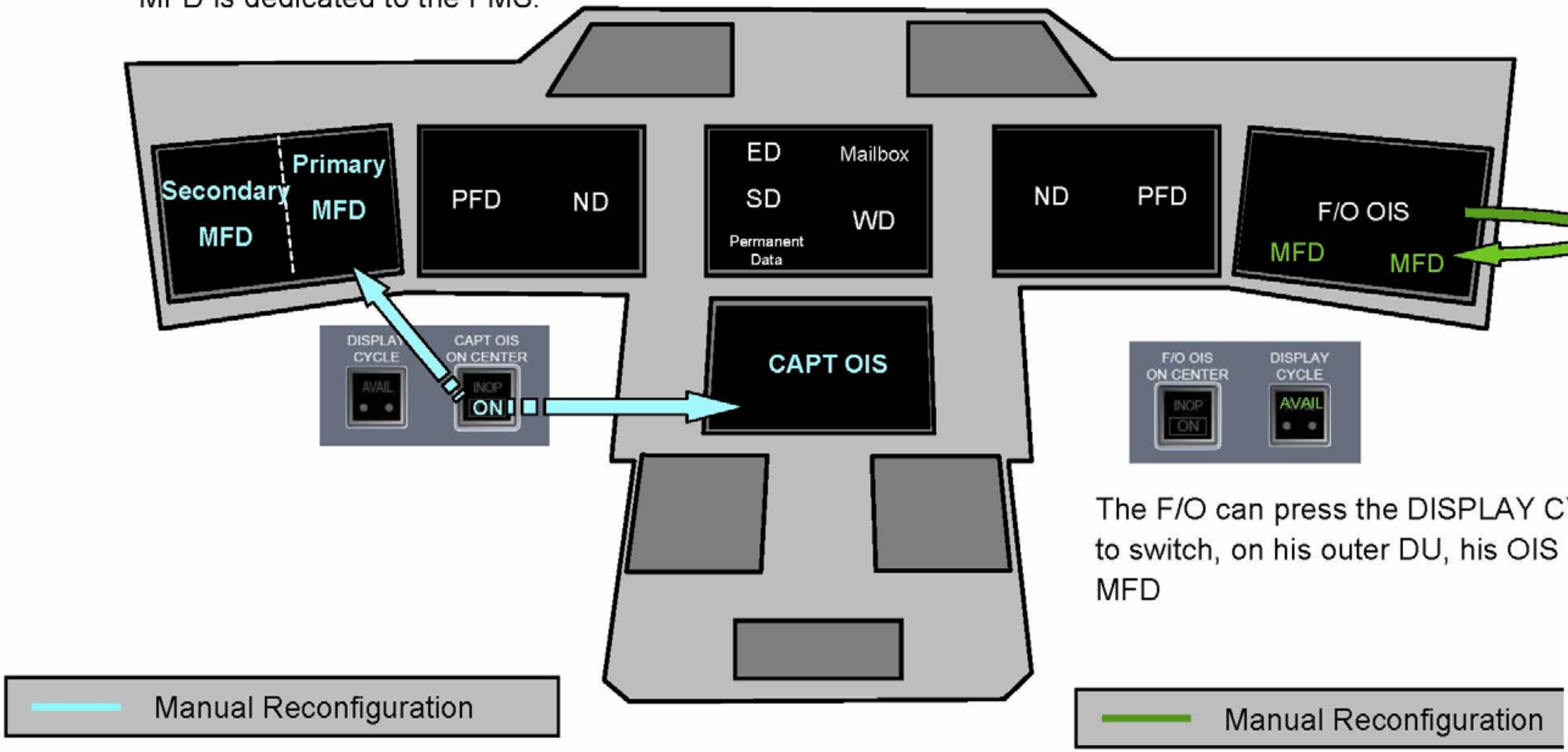

*** MFD on outer DU:**
When the MFD is displayed on t
an additional secondary MFD is

## Reconfiguration rules: Manual reconfiguration in Normal Operation

OIS ON CENTER


For operational needs, the flight crew can manually reconfigure the Dus, thanks to the OIS ON CENTER function. The CAPT(F/O) OIS ON CENTER pb enables the captain or the F/O to display their OIS on the center lower DU.

When CAPT (F/O) OIS ON CENTER pb is selected ON, the CAPT(F/O) MFD is transferred on the outer DU. When the MFD is transferred on the outer DU, an additional secondary MFD, is also displayed. The secondary MFD is dedicated to the FMS.




The F/O can press the DISPLAY CYCLE pb, to switch, on his outer DU, his OIS and the MFD

# Display System

## General

The **Electronic Flight Instrument System (EFIS)** displays flight parameters and navigation data.
The EFIS is displayed on CAPT and FO inner DUs. Each DU displays:

- 1 Primary Flight Display (PFD) for short-term flight information
- 1 Navigation Display (ND) for long-term navigation.

The flight crew interacts with the EFIS displays through the:

- KCCUs
- EFIS control panels

# Display System

A350 XWB

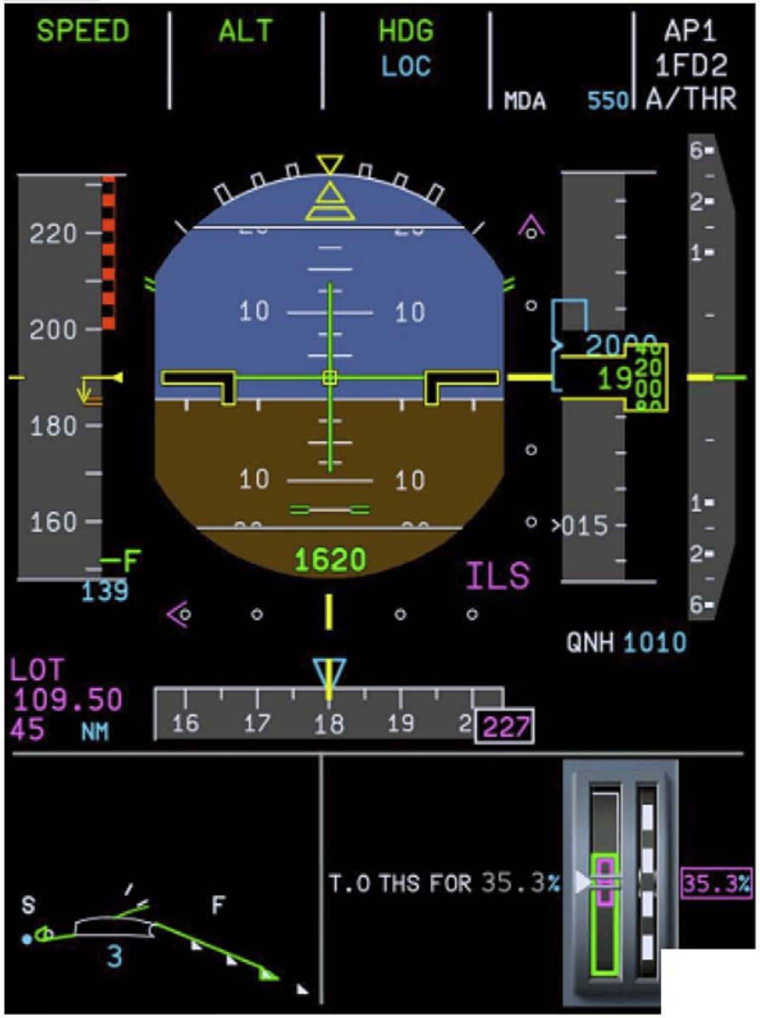
## Controls and Indicators

The Primary Flight Display (PFD) has two parts:

- The upper part displays:...
  - Complete Basic T including the:
    - Attitude
    - Airspeed / Mach
    - Altitude / Vertical speed
    - Heading
  - AFS status
  - (X)LS deviation / marker (ILS, FLS, SLS etc…)
  - Radio altitude.

- The lower part displays:
  - Memos and limitations (refer to *ECAM*)
  - Slat/Flap positions
  - Speed brakes and ground spoilers positions
  - Pitch trim indications (on ground only)
  - Landing Gear positions (at retraction and extension only)

PFD

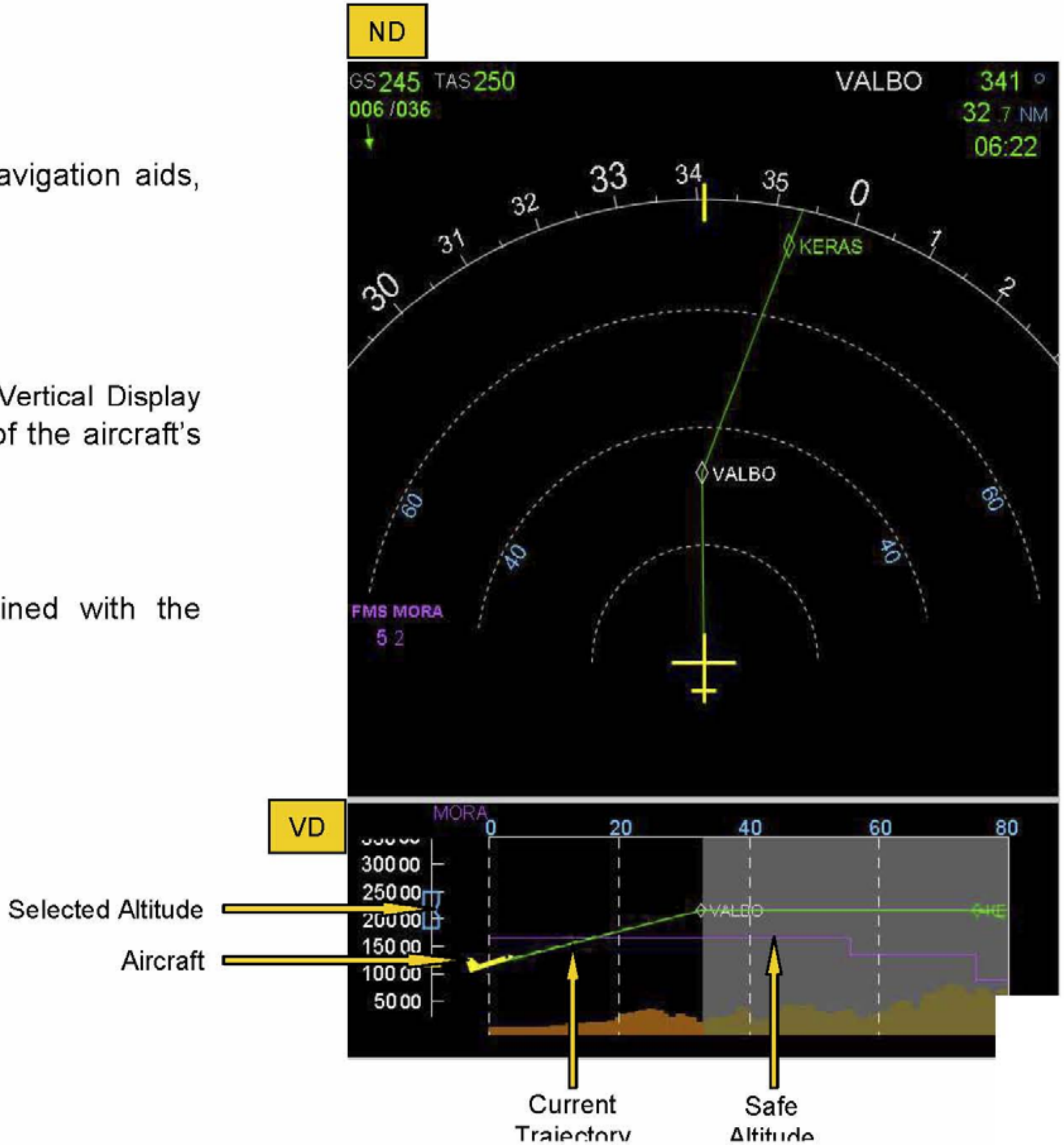


# Display System

The Navigation Display (ND) has two parts:

- The upper part of the ND displays:
  - Aircraft position with respect to navigation aids, FMS flight plan and map data
  - Weather radar information
  - SURV information.

- The lower part of the ND displays the Vertical Display (VD). The VD provides a synthetic view of the aircraft's vertical situation :
  - Vertical flight profile
  - Weather radar information
  - SURV vertical information combined with the vertical flight profile.



FlightFactor aero

# ECAM

A350 XWB

# ECAM



## General

The Electronic Centralize Aircraft Monitoring (ECAM) function assists the flight crew in managing and monitoring the aircraft systems during both normal and abnormal conditions.

The ECAM:

- Displays aircraft system information
- Monitors aircraft systems, and triggers alerts
- Indicates required flight crew actions in abnormal and emergency situations
- Provides operational information to the flight crew
- Displays the checklists.

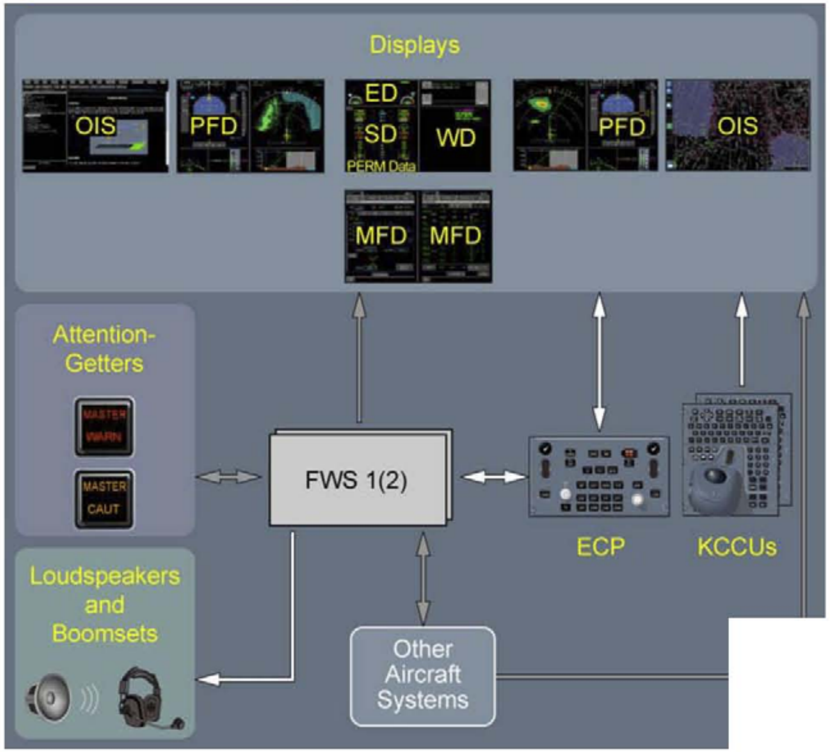
The ECAM has:

- Two Flight Warning Systems (FWSs) that compute alerts and manage the display of the ECAM information
- One ECAM Control Panel (ECP)
- Two sets of visual attention-getters
- Four loudspeakers for aural indicators.

The ECAM can display information on the:

- Engine Display (ED)
- System Display (SD)
- Permanent Data
- Warning Display (WD)
- Primary Flight Display (PFD)
- Multi-function Display (MFD)

ECAM Architecture



# ECAM

## Operation

In **normal aircraft condition**, the ECAM provides the necessary information to assist the flight crew to operate and monitor the aircraft systems:

- SD pages on the SD: The SD pages are automatically displayed in accordance with the flight phase, but can also be requested manually
- Memos (e.g. SEAT BELTS, ENG A-ICE, TO and LDG memos) on the WD and PFD
- Normal checklists on the MFD, on flight crew request.

The ECAM also emits:

- Altitude alerts
- Automatic callouts during approach.

*<u>Note</u>: The ECAM also computes flight phases to inhibit alerts and memos that can be delayed to a more appropriate time (e.g. inhibition during takeoff).*

In **abnormal aircraft condition**, the ECAM helps the flight crew to manage system failures and aircraft abnormal configurations by:

- Producing visual and aural alerts, if failures are detected
- Providing associated sensed procedures and associated limitations and memos, if any
- Displaying the applicable system SD pages
- Providing access to not-sensed abnormal and emergency procedures, and deferred procedures on flight crew request

**Definition**:

- A sensed procedure is a procedure that the ECAM automatically activates and displays
- A not-sensed procedure is a procedure that the flight crew manually activates and displays
- In some cases, an emergency or abnormal procedure has complementary actions that the ECAM delays to a more appropriate time, later during the flight. These complementary actions are referred to as deferred procedures.

# ECAM

Automatic display of System Display pages in accordance with the flight phase

| Condition | SD Page |
|---|---|
| - Before first engine start, or<br>- During 5 minutes after last engine shutdown | DOOR |
| - When the APU MASTER sw is set to ON.<br>No longer appears when:<br>- APU is AVAIL for 10 s, or<br>- The APU MASTER sw is set to OFF | APU |
| - When the ENG START selector is set to IGN/START until the end of the start sequence, or<br>- When at least one engine is in cranking, or<br>- From the setting of take off power to thrust reduction or 1500 ft AGL, whichever occurs first | ENGINE |
| - During taxi-out, until takeoff thrust is set, or<br>- After landing gear extension, until last engine shutdown | WHEEL |
| - During F/CTL checks | F/CTL |
| - At 1500 ft AGL or at the thrust reduction, whichever occurs first, until landing gear extension in approach | CRUISE |

*Note:*
*An SD page manually-selected by the flight crew has priority over an SD page that automatically appears depending on the flight phase.*

To engage the automatic display press on the engaged screen button. You will see “A” indication

A350 XWB

## Color Codes

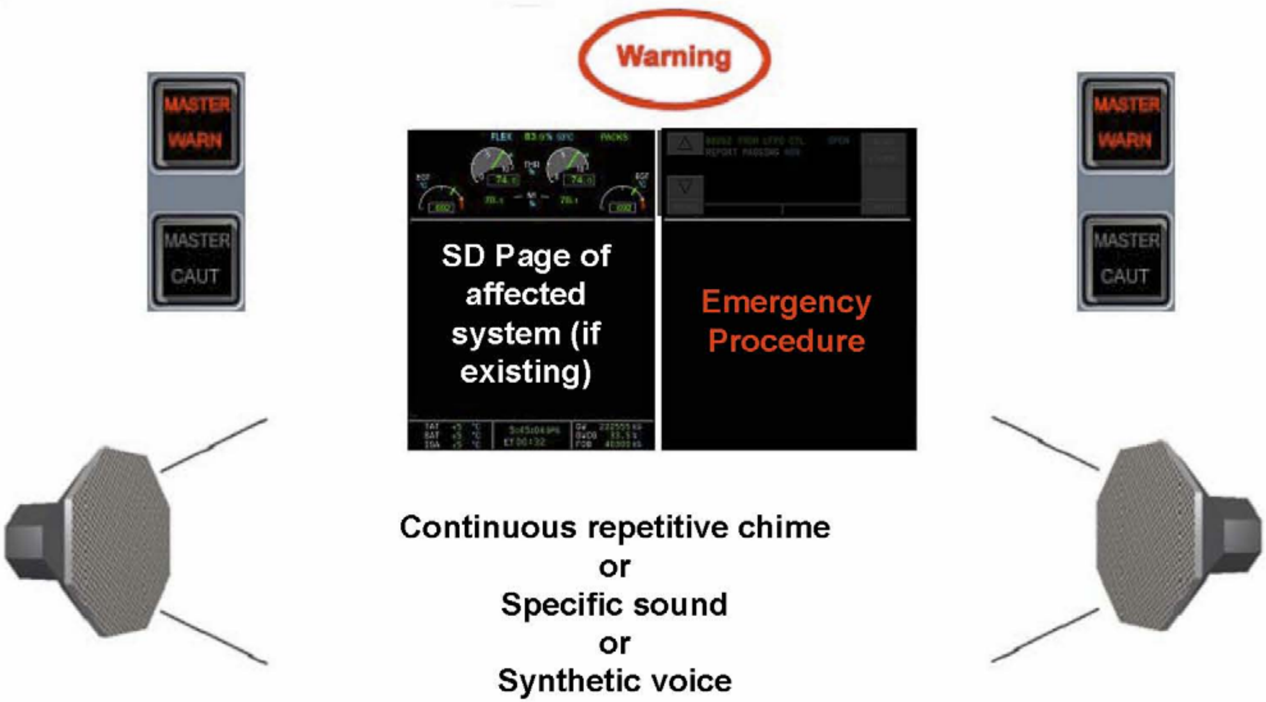
The ECAM displays information in various colors. Each color indicates the importance of the displayed information, or of the failure.

| | |
|---|---|
| RED | • For configurations or failures requiring immediate action. |
| AMBER | • For configurations or failures requiring awareness but not immediate action. |
| GREEN | • For Information in procedure, or in the STATUS page<br>• For checklist items completed by the flight crew.<br>• For memo items |
| WHITE | • For a procedure completed by the flight crew.<br>• For submenus, condition lines, and titles.<br>• For more information item on the STATUS MORE page.<br>• For a completed deferred procedure title in the checklist menu. |
| BLUE | • For actions to be completed, limitations to be followed, checklist items to be checked, or for not completed checklists in the checklist menu. |
| MAGENTA | • For a specific memo (e.g. TO or LDG inhibition). |
| GRAY | • For checklists completed by the flight crew.<br>• For an action not yet validated by the flight crew (e.g. condition items or a not-sensed procedure that are not activated). |

# ECAM

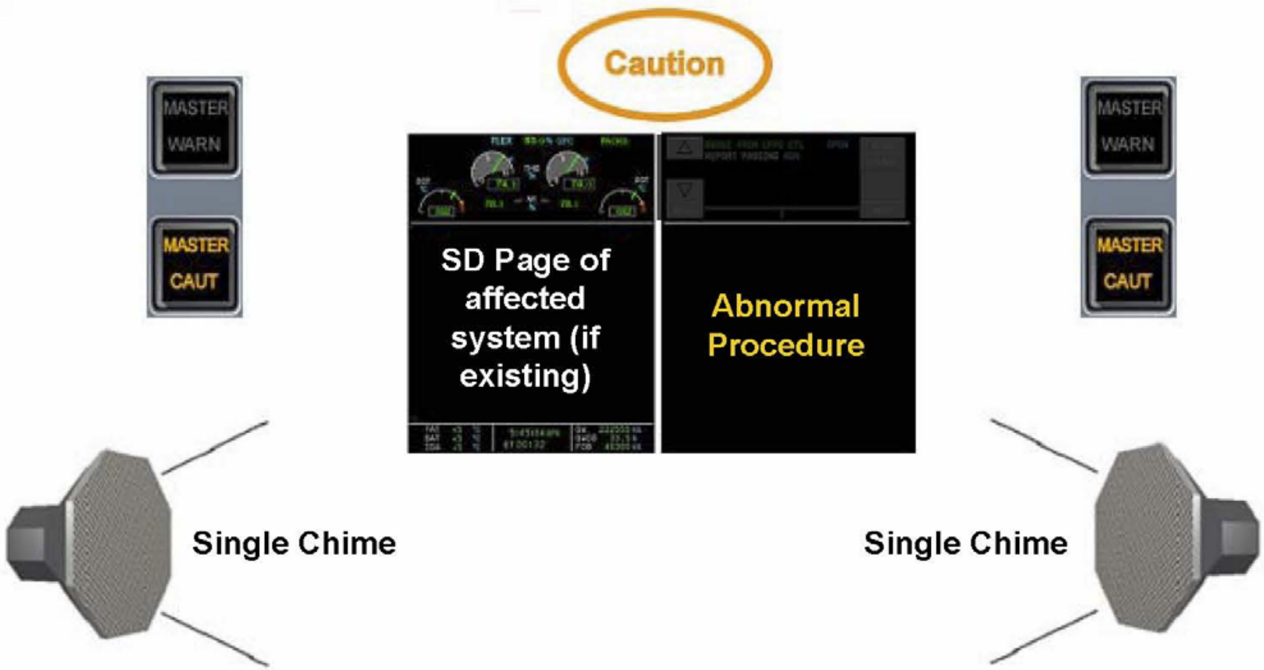
## ECAM Alerts

| Alert Type | Description |
|---|---|
| Warning | For an emergency situation that requires immediate crew action:<br>• The aircraft is in a dangerous configuration or in a limiting flight condition (e.g. engine on fire)<br>• Failure of a system that impacts the safety of the flight (e.g. engine fire). |

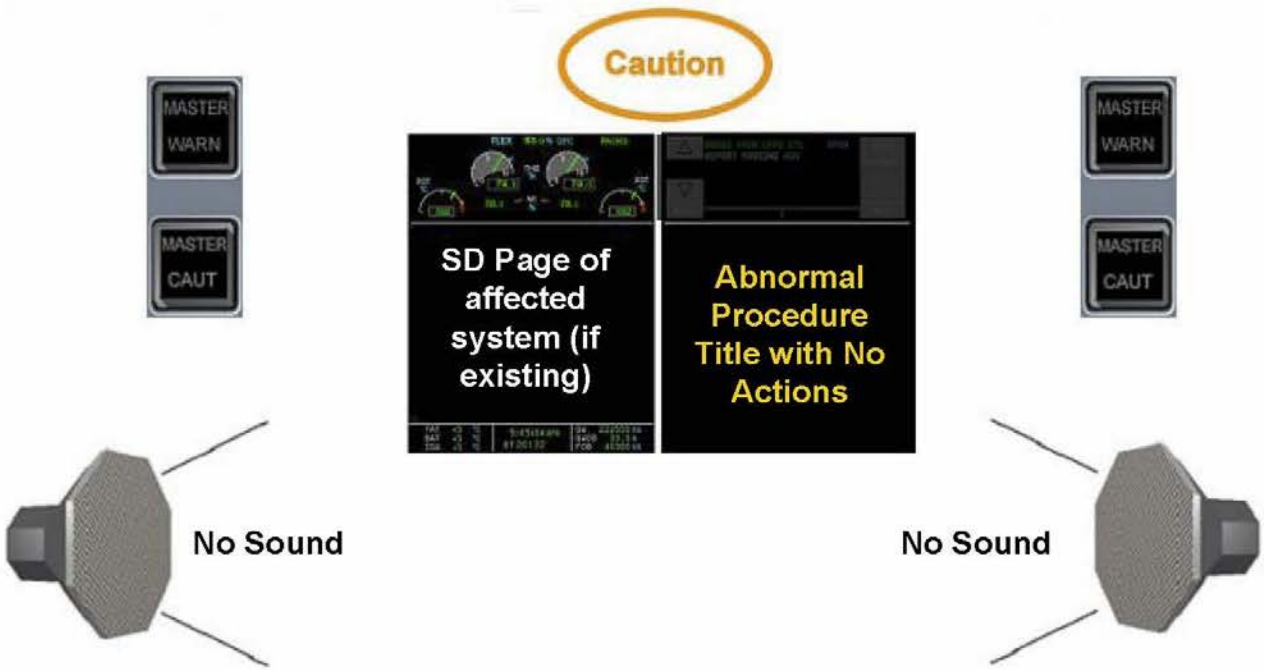


# ECAM

| Alert Type | Description |
|---|---|
| Caution | For an abnormal situation requiring awareness but not immediate action:<br>• Failure of a system that does not impact the safety of the flight. However, to prevent any subsequent degradation of the affected system, a crew action is required whenever possible. |



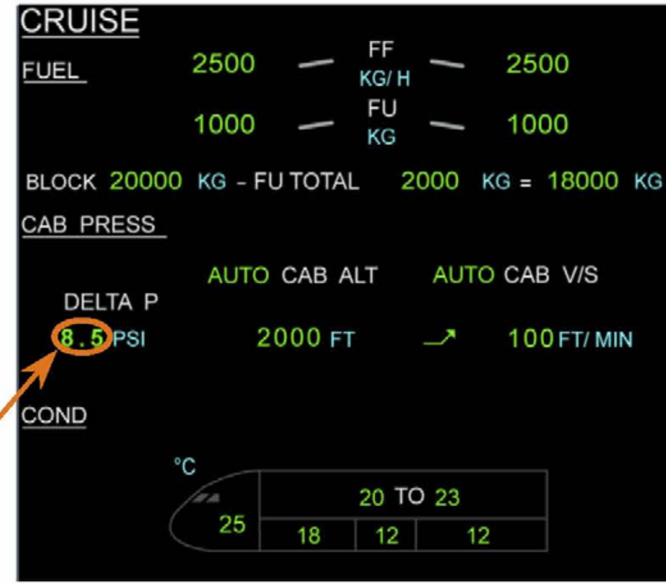
| Alert Type | Description |
|---|---|
| Caution | For a situation that requires the flight crew to be informed (crew awareness), but does not require a flight crew action (e.g. redundancy loss or system degradation). |



| Advisory | Description |
|---|---|
| | An advisory indicates that a monitored parameter of a system goes out of its normal operational range, but does not reach a level that triggers an alert. . |

If there is an advisory condition, the ADV reminder appears on the WD.


The applicable SD page is automatically displayed. The parameter that deviates from its normal range pulses.

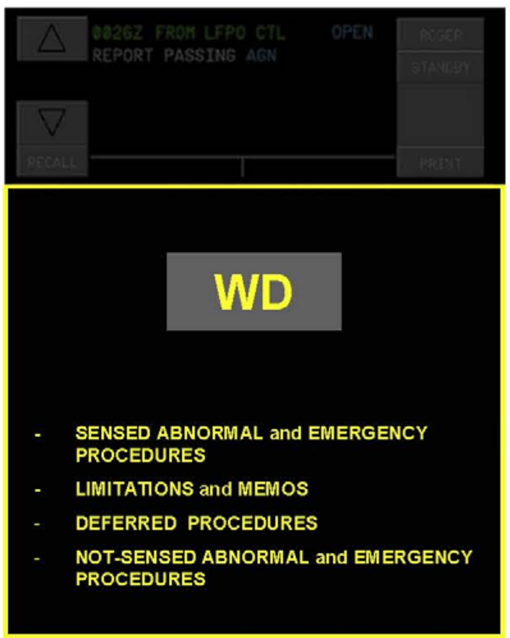


# ECAM

## ECAM Displays

The ECAM information appears on the following displays:

- Warning Display (WD)
- Engine Display (ED)
- System Display (SD)
- Permanent Data
- Primary Flight Display (PFD)
- Multi-function Display (MFD) (refer to *Multifunction Display*)





# ECAM

## Warning Display (WD)

The WD displays:

- All the memos and limitations
- Sensed abnormal and emergency procedures that automatically appear, if there is an ECAM alert
- Deferred procedures
- Not-sensed abnormal and emergency procedures and associated menus requested by the flight crew
- Advisory Indications, if a monitored parameter deviates from its defined operational range
- Status indication, following an ECAM alert.

<u>Note</u>:

- *If a system fails or if the aircraft is in abnormal configuration, the ECAM may delay some actions to a more appropriate time, later in flight. These actions are called **deferred procedures**.*

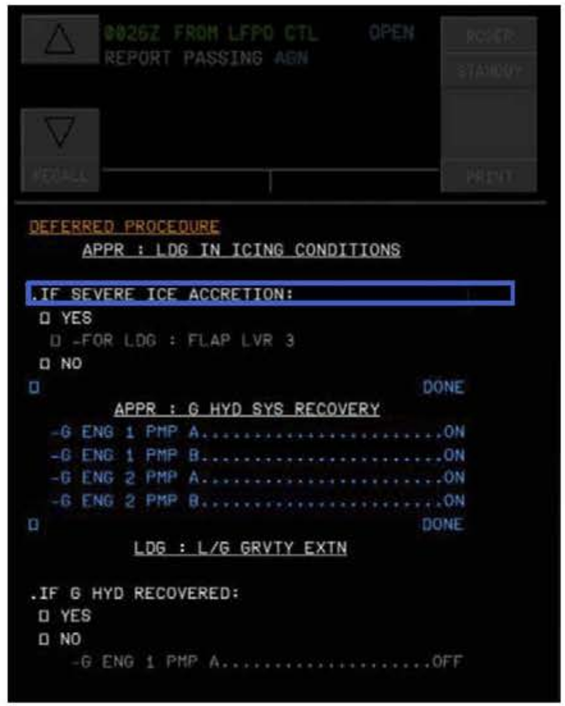
- *The **not-sensed abnormal and emergency procedures** are specific procedures which correspond to system failures and some aircraft configuration that the ECAM is unable to detect or that requires airmanship before activation (e.g.: fuel jettison procedure).*

Abnormal and Emergency Procedures

# ECAM

Limitations and Memos


Deferred Procedures




Not-Sensed Procedures Menu

# ECAM

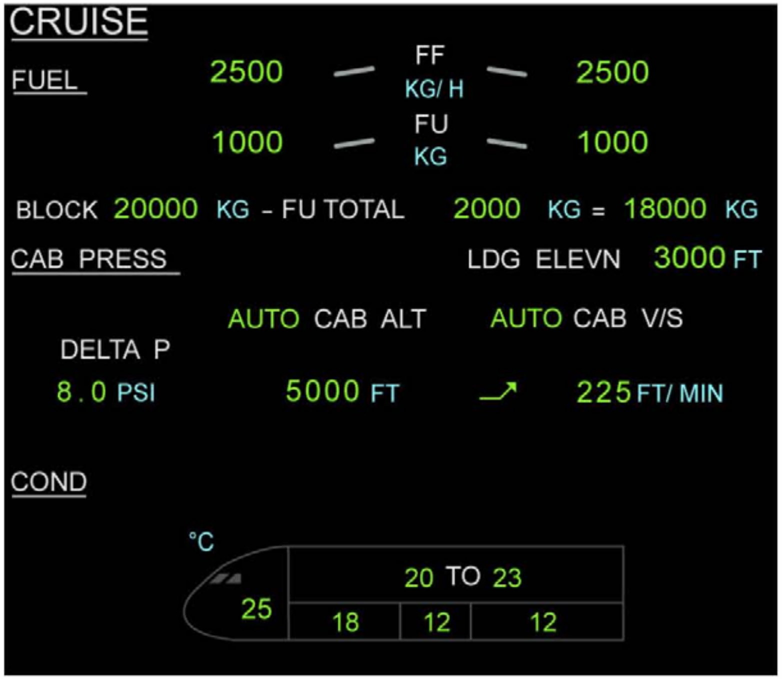
**System Display**

The SD displays:

- In normal aircraft condition:
  - A SD page or the CRUISE page, depending on ECAM flight phases (refer to ***Automatic display of System Display pages***).

- In abnormal aircraft condition :
  - The SD page of the system related to the ECAM alert
  - The STATUS page after the flight crew has cleared the procedure(s) on the WD. The STATUS page indicates the aircraft status by displaying limitations and deferred procedures (if any), inoperative systems and general information.

SD CRUISE Page



# ECAM

When MORE appears next to the STATUS title, or next to the system page title, it indicates that the MORE INFORMATION page is available. The MORE INFORMATION page provides information in addition to the STATUS page, or to a system synoptic page.

The different SD pages are:

- APU: for APU status and parameters
- BLEED: for bleed parameters
- COND for air conditioning status and parameters
- CRUISE with some data from fuel, air conditioning and pressurization systems
- DOOR/OXY for Doors/Oxygen status and parameters
- ENG for secondary engine parameters
- ELEC DC for DC electrical power status and parameters
- ELEC AC for AC electrical power status and parameters
- F/CTL for flight controls status
- FUEL for fuel system status and parameters
- HYD for hydraulic system status and parameters
- PRESS cabin pressurization status and parameters
- WHEEL for landing gear, braking, ground spoilers status and parameters.

## Permanent Data


The Permanent Data displays below the SD-page. It gives temperature, time and aircraft weight information.

*__Note__: The flight crew interfaces wit the time data via the POSITION/TIME page of the MFD.*

## Controls and Indicators

### ECAM Control Panel

Validates, selects or deselects the item that is in the selection box on the WD

Displays the menu of not-sensed abnormal and emergency procedures

Displays the deferred procedures, if any

Displays the STATUS page

Cancels ECAM alerts, turns off the attention-getters, deactivates the procedures

Initiates a takeoff configuration test


Displays all ECAM procedures that were previously performed and are still active

Scrolls through a procedure or a procedure menu on the WD

Displays the STATUS MORE page

Clear the display

Displays the last ECAM procedure that was previously performed (if still active)

Displays the SD page menu to select a SD page

When pressed and maintained, the SD successively displays all the SD pages at one second intervals

Display the SD pages

Attention-Getters

## Overview

The CDS has two **Multifunction Displays (MFDs).** The MFD is a software interface used to monitor and control systems or specific functions. This software interface designed for long term use provides generally a full set of controls. This software interface can be associated to a hardware interface designed for quick access.and with limited functions.

Five systems or functions are accessible through MFD interface:

- **Flight Management System**

  The MFD displays Flight Management System textual data. There are more than 50 FMS pages that provide information on the flight plan, aircraft position and flight performance

  **Electronic Centralized Aircraft Monitoring**

  The MFD displays the normal check lists

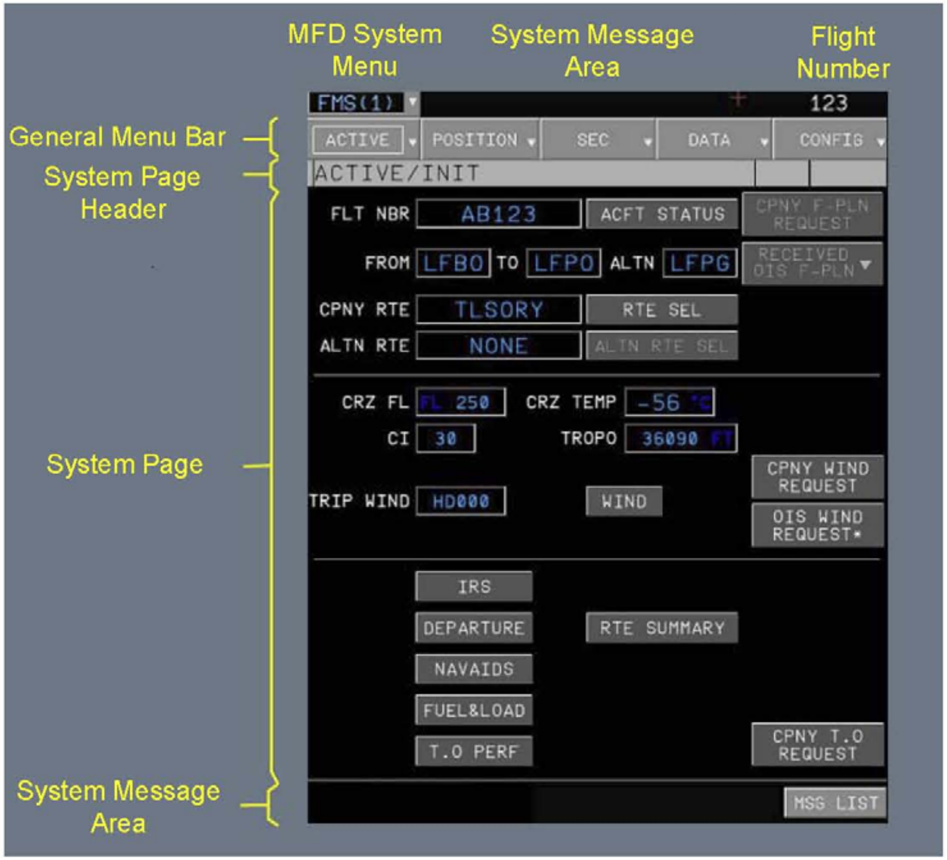
- **Air Traffic Control**

- **Surveillance**

- **Flight Control Unit (FCU) backup function** for the Auto Flight System (AFS).

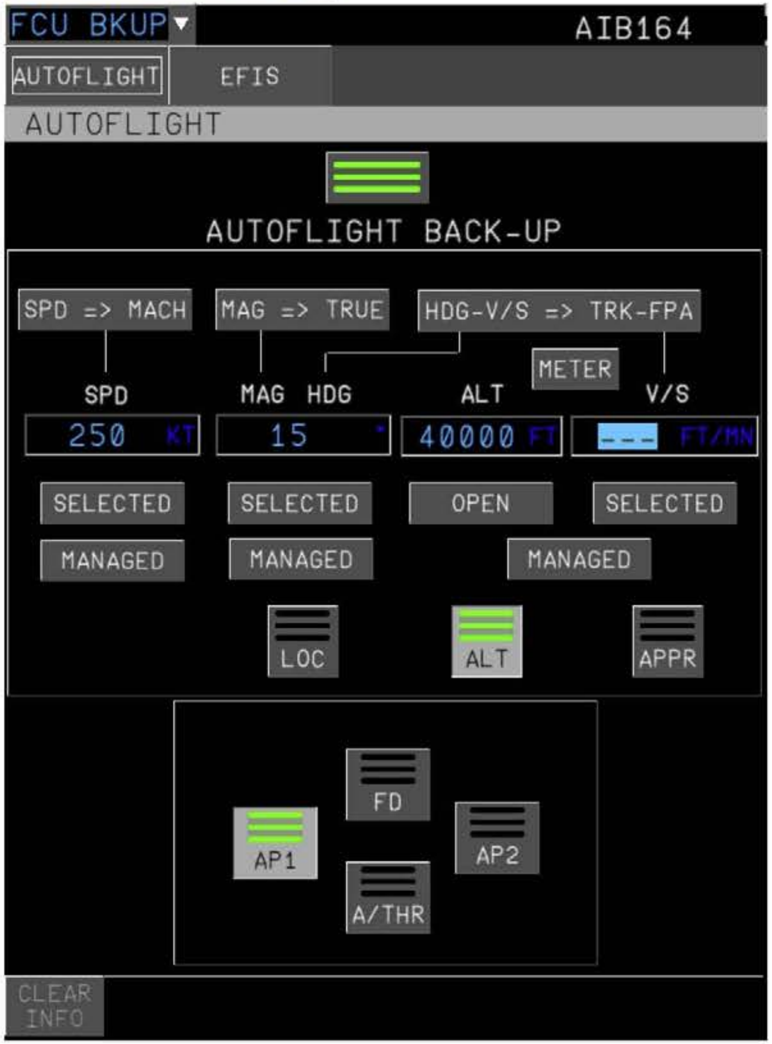
The MFD is interactive: The flight crew can navigate through the pages and can consult, enter or modify the data via the KCCU.

MFD Page

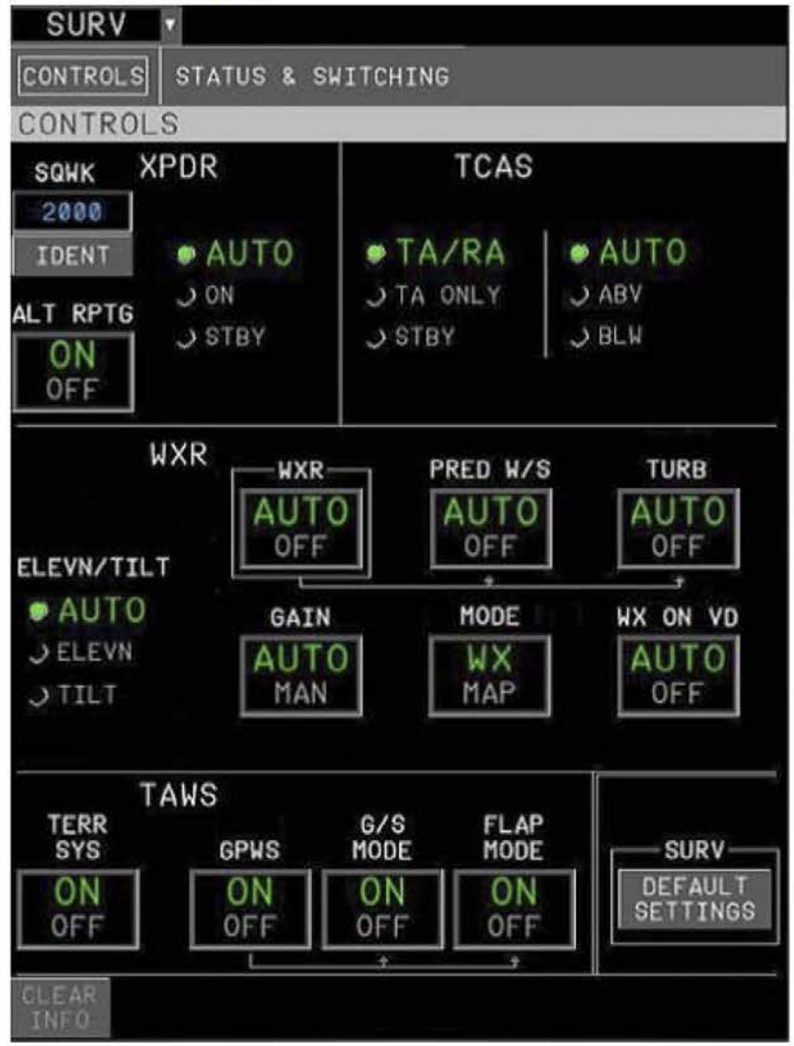


# ECAM

MFD FCU Backup Page

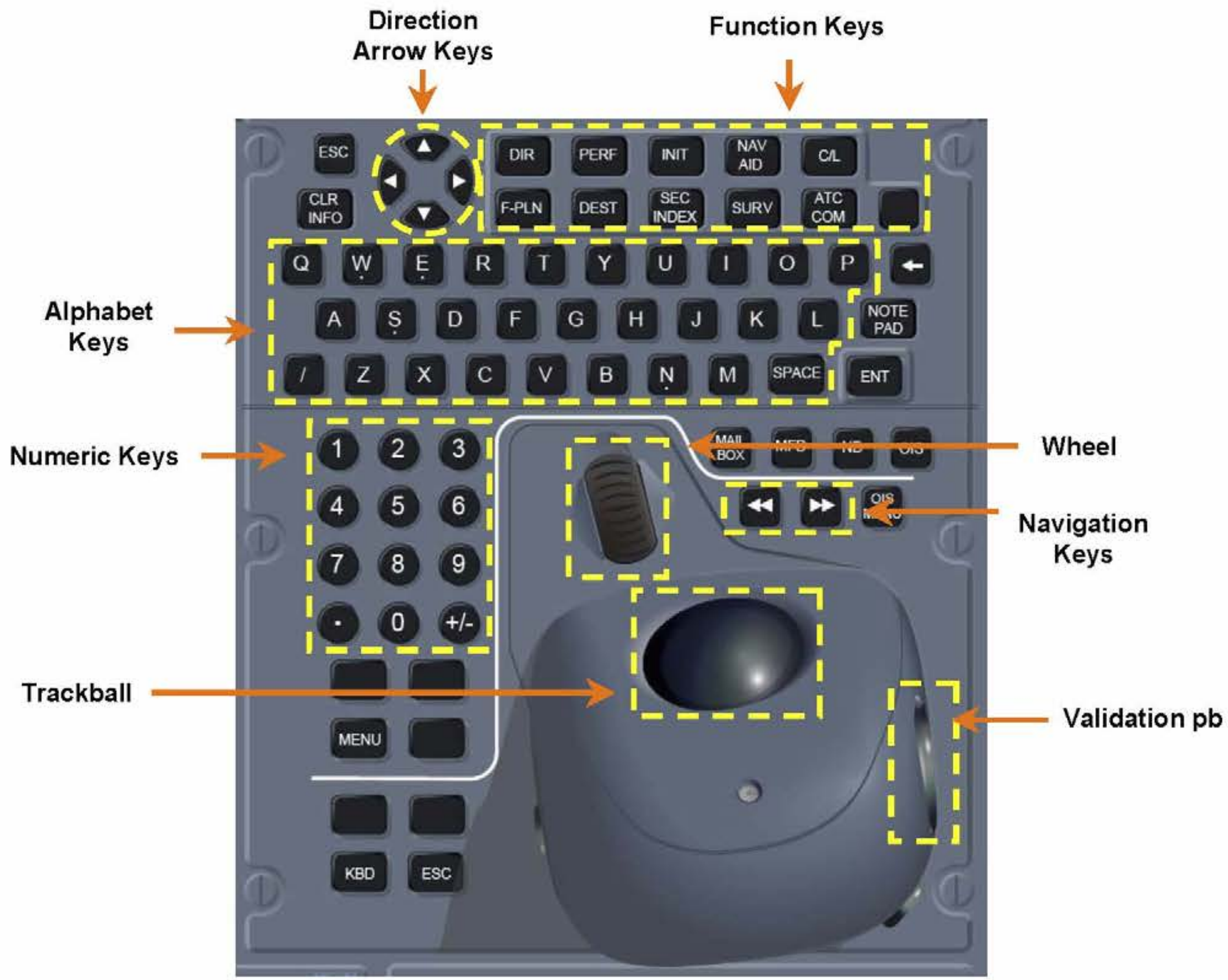



MFD SURV Page



A350 XWB

## KCCU



## Overview

The **Concentrator and Multiplexer for Video (CMV)** concentrates and multiplexes video signals coming from several aircraft video sources and transmits these signals to the CDS.

The different video sources are:

- The External and Taxiing Camera System (ETACS), as an option
- Cockpit Door Surveillance System (CDSS) as an option
- Cabin Video Monitoring System (CVMS) as an option.

ETACS

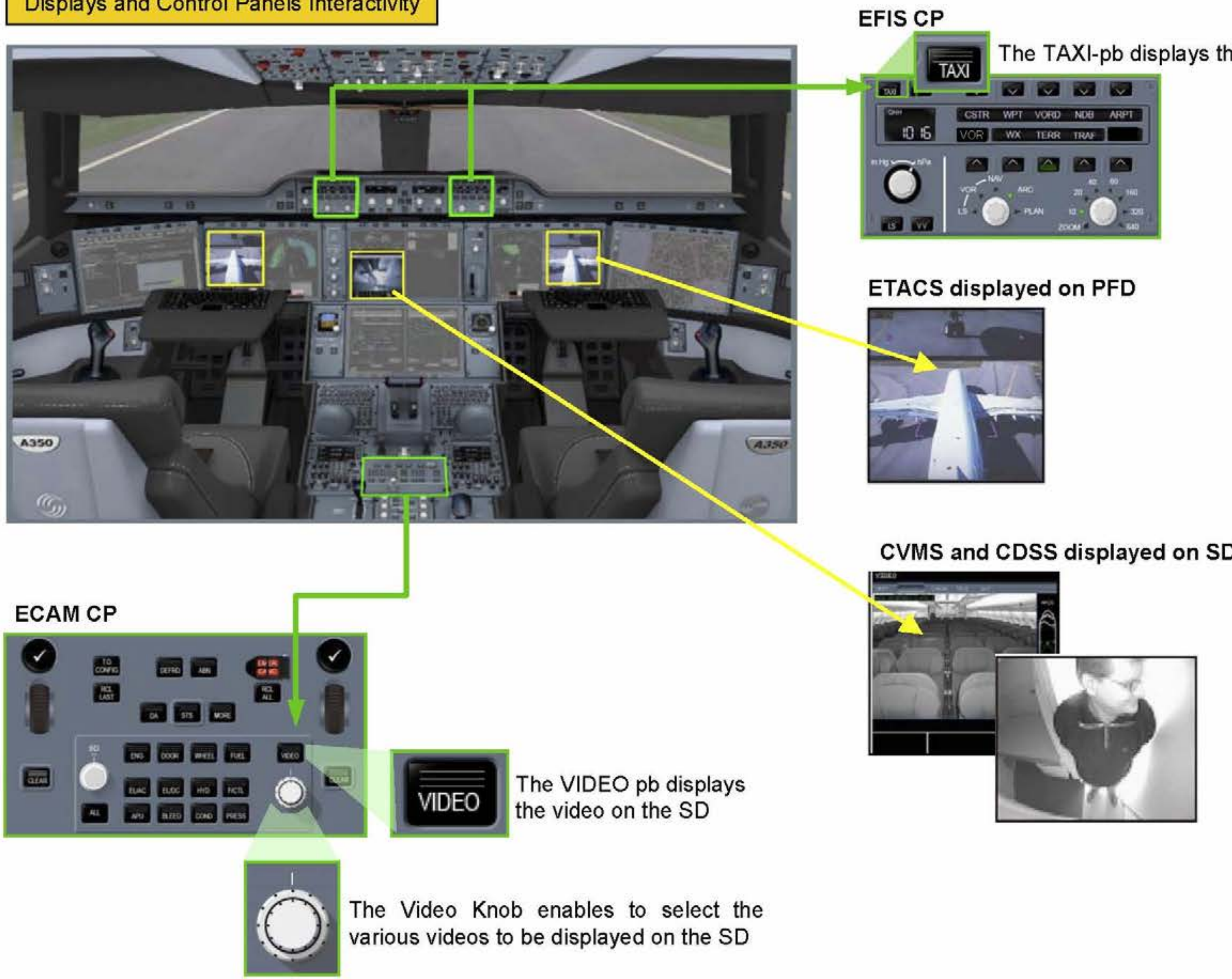
CVMS


CDSS

# ECAM

A350 XWB

**Displays and Control Panels Interactivity**



FlightFactor aero

# Landing Gear

A350 XWB

# Landing Gear

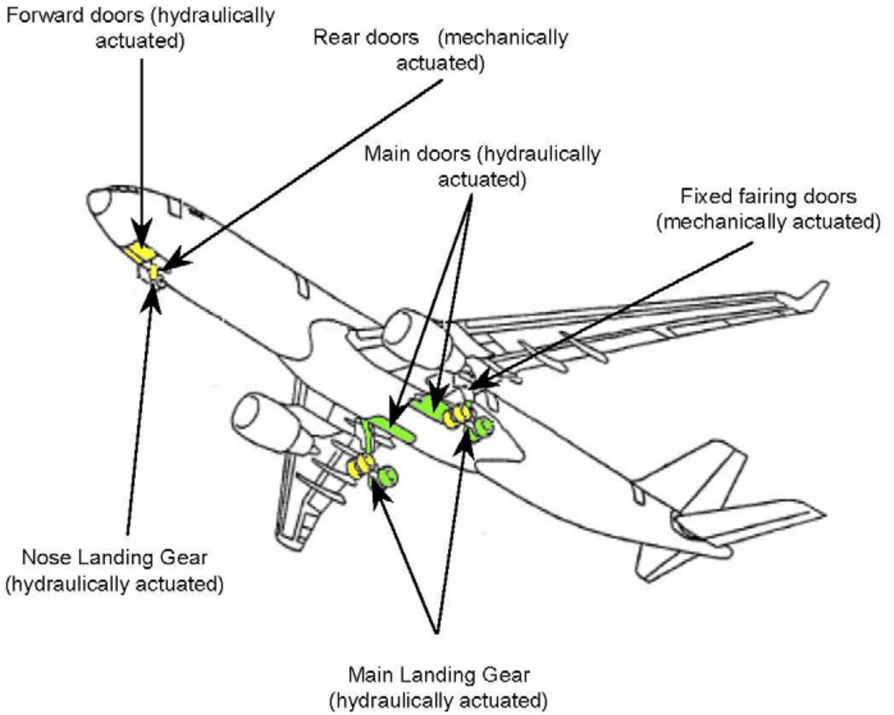
## Overview

The A350 has:

- One Nose Landing Gear (NLG)
- Two Main Landing Gears (MLG)

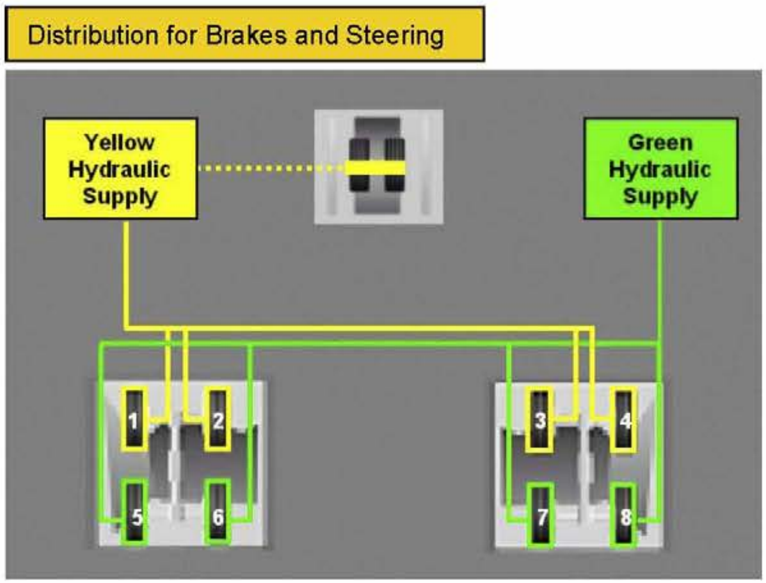
The following systems are associated with the landing gear:

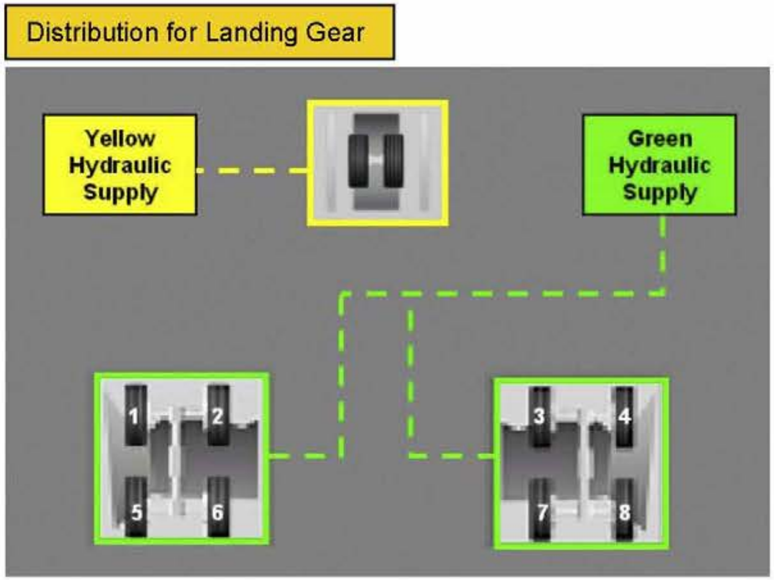
- The Landing Gear Extension and Retraction System
- The Braking System
- Antiskid and Autobrake Systems
- Brake To Vacate (BTV) Function
- Runway Overrun Warning (ROW) and Runway Overrun Protection (ROP)
- The Steering System
- Brake Temperature Monitoring System
- Tire Pressure Indication System
- Brake Cooling Fan Control *(option)*

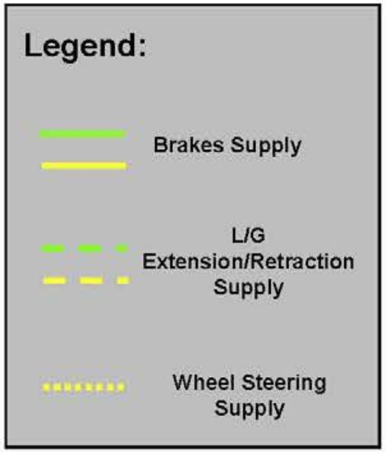


# Landing Gear

## Hydraulic Distribution for Landing Gear, Brakes and Steering



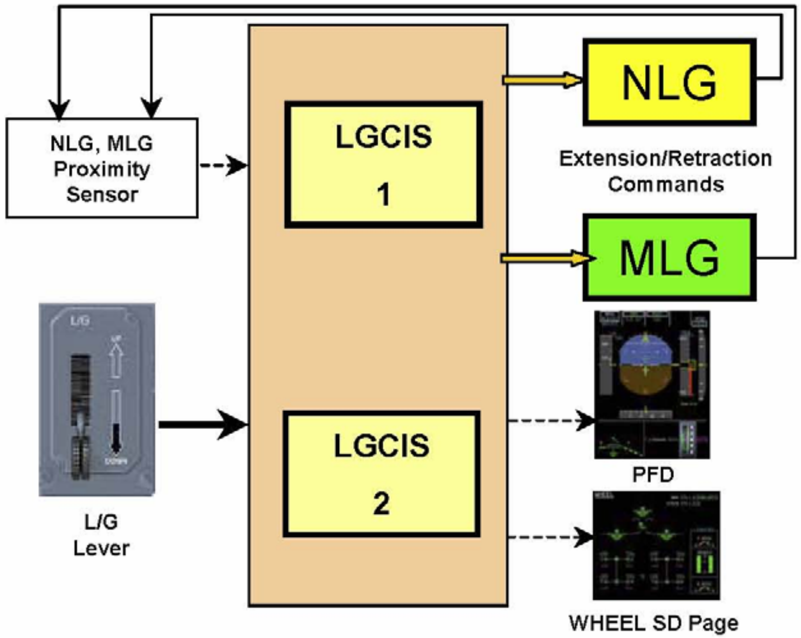



# Landing Gear

## Landing Gear Extension and Retraction System

### Normal Operation

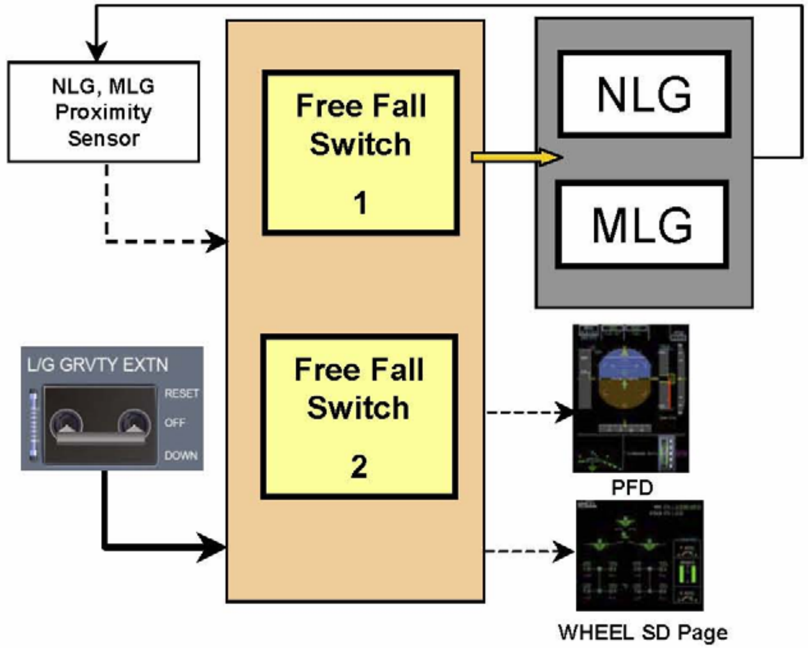
The landing gear hydraulically extends and retracts. The GREEN hydraulic system powers the MLG and associated doors. The YELLOW hydraulic system powers the NLG and associated doors.




One of the two redundant Landing Gear Control and Indicating Systems (LGCIS) monitors and electrically controls the extension and retraction sequences.

### Landing Gear Gravity Extension

If the normal extension and retraction system is not available, gravity-assisted landing gear extension can be performed using the independent freefall system. **Two Free Fall Switches** monitor and electrically control the extension sequence.




The landing gear gravity switch enables to exter landing gear by gravity when normal operati inoperative.

## Braking System

The A350-900 has 8 carbon brakes. There is one brake on each MLG wheel.

The MLG has two wheel groups:

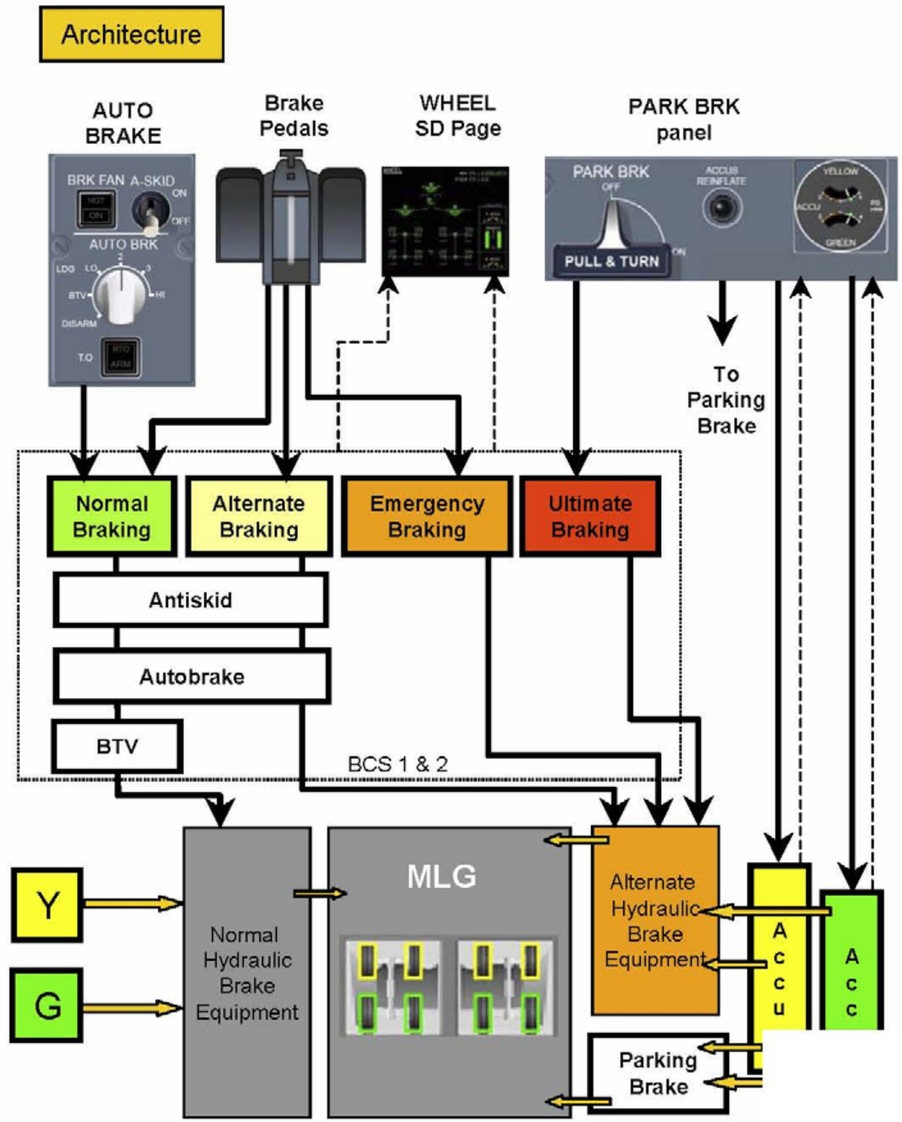
- The "Front" MLG group (wheels 1,2,3,4). The YELLOW hydraulic circuit supplies the brakes of this group.
- The "Rear" MLG group (wheels 5,6,7,8). The GREEN hydraulic circuit supplies the brakes of this group.

The braking system enables:

- **Manual braking** via flight crew action on:
  - The brake pedals
  - The PARK BRK handle.
- **Automatic braking** via:
  - The Autobrake (AUTO BRK) which includes the Brake To Vacate (BTV) function.

The braking system has **5 braking modes**:

- Normal
- Alternate
- Emergency
- Ultimate
- Parking Brake



## Steering System

The Nose Wheel Steering (NWS) system enables directional control of the aircraft on ground.

The flight crew can steer the aircraft via:

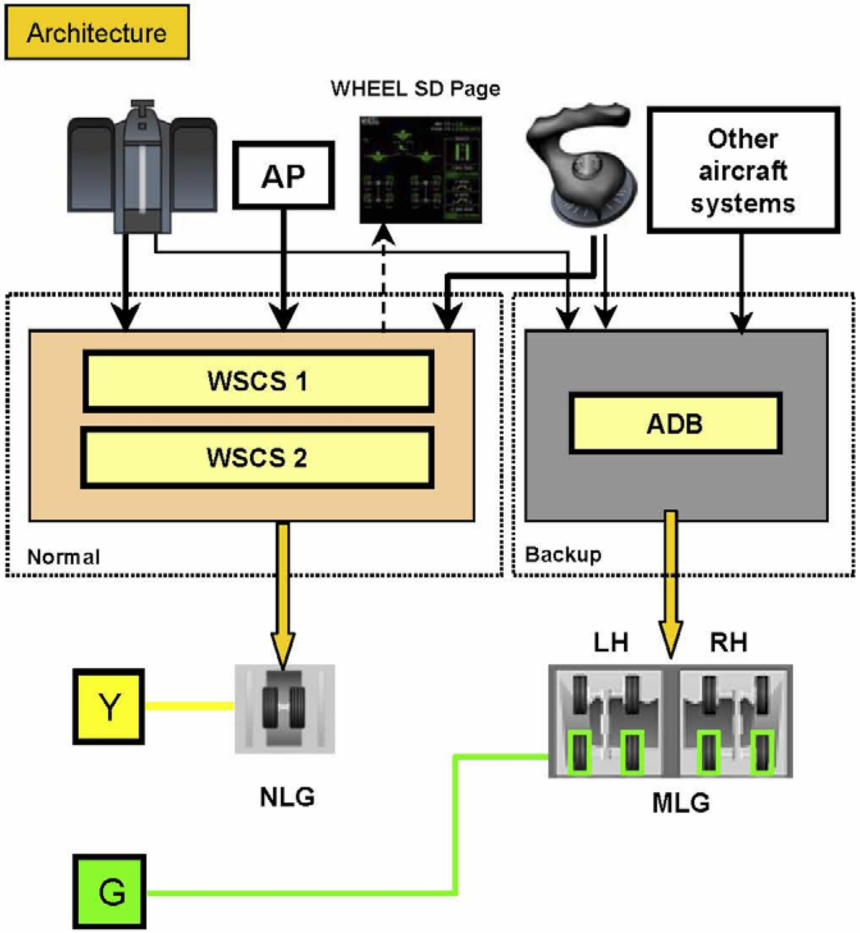
- The rudder pedals, or
- The steering handwheels.

The autopilot can also generate steering commands during an automatic landing.

The steering system has two redundant Wheel Steering Control Systems (WSCS) and two modes:

- In Normal mode, the YELLOW hydraulic circuit powers the NWS
- In Backup mode, the **Automatic Differential Braking (ADB)** provides a limited steering function. In this mode, the **GREEN** MLG brakes are used only. The flight crew still control the steering via the handwheel.

The NWS is not available when the engines are shut down.



## Landing Gear Monitoring Systems

### Brake Temperature Monitoring System

The Brake Temperature Monitoring System measures the temperature of each brake. The WHEEL SD Page displays temperature indications in the cockpit. An alert message warns the flight crew in the case of an abnormal situation.

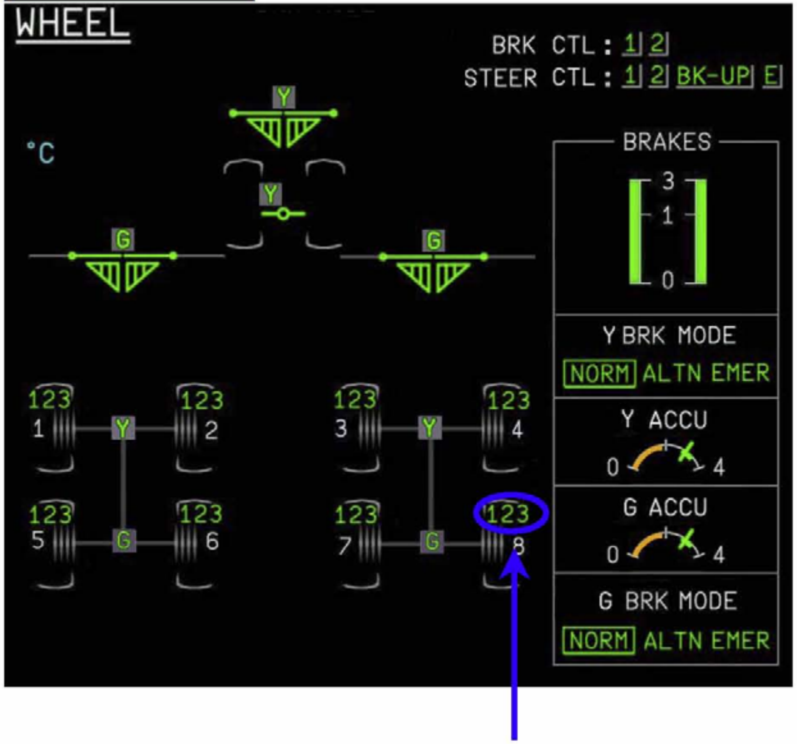
### Tyre Pressure Indication System

The Tyre Pressure Indication System measures the pressure of each tire. The WHEEL SD Page displays pressure indications in the cockpit. An alert message warns the flight crew in the case of an abnormal situation.

### Brake Cooling Fan Control (optional)

The basic aircraft has system provisions for brake cooling fans on the main landing gear.

WHEEL SD Page




Temperature (°C)

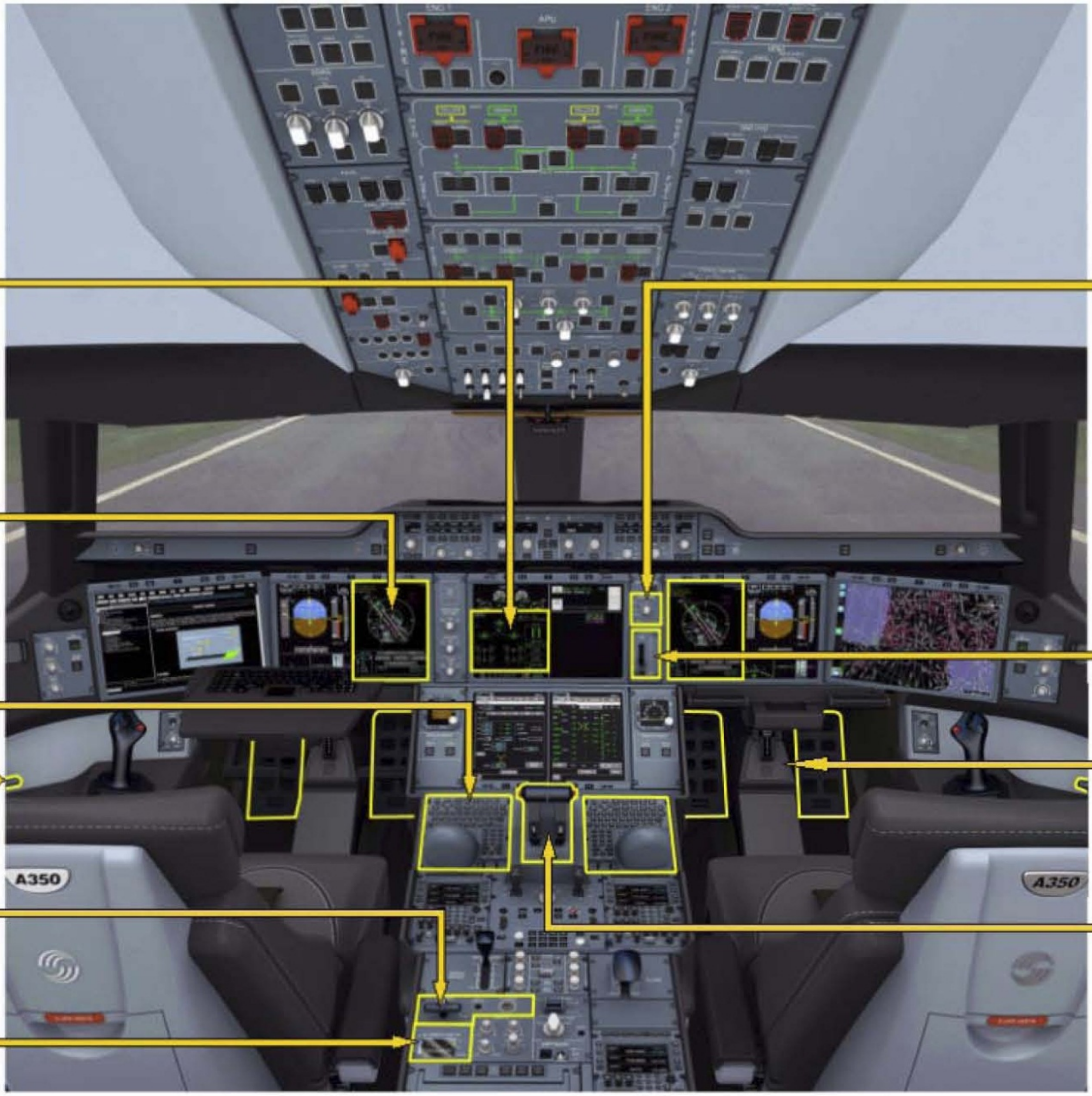
*Note:*

*the pressure is shown only in case of failure (alarm low press)*

# Landing Gear

A350 XWB

## Cockpit View



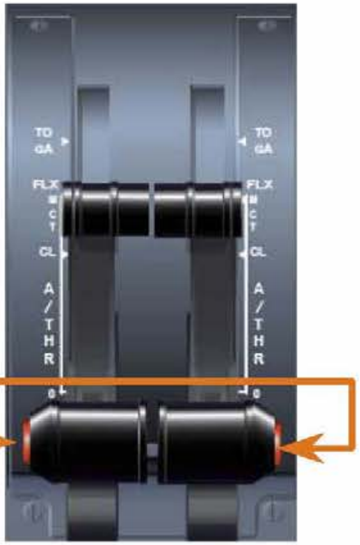
# Landing Gear

PARK BRK Panel


L/G GRVTY sw


KCCU

Thrust Levers




A/THR instinctive disconnection buttons

Autobrake and BTV instinctive disconnection using A/THR instinctive disconnection b

# Landing Gear

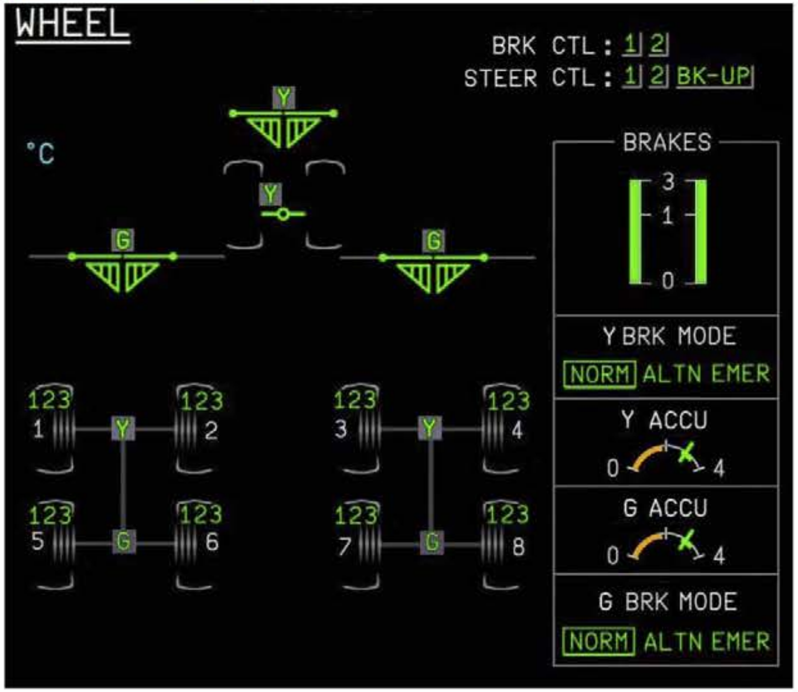
AUTO BRK selector & A-SKID sw


L/G Lever

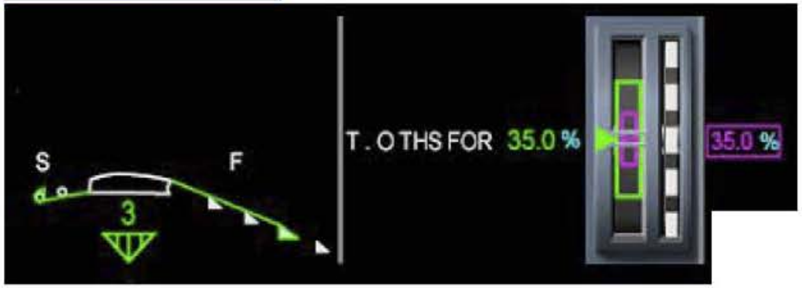

Brake Pedals

Steering Handwheel

WHEEL SD Page




L/G Display on PFD



# Lights

# Lights

## Overview

The lighting system provides the required internal and external illumination to perform flight in any day and night conditions

The lighting system provides the following function:

- **Internal lighting**
  - Cockpit lighting
  - Emergency lighting

- **External lighting**
  - External visibility (to see outside)
  - External lights (to be seen)

# Lights

## Internal Lighting

### Cockpit Lighting

Cockpit lighting provides the flight crew with the most suitable lighting environment, to carry out their mission. All cockpit lights use the Light Emitting Diode (LED) technology.

The cockpit lighting has:

- **Utility lights** to read map and documents
- **Ambient lights** (on the roof of the cockpit) to provide lighting for the various cockpit areas
- **Area and panel lights** to provide lighting for the instrument panels

The flight crew can dim most of the cockpit lights, if necessary.

The cockpit lights have two different colors:

- A white orangey color, that is restful for human eyes
- A bluish white color, that facilitates reading.

### Emergency Lighting

There are emergency lights in the:

- Cockpit
- Cabin

The flight crew can manually turn on the emergency lighting. However, if electrical power is lost, the emergency lighting comes on automatically in the cockpit and the cabin.

#### Cockpit Emergency Lighting

Ambient lights and cockpit way light provide emergency lighting in the cockpit.

#### Cabin Emergency Lighting System

The cabin has an emergency lighting system that provides sufficient lighting in the cabin, in the case of emergency or electrical power loss. The flight crew can manually turn on emergency lights via the emergency exit light (EMER EXIT LT) switch, if necessary.

The emergency lights come automatically when:

- The flight crew set the EMER EXIT LT switch to
- The aircraft electrical supply is degraded.

# Lights

## External Lighting

The A350 has the following external lights:

- **Navigation lights**
  The navigation lights provide an external visual indication of the position of the aircraft and its direction of flight.

- **Landing lights**
  The landing lights provide runway illumination during night operations. The landing lights can be used in combination with the takeoff and taxi lights.

- **Taxi lights**
  The taxi lights provide illumination of the taxiways and ground obstructions ahead of the aircraft.

- **Runway turnoff lights**
  The Runway Turnoff lights provide illumination on either side of the taxi line (approximately 45 degrees) forward of the nose landing gear.

- **Takeoff lights**
  The Takeoff lights provide illumination of the runway during taxi, takeoff roll, takeoff, approach and landing.

- **Logo lights**
  The logo lights illuminate the logo on the vertical stabilizer.

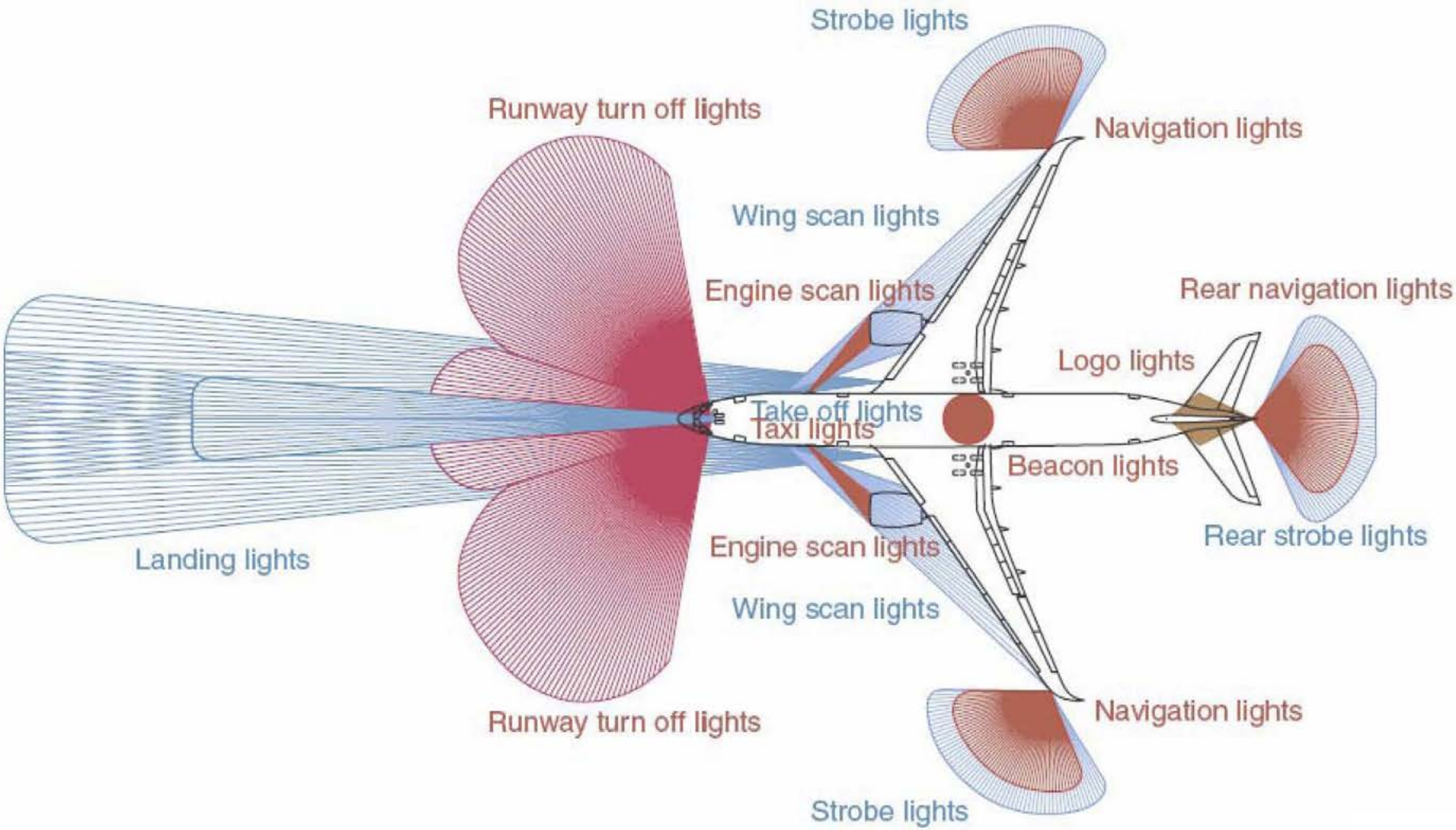
- **Beacon Lights**
  The beacon lights belong to the anti-collision lights system. The beacon lights provide a high-intensity red flashing light.

- **Strobe lights**
  The strobe lights belong to the anti-collision lights system. The strobe lights provide a high-intensity white flashing light.

- **Wing and engine scan lights**
  Wing and engine scan lights are used to illuminate the LH/RH wing tip leading edges and the engines (LH/RH) in order to identify any accumulation of ice.

- **Taxi Camera Lights (optional)**
  The Taxi Camera Lights are used to illuminate the Nose Landing Gear wheels and the Main Landing Gear wheels during taxiways, runway turn-off and a ground operations that may cause a hazar aircraft.

# Lights


Strobe lights
Runway turn off lights
Navigation lights
Wing scan lights
Engine scan lights
Rear navigation lights
Logo lights
Take off lights
Taxi lights
Beacon lights
Engine scan lights
Rear strobe lights
Landing lights
Wing scan lights
Runway turn off lights
Navigation lights
Strobe lights

# Lights

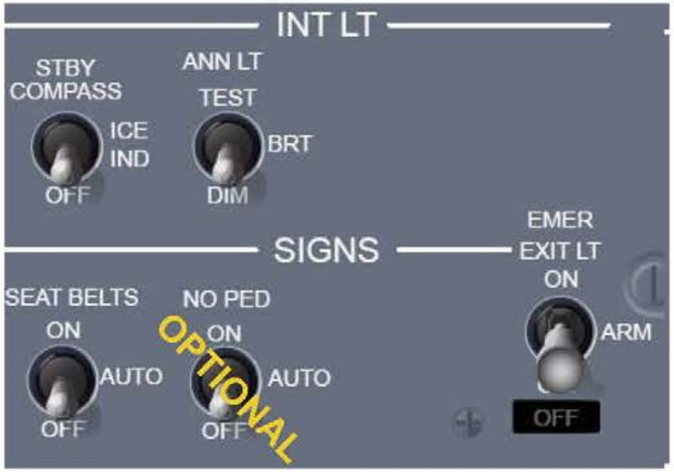
## Cockpit View

# Lights

EXT LT Panel


MAP LT and CONSOLE LT Selectors


INT LT Panel and SIGNS Panel




CKPT LT Panel

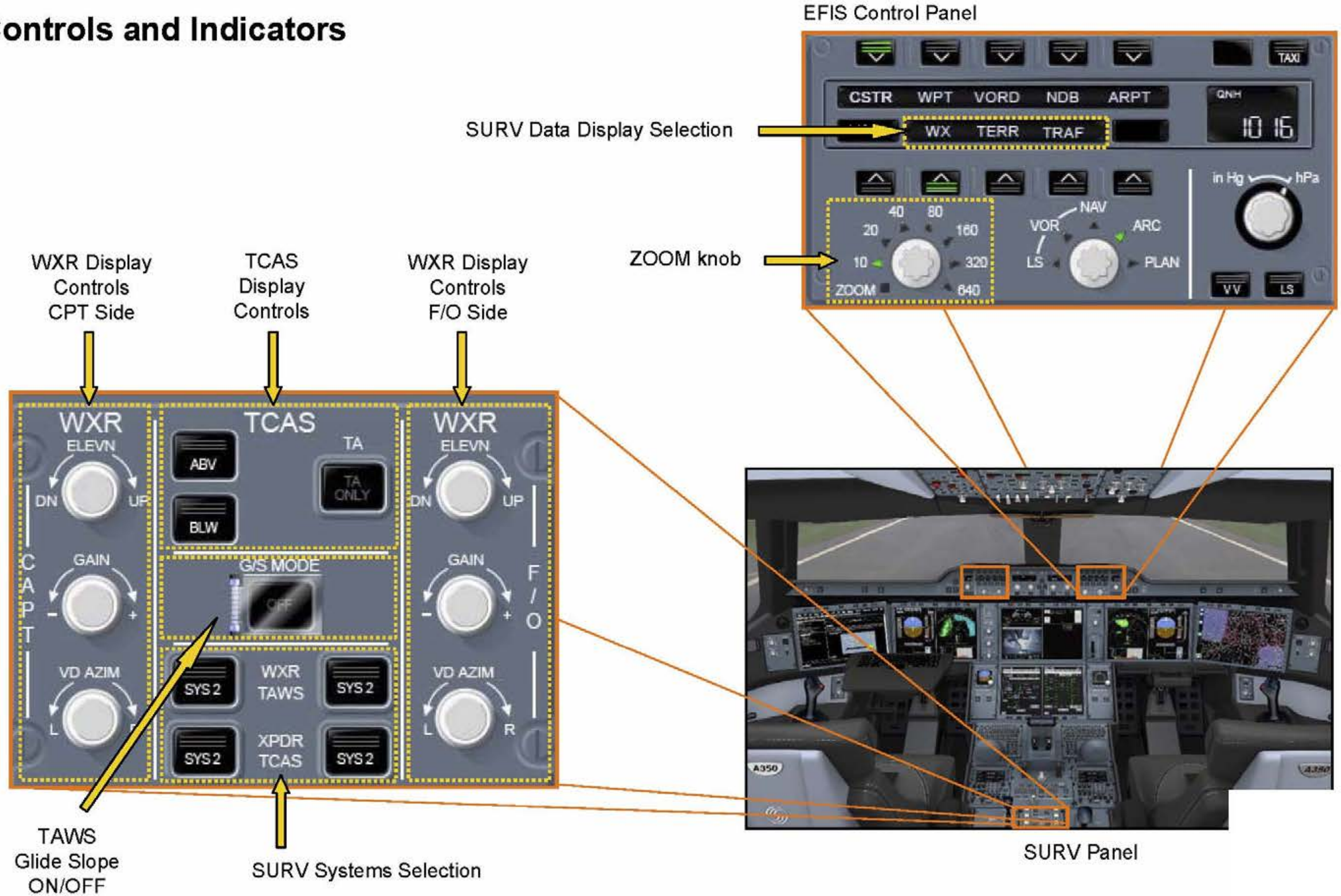
FlightFactor aero

# Surveillance

A350 XWB

A350 XWB

## Controls and Indicators



# Surveillance

## MFD SURV Page


Backup for SURV Control Panel
Additional System Switching Selections


Systems
Selection and Status

FlightFactor aero

# Auxiliary Power Unit

A350 XWB

## General

The APU is a single shaft gas turbine that enables the aircraft to be autonomous regarding:

- Electrical Power (230 VAC 150 kVA)
- Bleed Air

The Auxiliary Power Unit (APU) can provide:

- On ground:
  - Bleed air for engine start and for air conditioning
  - Electrical power via a Starter/Generator System
- During takeoff:
  - Bleed air for air conditioning, when needed
- In flight:
  - For the entire flight envelope:
    - A backup for electrical power
  - Up to 22 500 ft
    - Bleed air for engine start
    - Bleed air for cabin pressurization*

* This capability satisfies up to 350 minutes ETOPS requirements.

Electrical and pneumatic power can be provided to the aircraft separately or in combination. However electrical generation has priority over bleed air generation.

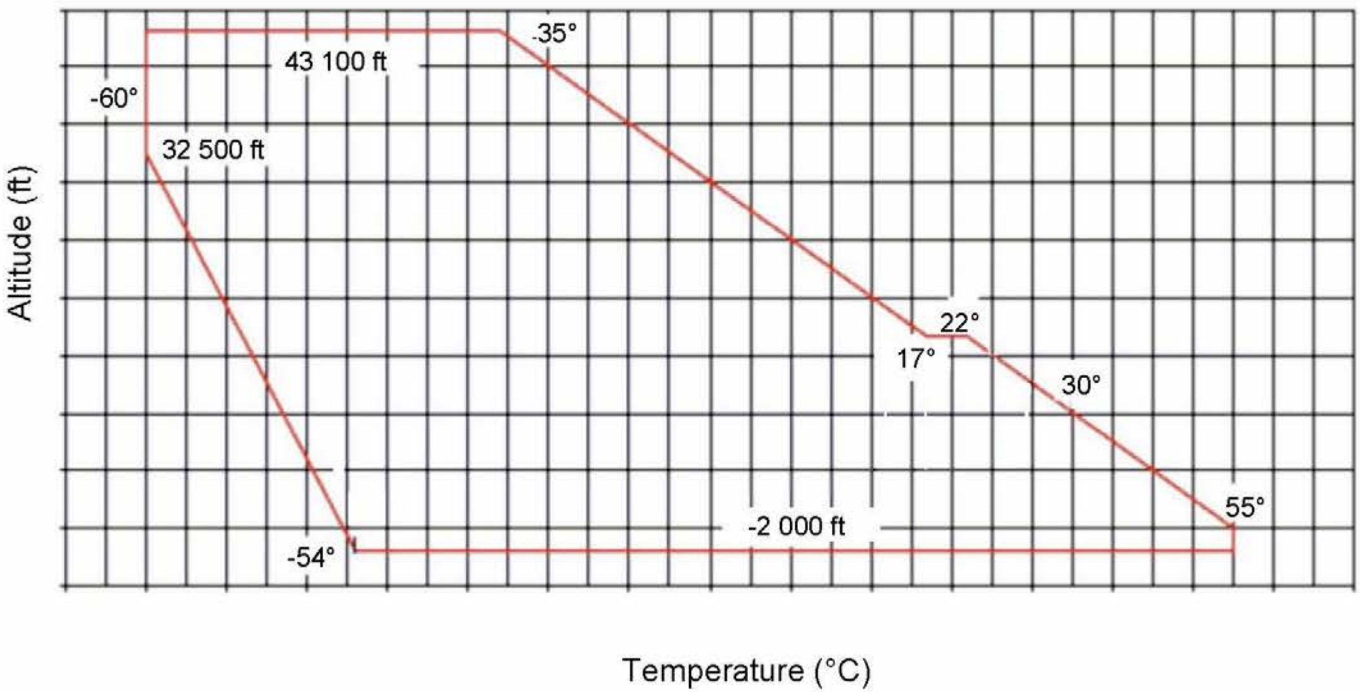
The APU system has:

- One Electronic Control Box (ECB) which permanently monitors and controls all APU functions
- One Starter/Generator System

The following power sources can start the APU:

- The aircraft batteries
- External power (GPU)
- The normal electrical network of the aircraft.

## Auxiliary Power Unit (APU) Flight Envelope




*Note:*

- *The APU and aircraft flight envelopes are identical*
- *The APU can be started up to a flight altitude of 43 100 ft.*

## System Architecture

### APU Engine

The APU has a:

- Load Compressor which provides power for bleed air and electrical generation
- Two-stage engine compressor
- Three-stage engine turbine

### Electronic Control Box (ECB)

The Electronic Control Box (ECB):

- Sequences and monitors the APU start
- Sequences and monitors the manual, automatic, and emergency APU shutdown
- Monitors the APU bleed air
- Monitors the operating parameters of the APU
  - Controls the rotation speed
  - Protects the APU from overtemperature or other malfunctions (overspeed)
  - Avoids load compressor surge
  - Supplies fault information for APU failure and engine trend monitoring
  - Commands directly the opening and closure of the Air Intake flap actuator
  - Displays the applicable information on the ECAM

### APU Starter/Generator System

The APU drives a Starter/Generator System which can either:

- Start the APU (in STARTER mode)
- Generate electrical power (in GENERATOR mode)

### APU Bleed Air

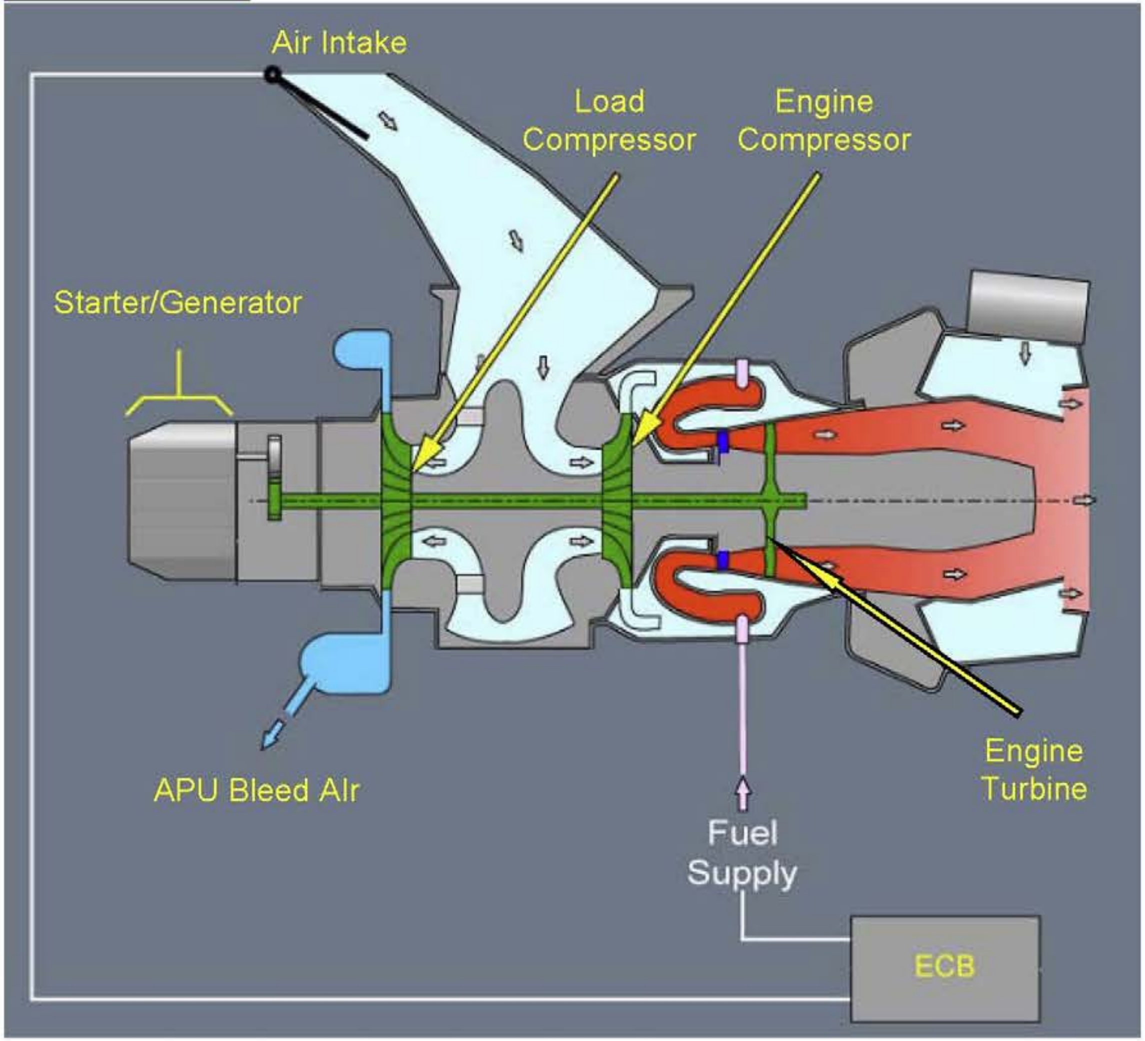
The APU can provide bleed air to the bleed system, via the APU bleed valve.

### APU Air Intake System

The APU Air Intake System has an:

- Air-Intake Flap. External air flows into the APU via this flap
- Ice Protection.

APU Architecture




*Note: for clarity reasons, this drawing displays only one stage of compressor and turbine.*

# APU

A350 XWB

## Cockpit View

# APU

A350 XWB

APU SD Page


APU pb-sw

# Engines

A350 XWB

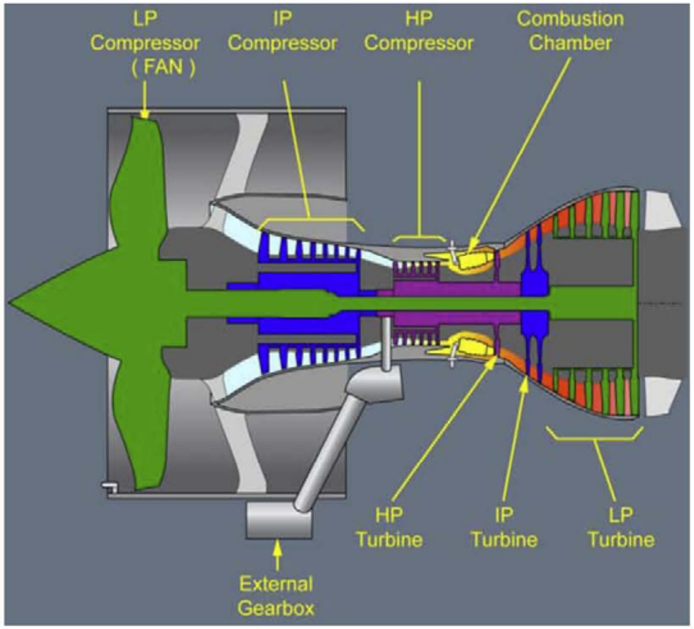
# Engines

## General

The Rolls-Royce TRENT XWB engine powers the A350 aircraft.

It is a high bypass ratio turbofan engine and is offered at different thrust levels to support all variants of the A350 family.

Rolls-Royce TRENT XWB




Nominal Static Thrust of A350 - 900 Engines

| Engine type | Thrust ratings (Maxi takeoff at MSL) |
|---|---|
| RR Trent XWB - 84 | 84,000 lbs |

# Engines

## Full Authority Digital Engine Control

Each engine has one Full Authority Digital Engine Control (FADEC). Each FADEC has two fully redundant channels that perform:

- Ignition and starting:
  - Automatic engine start monitoring, start abort and re-start when necessary
  - Automatic relight and quick relight functions
  - Manual engine start passive monitoring with fault annunciation

- Engine power management:
  - Thrust rating and thrust limit computation
  - Idle settings

- Engine protection in the entire aircraft envelope and weather condition:
  - N1, N2, (N3) and EGT overlimit protection
  - LP shaft breakage protection
  - Overthrust detection
  - Adverse weather management
  - Fan instability protection
  - Stall protection

- Engine parameters monitoring and display,including the Airbus Cockpit Universal Thrust Emulator (ACUTE):
  - The FADEC transmits engine parameters to the Engine Display (ED) and the System Display (SD) and engine monitoring information to the Flight Warning System (FWS).

## Engine Start

The engine has a pneumatic air turbine starter. This starter is supplied with air either from:

- The Auxiliary Power Unit, or
- The other engine, or
- An external ground air supply.

A350 XWB

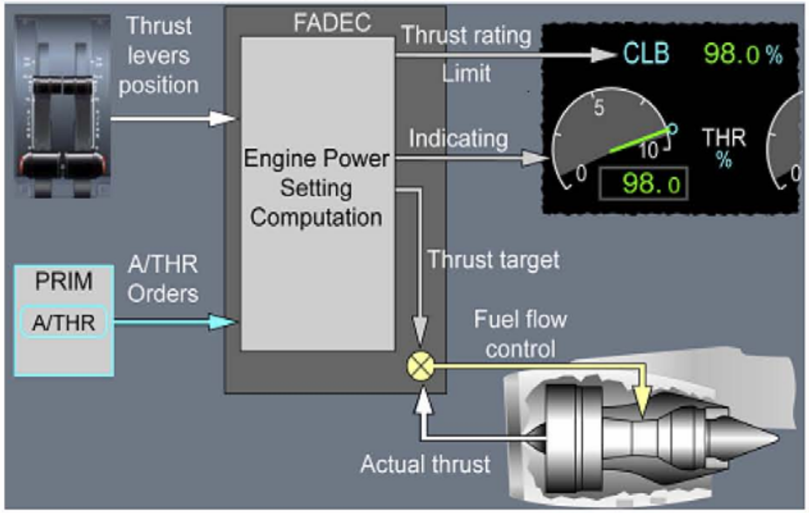
## Thrust Control

The FADEC provides engine thrust control. The FADEC controls the thrust either in:

- **Manual mode** according to the thrust control lever position, or
- **Automatic mode** (Autothrust) according to thrust targets coming from the Flight Guidance (FG) function.

When the autothrust is engaged, the thrust control levers are not moving according to to the thrust rating commanded by the A/THR system.

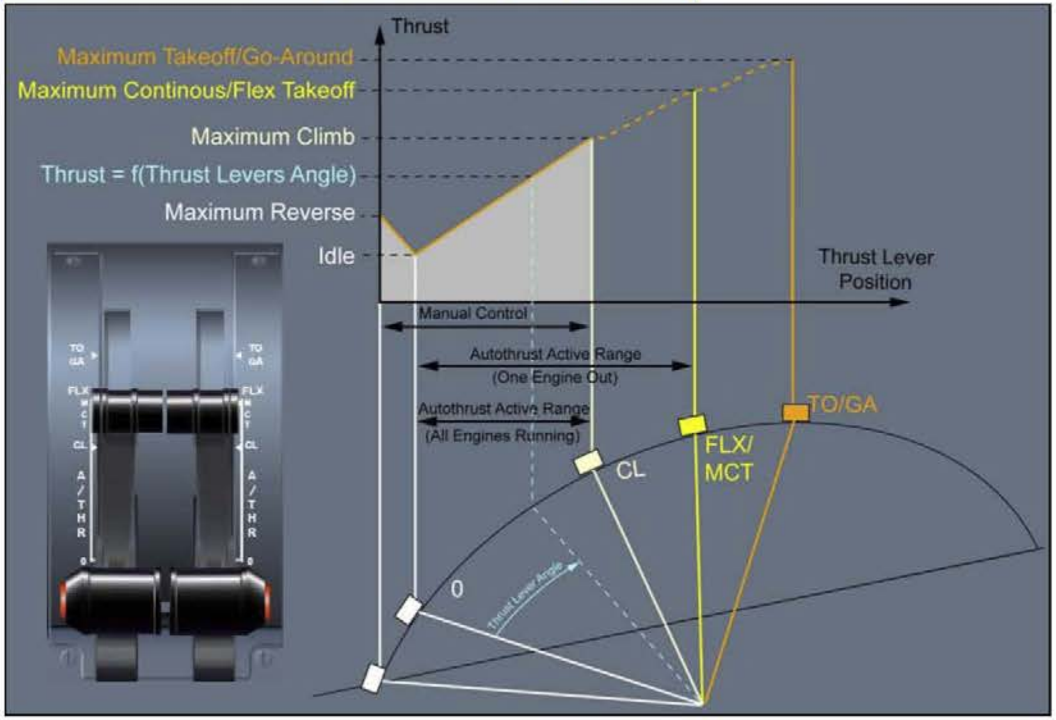
Thrust Control Architecture



# Engines



Thrust Levers Detents/Angle and Corresponding Thrust




There are **4 detents** on the thrust levers:

- **TO GA**: Maximum Takeoff/Go Around thrust
- **FLX MCT**: Maximum continuous thrust (or FLX at takeoff, in accordance with the FLX/TO temperature setting on the TO page of the MFD)
- **CL**: Maximum climb thrust
- **0**: Idle thrust.

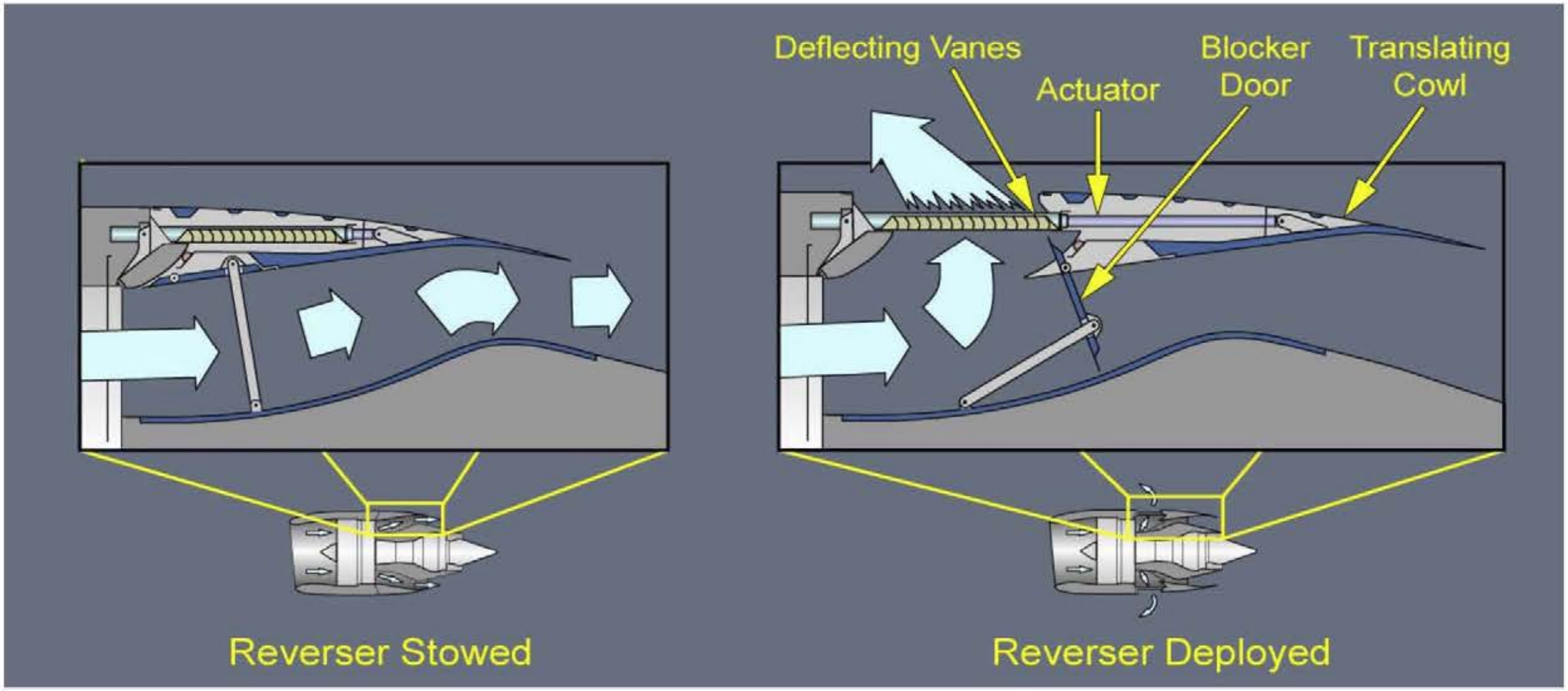
## Thrust Reverser

There are two thrust reversers: one on each engine. The thrust reversers are electrically actuated.

The thrust reverser system has several segregated lines of defence to protect the aircraft against deployment in flight.

These lines of defence are based on the following elements:

- Thrust lever positions
- Radio Altimeter altitude
- Aircraft-on-ground confirmation and
- Reverse levers positions.



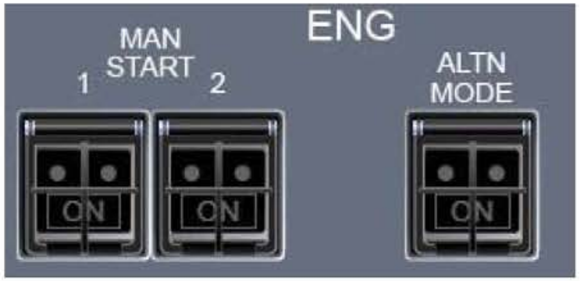
# Engines

## Cockpit View

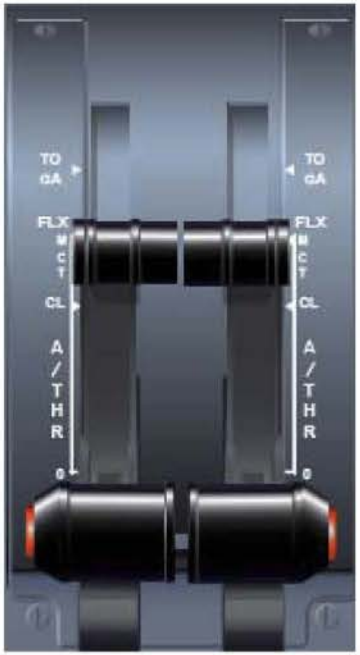
## Controls

ENG MAINTENANCE Panel


ENG Panel




Thrust Levers




ENG START Selector and sw

# Engines

## Indicators

ENG SD Page (Trent)


Engine Display (ED)

# Engines

## ACUTE

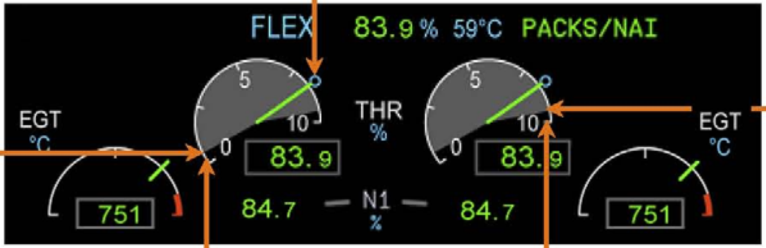
The **Airbus Cockpit Universal Thrust Emulator (ACUTE)** converts the engine control parameter into a common thrust parameter (THR) for all engine types.

The thrust parameter varies between 0% and 100% in all flight conditions and is defined as follows:

### ED: Forward Thrust

$THR_{REF}$ : Thrust corresponding to the thrust lever position

$THR_{IDLE}$ : Thrust produced when the engine is operating at IDLE




$THR_{MAX}$ : Thrust produced when thrust levers are at TOGA detent, taking into account the air bleed effect

$THR_{WML}$ : Thrust produced when the engine is windmilling

$THR_{MAX}$ : Thrust produced when thrust levers are at TOGA detent and bleed off

### ED: Reverse Thrust


$THR_{IDLE\ REV}$

$THR_{MAX\ REV}$

This model is produced under

Sep 1, 2014
Revision Date September 1, 2014
applicable for version v1.00