Navigation

A350 XWB

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The Navigation system provides:

- Flight and navigation parameters
- Navigation aids (NAVAIDS) tuning and reception
- Navigation backup

The systems providing navigation parameters are:

- ADIRS
- Multi-Mode Receivers (MMRs)
- Radio NAVAIDS
- Radio Altimeters (RAs).

The backup navigation system is provided by the Standby Navigation System (SNS) composed of one Integrated Standby Instrument System (ISIS) and one standby magnetic compass. A second ISIS can be installed as an option.

In addition to the navigation functions, the Navigation system provides two additional functions:

- **Surveillance Function**:
  This function protects the aircraft against external environment hazards.

- **Airport Navigation Function**:
  This function helps the flight crew for navigation on airport surfaces.

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System Description

The **Air Data and Inertial Reference System (ADIRS)** is the main component of the Navigation system. It provides:

- Flight parameters (air data, attitude, velocities) to ensure the control of the aircraft trajectory
- Navigation parameters (position (lat/long), heading, time) to determine the aircraft position (lat/long) and orientation (N/S/E/W).

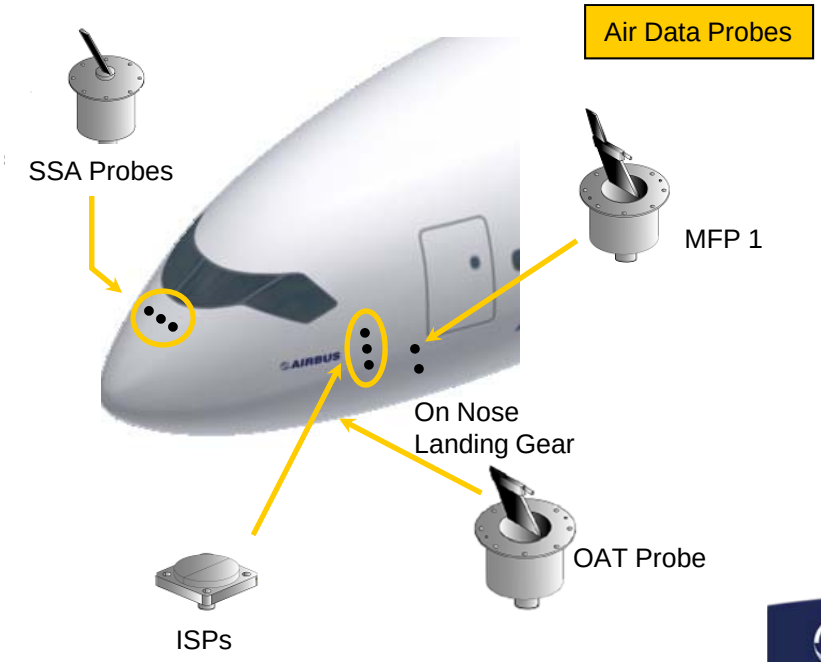
The ADIRS has three Air Data and Inertial Reference Units (ADIRU). Each ADIRU is divided into two parts:

- The ADR (Air Data Reference) part
- The IR (Inertial Reference) part.

Each part (either ADR or IR) can work separately in the case of failure of the other part.

- The **Air Data Reference (ADR)** part computes AIR DATA parameters using data from different probes:
  - One Multi-Function Probe (MFP) per ADIRU provides total pressure (Pt), Total Air Temperature (TAT) and Angle of Attack (AOA) measurements
  - One Side Slip Angle (SSA) probe per ADIRU provides the sideslip angle
  - Two Integrated Static Probes (ISPs) per ADIRU provide the static pressure (Ps)
  - A fourth AOA probe provides additional angle of attack measurements
  - Two Outside Air Temperature (OAT) probes provide Static Air Temperature (SAT) on ground only.

- The **Inertial Reference (IR)** part computes attitude, position (lat/long), heading using data from its internal gyrometers and accelerometers sensors.
  In normal operation, each IR part also receives GPS data from the Multi-Mode Receiver (MMR) for initial alignment and computation of the GPIRS hybrid position.



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Aircraft Position Computation

The aircraft position is the result of a selection by the ADIRS of different candidate positions.
In flight, the selection is performed with the following priority:

- The consolidated hybrid solution
- The hybrid solution, called GPIRS
- The mix IRS/Radio solution, copied from the FMS
- The Pure IRS Position

On ground, the ADIRS compute a specific GPIRS hybrid position, with a high level of accuracy, that is used by all other systems, especially the Airport Navigation Function.

The Hybrid Position

The hybrid position is based on a combination of inertial and GPS data (1 IRS/GPS source).

The Consolidated Hybrid Position

The consolidated hybrid position is based on a combination of all hybrid positions (3 IRS/GPS sources).
The main purpose of the Hybridization function is to improve the Integrity, Availability, and Continuity performances of the solutions that come from the GNSS navigation sources.

FMS Position

Each FMS computes its aircraft position and the position accuracy, using three sources:

- Inertial via the ADIRS
- Global Positioning System (GPS) via the MMR
- Radio navigation via NAVAIDS receivers.

The FMS position is a combination of the inertial position and radio position, depending on which equipment provides the most accurate data. This results in three navigation modes, in decreasing order of priority:

- Inertial - DME/DME (IRS/DME/DME)
- Inertial - VOR/DME (IRS/VOR/DME)
- Inertial only (IRS).

Pure IRS Position

The pure IRS position is computed when only the IRS sources are available.

The ADIRS sends the aircraft position to the systems that need this information, including the FMS, which uses the aircraft position for the flight planning and predictions functions.

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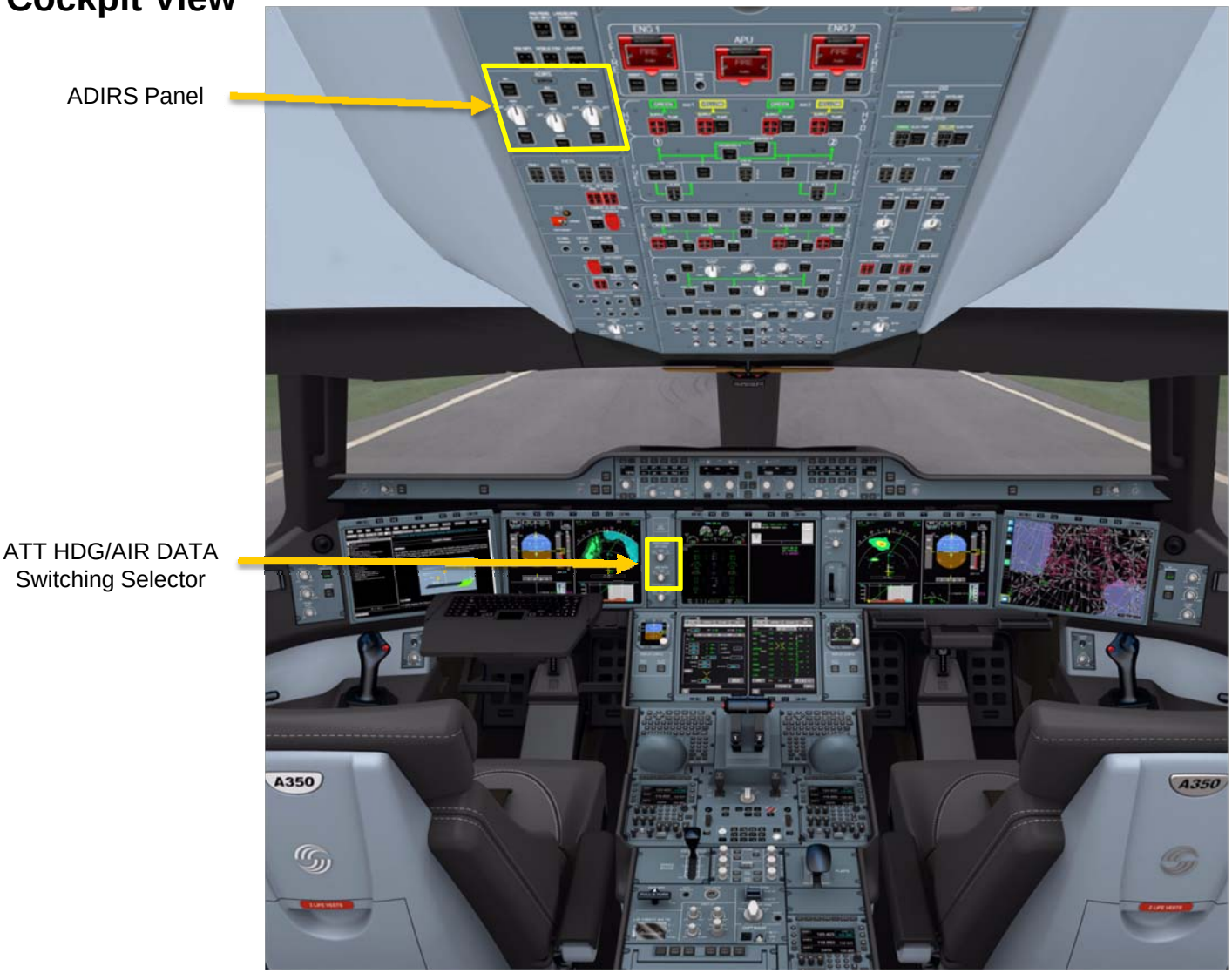
Cockpit View



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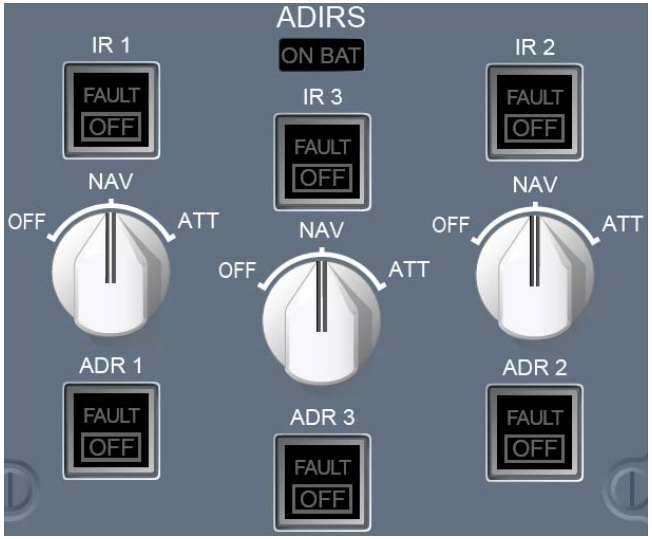
Controls

ATT HDG/AIR DATA Switching Selector

ADIRS Panel



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General

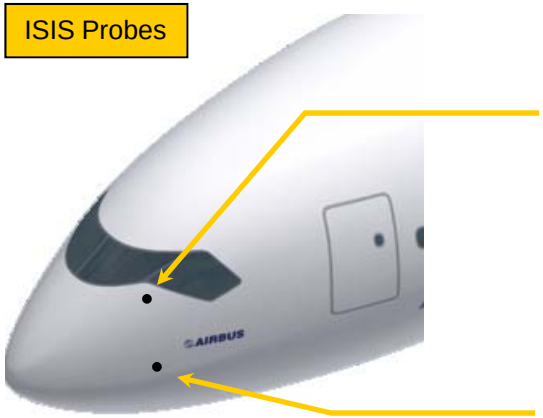
The **Standby Navigation System** provides a navigation backup function. The SNS is composed of one or two Integrated Standby Instrument System (ISIS), one standby pitot probe, two standby static probes, and one standby magnetic compass.

The ISIS can be considered as a small simplified ADIRU coupled with a display unit.

It provides:

- An independent source of computation for attitude information (pitch angle, roll angle), and air data parameters (Computed Air Speed, Altitude, Mach…) in case of all ADIRUs failure
- An independent source of display in case of all DUs failure.

ISIS Probes



Standby Static Probe

Standby Pitot Probe

System Description

There is one basic ISIS (LH) and one optional ISIS (RH). Each unit can display:

- The **Standby Flight Display (SFD),** or
- The **Standby Navigation Display (SND).**

If only one ISIS is installed, it can only display the SFD. If there are two ISIS, both cannot display the same mode.

In normal configuration, ISIS computes air data parameters (speed, altitude…) using its independent standby probes. In addition:

- ISIS gyrometers and accelerometers compute attitude information
- ISIS connected to IR 1 or 3 acquires:
  - Heading (magnetic and true)
  - True track (magnetic track is calculated using deviation)
  - Ground speed, latitude, longitude.
- ISIS connected to MMR 1 acquires:
  - LOC & Glide deviations
  - The associated identifier, frequency and the selected course
  - True track
  - The GPS latitude/longitude
  - The ground speed.

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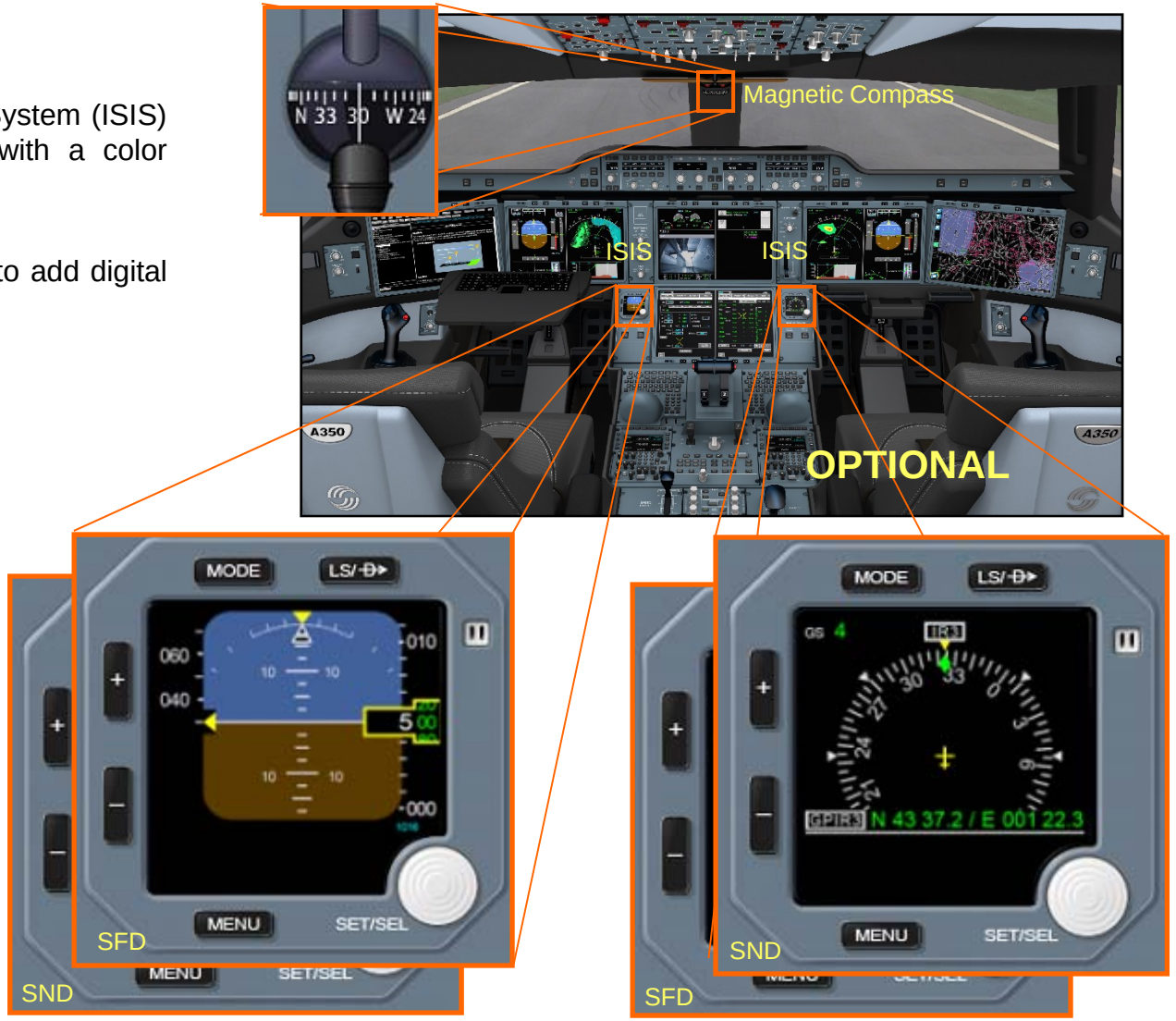
Controls and Indicators

The Integrated Standby Instrument System (ISIS) is a combined multi-function unit, with a color liquid crystal display that provides:

- Altitude:
  - Scale in feet with capability to add digital altitude read-out in meters
  - Baro setting - hPa or in Hg
- Airspeed in knots and Mach number
- Attitude situation with pitch and roll
- Landing systems deviation data
- Present position and single fix
- Bugs (speed and altitude)
- Heading and track
- Ground speed.



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System Description

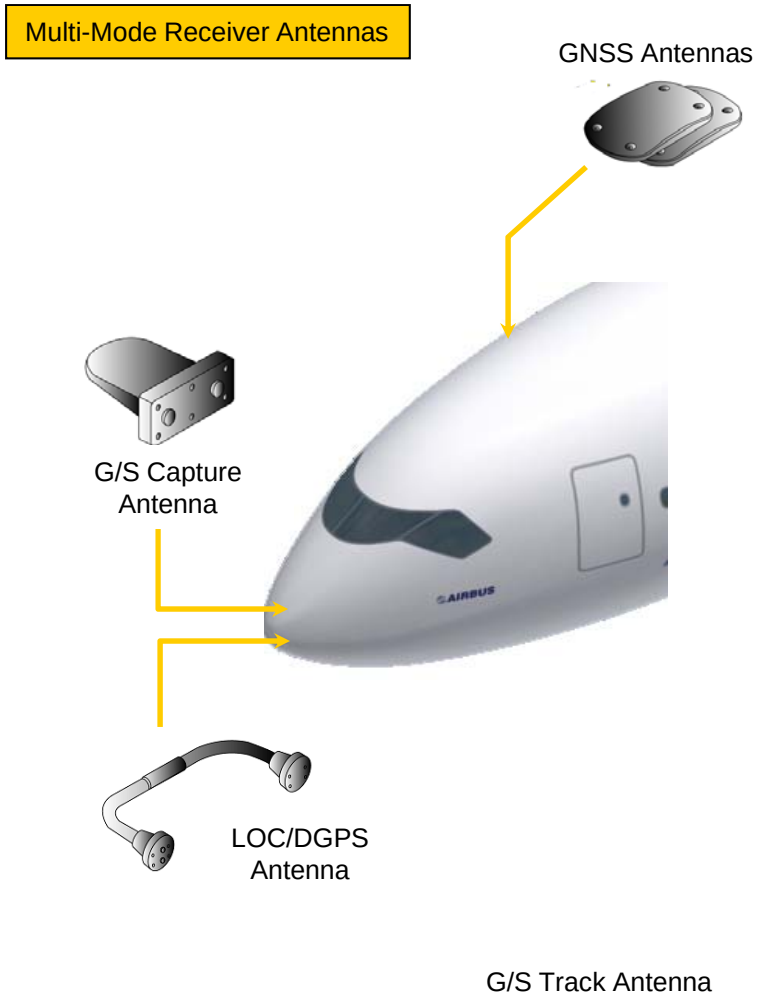
The main function of the **Multi-Mode Receiver (MMR)** is to compute lateral and vertical deviations of the aircraft to the approach and landing trajectory.

The MMR system consists of:

- Two MMR receivers
- Two Global Navigation Satellite System (GNSS) antennas
- One Localizer / Differential Global Positioning System (LOC/DGPS) antenna
- One glide slope capture antenna.

The MMR includes the following functions:

- Landing systems:
  - The Instrument Landing System (ILS) function
  - The FMS Landing System (FLS) function
  - The Ground Based Augmentation System (GBAS) Landing System (GLS) function (optional)
  - The Satellite Landing System (SLS) function (optional).
- Navigation system: Global Navigation Satellite System (GNSS) function.



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Overview

The SURV system is an integrated solution that regroups all aircraft surveillance functions into one system. It includes:

- Weather Radar (WXR) with Predictive Windshear (PWS) and Turbulence (TURB) detection functions for atmospheric disturbance hazards
- Traffic Alert and Collision Avoidance System (TCAS) which includes:
  - AP/FD TCAS
  - Air Traffic Situational Awareness (ATSAW)
- Terrain Awareness and Warning System (TAWS)
- ATC mode S Transponder (XPDR).

The SURV system includes two identical surveillance systems (SYS 1 and SYS 2).

Each system can perform all the aircraft environmental surveillance functions, that are grouped in pairs:

- The WXR/TAWS
- The TCAS/XPDR.

The SURV system has the following equipment:

- Two Aircraft Environmental Surveillance Units
- Two Radar Transceiver Units
- One weather radar system
- One SURV control panel
- Four combined TCAS and Mode S antennas.

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Weather Radar (WXR)

The weather radar provides:

- A weather (WX) display function
- A predictive windshear (PWS) function (detection and localization)
- A turbulence (TURB) function (detection and localization).

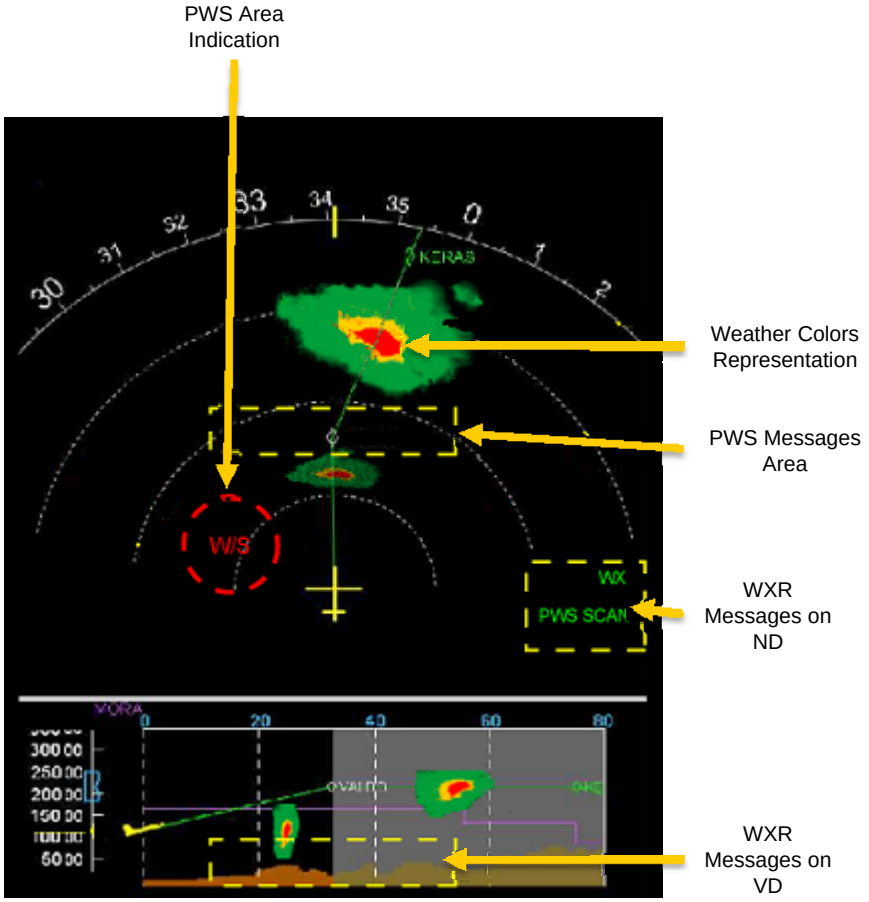
The Navigation Displays (NDs) and the Vertical Displays (VDs) show the weather information, discriminating between relevant and non-relevant weather information in automatic mode.

The weather radar continuously scans a volume of space ahead of the aircraft, and stores this data in a 3D buffer.

The WX display function displays weather data on the:

- ND for views along the:
  - Vertical flight path (in AUTO mode), or
  - Selected altitude (in ELEVN mode), or
  - Selected tilt angle (in TILT mode)

- VD for views along the:
  - Lateral flight path in (AUTO mode), or
  - Selected azimuth (in AZIM mode).



<u>Note</u>: The A350 also has a reactive windshear protection.

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Traffic Collision Avoidance System (TCAS)

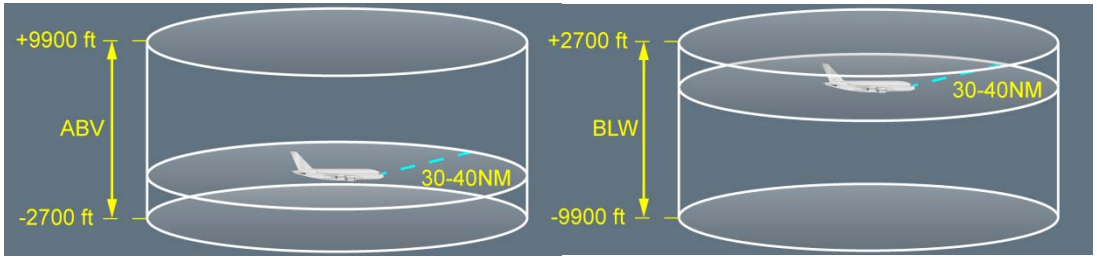
The main TCAS functions are:

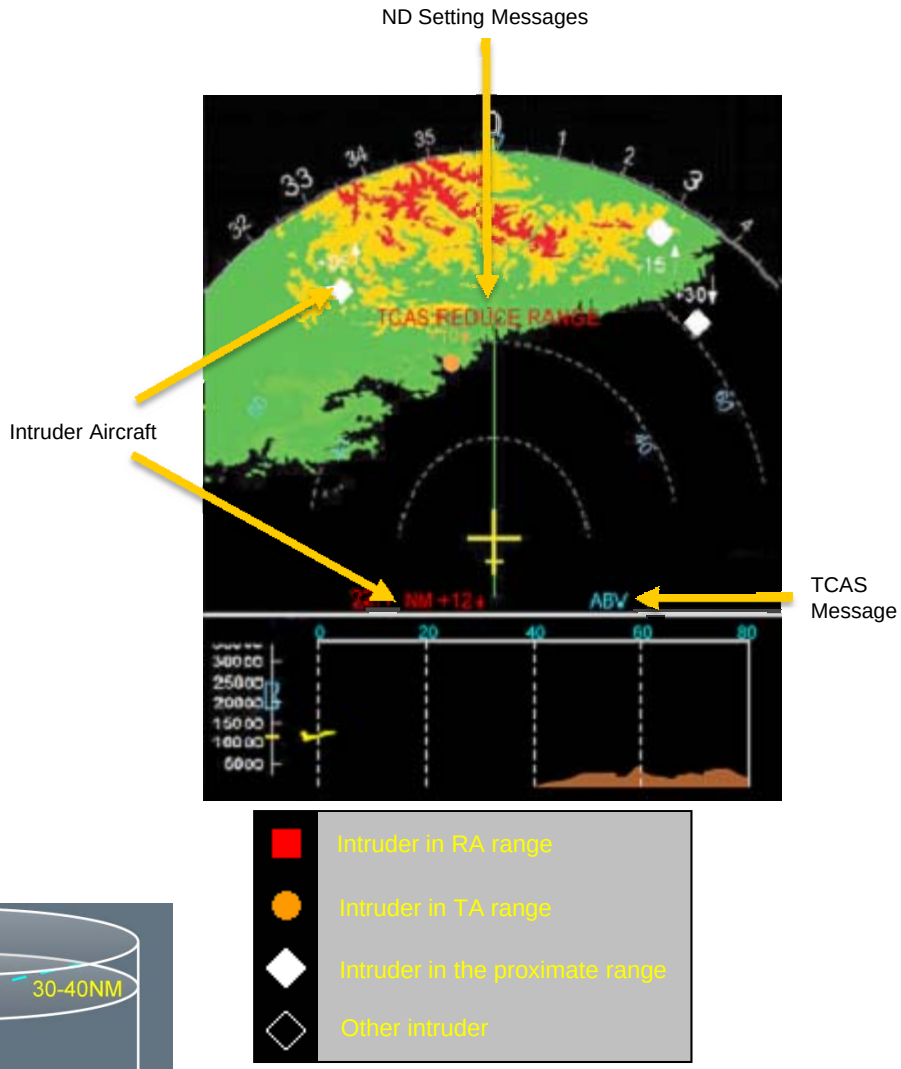
- Traffic active surveillance
- Traffic collision avoidance
- Display of Automatic Dependent Surveillance Broadcast (ADS-B) traffic for improved situational awareness (ATSAW)
- Event recording.

The **Navigation Displays (NDs)** show the TCAS information. The **Primary Flight Displays (PFDs)** show TCAS Resolution Advisory information.

On the ND, the TCAS displays traffic that is within a volume of space around the aircraft:

- In normal selection, the upper and lower boundaries of this volume are set to +2 700 ft and -2 700 ft
- In manual selection, the flight crew can choose between two displays: Above (ABV) or Below (BLW).





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AP/FD TCAS

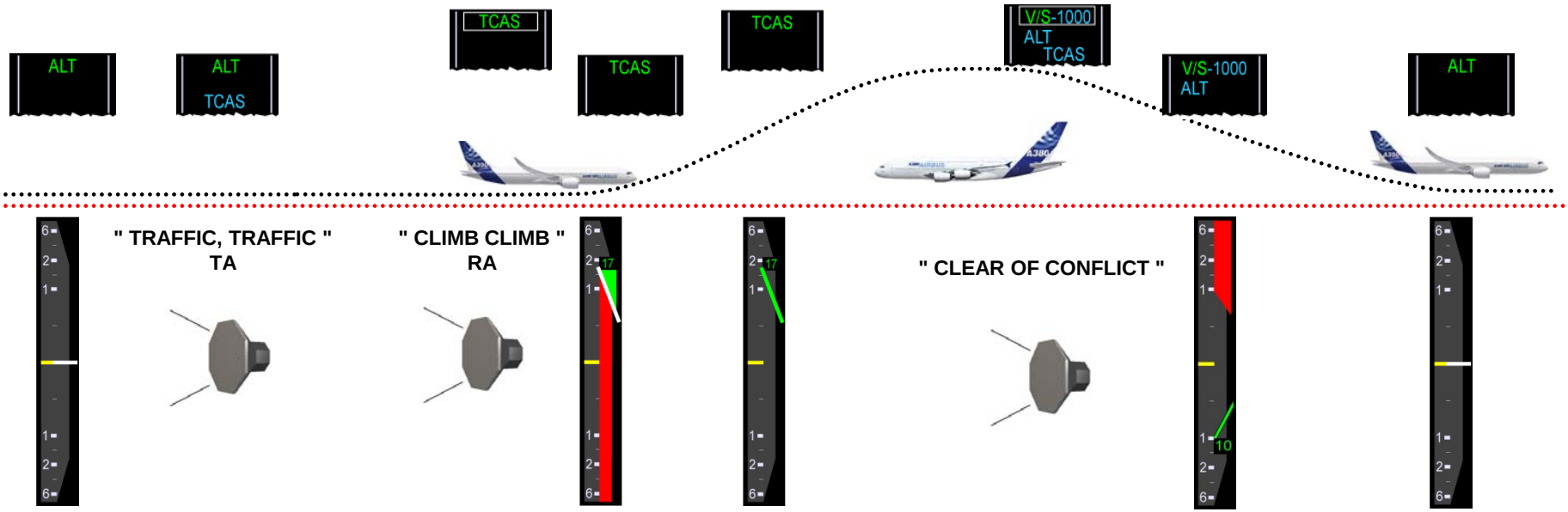
The AP/FD TCAS mode is an AP/FD vertical mode that provides vertical guidance in the case of a TCAS Resolution Advisory alert. This mode:

- Provides the pilot with clear flying orders adapted to each TCAS Resolution Advisory in addition to the TCAS aural and visual alerts
- Avoids the potential opposite or over-reactions to the RA
- Enables to minimize the deviations from the initial ATC clearance during the RA.

The AP/FD TCAS mode automatically arms if a Traffic Advisory is triggered.

When a Resolution Advisory is triggered:

- The AP/FD TCAS **automatically** performs the avoidance manoeuvre if the Auto Pilot is engaged
- In the case both APs and FDs are disengaged, the FDs automatically engage. The flight crew manually executes the avoidance manoeuvre by following the FD bars.



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Aircraft Traffic Situation Awareness (ATSAW)

The ATSAW (optional) is based on the display of:

- Traffic information that comes from the ADS-B OUT, and
- Suitable information taking into account the operational context and the different phases of flight, piloting tasks, and flight crew workload.

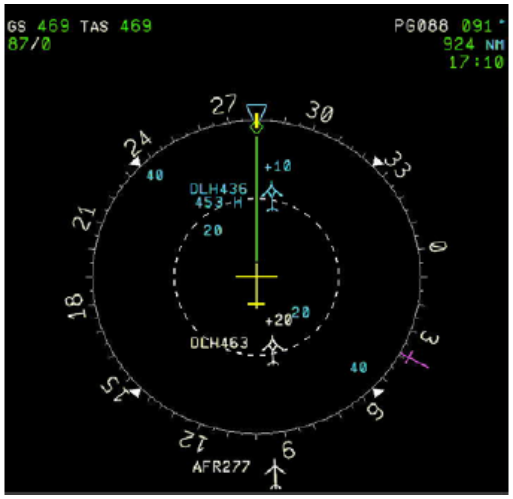
Four applications use the ATSAW information:

- ATSA-AIRB: to improve situational awareness during airborne operations

- ATSA-VSA: to support visual acquisition and to maintain visual contact and separation with the preceding aircraft during approach

- ATSA-ITP: to enable flying at an optimum flight level, through more frequent altitude changes. The flight crew will be able to detect if an opportunity to climb exists, and thus optimize their flight level. Flying at an optimum flight level brings significant fuel savings

- ATSA-SURF: to improve situational awareness, during surface operations (taxi, takeoff, landing). The application displays on the airport moving map all the traffic and aircraft/vehicles information (future evolution).



AIRB:	Airborne
VSA:	Visual Separation Approach
ITP:	In Trail Procedure
SURF:	Surface

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Terrain Awareness and Warning System (TAWS) and Vertical Display (VD)

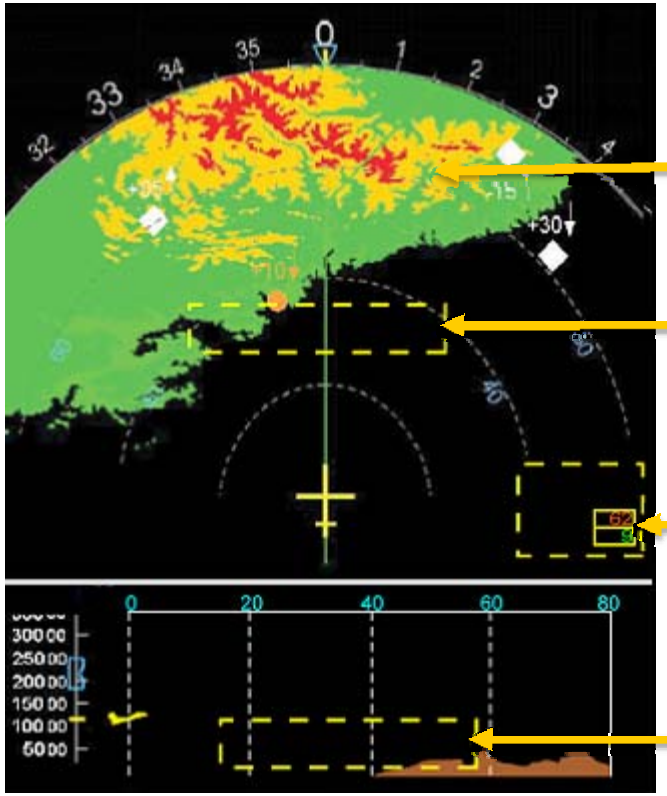
The TAWS provides both horizontal and vertical background terrain images respectively on the Navigation Display and the Vertical Display.

The purpose of the TAWS is to:

- Detect terrain collision threats
- Display terrain information
- Trigger applicable aural and visual alerts.

The TAWS provides a:

- Basic ground proximity warning (GPWS Modes 1 to 5)
- Terrain (TERR) and obstacle function awareness, alert and a display function that includes:
  - Horizontal profile terrain displays
  - Vertical profile terrain displays
- Database that includes:
  - A terrain database
  - An obstacle database that can be enriched with man-made obstacles
  - A runway database that contains all hard surface runways worldwide that are at least 3 500 ft long
  - An envelope modulation database which is used to adapt TAWS alert/warning protections to specific areas in the world.



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Ground Proximity Warning System (GPWS)

The purpose of the GPWS function is to warn the flight crew of potentially hazardous situations, such as a collision with terrain.

The GPWS function detects terrain collision threats by comparing the geometric altitude of the aircraft and its trajectory with the information provided by the Radio Altimeters (RAs).

The Terrain (TERR) Function

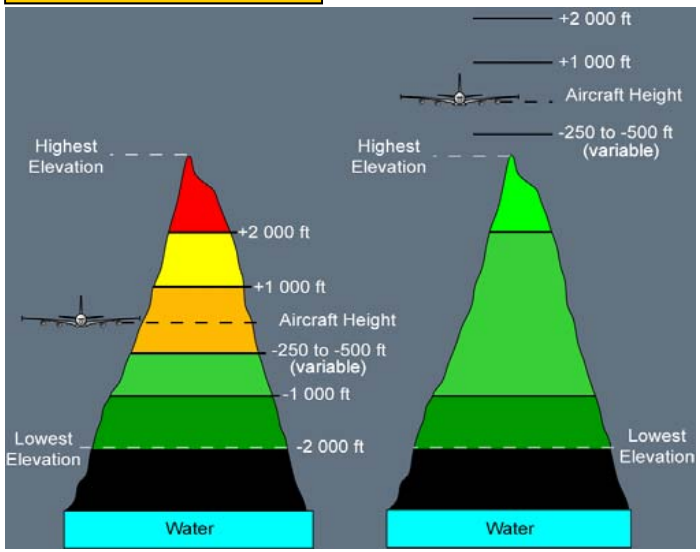
The TERR function provides displays and alerts, based on the comparison between the current aircraft position and a worldwide terrain database. It displays a horizontal and vertical view of the terrain on respectively the Navigation Displays and the Vertical Displays.

The TERR protection features two modes:

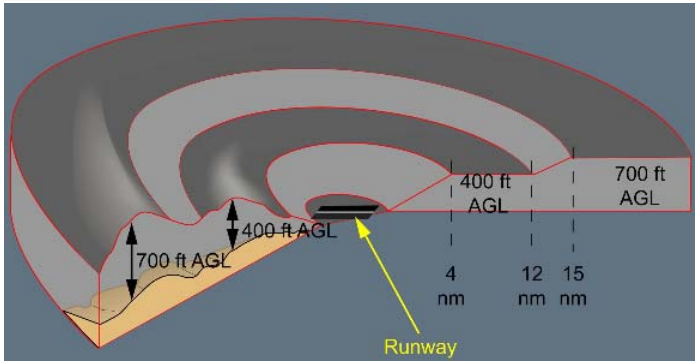
- A Terrain / obstacle Awareness and Display (TAD) that computes a caution and a warning envelope ahead of the aircraft

- The Terrain Clearance Function (TCF) that provides alerts based on insufficient terrain clearance even when in landing configuration.

ND Terrain code color



TCF envelope



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Controls and Indicators

EFIS Control Panel

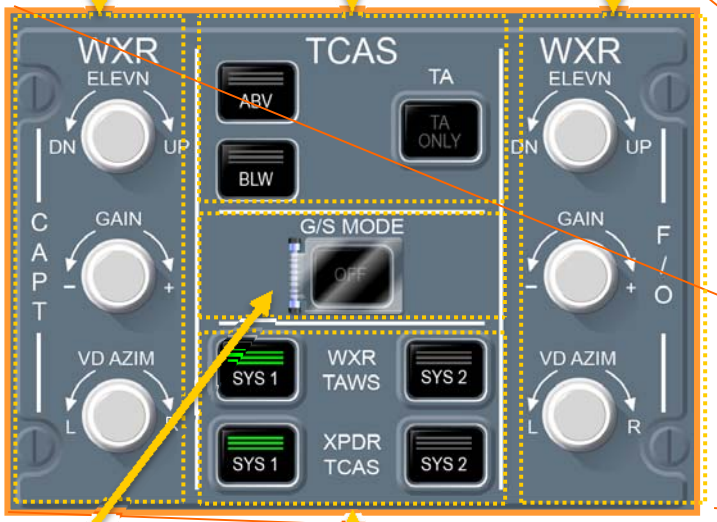
SURV Data Display Selection

ZOOM knob

WXR Display Controls CPT Side

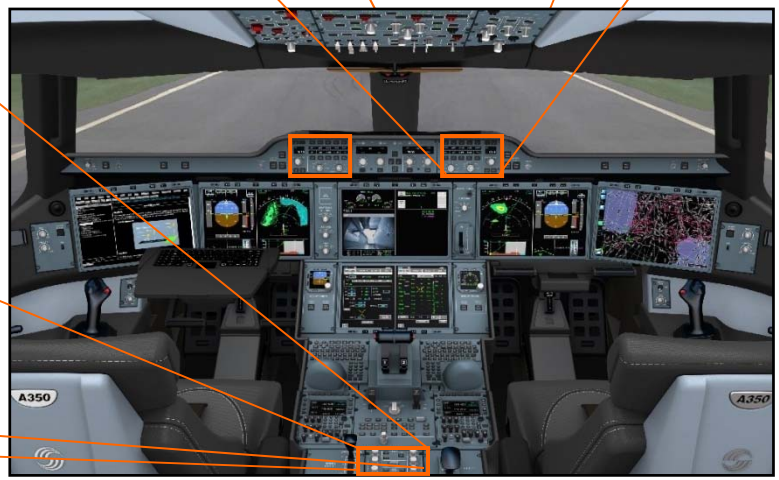
TCAS Display Controls

WXR Display Controls F/O Side



TAWS Glide Slope ON/OFF

SURV Systems Selection



SURV Panel

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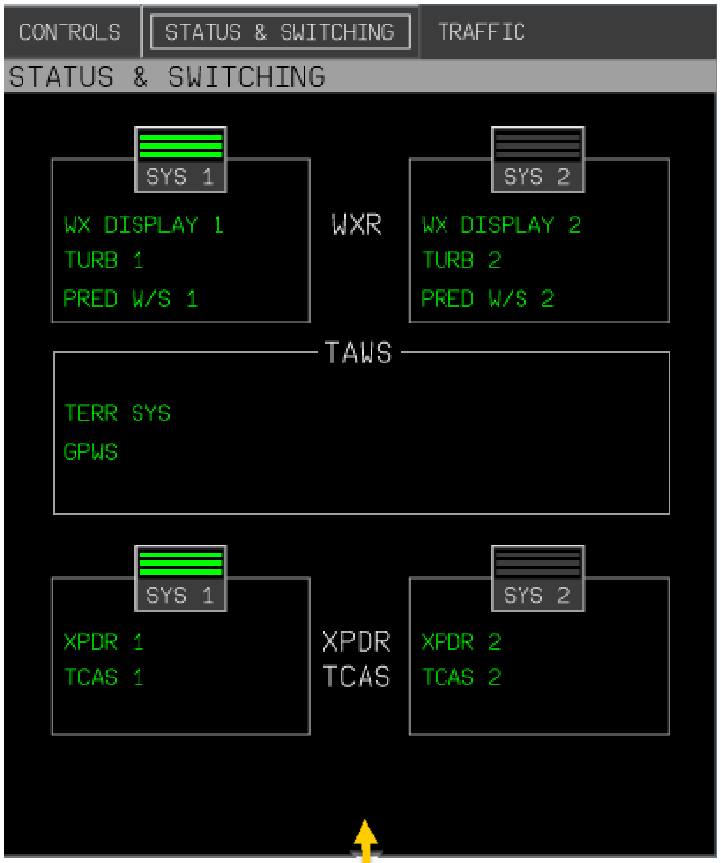
MFD SURV Page

Backup for SURV Control Panel
Additional System Switching Selections



Systems
Selection and Status

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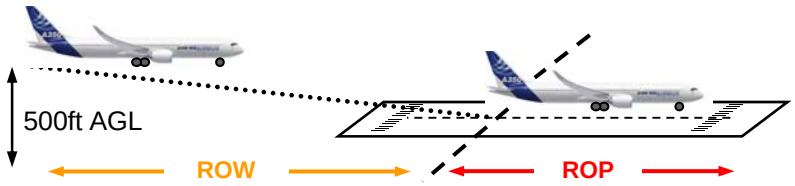
Runway Overrun Warning (ROW)
Runway Overrun Protection (ROP)

The objective of the ROW and ROP functions is to minimize the risk of runway overrun at landing. The ROW and ROP are available at landing.

In addition, if the BTV is selected, the Onboard Airport Navigation System displays a line that indicates the stop point. This line moves in real time below 500 ft and turns red if a potential runway end overrun is detected.



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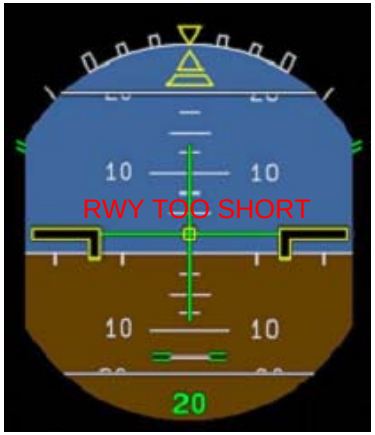
Runway end Overrun Warning (ROW)

The ROW function computes in real time the required DRY and WET landing distances during the short final.

The objective of the ROW function is to enhance the pilot situation awareness during the approach and to encourage either:

- To perform a Go Around, or
- To correct the flight parameters (speed, V/S…)

If the predicted braking distances overrun the remaining runway length, the here below alerts are triggered.



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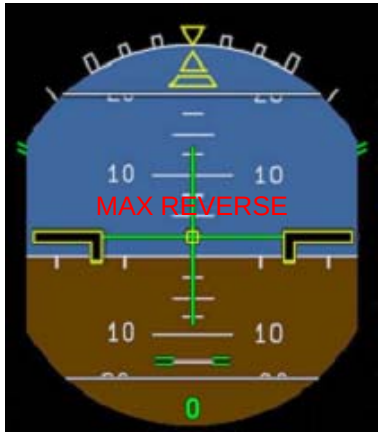
"RWY TOO SHORT"

Runway end Overrun Protection (ROP)

The ROP function arms as soon as the autobrake is active (e.g. at Nose L/G touchdown or five second after Main L/G touchdown). It can also be armed manually.
If a runway end overrun is detected and confirmed by the system, ROP activates. ROP commands the maximum braking (equivalent to RTO mode). In addition, the "MAX REVERSE" and "KEEP MAX REVERSE" alerts flash on PFD with the associated aural alerts.
If maximum braking is no longer necessary, ROP reverts to the braking level of the selected autobrake mode.



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"MAX REVERSE"
"KEEP MAX REVERSE"

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System Description

The Onboard Airport Navigation System (Airport Nav) provides the flight crew with a moving airport map.

The Airport Nav is designed to improve the flight crew awareness of airport surfaces.

The Airport Nav generates the airport navigation image using:

- Airport data stored in the airport database
- Aircraft data mainly from the FMS and the ADIRS
- Flight crew data entries.

The Airport Nav can also be associated with a Runway Proximity Advisory system to further improve the flight crew awareness during taxi phases.

The function displays the aircraft position superimposed on the airport map on the **Navigation Display**.

The Airport Nav can also display traffic of other aircrafts on the airport.

The flight crew uses the Keyboard and Cursor Control Unit (KCCU) to interact with the airport map.

*<u>Note</u>: The ROW and ROP (refer to **Landing Gear**) use the Airport Nav database.*

Caption:

Own aircraft

Other traffic

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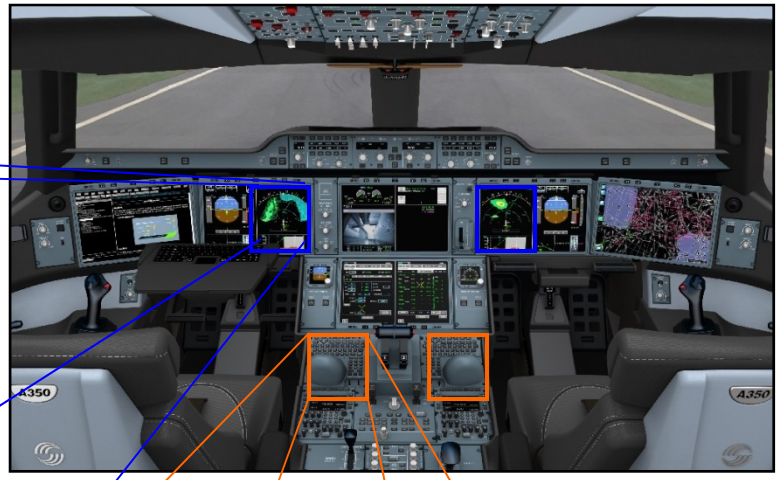
Controls and Indicators

Airport Nav Map on ND (NAV mode)



KCCU

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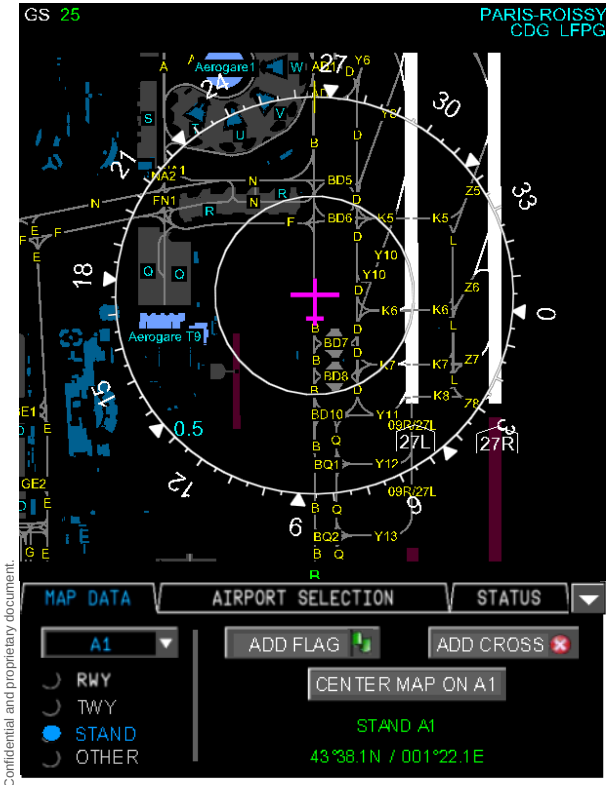
Controls and Indicators

ROSE mode



ARC mode

PLAN mode

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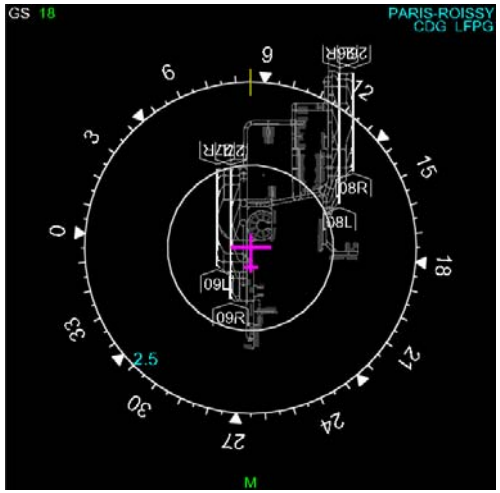
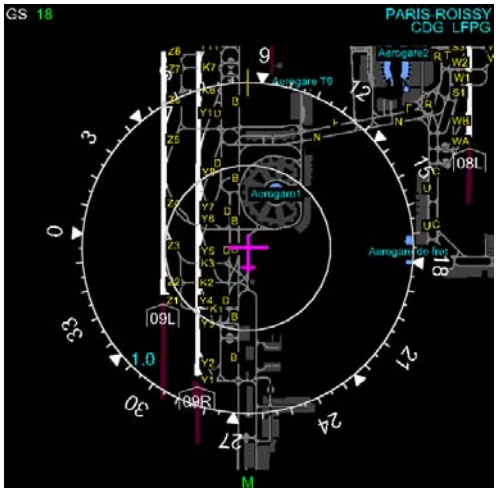
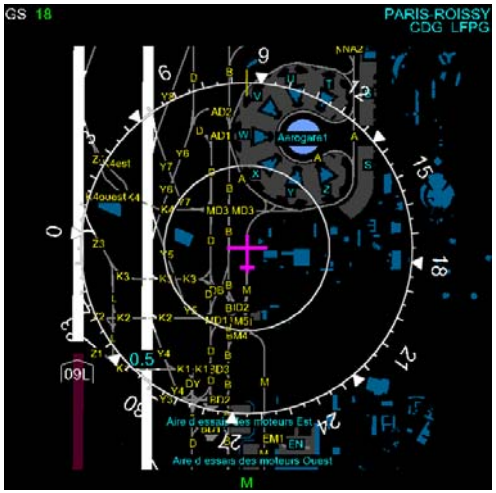


ROSE 5 NM

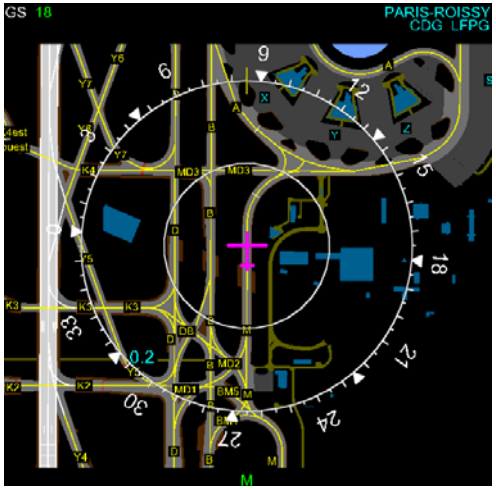


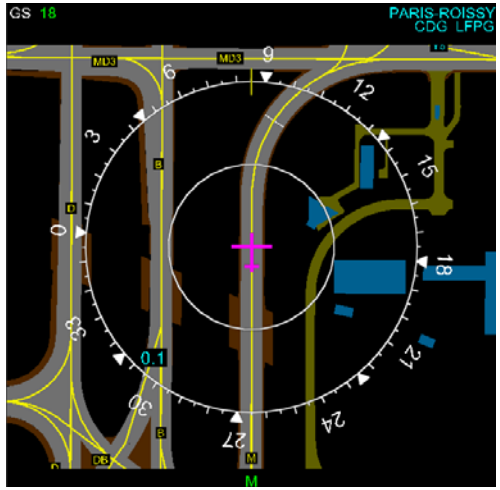
ROSE 2 NM



ROSE 1 NM

ROSE
0.5 NM





ROSE
0.2 NM

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CPDLC (Controller/Pilot Datalink Communication) Ground Clearance on Airport Nav

The combination of the CPDLC Ground Clearance and the Airport Nav provides an assistance to guide the aircraft to taxi:

- From the parking stand (gate) to the runway holding point before take-off (TAXI OUT)
- From the runway exit point (after landing) to the parking stand (gate) (TAXI IN).

The CPDLC application enables to construct, send, and receive the ground clearance message.

Before acknowledgement

After acknowledgement

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Runway Proximity Advisory (RPA)

The purpose of the RPA is to:

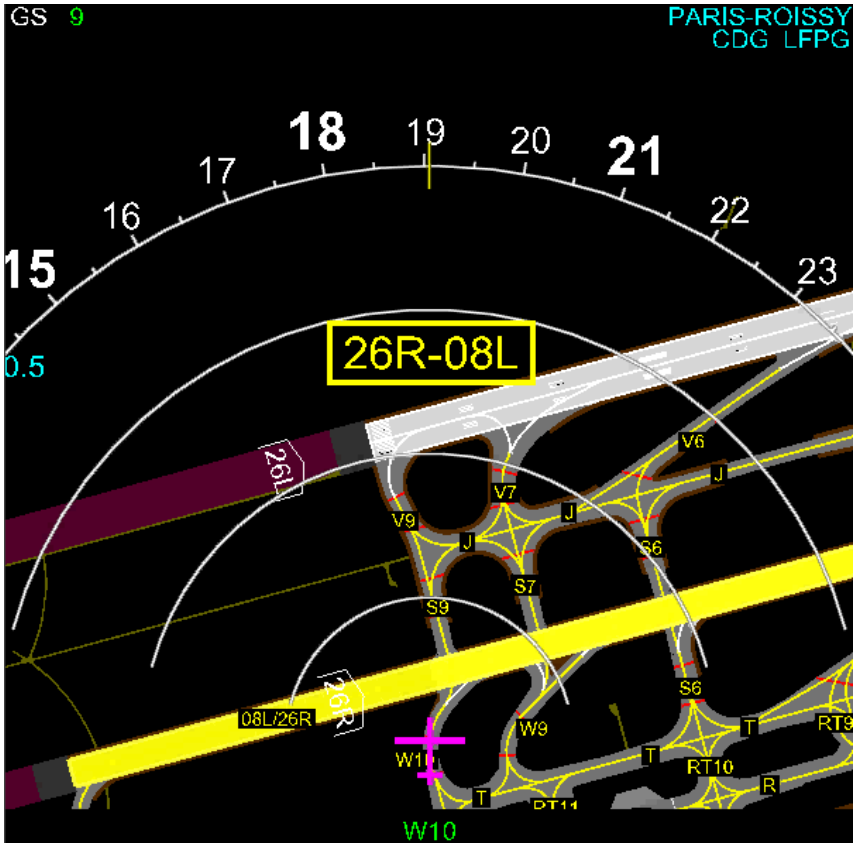
- Reduce the risk of runway incursions and thus, to reduce the risk of ground collision
- Improve runway situational awareness.

In order to reinforce the pilot attention, when the aircraft approaches a runway:

- The runway name pulses
- The runway flashes on the airport map

This visual advisory is triggered **7 seconds before aircraft entry in the runway area** (60 m around the runway in use).

Note: There is no aural advisory but the message is also displayed on the PFD screen and on the ETACS video if it is displayed on the PFD.



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