



Anne-Marie BELLEVILLE  
Airport Navigation and FMS Project leader

## Airport Navigation

ISAE - 1MAE208 - CONTROL &  
GUIDANCE

January 27<sup>th</sup> 2020

**Airport Navigation** provides the crew **with situational awareness** during **surface operations**.

- Airport Moving Map
- Approaching Runway Advisory
- Take off Securing

**Airport Navigation** also provides **pilot interface** on Navigation display for

- Runway Overrun Protection System
- Brake To Vacate

# Airport Moving Map

# Airport Navigation - introduction

Everyday issues met by the pilots during taxi phase

- Low visibility :

- Reflection on wet surfaces
- Flash of the sun

Reflection in the rain at night



- Non nominal airport configuration :

- Downgraded or failed ground system
  - radar
  - lights
  - Construction on the airport



Dazzling & Flash of the sun



# Airport Navigation - introduction

- Consequences



# Airport Navigation - introduction

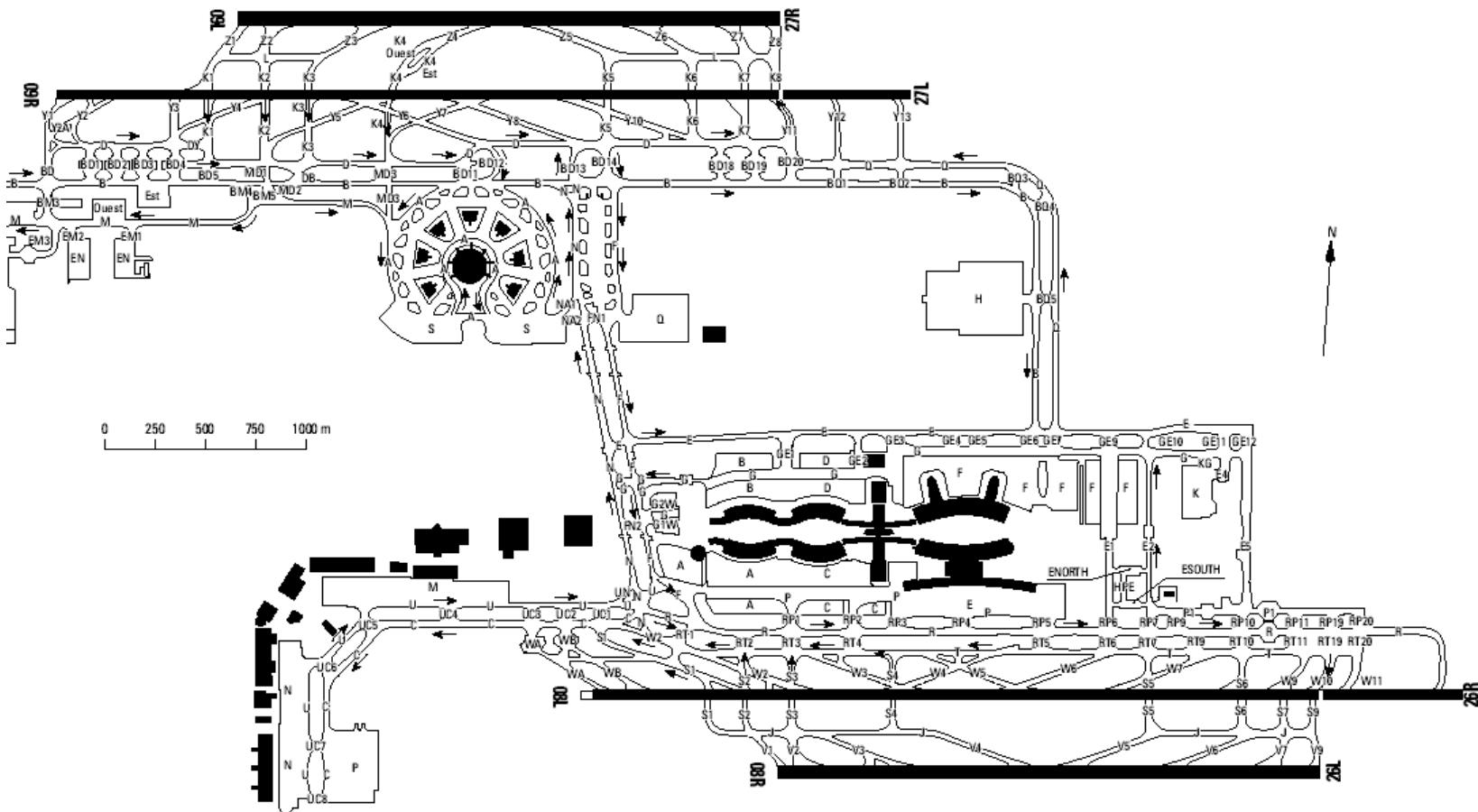
South Africa Hoedspruit (South Africa) - 9th Feb 2014, 02:06

Erroneous taxi lead the crew to a dead end taxiway → attempt at U turn ended in the grass



# Airport Navigation - introduction

## Complex airport → Example of CDG



# Airport Navigation - introduction

## Confusing crossing

### Example of Hotspot Map

**Not for operational use**

Confusing Taxiway crossing of the Runway.

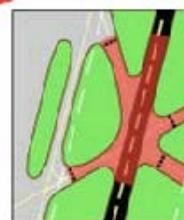


Brussels National Airport

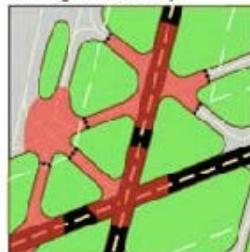
B1. Confusing Runway entry.  
Make sure you are lining up  
on the correct Runway.



B3 and E6. Make sure  
not to cross the holding  
position markings  
without a clearance.



Confusing Taxiway  
crossing of the Runway.



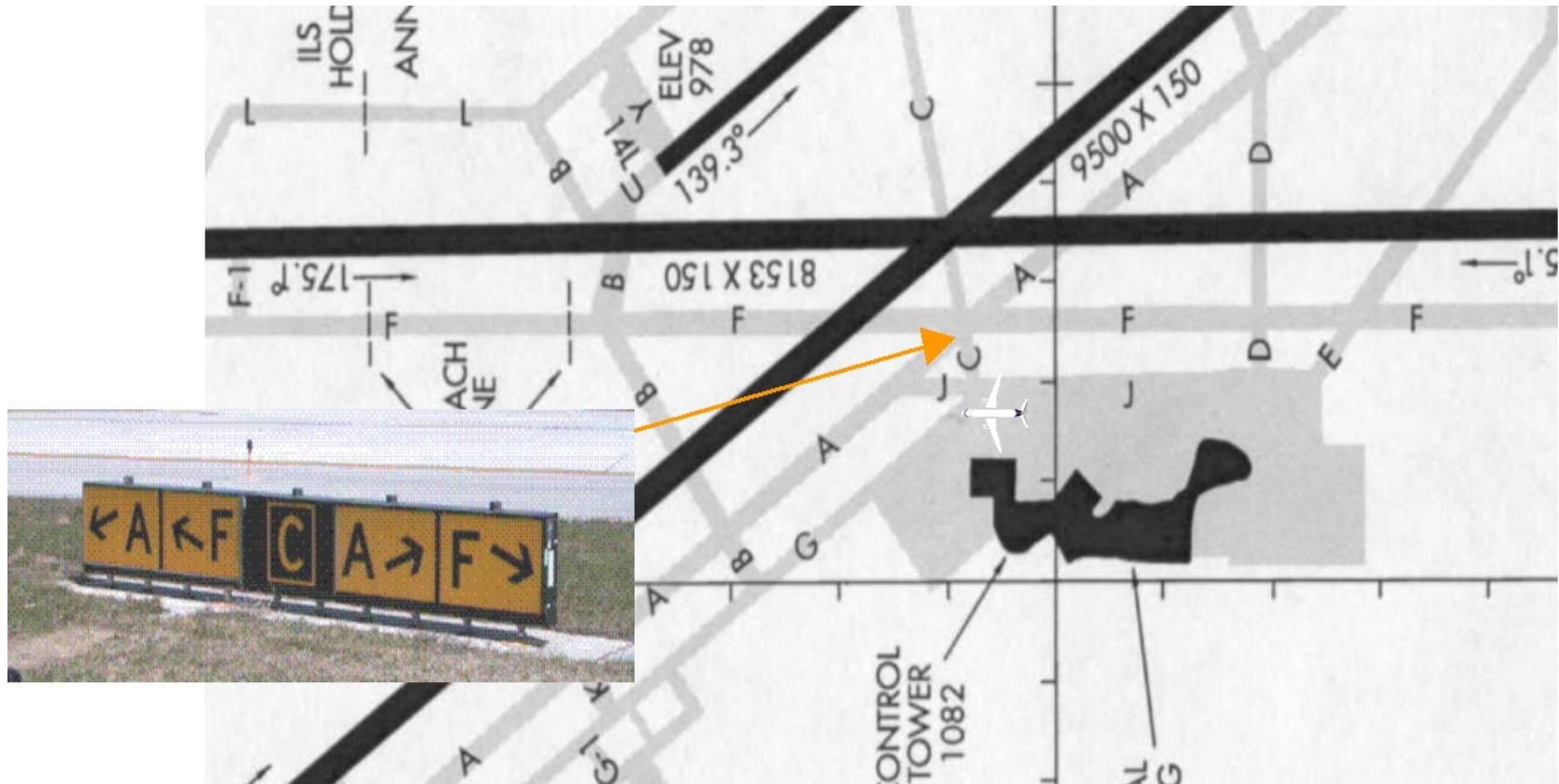
**Explicit RWY crossing clearance required.**

DGA/74487/CL-12E (08) - 27.02.03



# Airport Navigation - introduction

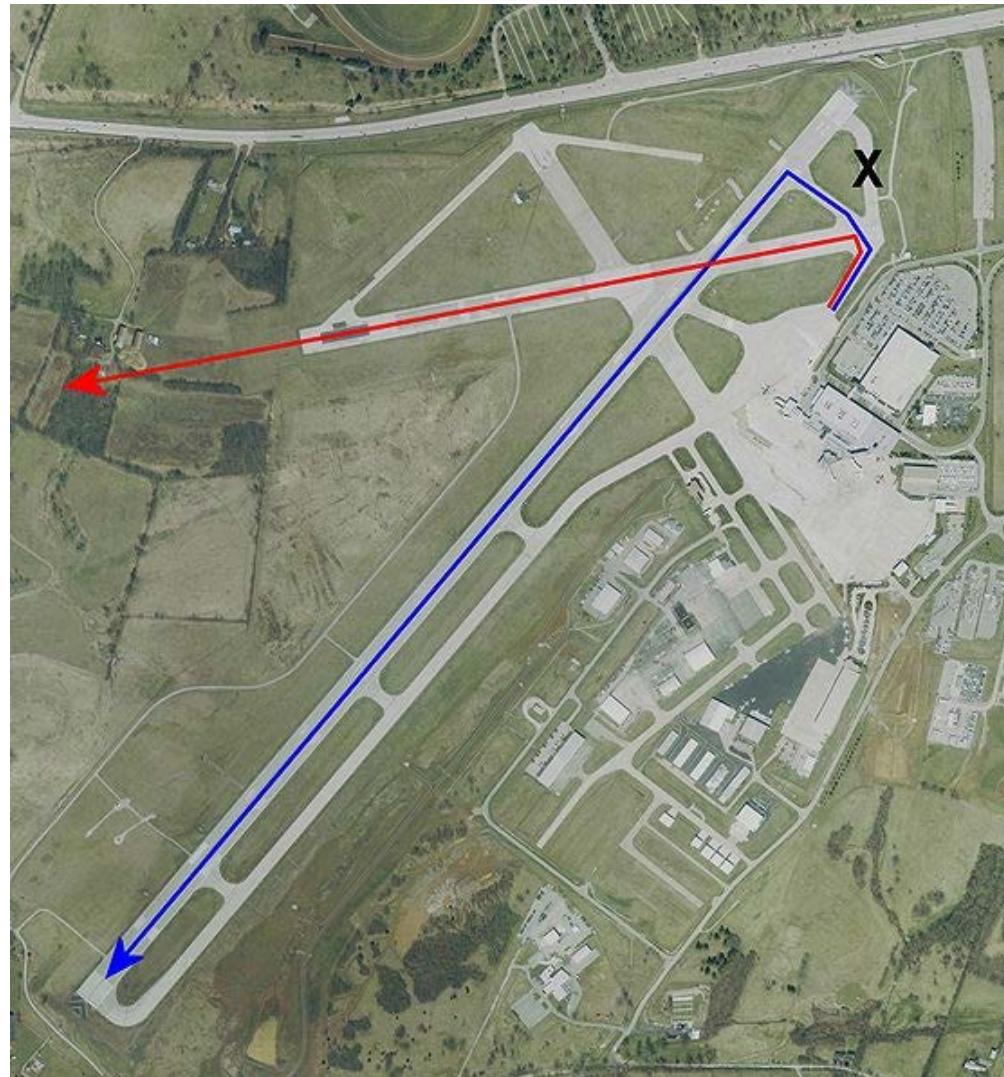
## Relation between Outside marking & Map



# Airport Navigation - introduction

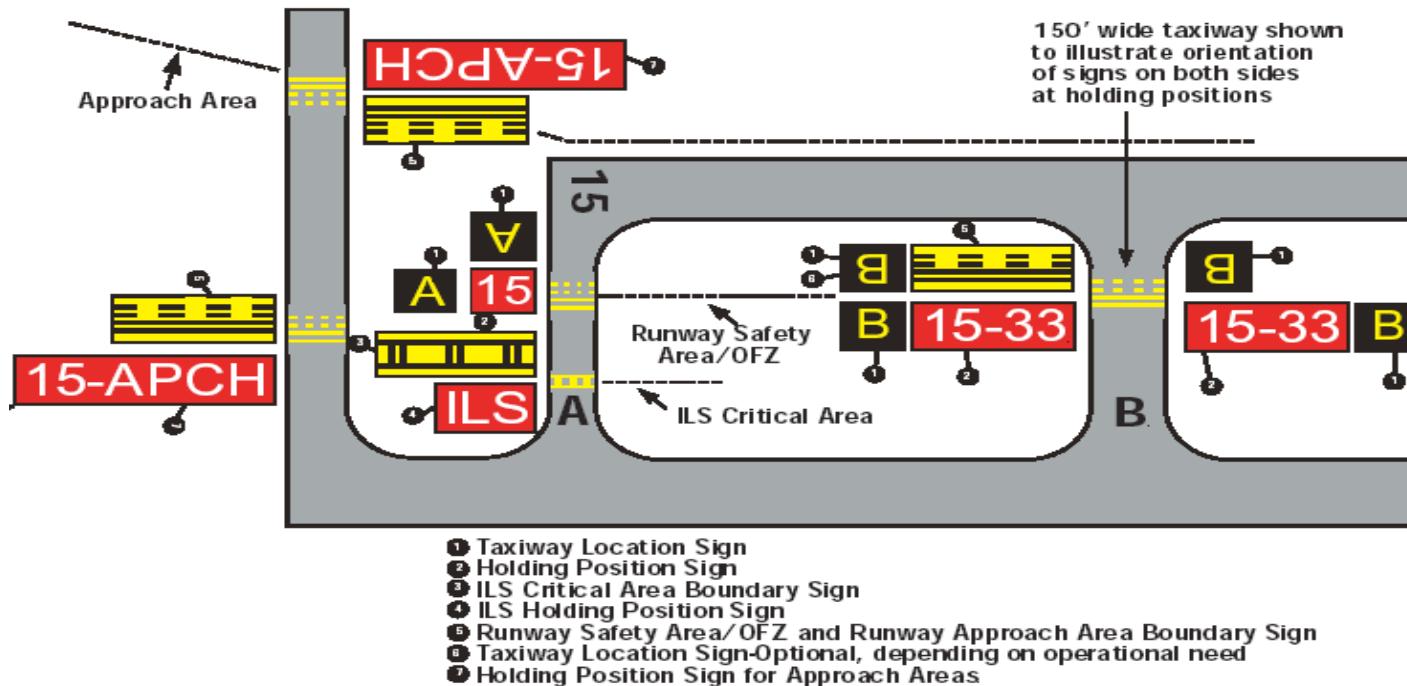
## Example of runway confusion

- Aug 2006 : runway confusion leads to loss of a Bombardier Regional Jet attempting take off from Blue Grass Airport, Lexington, USA.
- The aircraft was assigned the airport's runway 22 for the takeoff, but used runway 26 instead. Runway 26 was too short for a safe takeoff.



# Airport Navigation - introduction

## Abundance of marking, lights & signs



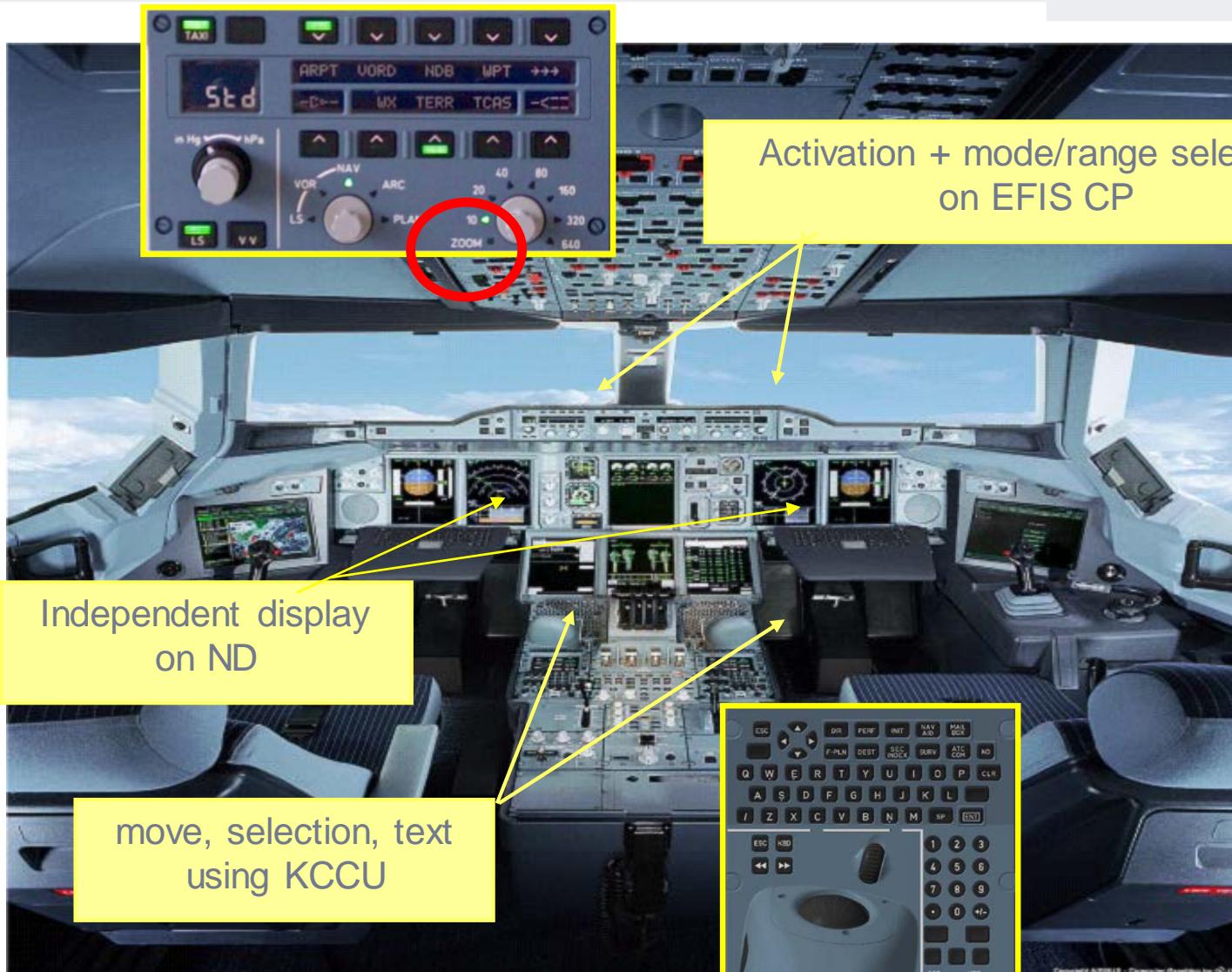
# Airport Navigation - introduction

→ **Airport Navigation answer:** display of an Airport Map with Aircraft position providing the flight crew with improved situational awareness on the airport surface.

In order to :

- Improve operational efficiency during taxi phase
  - Reduce pilot workload in the day-to-day task of navigating around complex airfields
  - Reduce taxiing time
- Contribute to improve safety on airports which become more complex and busy
  - Contribute to potentially reduce taxiing incidents
  - To help prevent dangerous errors in surface navigation
  - Reduce Runway Incursion occurrence

# OANS implementation – Airbus A380 and A350



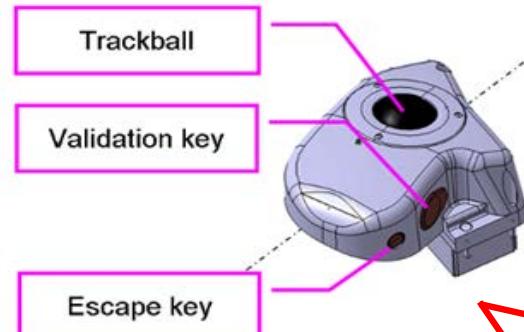
1 OANC in  
avionics bay  
(A380)

Software hosted  
in Display Units  
(A350)

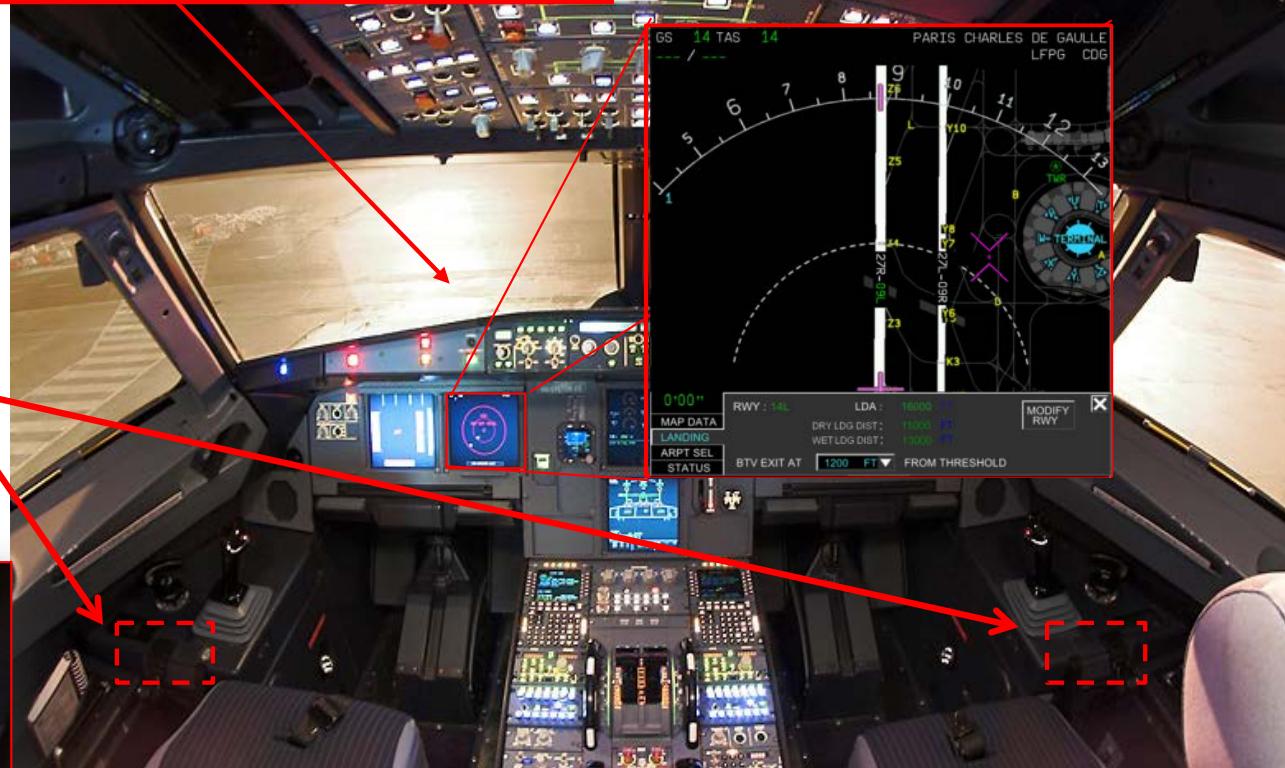
Supplier : Thales

# OANS implementation – Airbus A320 family and A330/A340

Activation + mode/range selection  
on EFIS CP



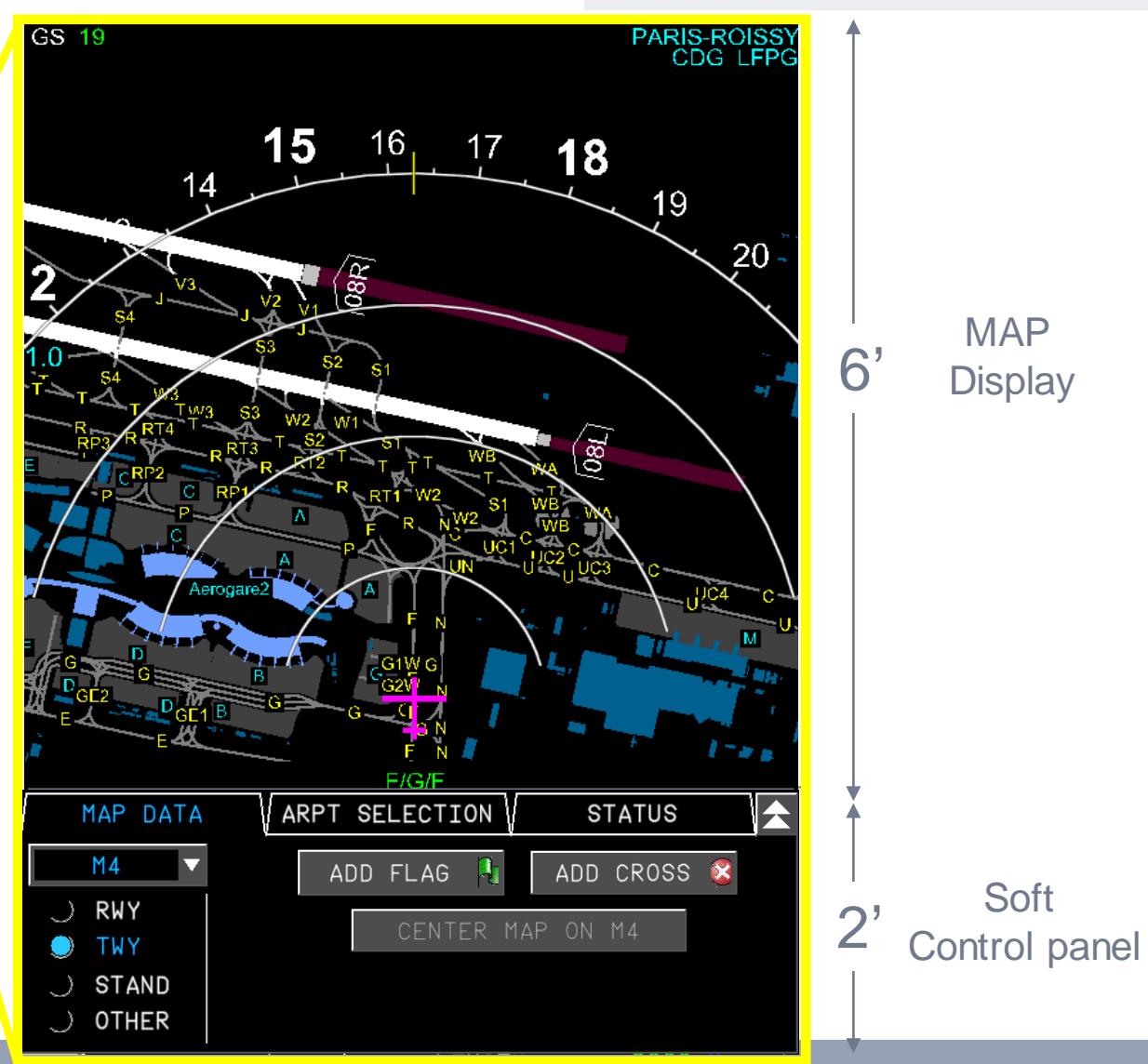
CCD (designator)



1 OANC in avionics bay - Supplier : Thales

# OANS – Function Description

On Navigation  
Display



# OANS – Function Description

## EFIS Control panel

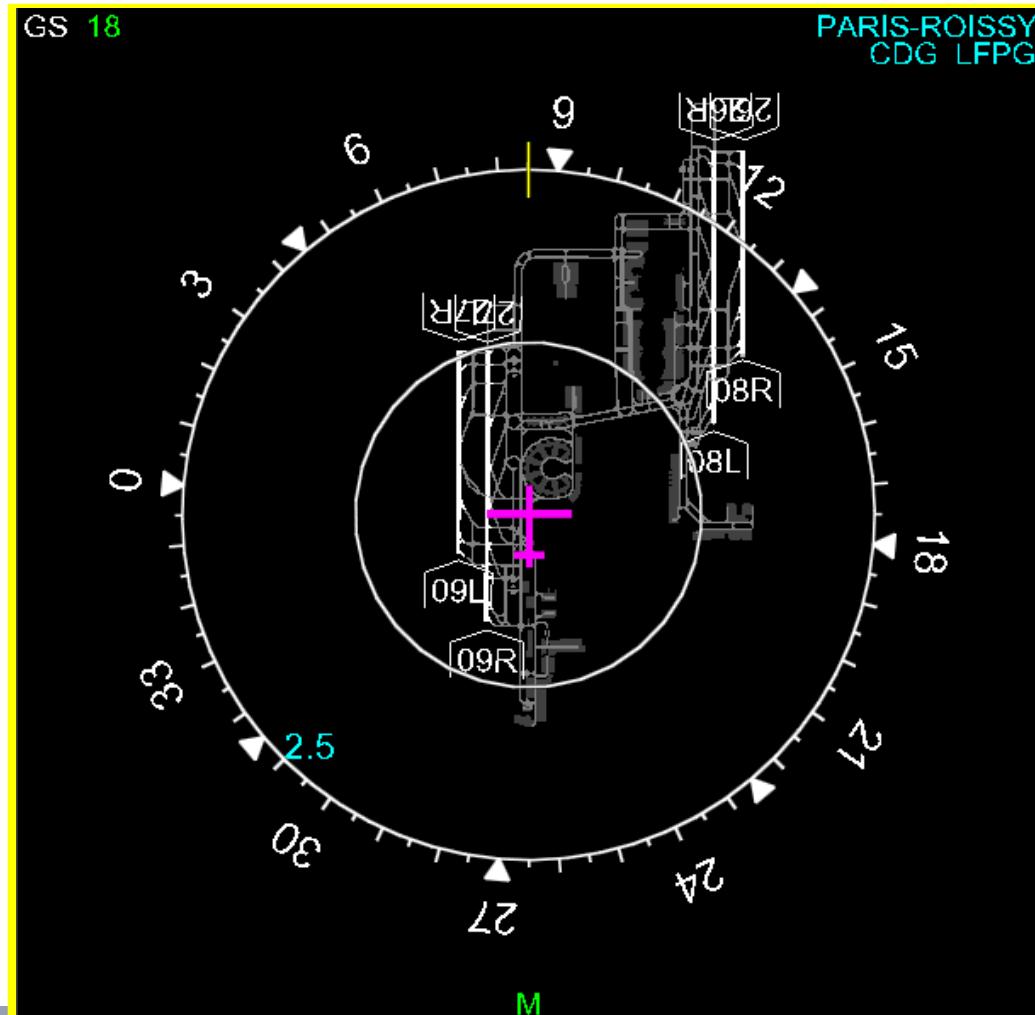
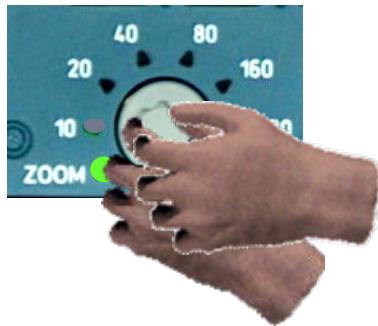


KCCU



- To activate the function
- select ZOOM
- Select Ranges
  - 5 Nm, 2Nm, 1Nm, 0.5 Nm, 0.2 Nm
- Select Modes
  - ARC, ROSE, PLAN
- ▶ To move cursor on the map
- ▶ To select an element on the map
- ▶ To Add/Remove markers
- ▶ To Move the MAP
  - PLAN Mode “Move & Stay”
    - The map stays at cursor position
  - ARC & ROSE “Elastic device”
    - The map moves but does not stay at cursor position, as soon as CCD click button is released the map automatically goes back to normal A/C centered position.
- ▶ To input text ( for search feature)

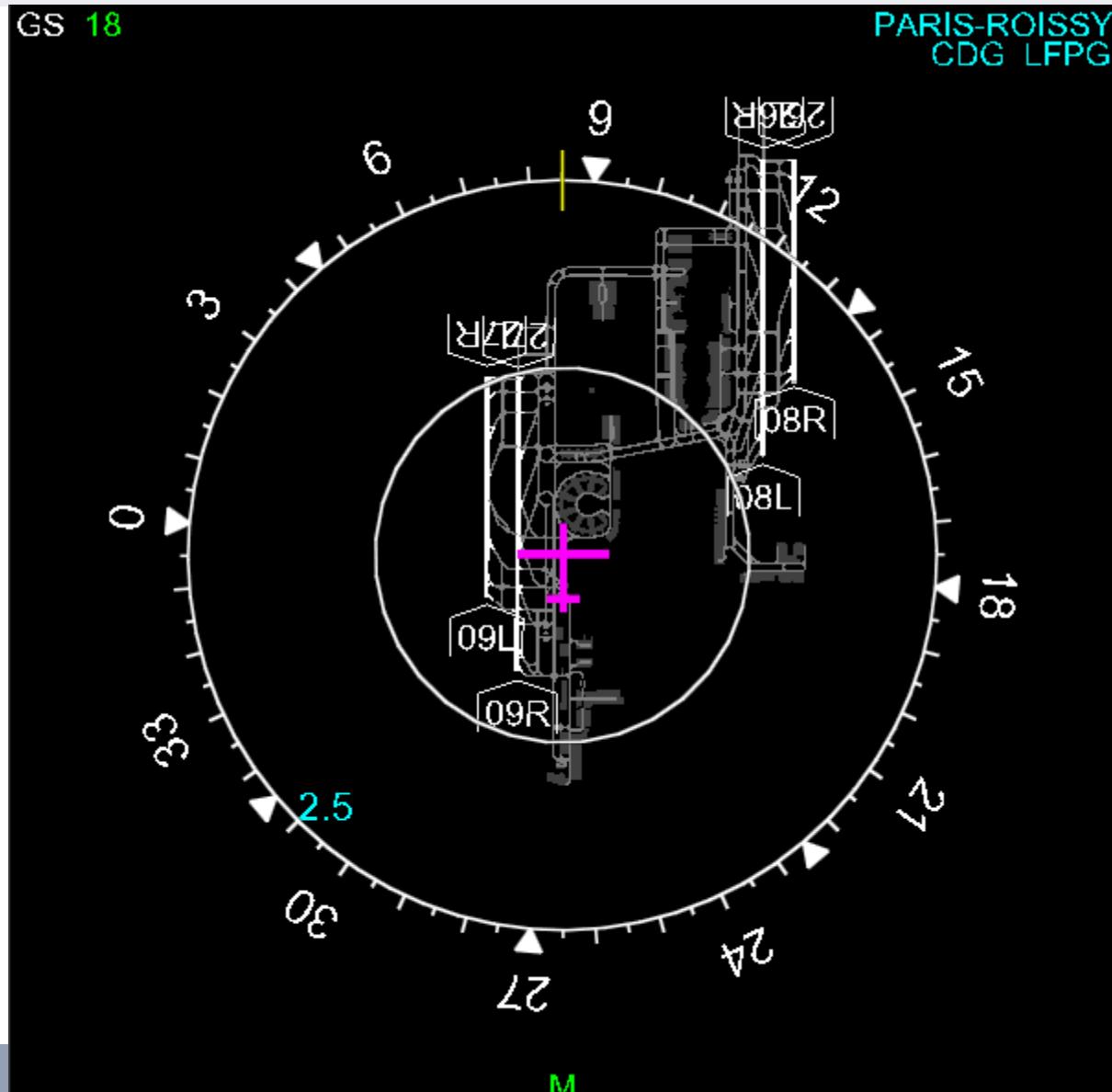
# OANS – Function Description



# OANS – Function Description



ROSE mode  
5 NM

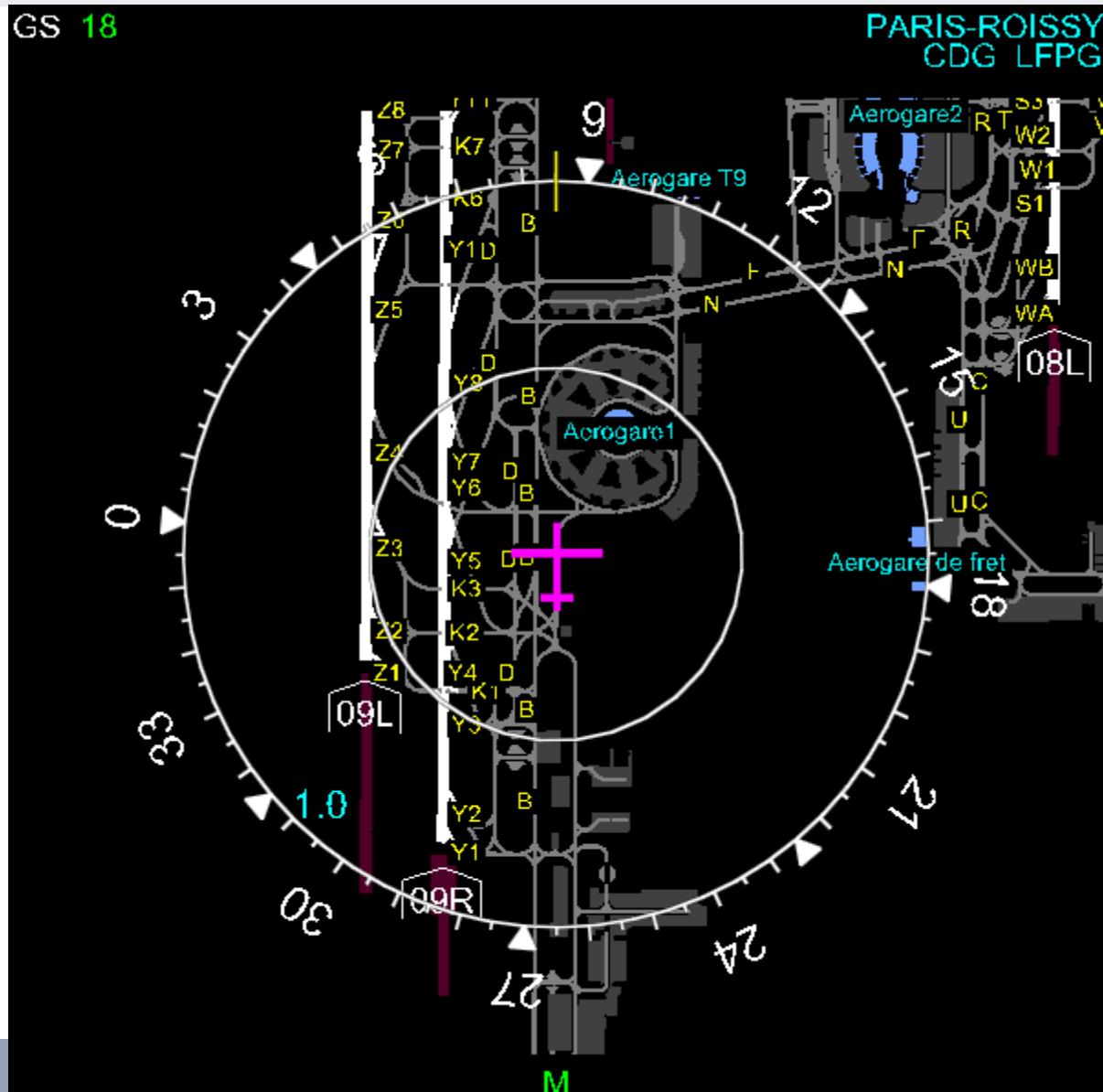


# OANS – Function Description



# ROSE mode

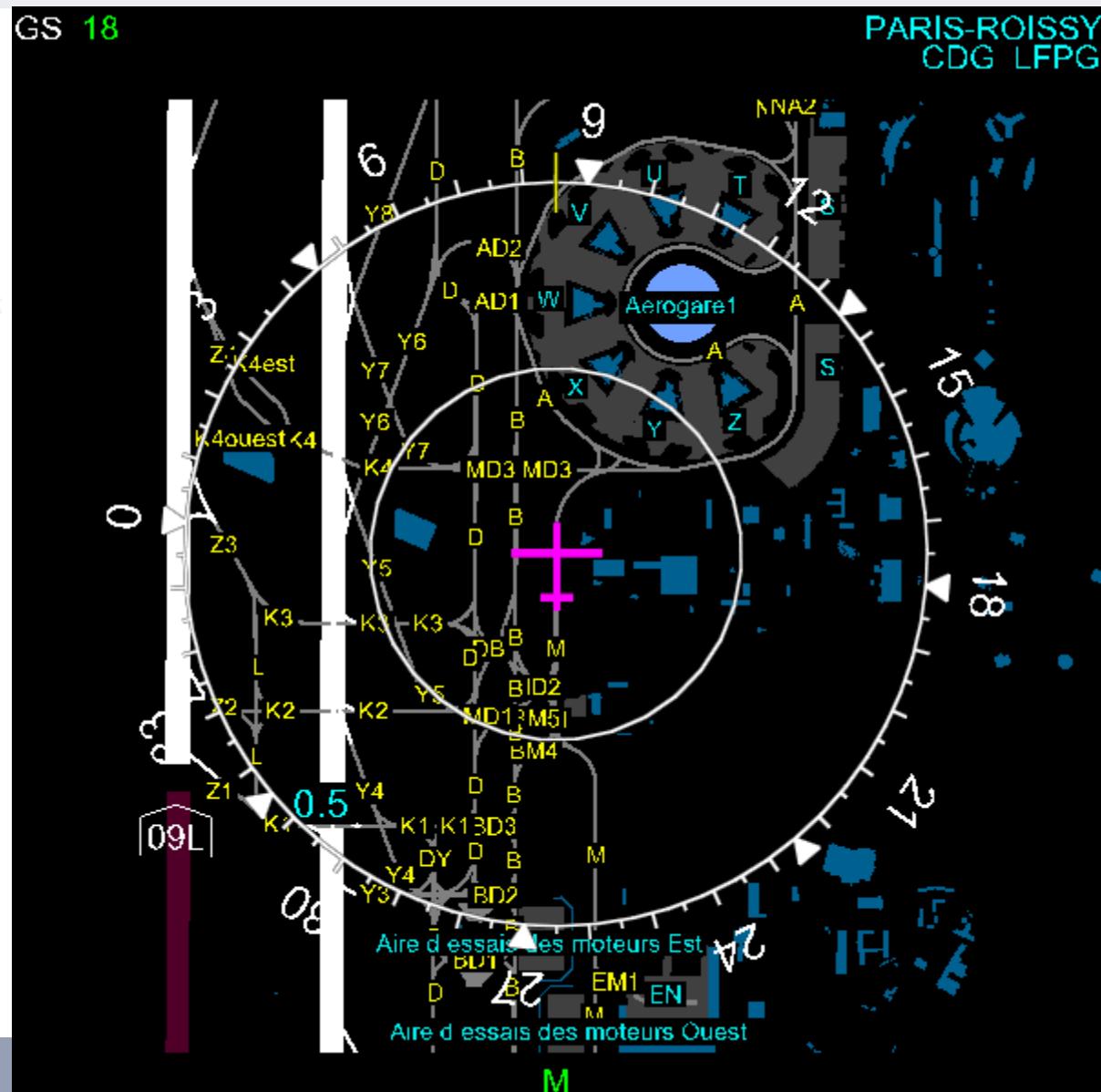
## 2 NM



# OANS – Function Description



ROSE mode  
1 NM

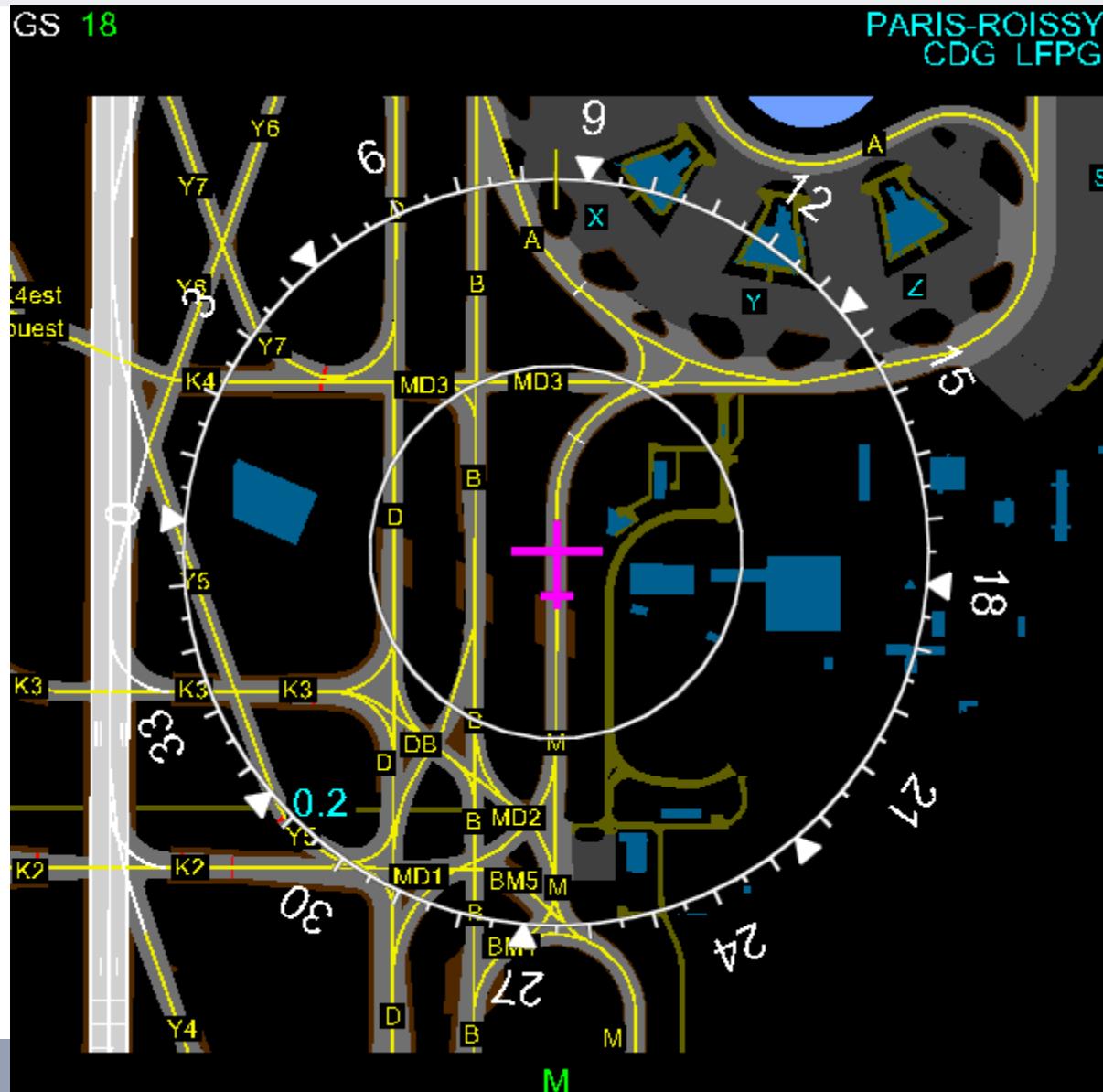


# OANS – Function Description



# ROSE mode

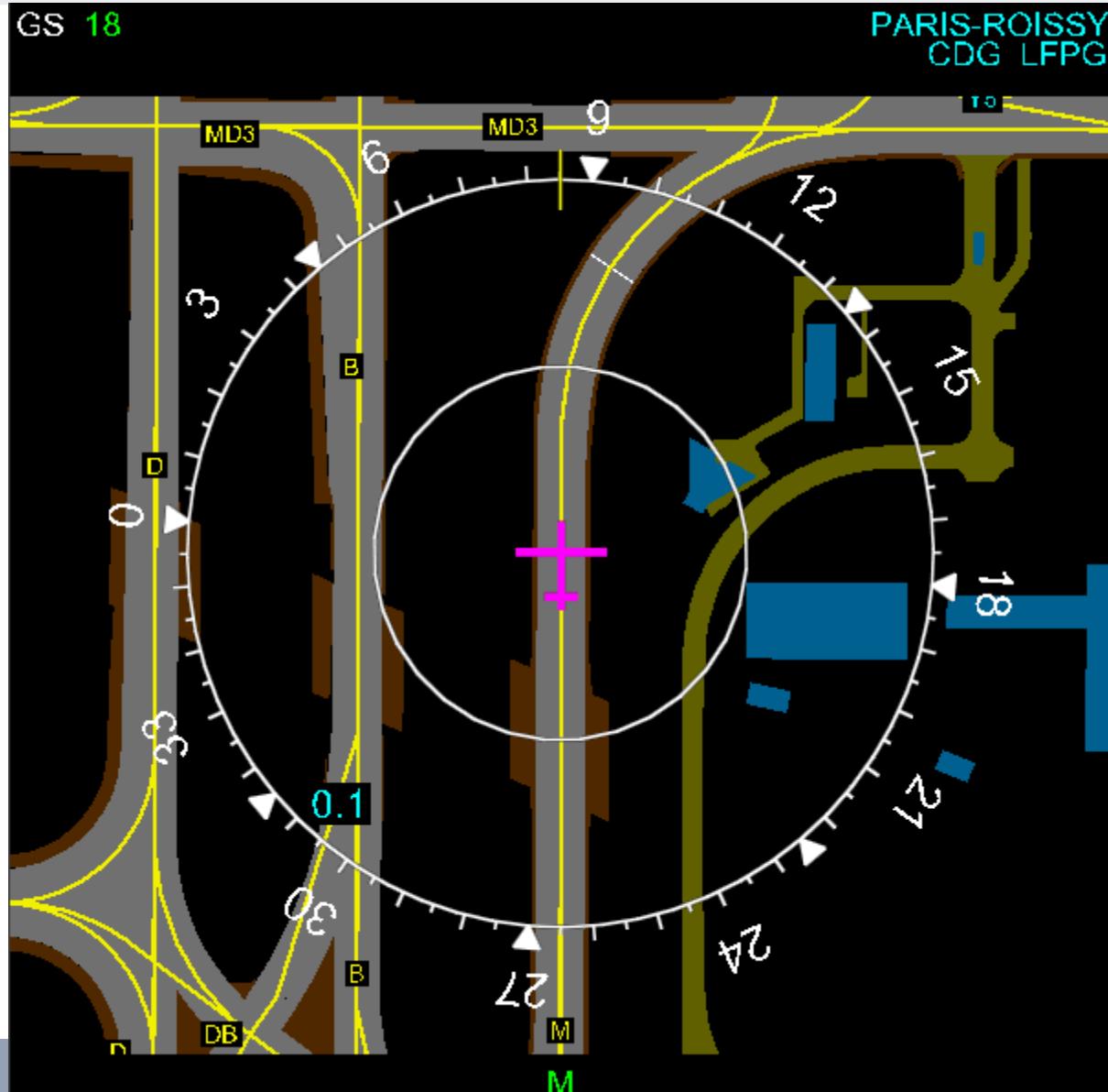
## 0.5 NM



# OANS – Function Description



ROSE mode  
0.2 NM



# OANS – Function Description

- Airport moving map display with A/C position overlay
  - 3 modes (ARC, ROSE-NAV or PLAN)

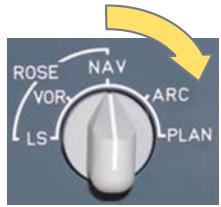


ROSE-NAV

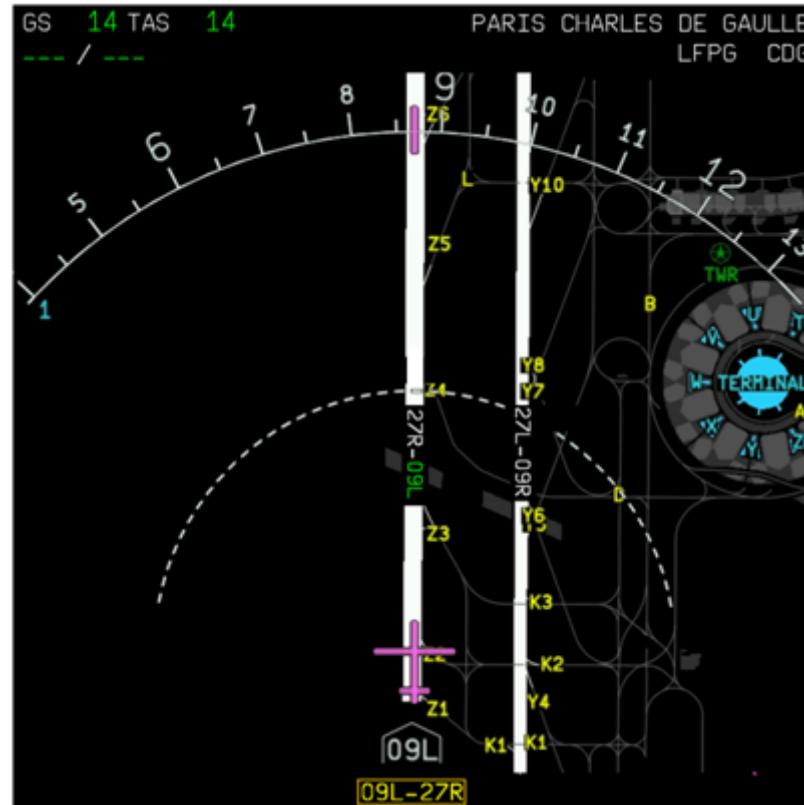


# OANS – Function Description

- Airport moving map display with A/C position overlay
  - 3 modes (ARC, ROSE-NAV or PLAN)



ARC

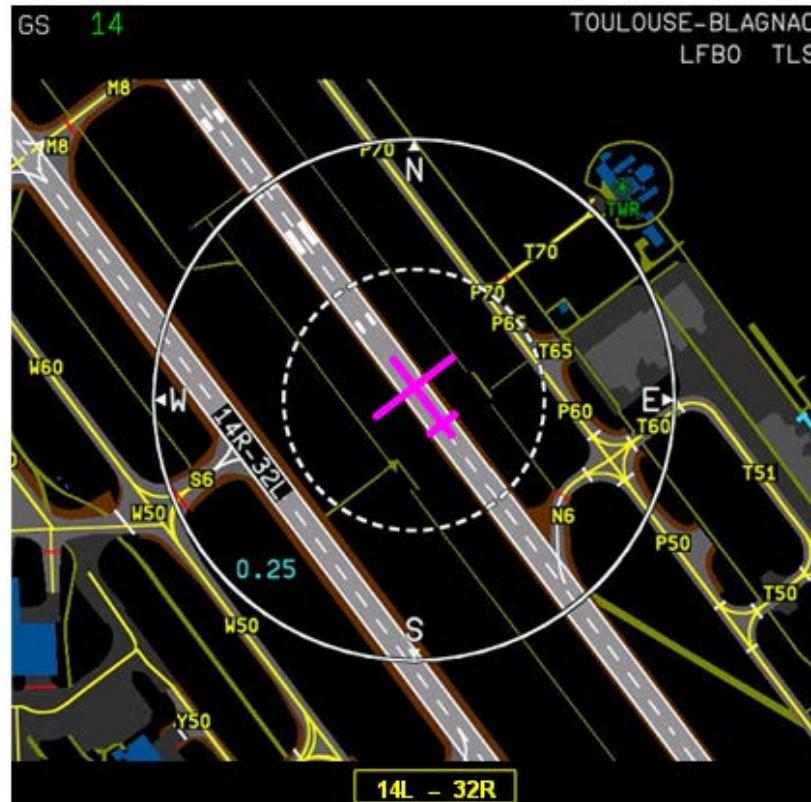


# OANS – Function Description

- Airport moving map display with A/C position overlay
  - 3 modes (ARC, ROSE-NAV or PLAN)



PLAN



# OANS – Function Description

- Airport moving map display with A/C position overlay
  - To locate the A/C symbol on the Airport Moving Map, OANS computes the A/C position from a GPS/IRS hybridization by using
    - ✓ GPS position from the MMRs every second
    - ✓ Extrapolated with IRS velocities from the ADIRS at 15 Hz
  - Position algorithm is designed to take benefit of GPS accuracy, with filtering to avoid position jumps that may be induced by GPS discontinuities
  - A/C position represented by a magenta symbol displayed on Airport Map

# OANS – Function Description

## Position algorithm

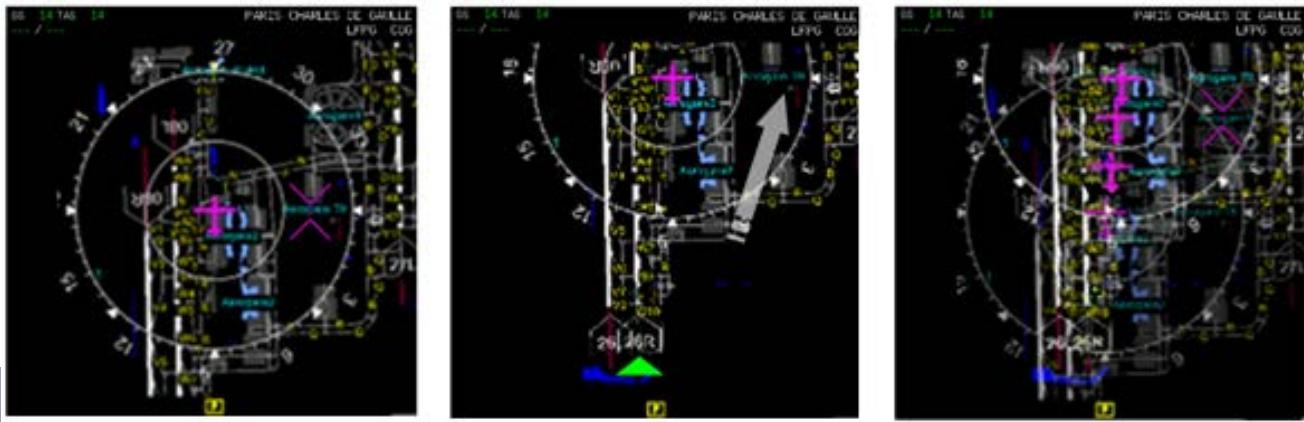
- A. The GPS position, available at 1 Hz and used for OANS position update is first corrected from ADIRU/MMR lever arms with IRS heading. ADIRU data are also corrected from lever arms.
- B. The GPS position is monitored with current OANS position in order to detect any discrepancy and to reject the new GPS position if necessary.
- C. The position is then filtered through a dedicated filter. The position filter is tuned differently according to the OANS localization sub-mode. When transitioning from one sub-mode to another, the last correction applied to GPS position through the position filter is saved and the filter is re-initialized.
- D. Between 2 updates with the GPS position, the OANS position is computed by integrating corrected inertial velocities at 15 Hz

# OANS – Function Description

- Airport moving map display with A/C position overlay

- Drag function

- ✓ Allows to « click and move » the map
    - ✓ Available in all modes and at all ranges
    - ✓ In ARC and ROSE-NAV mode only, the map displacement is temporary; the display automatically comes back to the normal ARC or ROSE-NAV center, with a smooth transition as soon as the CCD click button is released
    - ✓ In PLAN mode , drag is only enable as long as airport boundaries remain visible on the ND . In ARC and ROSE-NAV modes, drag enable as long as A/C is located less than 20NM from the ARP



# OANS – Function Description

- Airport moving map display, Software Control Panel

- Soft control panel display after click on the map to enable airport element data consultation and map annotations
- Airports elements data consultation
  - ✓ Possibility to select an element of the database (in particular runway, taxiway, stand) to see its characteristics or locate it on the map
- Map annotations
  - ✓ Possibility to add on any airport of the database a flag (way point) or a cross (restricted area)
  - ✓ Flags and crosses are erased at the beginning of a new flight or after database swap

Interactive Control Menu



MAP DATA panel

# OANS – Function Description

- Airport moving map display, Software Control Panel



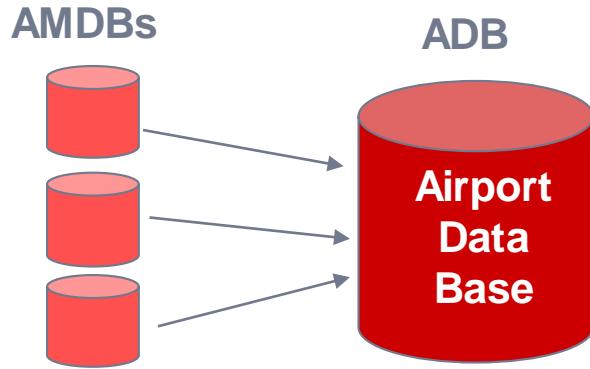
# OANS – Function Description

- Airport moving map display, Software Control Panel
  - Soft control panel also enables to swap from one database cycle to the other one
  - OANS database of airports follows the AIRAC cycles

MAP DATA	ACTIVE 14APR-12MAY	SWAP	SECOND 16MAR-13APR
ARPT SEL	AIRPORT DATABASE SXT5667483AAD02	OPC	SXT56G7483AAD02
STATUS	DATABASE CYCLE NOT VALID		

# OANS – Airport database

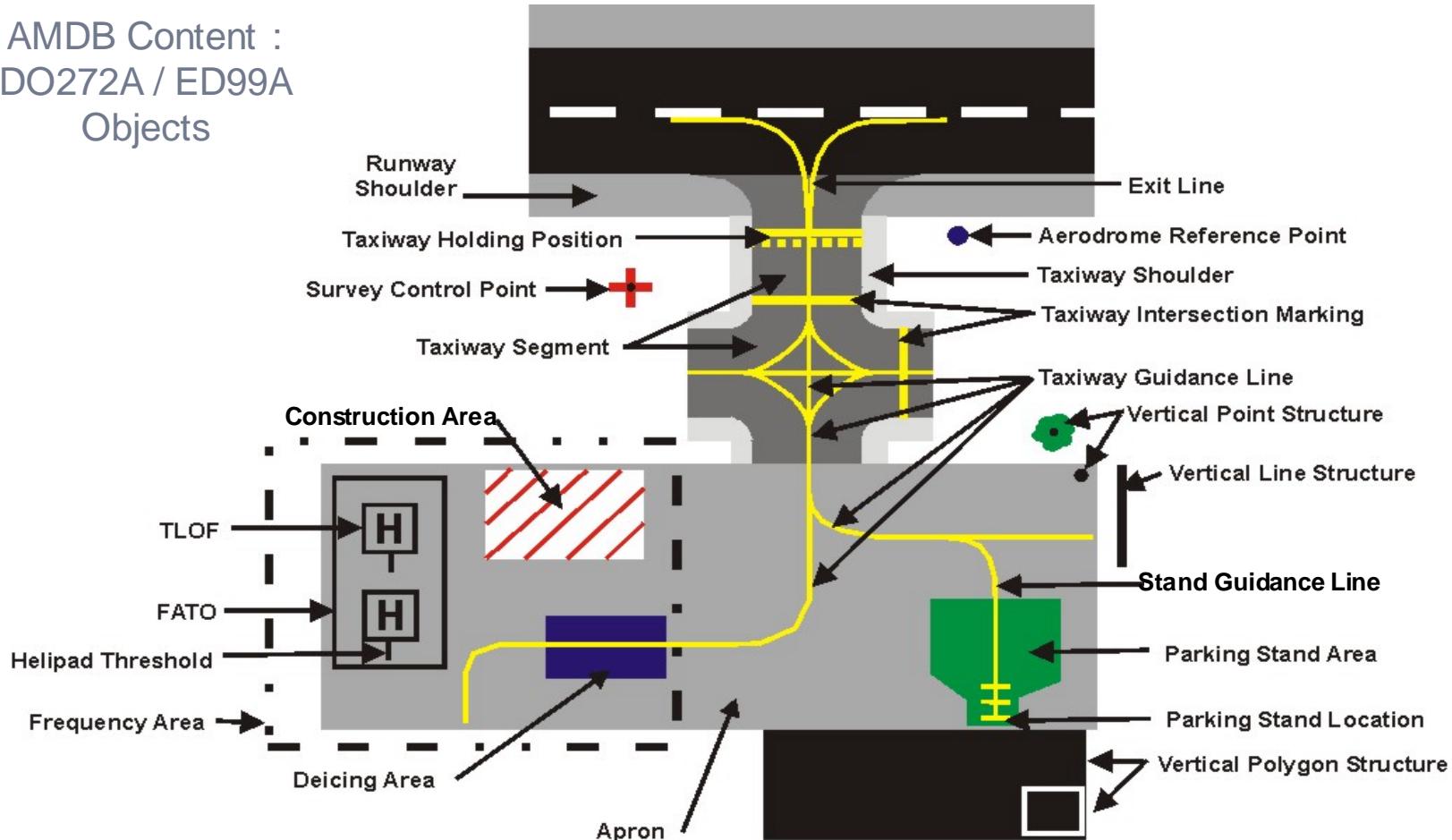
- The “ADB” Airport Data Base is a set of files called “AMDB”



- Airport Mapping DataBase (AMDB)
  - 1 AMDB per airport
    - Compliant with RTCA DO272A / EUROCAE ED99A and ARINC 816
- Characteristics of Airport Data Base:
  - AMDB Medium category (5 m accuracy)

# OANS – Airport database

AMDB Content :  
DO272A / ED99A  
Objects



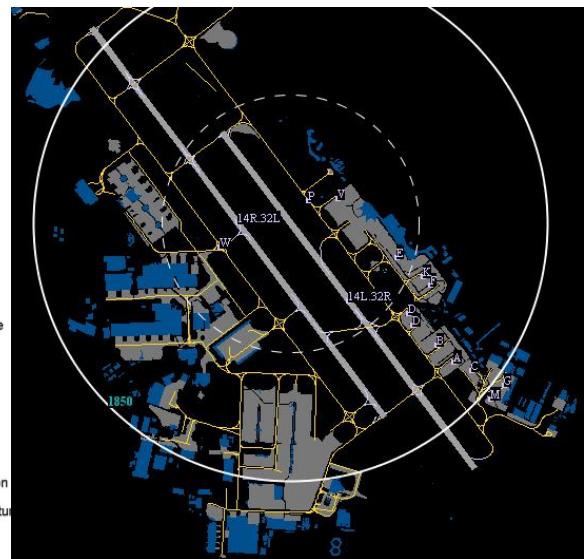
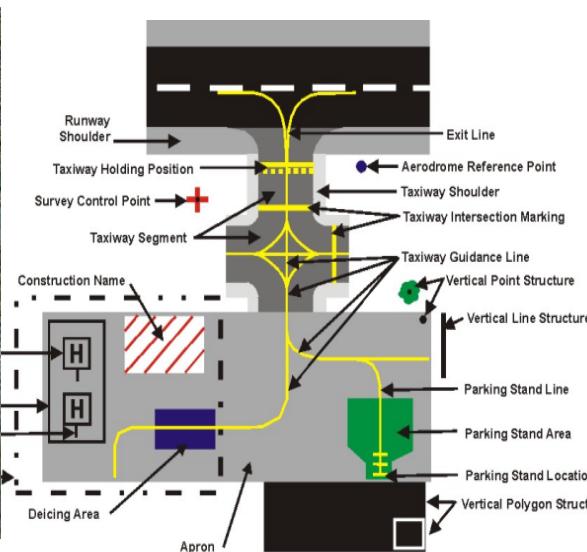
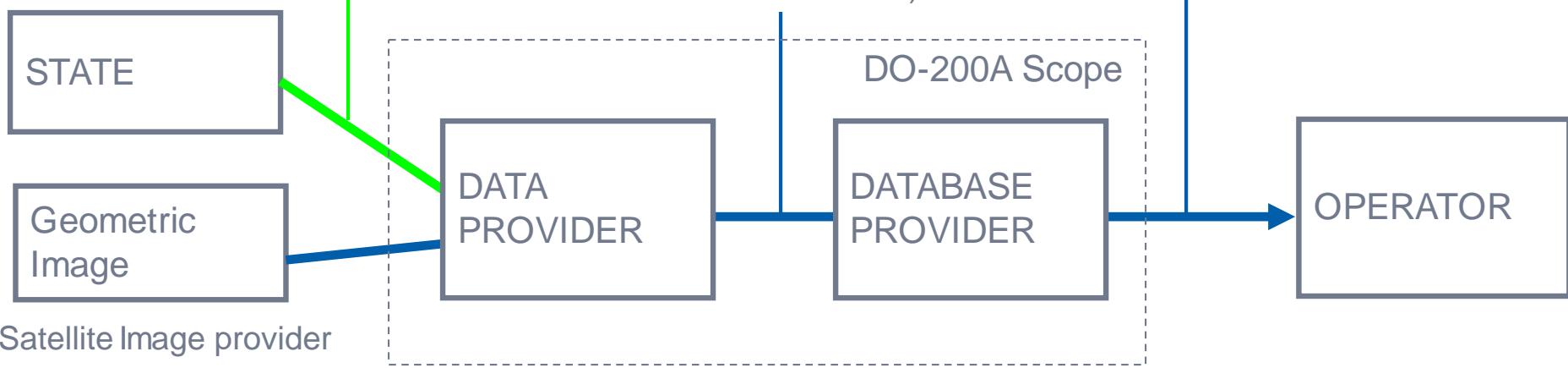
# OANS – Airport database

Source Data

Aeronautical Information Publications (AIP)

Generic Data Format  
(DO291 / ED 119  
DO272 / ED 99)

Loadable Media  
ARINC 816



# Approaching Runway Advisory

# Approaching Runway Advisory

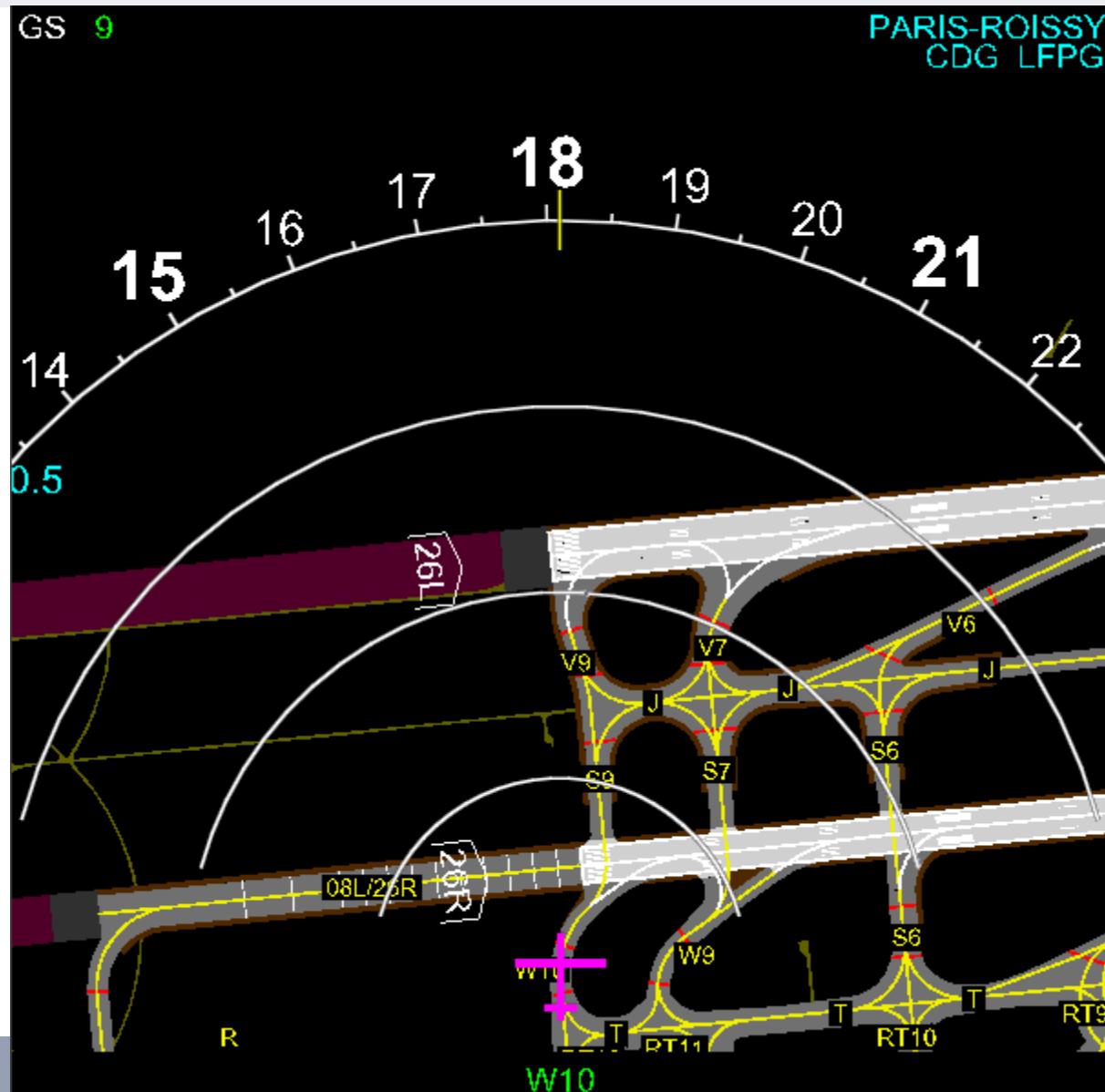
**New York (CNN)** - June 22, 2011 - A Lufthansa jumbo jet nearly collided with another plane at John F. Kennedy International Airport Monday after an EgyptAir flight apparently veered into its path just as the jet barreled down the runway, according to air traffic controller tapes.

The near miss was captured on audio recordings, revealing an air traffic controller communicating with the Lufthansa pilot, yelling "Cancel takeoff! Cancel takeoff plans!" as the two planes moved toward each other.



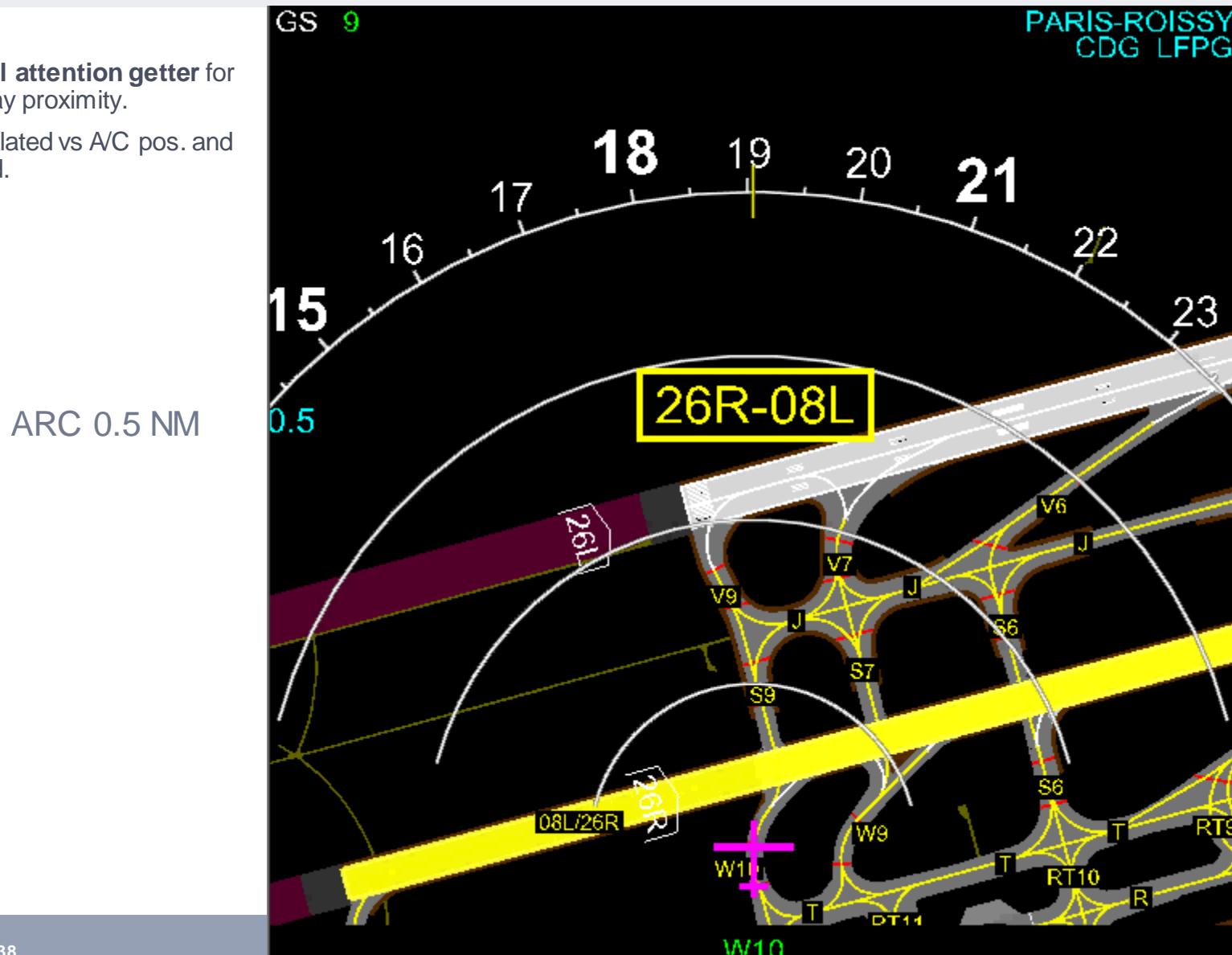
# Approaching Runway Advisory

- Visual attention getter for runway proximity. Calculated vs A/C pos. and speed.



# Approaching Runway Advisory

- Visual attention getter for runway proximity.  
Calculated vs A/C pos. and speed.



# Approaching Runway Advisory

- **Visual attention getter** for runway proximity.  
Calculated vs A/C pos. and speed.

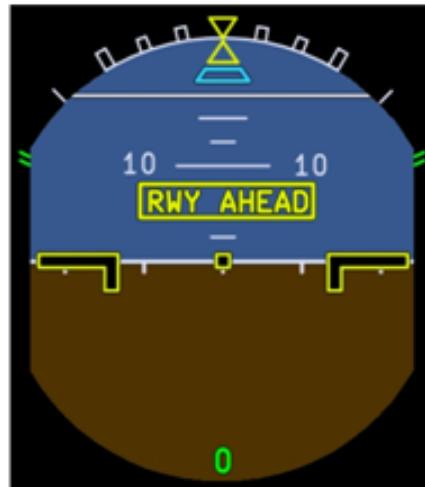


# Approaching Runway Advisory

- Approaching runway advisory on ND and PFD



ND at range > 5NM ROSE-NAV mode



PFD

- Also on Head-Up Display on A380 and A350



# Approaching Runway Advisory

- Improves flight crew awareness when approaching a runway
- The Runway Approaching advisory is displayed at least 5s before the A/C nose enters the Runway Area. This value is designed to allow the crew to stop the A/C before physically entering the runway.
- Displayed on ND at all ranges (zoom activated or not), on PFD and above ETACS (video) when displayed in PFD position
- Activation condition: A/C speed below 40kts and flight phase is “taxi out” or “taxi in” in order to prevent triggering during take off and landing

# **Runway Overrun Protection System (ROPS)**

# OANS contribution to « Runway Overrun Protection »



# OANS contribution to « Runway Overrun Protection »



# OANS contribution to « Runway Overrun Protection »

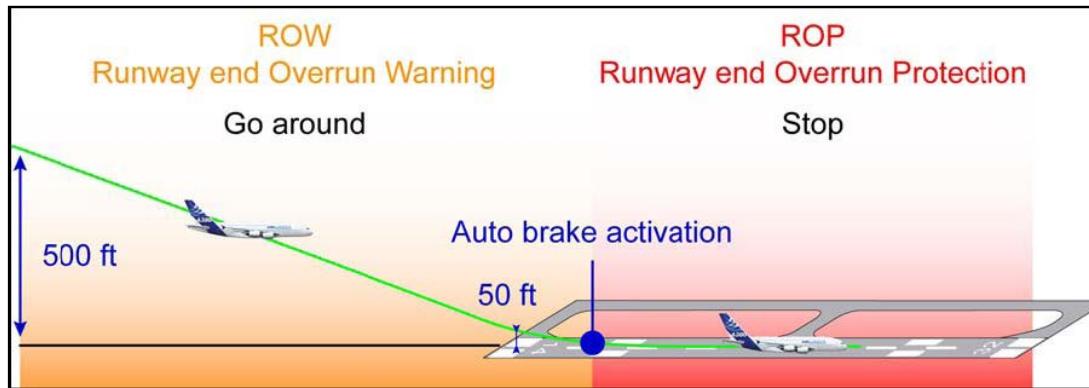


2 August 2005 - Air France Flight 358, an Airbus A340 with 297 passengers and 12 crew, overshot the end of runway 24L at Toronto International Airport and came to rest in a small ravine 300 meters past the end of the runway. All passengers and crew evacuated the aircraft successfully.

# OANS contribution to « Runway Overrun Protection »

- Concept

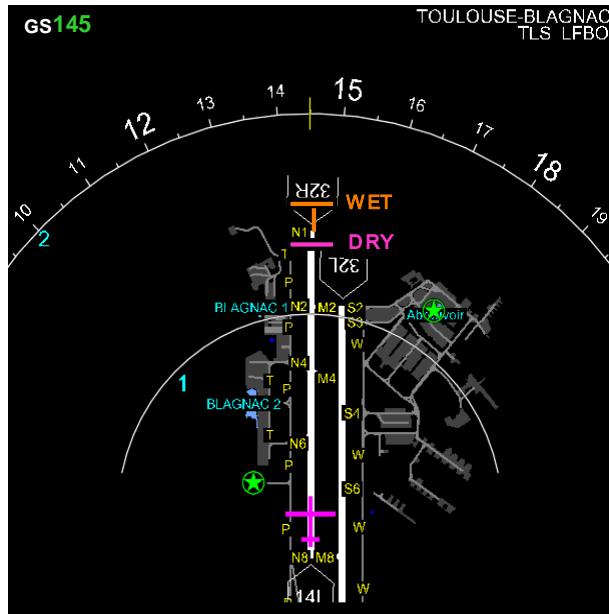
- Estimate the required landing distance based on performance
- The system will warn the crew in case of abnormal situations



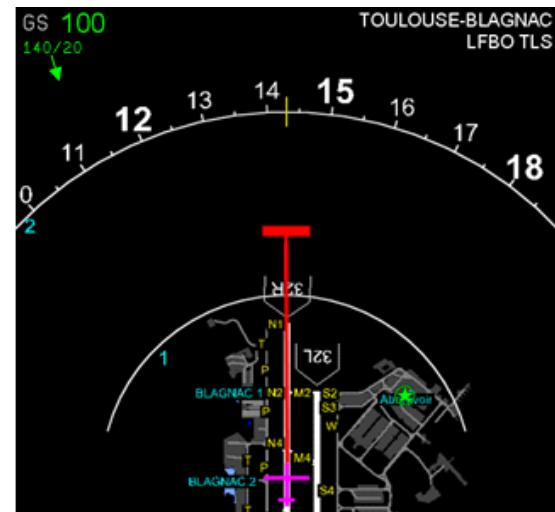
- Systems involved : OANS, Surveillance system and FWS (alert)

# OANS contribution to « Runway Overrun Protection »

**IF WET: RWY TOO SHORT**



**MAX REVERSE**

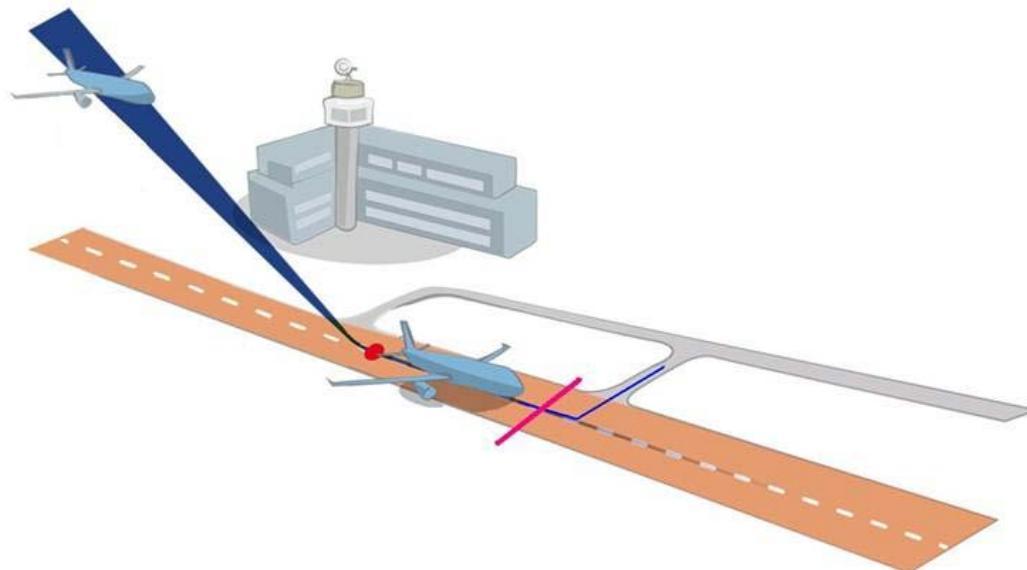


# OANS contribution to « Runway Overrun Protection »

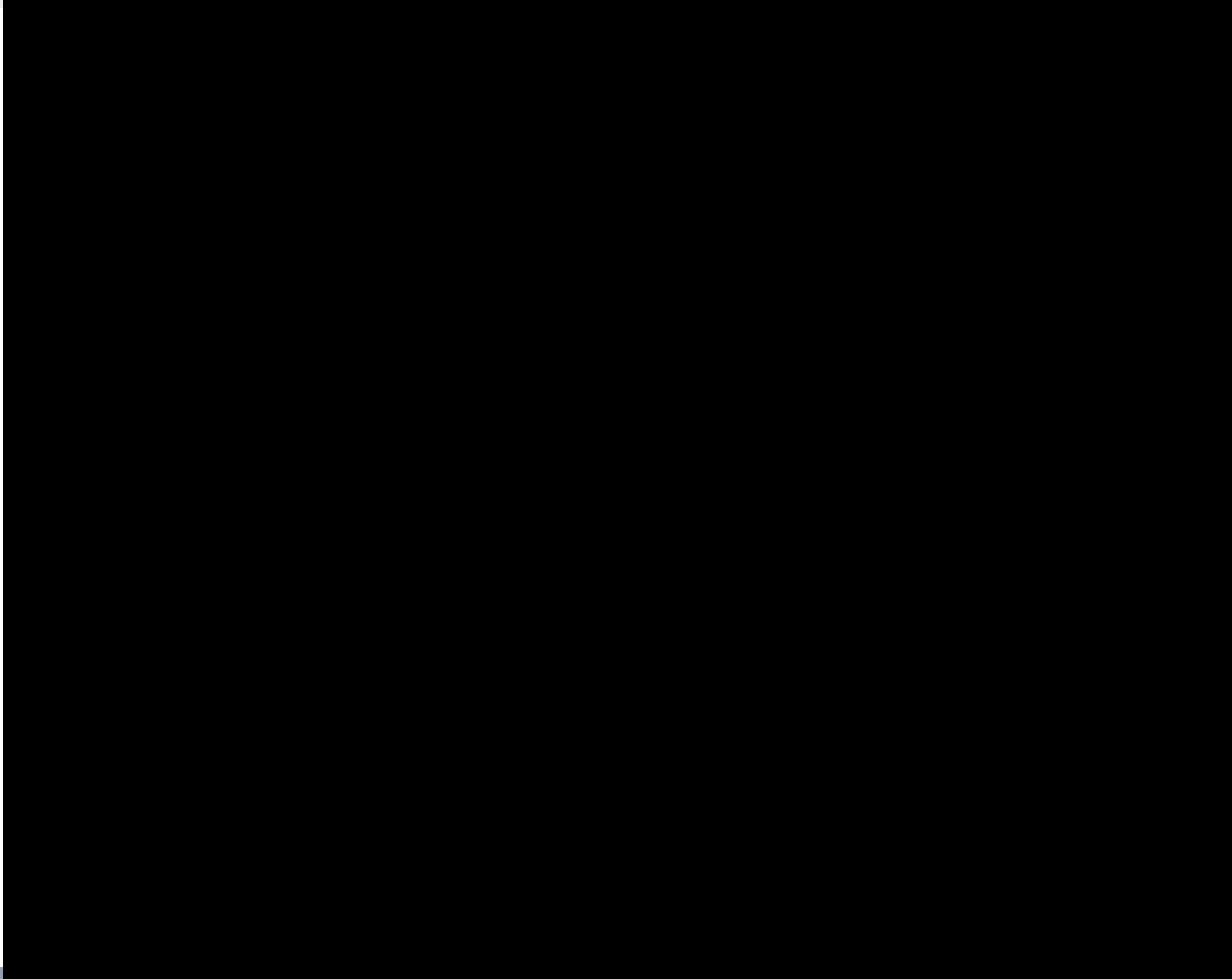
# **Brake to Vacate**

# OANS contribution to « Brake To Vacate »

- Concept
  - The auto-braking system manages the braking phase according to the runway exit selected by the crew
  - The crew will then manually steer the aircraft off the runway.

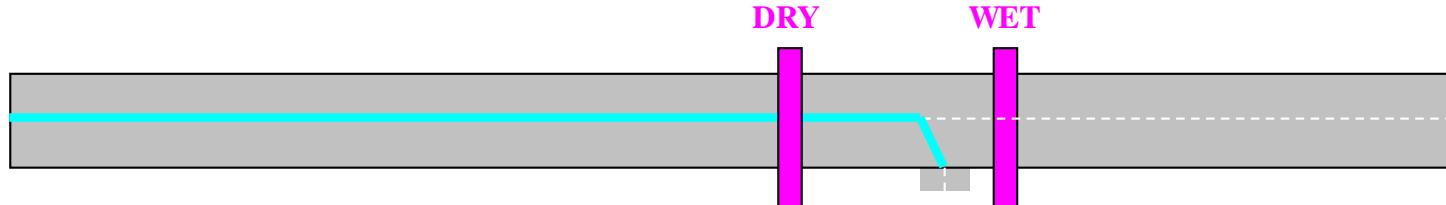


# OANS contribution to « Brake To Vacate »



# OANS contribution to « Brake To Vacate »

- Concept
  - ▶ The auto-braking system manages the braking phase according to the runway exit selected by the crew
  - ▶ The crew will then manually steer the aircraft off the runway.



- ▶ Systems involved :
  - ▶ FG : logics / laws
  - ▶ OANS : HMI, computation of A/C position along runway
  - ▶ Auto-Braking System
  - ▶ CDS (EIS on A320 / A330 / A340), HUD, FWS, DFDRS

# OANS contribution to « Brake To Vacate »



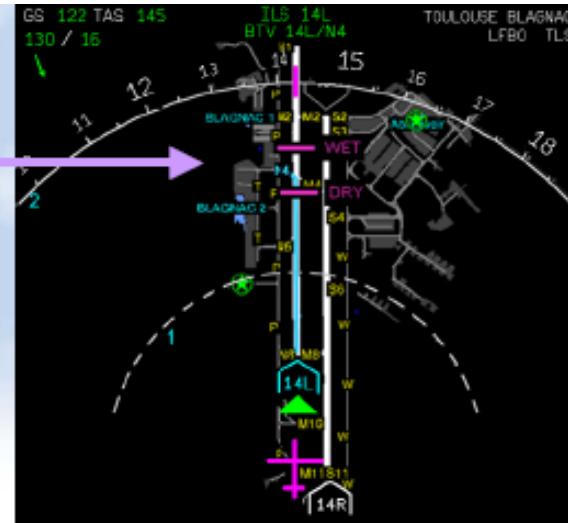
BTV configuration using Airport Navigation display. The crew must designate :

- Landing runway QFU
- Assigned exit

Dry & Wet predicted landing distances are displayed to improve situational awareness

Airport Navigation display prior to landing :

Dry & Wet predicted landing distances are displayed.



Airport Navigation display after landing :

Dry & Wet predictions are replaced by a single estimation bar based on actual real-time braking performance.



# OANS contribution to « Brake To Vacate »

- Operation on grooved runways:
  - SIA projects to replace 777-200 by A350-900 in Wellington
  - The Landing Distance Available is 1815m and this LDA impacts the A350-900 maximum landing weight which can be operated there.
  - However, Wellington runway is grooved and this provides, when wet, a better friction than “classical” smooth runways.



Grooved runway pavement

- It is therefore possible to improve WET braking performances by taking credit from grooved pavement and so this may permit:
  - Take-Off and landing on runways too short for standard WET performance computation.
  - Or to increase the security of Take-Off and landing on WET runways keeping standard computations.

# Take-Off Securing

# OANS contribution to « Take Off Securing »



Norwegian investigators have opened an inquiry after an Aeroflot Airbus A320 bound for Moscow Sheremetyevo took off from a taxiway at Oslo Gardermoen yesterday.

The aircraft had been intending to depart from runway 01L but a spokesman for Gardermoen says that, at around 15:10, the aircraft turned right onto taxiway M, which runs parallel and immediately to the right of the runway, and took off.

# TAP A340 runway overrun in Rio de Janeiro

- What Happened

Runway length :4000 metres but first 1270 metres closed (notified by NOTAM)

Take-off start a further 600m down the runway, in line with taxi way exit

FMS runway position and Flex take-off temperature ( $34^{\circ}$ )  
consistent with NOTAM position but not with real position

- Consequence

Computed VR is 145kt, real rotation at  $\approx 140$ kt

Runway overrun by 300m

MLG then impacted lights after take-off



# 31 Oct 2000 - SIA Boeing 747 Take off from wrong runway in Taipei

## • What Happened

Take-off at night (23h) during heavy rain/heavy wind caused by typhoon proximity.

No ground radar on the airport and the plane was out of sight of the tower at the time of its takeoff

Airport cleared the aircraft to takeoff at **05L** but the crew attempted takeoff on runway **05R**, closed for repairs

## • Consequence

- The aircraft collided with the construction equipment and broke into pieces
- 83 people died

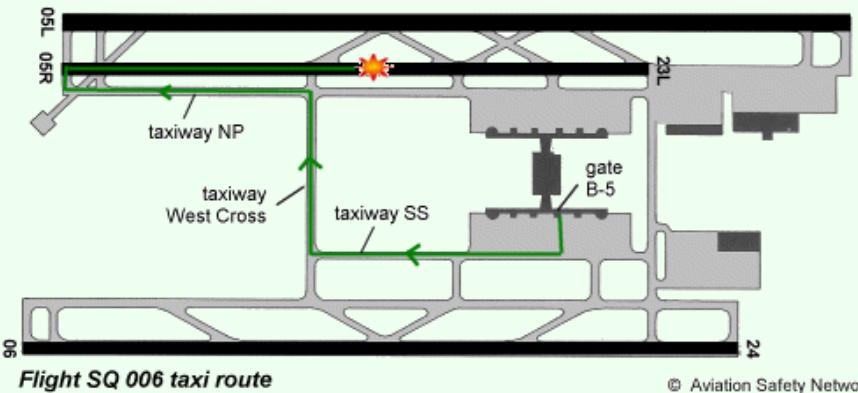
## • Possible root causes

ASC report :

- the flight crew did not review the taxi route, despite having all the relevant charts
- Upon entering the wrong runway, the flight crew had neglected to check the paravision display (PVD) and the primary flight display (PFD)

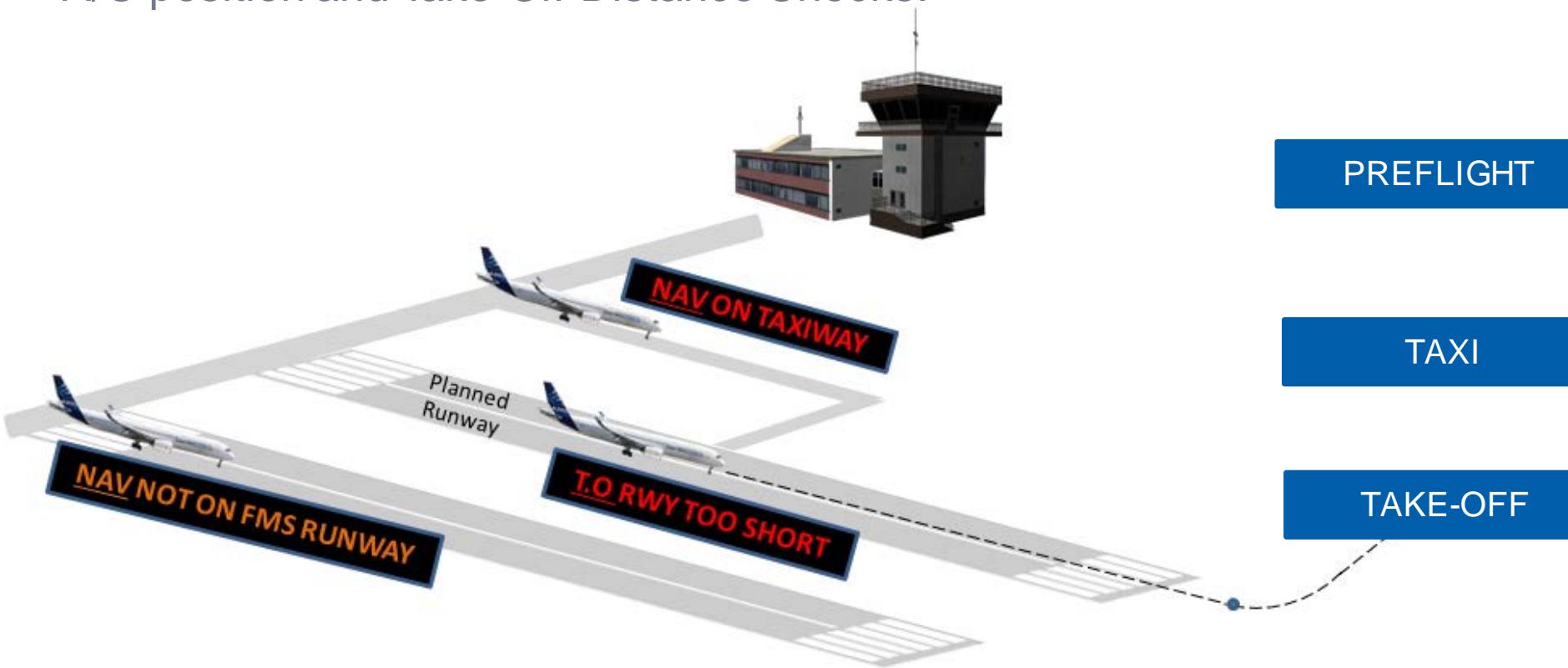
SIA :

- No barriers or markings at the start of the closed runway
- Some critical lights were missing or not working



# OANS contribution to « Take Off Securing »

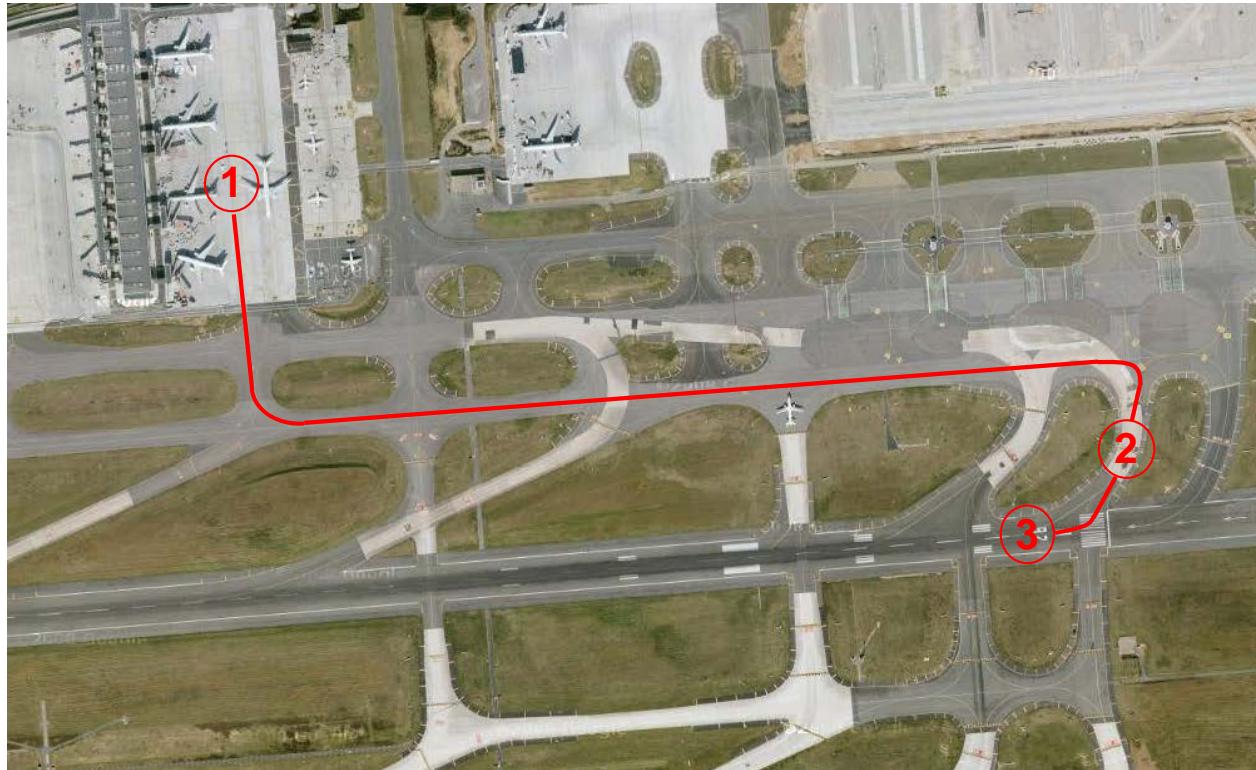
## A/C position and Take-Off Distance Checks:



TOS2 has been certified in 2014 on A350  
TOS2 has been certified in 2019 on A320 and A330

# OANS contribution to « Take Off Securing »

Description: check that the **A/C has a sufficient runway length** to perform a safe take-off.  
*Performed in preflight/take-off phases.*



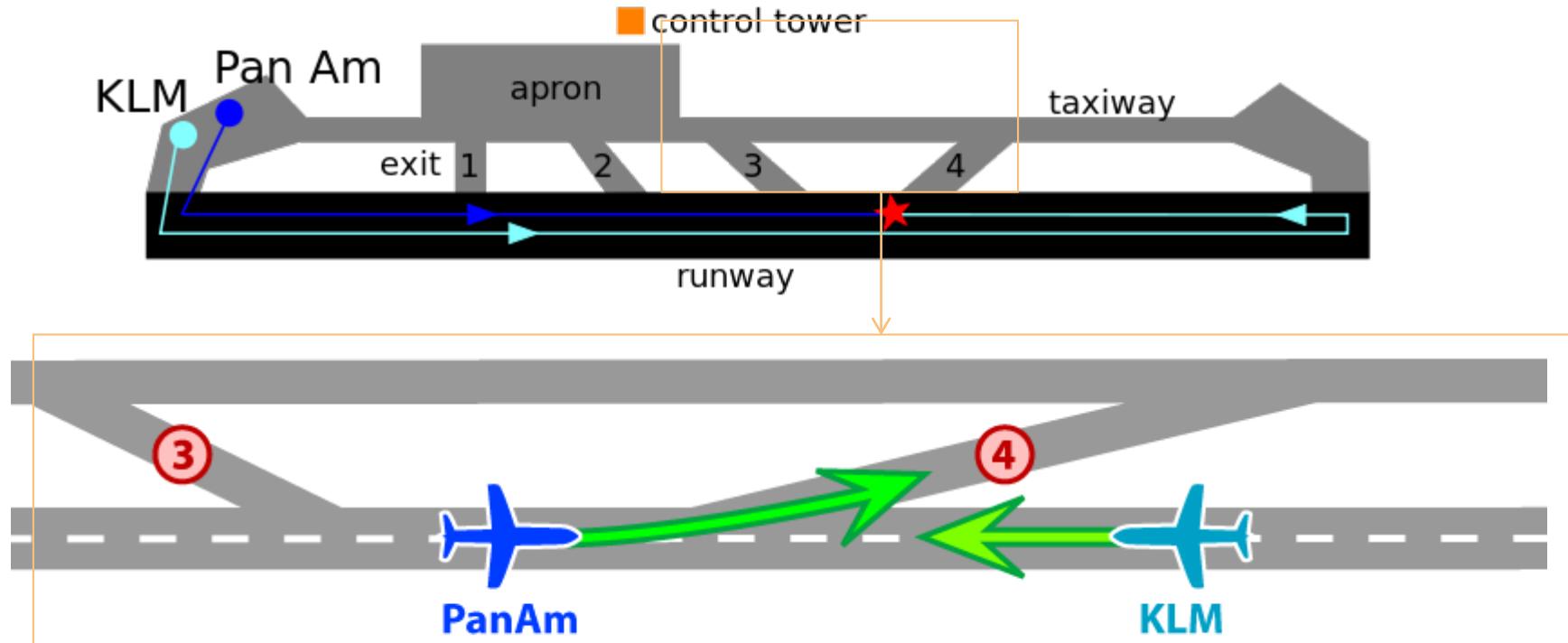
- ① At preflight
- ② At take-off config test
- ③ At take-off power

TOS 2 “take-off distance check” prevents risk of **runway overrun**.

# Future Airport Nav functions ?

# Tenerife accident

- Collision between 2 aircrafts on Los Rodeos Airport in Tenerife on 27 March 1977
- Pan AM aircraft was taxiing up the runway (side taxiway was occupied) while KLM was taking off on counter QFU, with dense fog
- 583 fatalities, 61 survivors



# OANS contribution to Traffic Display

## → Display of other A/C or vehicles on ND

Systems involved :

- AEES (TCAS on A320 / A330 / A340) : traffic detection
- OANS : ground traffic filtering and display on airport map
- CDS (EIS on A320 / A330 / A340), EFIS CP, FWS, DFDRS, FMS



# TAXI ROUTE

Taxi routes are given by ATC

- for global traffic optimiation purpose
- to ensure aircraft weight-size / taxiway type consistency



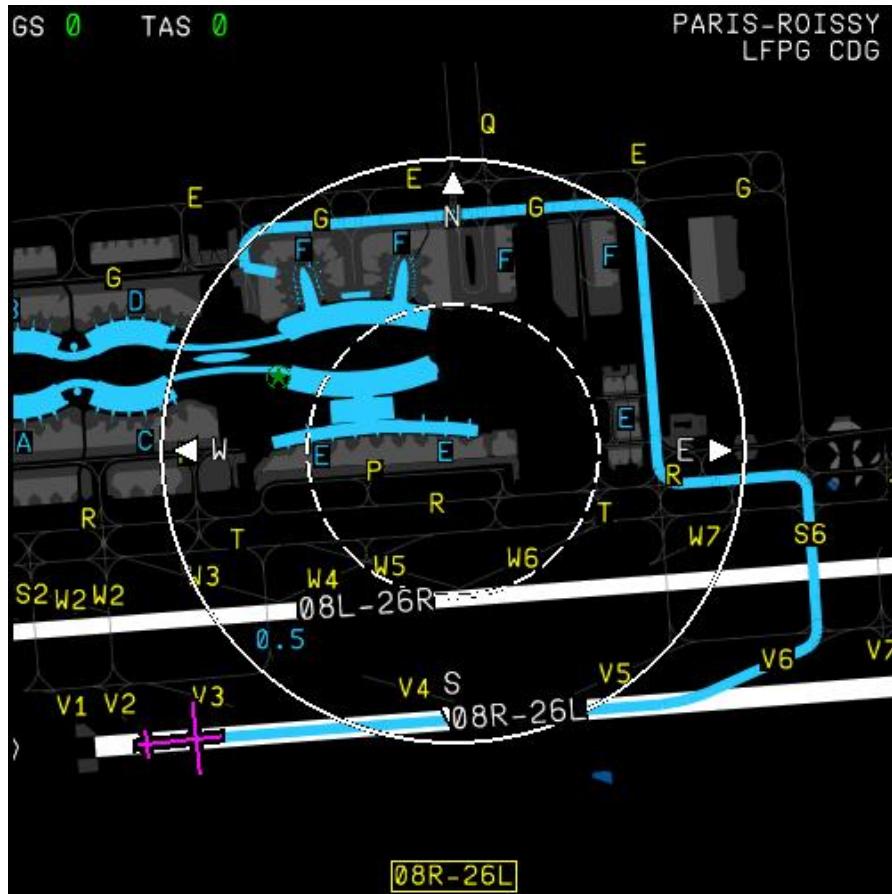
## TAXI ROUTE

- Air France A380 clipped a smaller regional jet sending it into a violent spin at JFK Airport



# TAXI ROUTE

→ Display of cleared taxiway path to the crew



- Step 1 : based on pilot entered clearance
  - Step 2 : based on clearance received from ATSU
  - Need connectivity information in databases (new issue of A816 : A816-2)

# Competition overview

# Airport Nav implementation – Airbus competitors



L: Jeppesen Airport Moving Map (AMM) on Class 2 EFB.



R: Jeppesen AMM on Boeing Class 3 EFB.

# Airport Nav implementation – Airbus competitors



(Supplier Rockwell-Collins)

**Airport Moving Map on  
Navigation Display  
787 and 747-8**

# Airport Nav implementation – Airbus competitors

## Future Equipage Studies - AMM



Competition with  
Airbus functions

- Ground path
- ATSAW surface
- Runway Advisory
- TOS
- Prevention of Runway Incursion
- BTV
- ROPS

# Airport Nav implementation – Airbus competitors



RAAS: main characteristics

- It is an autonomous aural alert (not integrated with cockpit systems)
- No visual feedback
- can be very intrusive (A318 flight test campaign has shown periodic intrusions during taxiing phases just before ATC clearance for take-off)

competitor for Airbus Runway Advisory and partly for Take Off Securing

# Q & A



© AIRBUS Operations S.A.S. All rights reserved. Confidential and proprietary document. This document and all information contained herein is the sole property of AIRBUS Operations S.A.S. No intellectual property rights are granted by the delivery of this document or the disclosure of its content. This document shall not be reproduced or disclosed to a third party without the express written consent of AIRBUS Operations S.A.S. This document and its content shall not be used for any purpose other than that for which it is supplied. The statements made herein do not constitute an offer. They are based on the mentioned assumptions and are expressed in good faith. Where the supporting grounds for these statements are not shown, AIRBUS Operations S.A.S. will be pleased to explain the basis thereof.  
AIRBUS, its logo, A300, A310, A318, A319, A320, A321, A330, A340, A350, A380, A400M are registered trademarks.

# Glossary (1/2)

Important

- ABD Airbus Directive
- A/BRK Auto-Brake
- A/C Aircraft
- ADB Airport DataBase
- ADCN A/C Data Communication Network
- ADIRS Air Data and Inertial Reference System
- ADIRU Air Data and Inertial Reference Unit
- AFDX Avionics Full DupleX ethernet
- AI Airbus
- AIRAC Aeronautical Information Regulation And Control
- A/L Airline
- AMDB Airport Mapping DataBase
- ANF Airport Navigation Function
- ARP Aerodrome Reference Point
- ARPT AiRPorT
- BITE Built In Test Equipment
- BTV Brake To Vacate
- CAPT CAPTain
- C/B Circuit Breaker
- CCD Cursor Control Device
- CFDIU Centralized Fault Display Interface Unit
- CMU Central Maintenance Computer
- DAL Development Assurance Level
- DMC Display Management Computer
- EDU Enhanced Display Unit
- EEIS Enhanced Electronic Instrument System
- EFIS CP Electronic Flight Instrument System Control Panel
- FCU Flight Control Unit
- F-PLN Flight Plan
- FMGC Flight Maintenance and Guidance Computer
- FMGEC Flight Management Guidance and Envelope System
- FMS Flight Management System
- F/O First Officer
- FWC Flight Warning Computer
- FWS Flight Warning System
- GPS Global Positioning System
- HMI Human Machine Interface
- H/W Hardware
- IRS Inertial Reference System
- JAA Joint Aviation Authorities
- JAR Joint Airworthiness Requirement
- LAHSO Land And Hold Short Operations
- LDA Landing Distance Available
- ...

# Glossary (2/2)

- LGCIU Landing Gear Control and Interface Unit
- LR Long Range
- LRU Line Replaceable Unit
- LS Landing System
- MCDU Multipurpose Control & Display Unit
- MMR Multi Mode Receiver
- N/A Not Applicable
- NAV NAVigation
- ND Navigation Display
- OANC On-board Airport Navigation Computer
- OANS On-board Airport Navigation System
- OPC Operational Programming Configuration
- PCN Pavement Classification Number
- PDL Portable Data Loader
- PGM Processing and Graphics Module
- PMC PCI Mezzanine Card
- P/N Part Number
- ROP Runway Overrun Protection
- SA Single Aisle
- SCP Soft Control Panel
- SDAC System Data Acquisition Concentrator
- S/W Software
- TORA Take Off Run Available
- VL Virtual Link
- VOR VHF Omnidirectional Range

© AIRBUS Operations S.A.S. All rights reserved. Confidential and proprietary document. This document and all information contained herein is the sole property of AIRBUS Operations S.A.S. No intellectual property rights are granted by the delivery of this document or the disclosure of its content. This document shall not be reproduced or disclosed to a third party without the express written consent of AIRBUS Operations S.A.S. This document and its content shall not be used for any purpose other than that for which it is supplied. The statements made herein do not constitute an offer. They are based on the mentioned assumptions and are expressed in good faith. Where the supporting grounds for these statements are not shown, AIRBUS Operations S.A.S will be pleased to explain the basis thereof. AIRBUS, its logo, A300, A310, A318, A319, A320, A321, A330, A340, A350, A380, A400M are registered trademarks.