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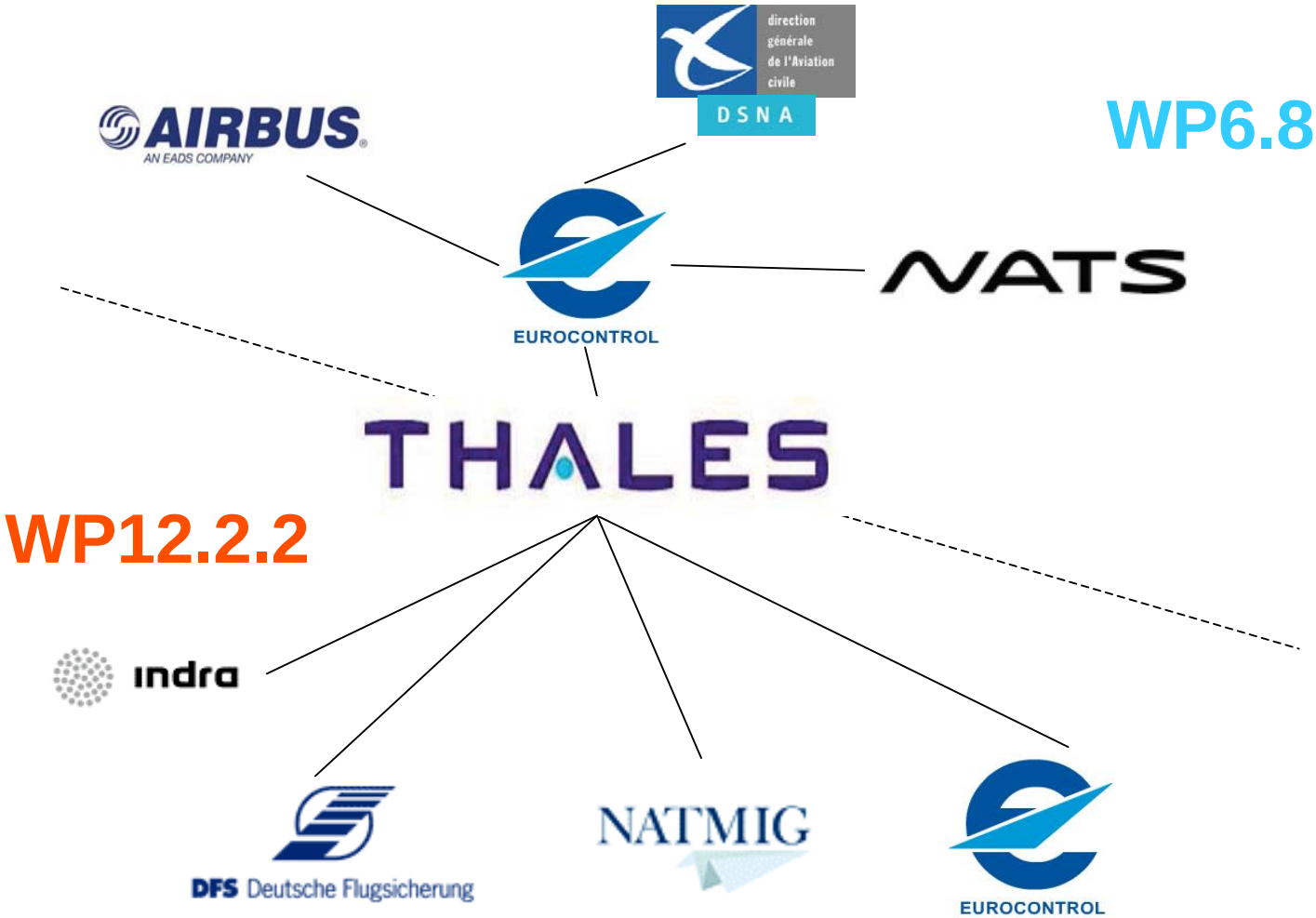
SESAR - Project 12.2.2

Concepts Validation and Research Needs

F.BARBARESCO

P12.2.2 Team & Interfaces



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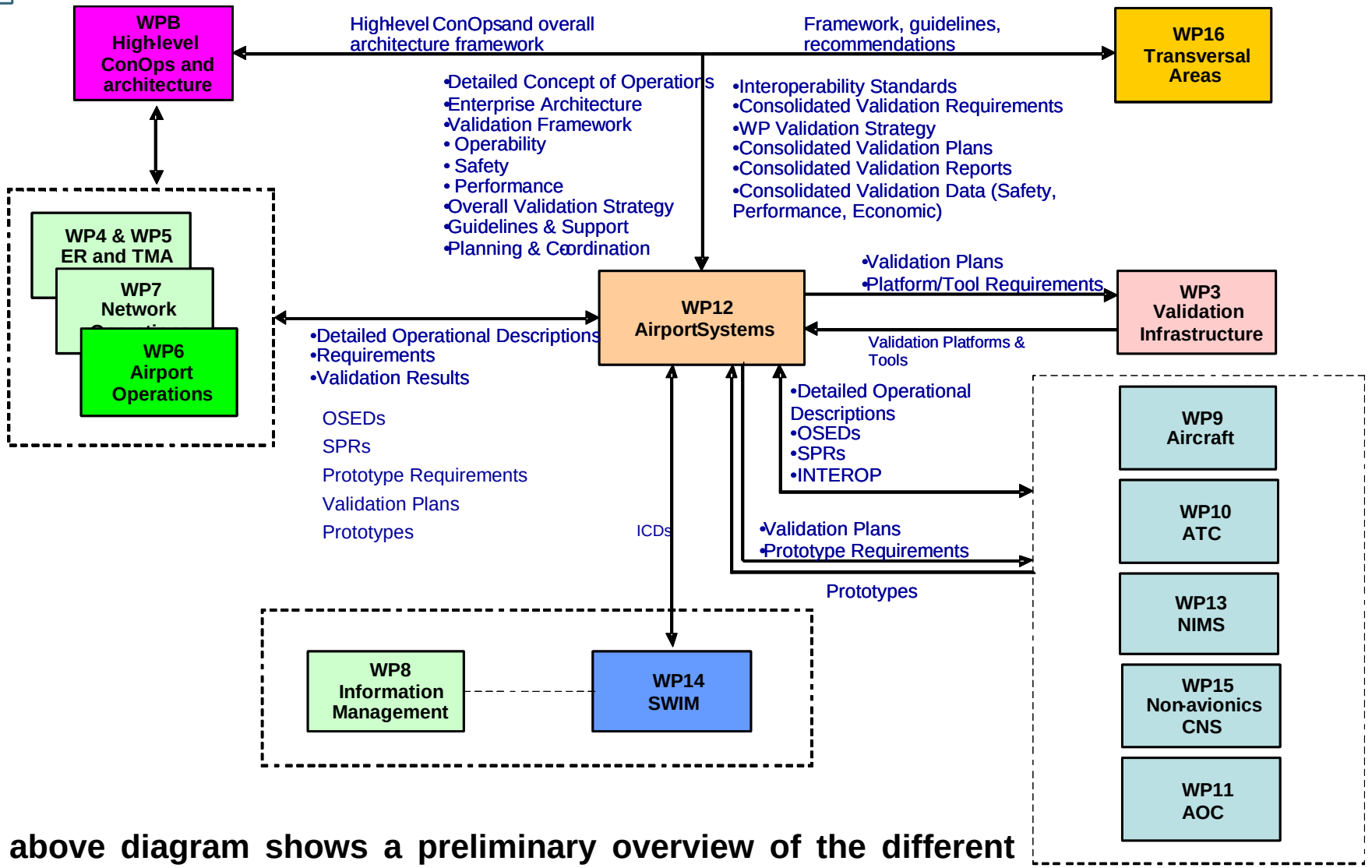
P12.2.2 Dependencies within SESAR WPs



The above diagram shows a preliminary overview of the different dependencies identified between WP12 and other WPs

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Acceptance of Deliverables “delivered”

- 12.2.2-D01 Preliminary system Requirements
  - Delivered on July 20th 2010
  - 20 days delay accepted by SJU (email 11/06/2010)
  - No comment received
  - Approved by P6.8.1 PM (email 15/07/2010) as planned for milestone n°1
- 12.2.2-D02 Preliminary system architecture
  - Delivered on October 27th 2010
  - No comment received

- Preliminary system requirements :

- 61 high level requirements covering the three phases of the project, sub-divided in five main parts:
  - Top level requirements
  - Functional system requirements
  - Human Machine Interfaces (HMI)
  - Interfaces with other systems
  - Non-functional specifications
- Definition of recommendations for operational system
- Will be refined during each successive phase of the project, taking into account :
  - Inputs from P6.8.1 (OSED)
  - Results from previous phase

Work achieved (2/2)

- Preliminary system architecture :

- Compliant with Entreprise Architecture as defined by WPB4.3
- Definition of each interface
- Allocation of each system requirement to sub-systems
- Creation of a local weather data cube
- Will be refined during each successive phase of the project, taking into account :
  - Requirements refinement
  - Results from previous phase
  - EAEA refinement

P12.2.2 Objective

- Define, analyse, develop and verify a Wake Vortex Decision Support System (WVDSS) according to the operational concept defined by P6.8.1 mirror project
- Operational Concepts defined by P6.8.1 should be validated by :
  - Use of WVDSS Simulation platform
    - calibrated with XP0 trial (2011)
      - Recorded real Weather/Wind Data base (based on XP0)
      - Weather Forecast (tested during XP0)
      - Wake Vortex Sensors simulators (calibrated with XP0)
      - Wake-Vortex Predictor (benchmark with XP0)
    - validated with XP1/XP2 trial (2012)
      - « Off Line » WVDSS with Sensors in the loop
  - Use of full scale WVDSS platform on 2 major european airports in « shadow mode » with controllers in the loop:
    - XP3 trial at Paris CDG in 2014
    - XP4 trial at Francfort Airport in 2016

P12.2.2 Operational Concepts to be validated

- WVDSS iterative development, verification and validation for
  - **TBS (Time Based Separations)**
    - Acquisition and processing of the needed information about position, strength and behaviour of wake vortex in case of significant headwind
  - **WDS (Weather Dependent Separation)**
    - Real time assessment of wake vortex position, strength and prediction of wake vortex behaviour to allow reduction of separation; depending on weather conditions
  - **PWS (Pair Wise Separations)**
    - Demonstration of the system capacity to dynamically deliver separation per aircraft pair; requires aircraft characteristics database (generation of wake vortex, sensitivity to wake vortex)
    - Customization to different airports and runways configurations

WVDSS pragmatic & iterative development

P12.2.2 Objective

- Final Customizable WVDSS version will be able to validate the global concept to be deployed on airports with different runways layout (CGD & FKT)
- Final WVDSS version will be able to optimize runway throughput and reduce delays
- Final WVDSS should be operational in all weather conditions (weather resilient)

WVDSS able to optimize runways throughput and reduce delays on different kind of airports as well as runways configurations in all weather conditions

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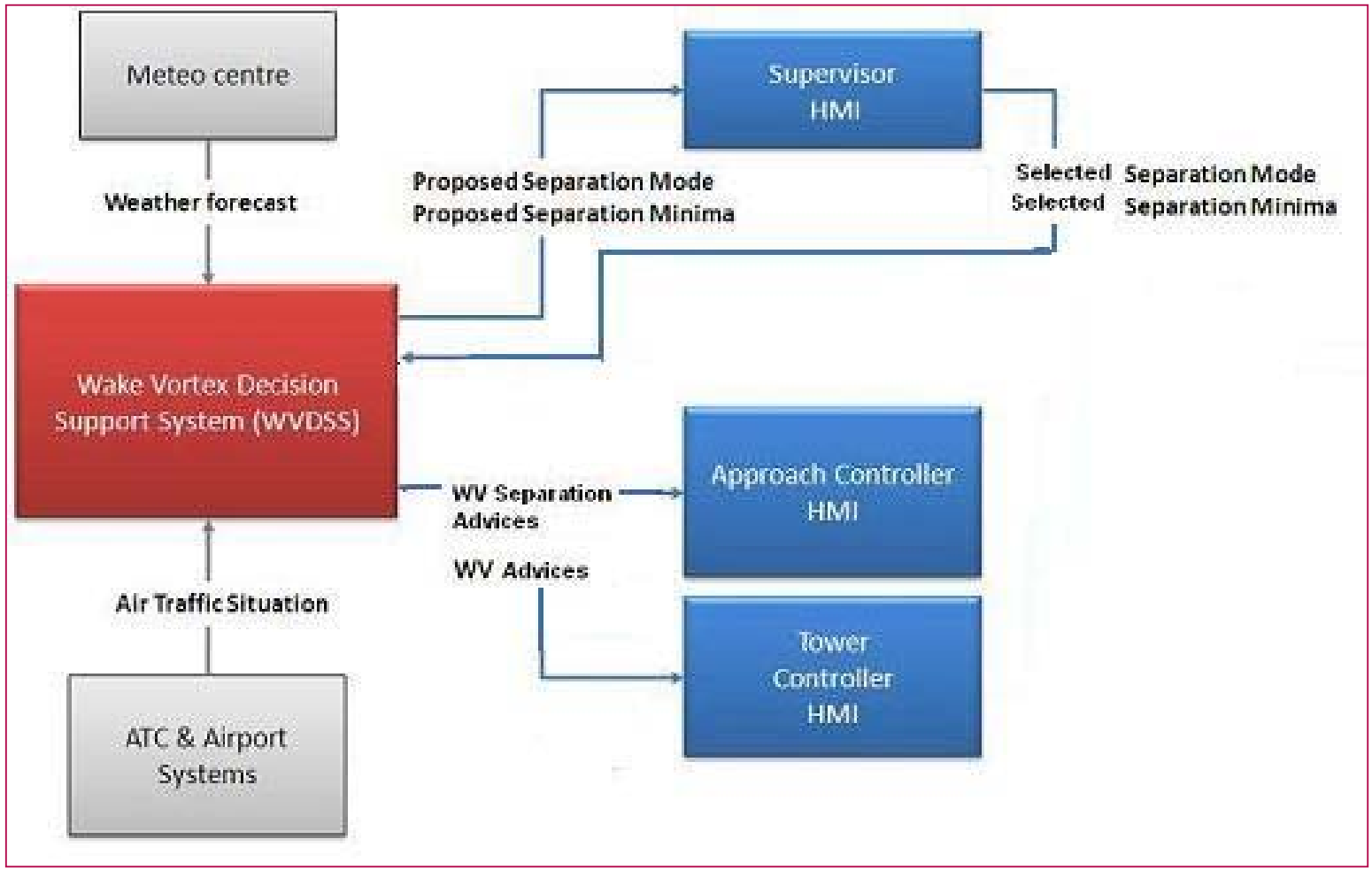
A network on Aircraft Wake Turbulence

SESAR - Project 12.2.2

Preliminary GENERIC System Architecture Definition for Concepts Validation

System overview



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SESAR - Project 12.2.2 Research Needs for Weather Tools Services Requirements : 4D Weather Data Cube

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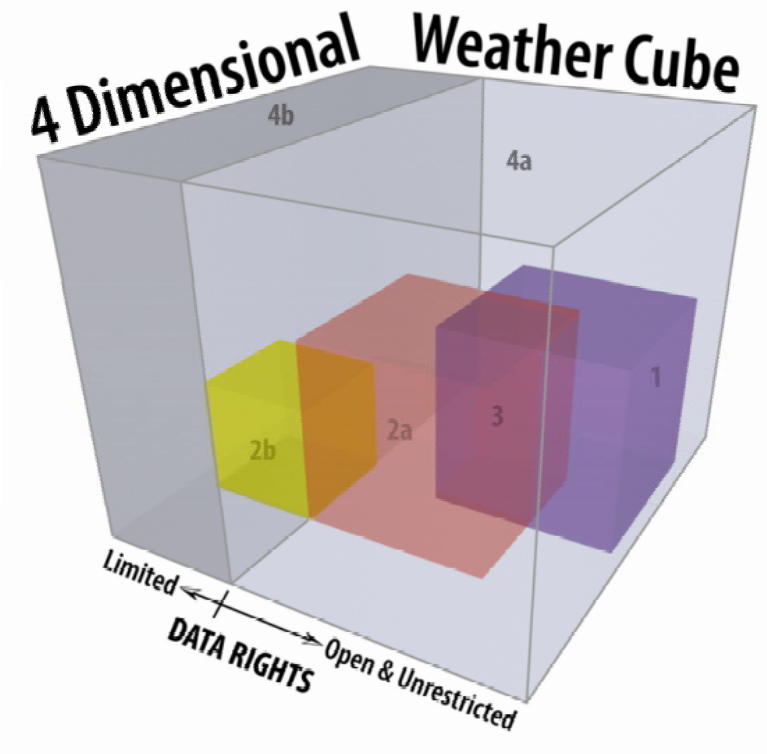
Concepts/System Requirements vs Weather Services Req.

- Operational Concepts Requirements and WVDSS System Requirements will be constrained by:
  - Operational Weather services Capabilities:
    - Local Weather Forecast models
    - 4D Weather Data cube
  - Operational Weather Sensors Capabilities
    - Wind (Coverage, resolution, update rate, resilience in all weather conditions, accuracy)
    - EDR/TKE (accuracy)
  - Operational Wake-Vortex Sensors Capabilities
    - Wake-Vortex Positions (in critical areas)
    - Wake-Vortex Circulation
    - Wake-Vortex Tracking
- P12.2.2 has scheduled XP0 trials at CDG Airport from 15th of March to 15 of April 2011 for first study of sensors and weather forecast models

Rationale for Local 4D Weather Data Cube

- Standardized weather information data storage approach containing :
  - observation data
  - forecast data
- Driver for P12.2.2 Architecture (avoid all problems of synchronization)
- Providing a common consistent weather picture usable in real time
- Information may be :
  - pushed by data providers (publish)
  - pulled by users (subscribe)
- Local 4D Weather Data Cube Requirements for P12.2.2 :
  - X, Y, Z + time (3-dimensional data products over time)
  - Continuously Updated by sources (sensors & forcast models)
  - Flexible, standardized & gridded format
  - High resolution (space and time)
  - Disseminated in seconds



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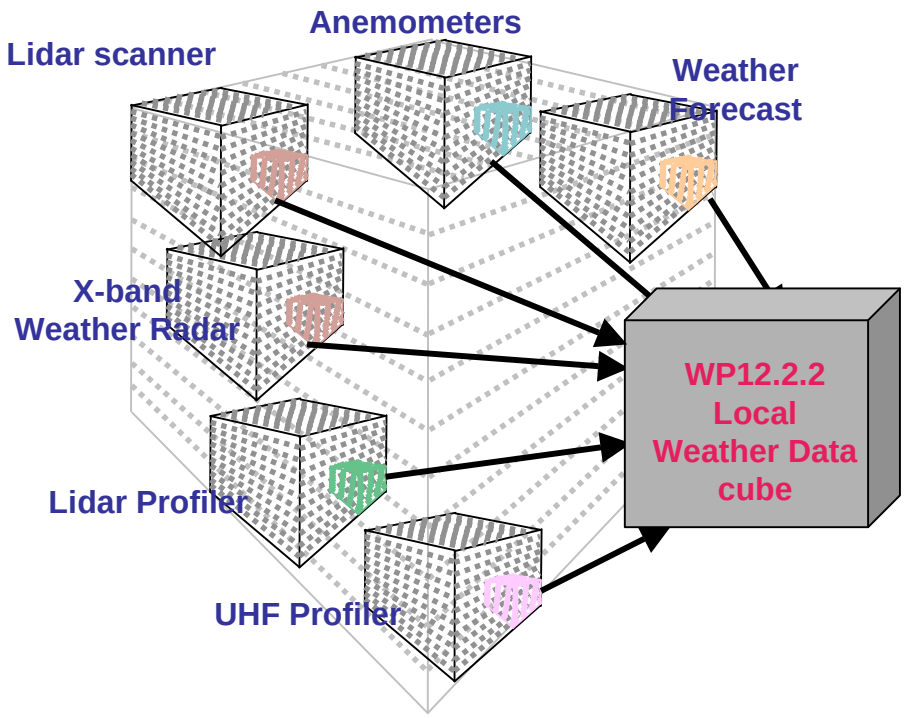
Sources of P12.2.2 4D Weather Data cube

- Data of 4D Weather Data Cube will be published by:
  - **Anemometers:**
    - Ponctual measurement associated to nearest grid point
  - **Profilers (Lidar Profiler UHF Profiler & Sodar Profiler):**
    - Vertical Profiles associated to nearest grid point
  - **Volumetric Sensors (X-band weather Radar, Lidar Scanner):**
    - Volumes in polar coordinates interpolated to nearest grid point
  - **Weather/Turbulences Forcast Models:**
    - Gridded Data



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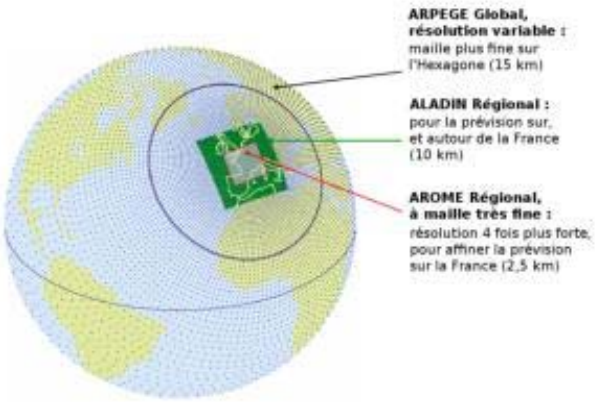
Multiscale Gridded Weather Forecast Models

- The meteorological centre provides data from the operational weather forecast model "LM" of national Weather Service (e.g. METEO FRANCE, DWD,…) which runs at a horizontal resolution of 7 to 10 km covering most of Europe. METEO-France uses 4 encasulated models :
  - **IFS (Integrated Forecasting System)** : European Weather Forecast with a grid of **25 km**
  - **Arpège (Action de recherche petite échelle *I* grande échelle)** : France Weather Forecast with a grid of **25 km** for 1 to 3 days
  - **Aladin (Aire limitée et adaptation dynamique)** : France Weather Forecast with a grid of **10 km**.
  - **AROME (Application de la recherche à l'opérationnel à mésoéchelle)** : France Weather Forecast with a grid of 2.5 km
- AROME 3Dvar model will be adapted for P12.2.2 Weather Forecast Needs
  - **MHRPS : Airport Local Weather Forecast with a grid of 0.5 km**
  - **Turbulence Forcast (by NATMIG) : Airport local Turbulence Forecast with a grid 0.1 km**



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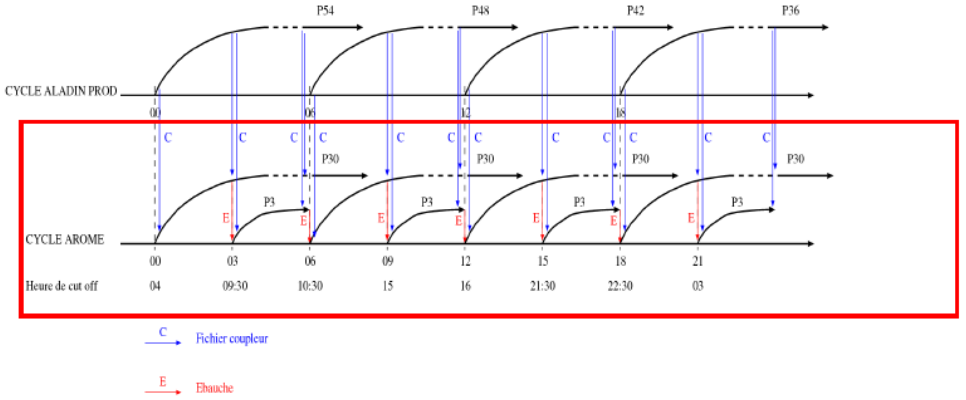
Multiscale Gridded Weather Forecast Models

Weather Forecast Model (resolution : 500 m) : Meteo-France

- Meteorological High-Resolution Prediction System (MHRPS) :
  - MHRPS development will be based on the French non-hydrostatic AROME model
  - The MHRPS will be implemented on the Météo-France super-computer
  - MHRPS will assimilate not only dedicated airport sensors data but also all the routine data coming from the European Meteorological Infrastructure
- MHRPS Requirements :
  - Required parameters : Horizontal and vertical wind (U, V, W), Temperature (T), Humidity (Hu), Eddy Dissipation Rate (EDR), Surface Pressure (PS);
  - Required horizontal resolution : 500 m;
  - Required coverage area : 100x100 km² centered on the airport;
  - Required vertical resolution : 10 m up to 100 m, 100 m up to 1000 m, 1000 above;
  - Required forecast horizon : 3 h;
  - Required frequency of forecast outputs : 5';



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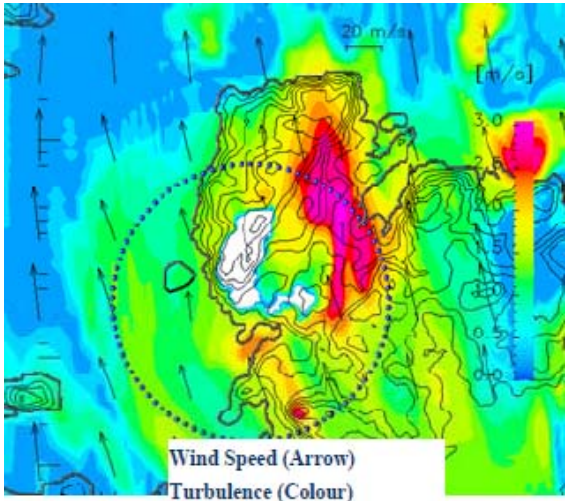
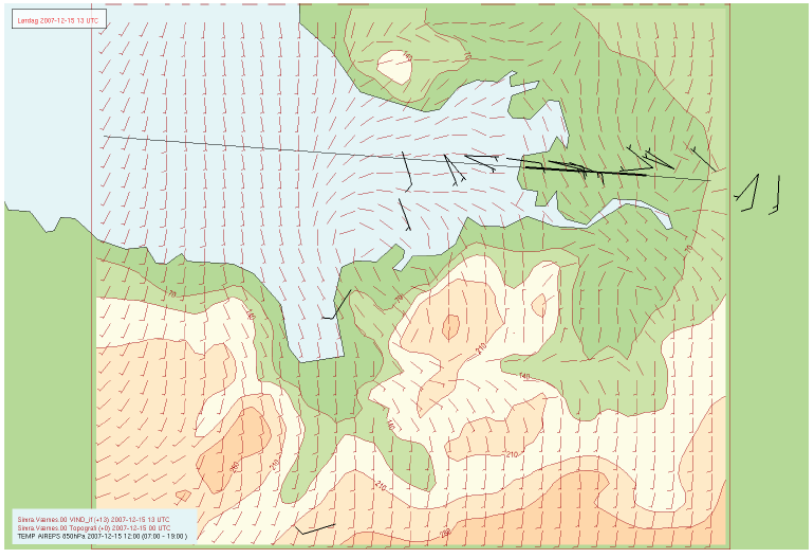
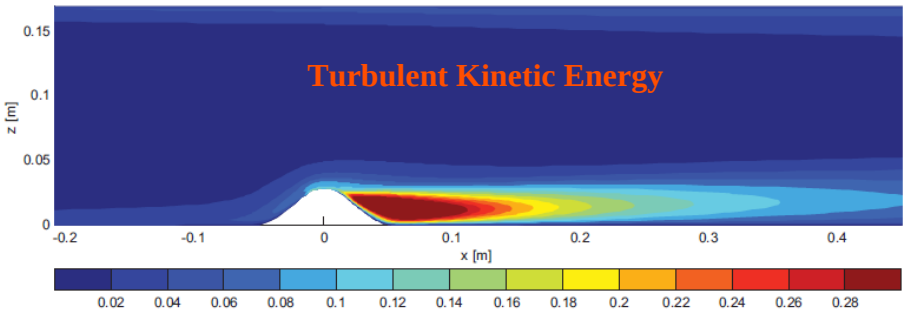
Multiscale Gridded Weather Forecast Models

- Turbulence Forecast Model (resolution : 100 m) : NATMIG
  - A Reynolds averaged Navier-Stokes model (SIMRA) has been developed by NATMIG member SINTEF in order to predict local wind and turbulence around airports.
  - Forecast EDR/TKE model will be adapted for airport infrastructure (buildings,…)

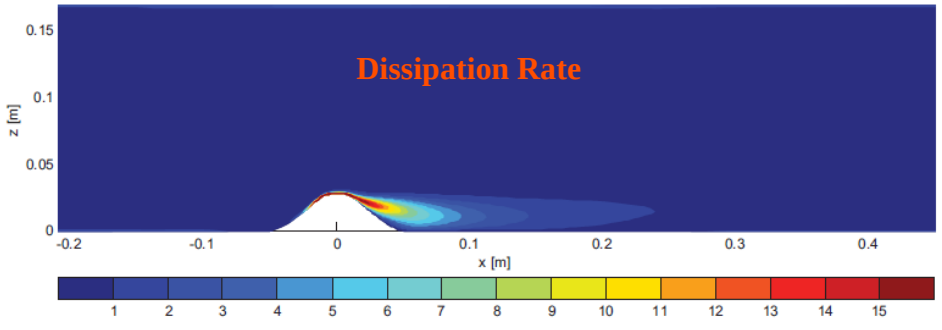




Turbulent Kinetic Energy (k) [m^2/s^2]



Dissipation rate (ε) [m^2/s^3]



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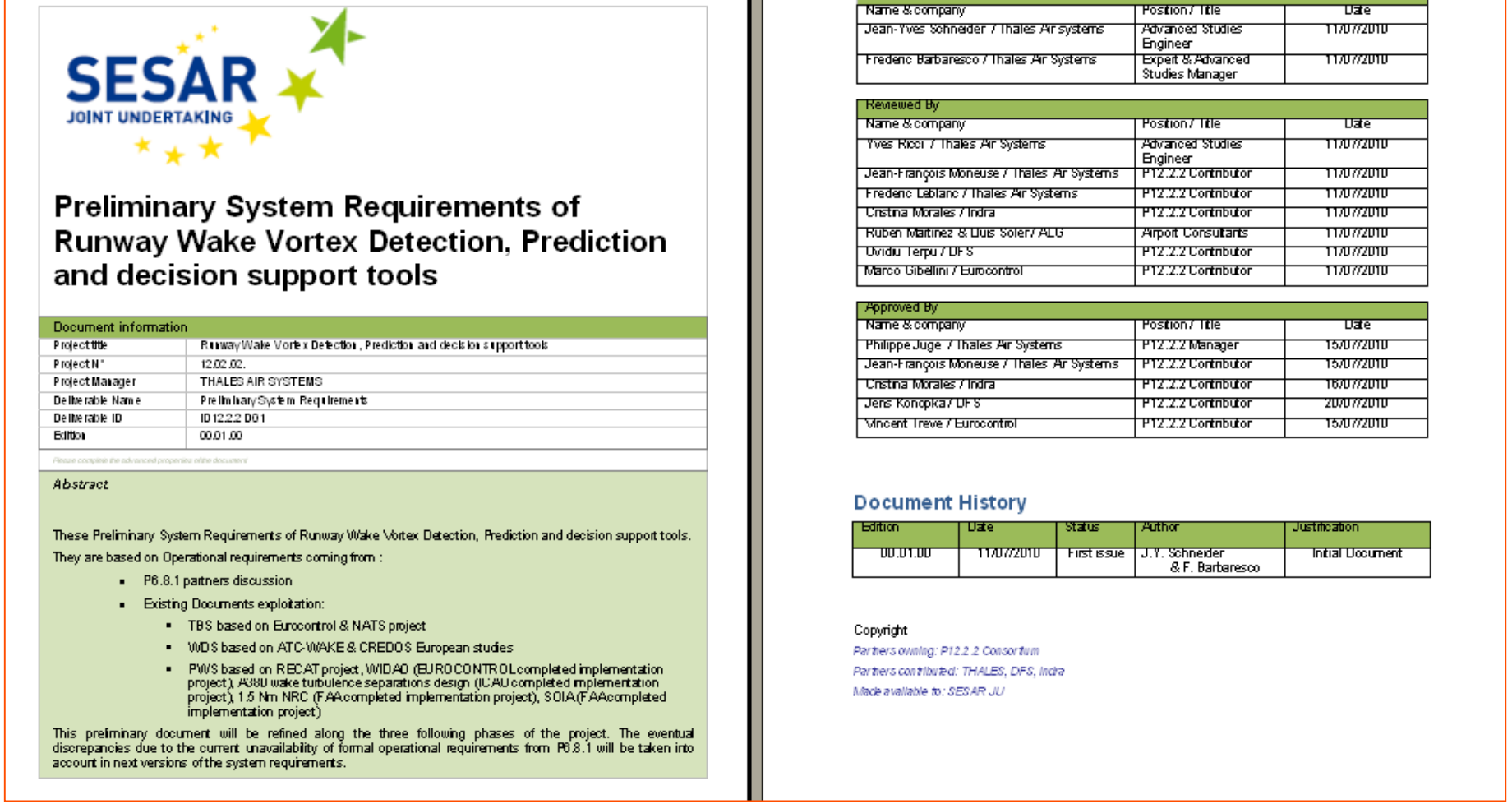
SESAR - Project 12.2.2

Preliminary System Requirements declined from 3 Operational Concepts

Categories of Operational Requirements

Requirements Categories	Definitions
Services requirements	They define the services to be provided to the users
Operational range	These requirements define the operational range covered by the systems, they fix the operational limits of the system
Responsibilities	Requirements related to assignment of responsibilities when using SESAR system
Interfaces	Requirements related to interfaces between SESAR and users or other systems
Performances	These requirements define the performances to be fulfilled by SESAR system at an operational level
Monitoring	Requirements related to monitoring of SESAR equipment, Quality of Service, Performances, …
Environmental constraints	Requirements related to interference between SESAR system and its environment
System evolution	They are not “pure” operational requirements but more general principles on future evolutions of the system

Categories of Operational Requirements



SESAR JOINT UNDERTAKING

Preliminary System Requirements of Runway Wake Vortex Detection, Prediction and decision support tools

Document information	
Project title	Runway Wake Vortex Detection, Prediction and decision support tools
Project N°	12.02.02.
Project Manager	THALES AIR SYSTEMS
Deliverable Name	Preliminary System Requirements
Deliverable ID	ID 12.2.2 D01
Edition	00.01.00

Abstract

These Preliminary System Requirements of Runway Wake Vortex Detection, Prediction and decision support tools.

They are based on Operational requirements coming from :

- P6.8.1 partners discussion
- Existing Documents exploitation:
  - TBS based on Eurocontrol & NATS project
  - WDS based on ATC-WAKE & CREDOS European studies
  - PWS based on RECAT project, WIDAO (EUROCONTROL completed implementation project), A380 wake turbulence separations design (ICAO completed implementation project), 1.5 Nm NRC (FAA completed implementation project), SOIA (FAA completed implementation project)

This preliminary document will be refined along the three following phases of the project. The eventual discrepancies due to the current unavailability of formal operational requirements from P6.8.1 will be taken into account in next versions of the system requirements.

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Vincent Treve / Eurocontrol	P12.2.2 Contributor	15/07/2010

Document History

Edition	Date	Status	Author	Justification
00.01.00	11/07/2010	First issue	J.Y. Schneider & F. Barbaresco	Initial Document

61 Preliminary System Requirements

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Organisation/Unit	Individual	Considered in P12.2.2
ANSP / ATS Unit ACC, APP, TWR (Civ., Mil.)	Air Traffic Controller • Executive Controller • Planning Controller • Ground Controller • Runway Controller	A1 : Planning controller A2 : Executive Controller A3 : Ground & Runway Controller A4 : Planning controller
ANSP / ATS Unit ACC,APP, TWR (Civ., Mil.)	ATS Supervisor	A1
MET Office (Civ., Mil.)	MET Data Manager	Automatic link with Met Office (No man in the loop) (TBC)
AIS Units (Civ., Mil.)	AI Data Manager	

Top Level Requirements

The top-level requirements are divided into four categories:

- **Requirements relative to TBS mode:**
  - REQ-12.02.02-TS-0001.0000 to REQ-12.02.02-TS-0004.0000,
- **Requirements relative to WDS mode:**
  - REQ-12.02.02-TS-0005.0000 to REQ-12.02.02-TS-0006.0000,
- **Requirements relative to PWS mode:**
  - REQ-12.02.02-TS-0007.0000 to REQ-12.02.02-TS-0008.0000,
- **Requirements relative to all separation modes:**
  - REQ-12.02.02-TS-0009.0000 to REQ-12.02.02-TS-0012.0000.

The functional requirements are divided into four categories:

- **Requirements relative to Airport Configurations:**
  - REQ-12.02.02-TS-0013.0000 to REQ-12.02.02-TS-0014.0000
- **Requirements relative to Separation Mode Planner Functioning:**
  - REQ-12.02.02-TS-0015.0000 to REQ-12.02.02-TS-0019.0000
- **Requirements relative to Wake-Vortex Prediction Functioning:**
  - REQ-12.02.02-TS-0020.0000 to REQ-12.02.02-TS-0030.0000
- **Requirements relative to Wake-Vortex Alerts Functioning:**
  - REQ-12.02.02-TS-0031.0000 to REQ-12.02.02-TS-0037.0000

Other functional requirements :

- **Requirements relative to Human Machine Interfaces (HMI):**
  - REQ-12.02.02-TS-0038.0000 to REQ-12.02.02-TS-0041.0000
- **Requirements relative to Interfaces with other systems:**
  - REQ-12.02.02-TS-0042.0000 to REQ-12.02.02-TS-0045.0000
- **Requirements relative to Non-functional Specifications:**
  - REQ-12.02.02-TS-0046.0000 to REQ-12.02.02-TS-0049.0000

Operational Product System Requirements

The Operational Product System requirements are divided into four categories:

- **Requirements relative to Top-Level Requirements:**
  - REQ-12.02.02-TS-0050.0000 to REQ-12.02.02-TS-0052.0000,
- **Requirements relative to Functional System Requirements :**
  - REQ-12.02.02-TS-0053.0000 to REQ-12.02.02-TS-0055.0000,
- **Requirements relative to Human Machine Interfaces (HMI):**
  - REQ-12.02.02-TS-0056.0000,
- **Requirements relative to Non-functional Specifications:**
  - REQ-12.02.02-TS-0057.0000 to REQ-12.02.02-TS-0061.0000

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SESAR - Project 12.2.2 Operational Concepts Constrained by weather/wake sensors Capabilities

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A network on Aircraft Wake Turbulence

SESAR WP12.2.2 Project schedule overview

Phase 1	Phase 2	Phase 3
2010-2012	2013-2014	2015-2016

Full scale simulation model

Model calibration & validation

XP0 Trials

Data acquisition:
Sensors Benchmark
(CDG)

March/April 2011

WV sensors :
- X-band radar (mech scan)
- 1.5 µm Lidar

Weather Sensors :
- Anemometers
- Lidar Wind Profiler
- UHF Radar Wind Profiler
- SODAR
- *X-band weather radar*
- *Visivility*

XP1 Trials

Partial prototype:
« Off-Line » demonstration
Time Based Separation
(CDG)

WVAS System :
- Separation Mode Planner
- Wake Vortex Predictors
- WV Alerts
- Operator HMI

WV sensors :
- X-band radar (elec scan)
- 1.5 µm Lidar

Weather Sensors :
- Selected Wind profiling sensors

XP2 Trials

Full scale prototype:
« Shadow Mode »
Weather Dependant Separation
(CDG)

WVAS System :
- Separation Mode Planner
- Wake Vortex Predictors
- WV Alerts
- Operator HMI

WV sensors :
- X-band radar (elec scan)
- 1.5 µm Lidar

Weather Sensors :
- Selected Wind profiling sensors

XP3 Trials

Full scale updated prototype:
« Shadow Mode »
Pair Wise Separation
(Frankfurt)

WVAS System :
- Separation Mode Planner
- Wake Vortex Predictors
- WV Alerts
- Operator HMI

WV sensors :
- X-band radar (elec scan)
- 1.5 µm Lidar

Weather Sensors :
- Selected Wind profiling sensors

Note: The Wake Vortex Advisory System: **WVAS**

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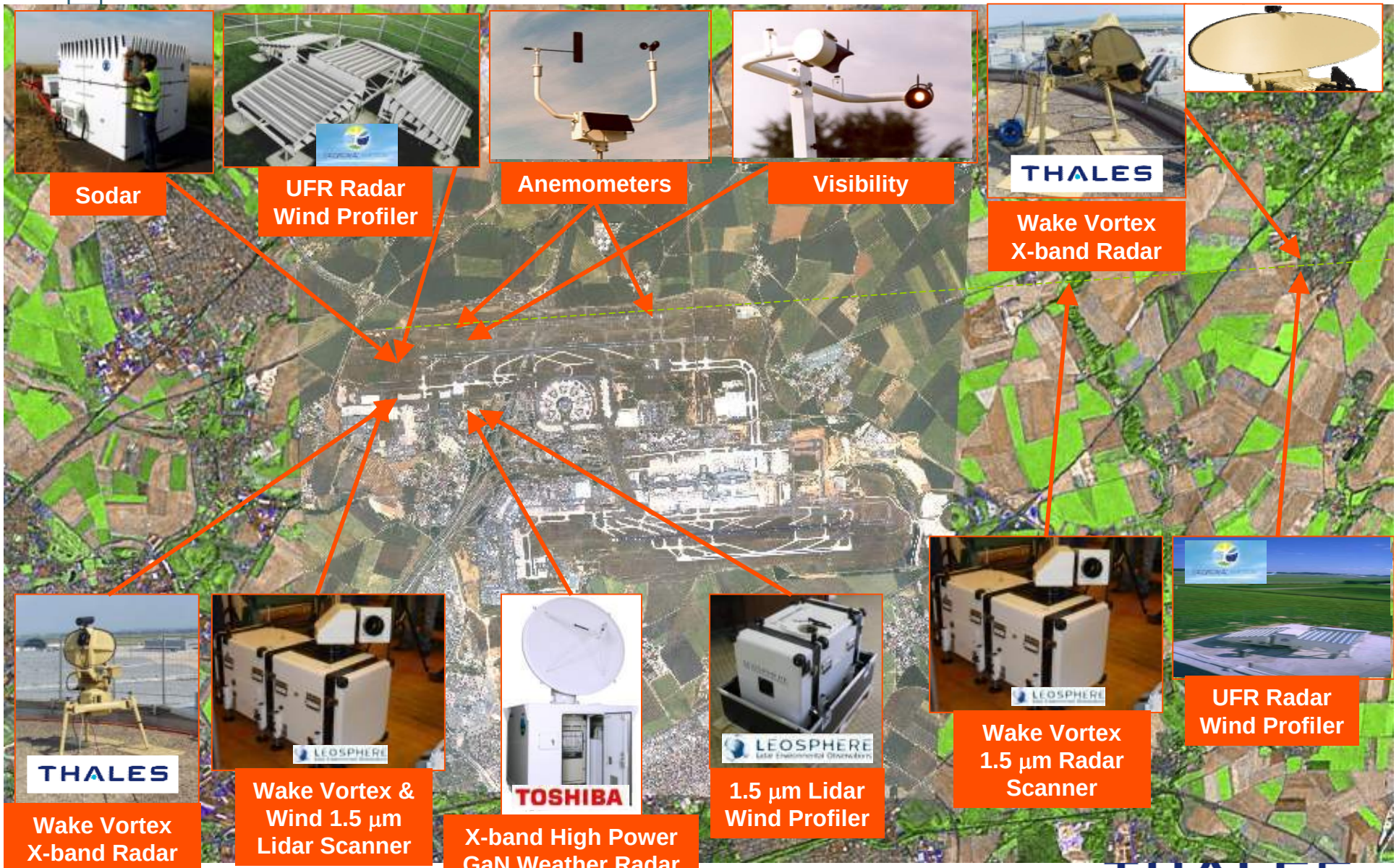
XP0 CDG Trials : WV & Wind Sensors Deployment



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Characteristics of all sensors deployed

Wake Vortex sensors

- X band radar BOR-A (THALES)
- Windcube 200S scanner Lidar (LEOSPHERE)

Weather sensors

- Anemometers (METEO FRANCE
- Windcube 70 wind profiler Lidar (LEOSPHERE)
- X band weather radar (TOSHIBA)
- SODAR (METEO FRANCE)
- UHF Wind Profiler radar-PCL1300 (METEO FRANCE)
- UHF Wind Profiler radar-PCL1300 (DEGREANE-HORIZON)





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BOR-A radar → AF A380 building / Lidar Windcube 200 → PC De-icing

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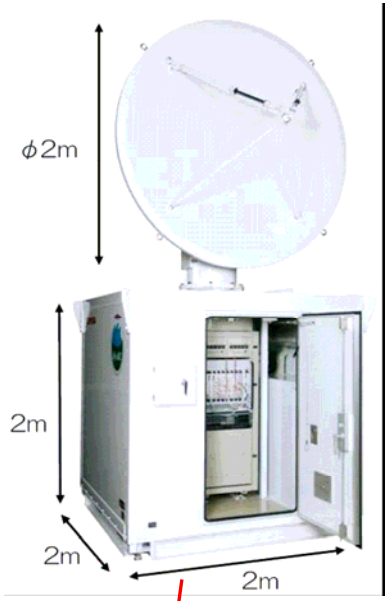
Lidar WLS70 / X-band Radar → 7300 building (PC neige)



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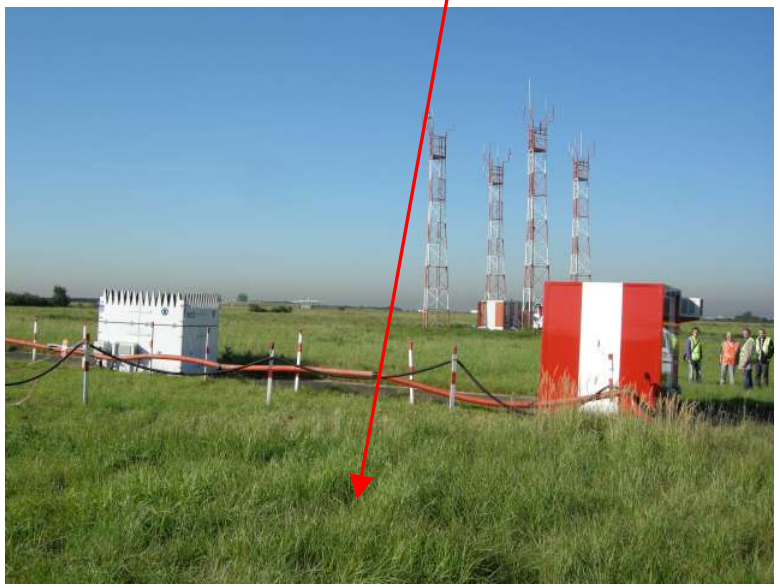
SODAR & UHF WP → 09L runway / UHF WP → RSY site at Juilly



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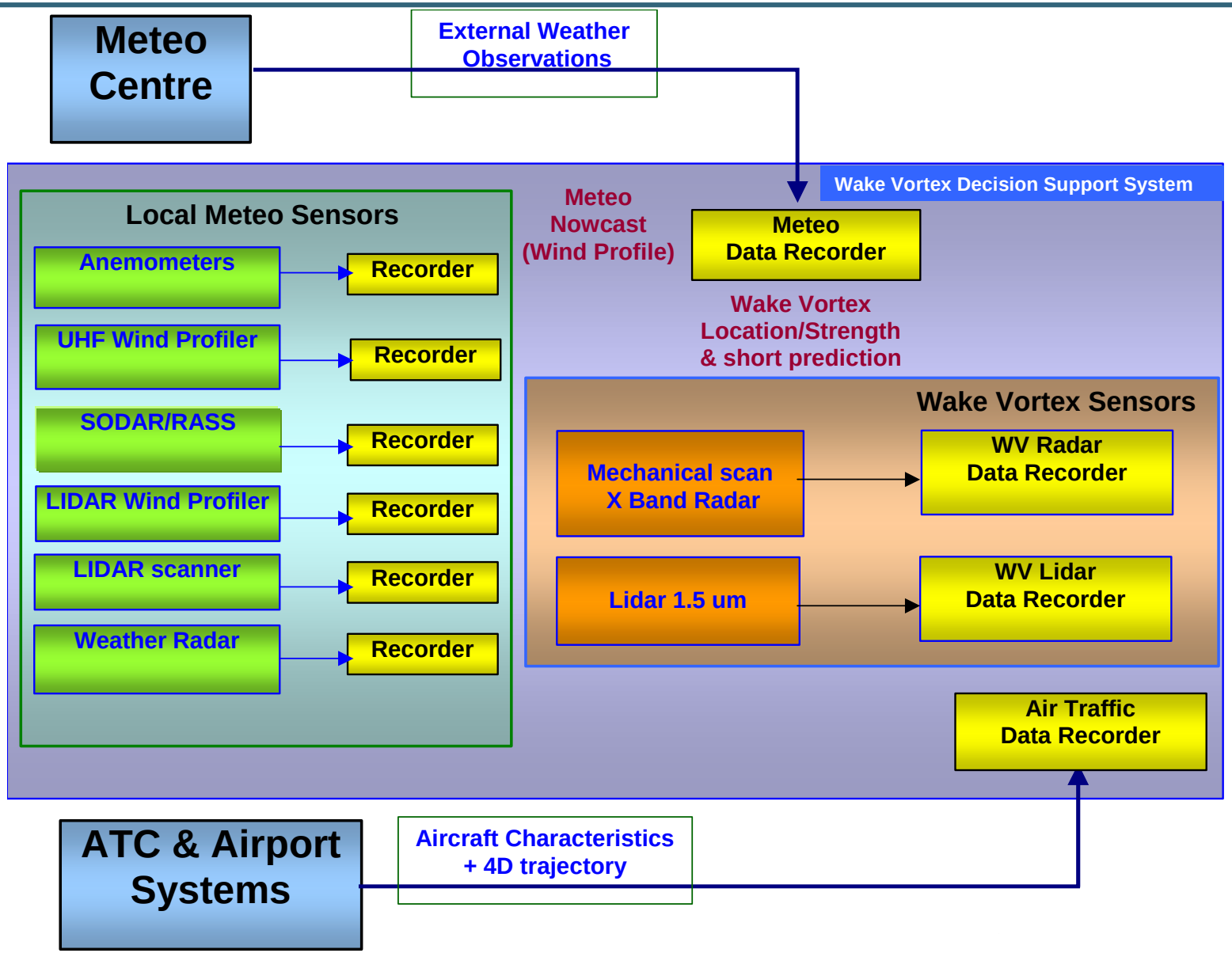
Architecture breakdown in XP0 trials



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