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WAKE VORTEX DETECTION BY X-BAND BOR-A550 RADAR : PARIS ORLY AIRPORT CAMPAIGN

F. Barbaresco, A. Jeantet, U. Meier

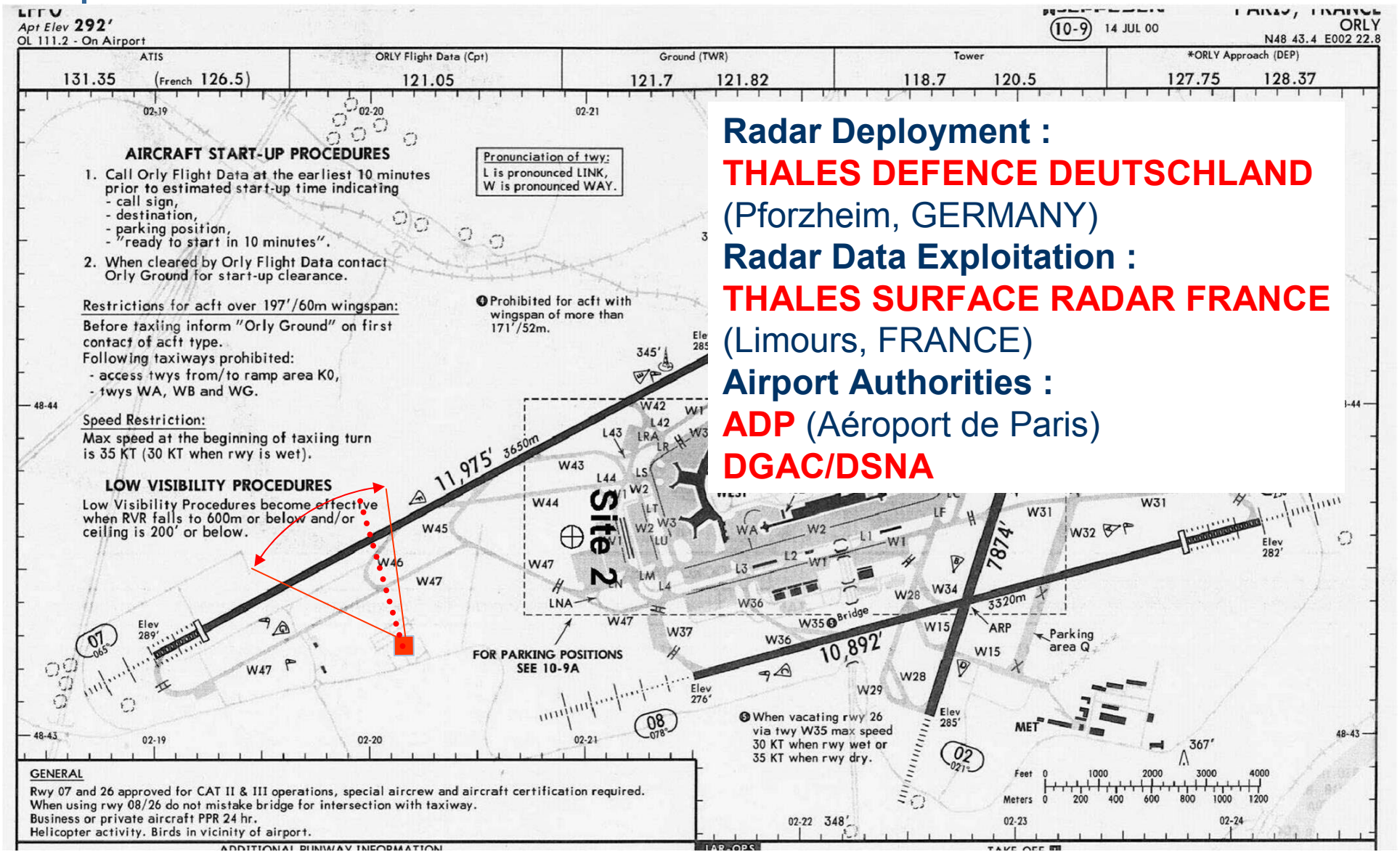
Thales Air Systems

- BOR-A550 Radar Description, Scenario & operating modes of Paris ORLY Airport Campaign
- High Resolution Doppler Radar Data Exploitation in Staring & Scanning Modes for Wake Vortex Detection/Monitoring in All Weather Conditions (Wet & Dry)
- Wake Vortex Reflectivity in Clear Air : Theory & Experiments
- BOR-A550 Radar for Safety Cases on Airports & Operational Use in a “Wake Vortex Alerts System”

Paris ORLY Airport Campaign

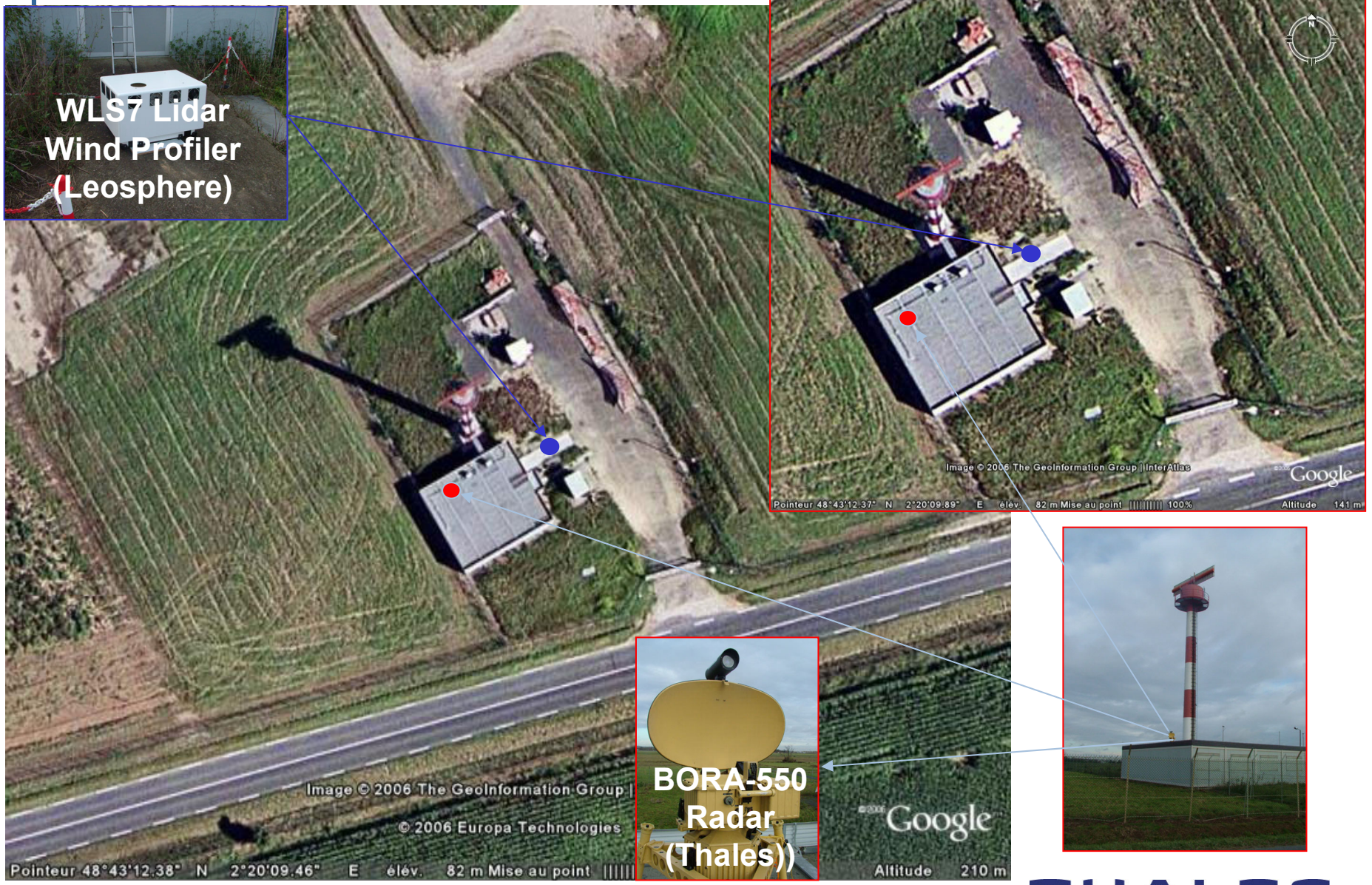
Scenario with BOR-A550 Radar

X-BAND RADAR POSITION AT PARIS ORLY AIRPORT



Radar Deployment :
THALES DEFENCE DEUTSCHLAND
(Pforzheim, GERMANY)
Radar Data Exploitation :
THALES SURFACE RADAR FRANCE
(Limours, FRANCE)
Airport Authorities :
ADP (Aéroport de Paris)
DGAC/DSNA

Radar (& Lidar Wind Profiler) Site at Paris Orly Airport



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Radar & Lidar Sensors Deployment

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BOR-A550 Radar Description, Scenario & operating modes of Paris ORLY Airport Campaign

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BOR-A550 Radar Description

BOR-A550 Radar View at Paris ORLY Airport Site

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Additional Sensor : Lidar Wind Profiler

LEOSPHERE
Lidar Environmental Observations

Collaboration with
ONERA

WLS7
Lidar
1.5 µm
for
Wind
Nowcasting
until
160 m
In Altitude

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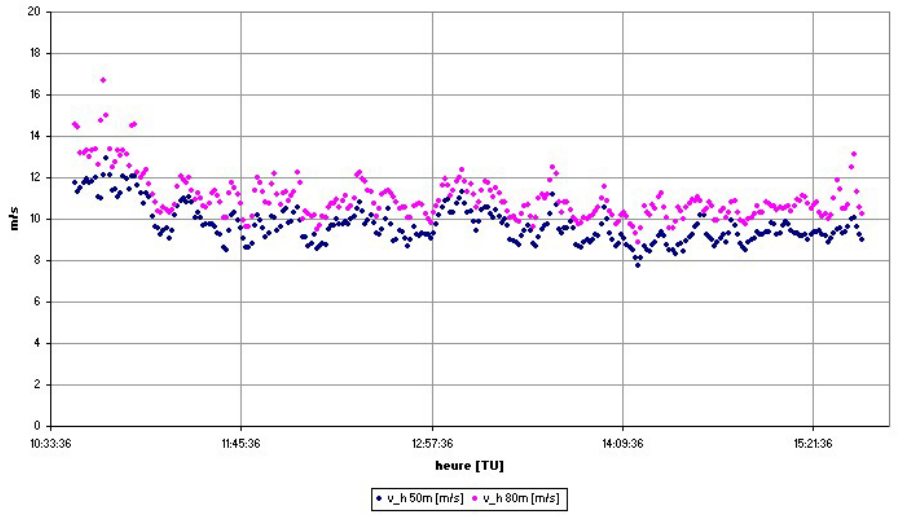
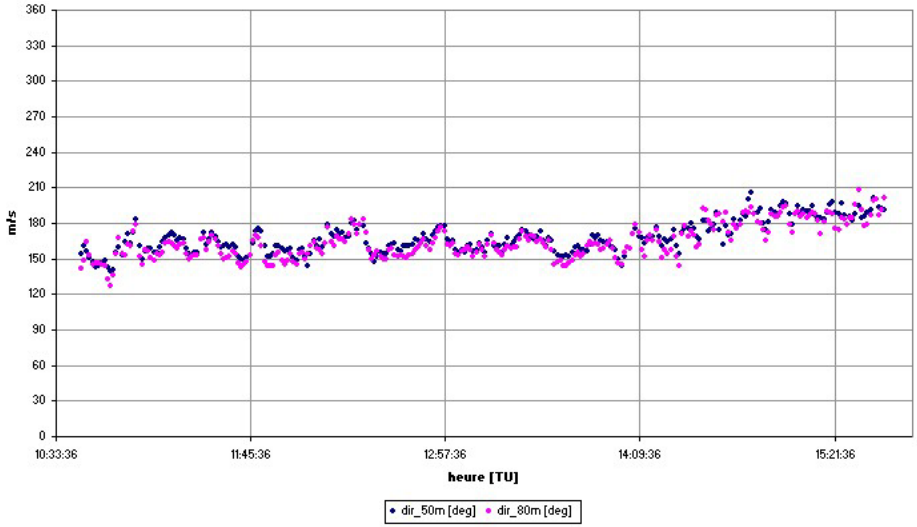
Wind Data from Lidar Wind Profiler : 27/11/2006

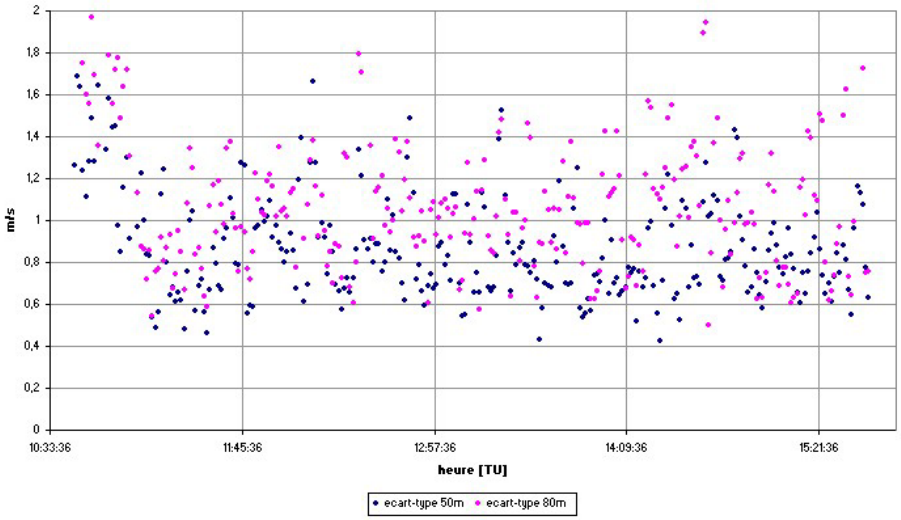
Horizontal Speed : 50 & 80 m (update rate : 1 mn)



Speed direction : 50 & 80 m (update rate : 1 mn)



Standard deviation : 50 & 80 m (update rate : 1 mn)



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Operating Modes of Data Recording & Meteo Data

Operating Mode : Staring Antenna

Recording Conditions

- **27th of November : without Rain**
- **28th of November : with Rain (1.19 mm/h)**

Recording only on Small & Medium Aircrafts (with longer take-off threshold, heavy aircrafts have not been recorded)

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Operating Mode : Scanning on 45°

Recording Conditions

- **29th of November :**
  - **scanning mode**
  - **scan angle : 45°**
  - **scan rate : 8°/s**
  - **without rain**

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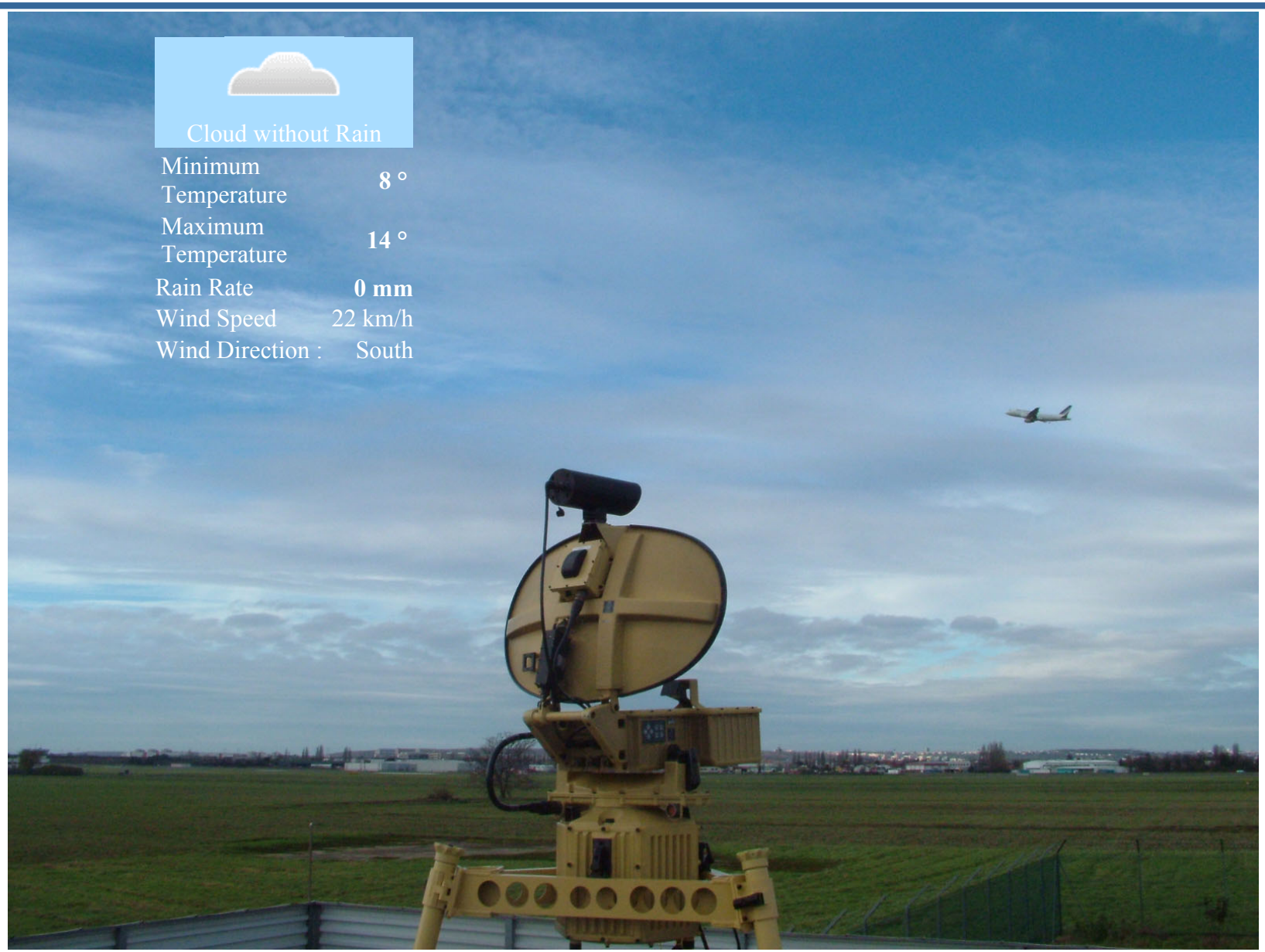
Weather Condition : 27th of November



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Weather Condition : 28th of November

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High Resolution Doppler Radar Data Exploitation in Staring & Scanning Modes for Wake Vortex Detection/Monitoring in All Weather Conditions (Wet & Dry)

DOPPLER RADAR SIGNATURE OF WAKE VORTEX

High Resolution Doppler Spectrum
of Radar Wake Vortex Signatures
and their exploitation
are Confidential

All Results have been presented in January 2007 to EUROCONTROL, ADP (Aéroport de Paris) & DGAC/DSNA

All Results of Paris ORLY Airport Campaign
(Commercial in Confidence)
could be presented on Demand
after a Non Disclosure Agreement (NDA)

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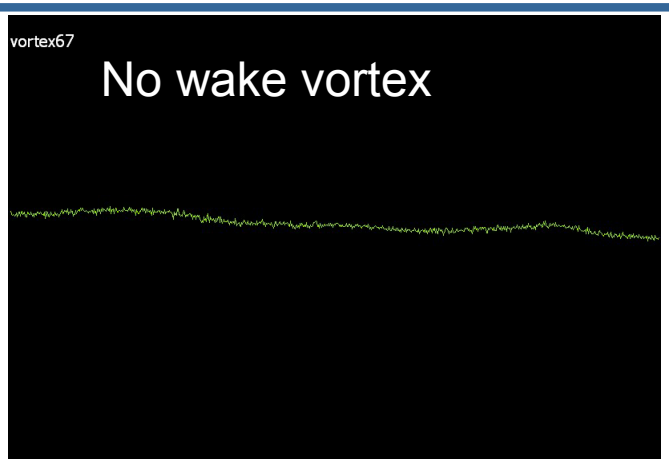
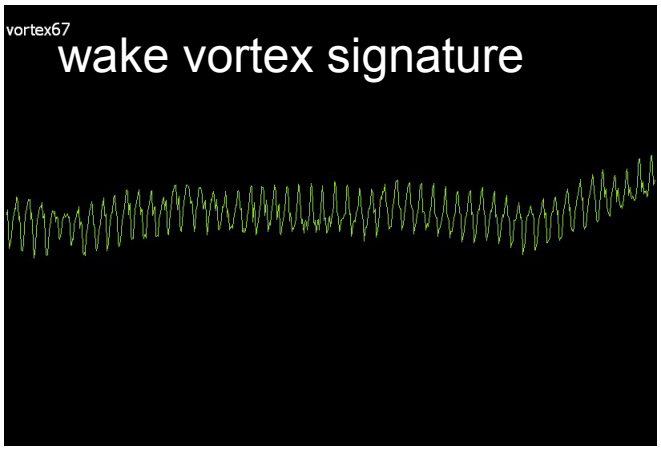
Doppler Radar Data Exploitation in Staring Mode

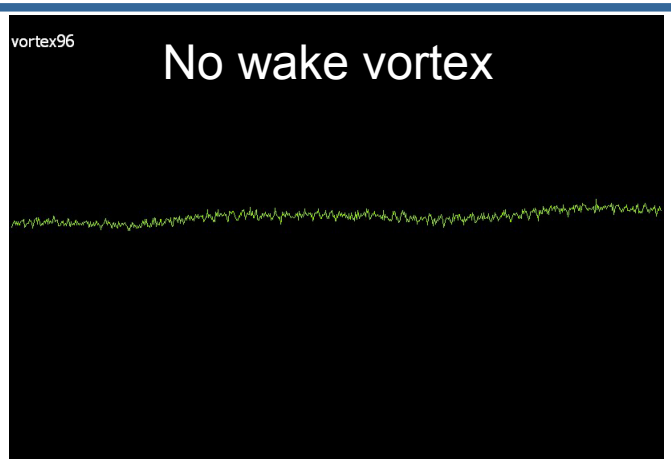
DOPPLER RADAR SIGNATURE OF WAKE VORTEX IN STARING MODE

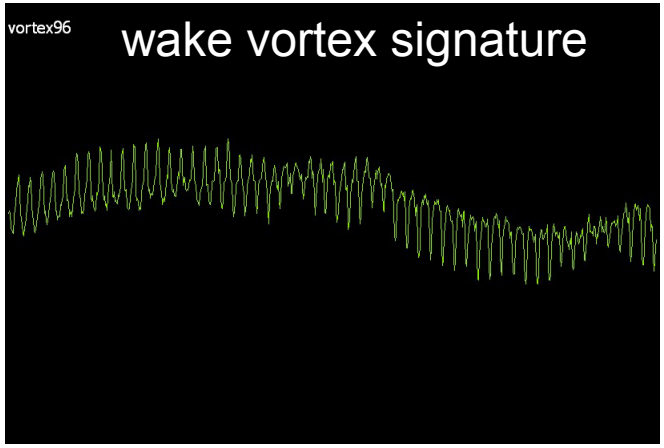




Wake Vortex Radar Signature
Without Rain

Doppler Spectrum are confidential





Wake Vortex Radar Signature
With Rain

All Wake Vortices (600 m from Radar) have been detected In Wet and Dry Weather Conditions

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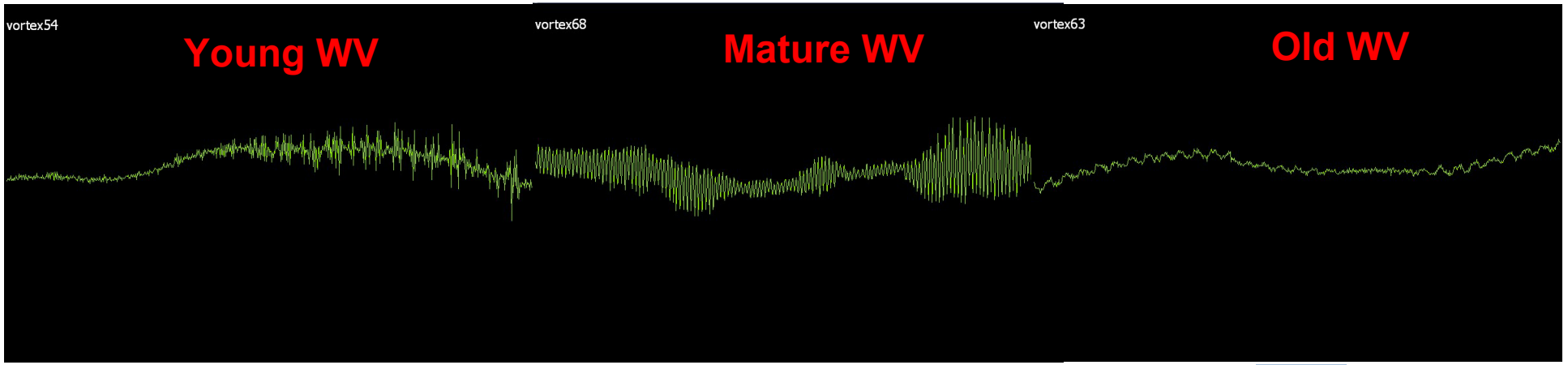
WAKE VORTEX EVOLUTION & ITS AGE



Doppler Spectrum are confidential

Wake Vortex Evolution with different Ages

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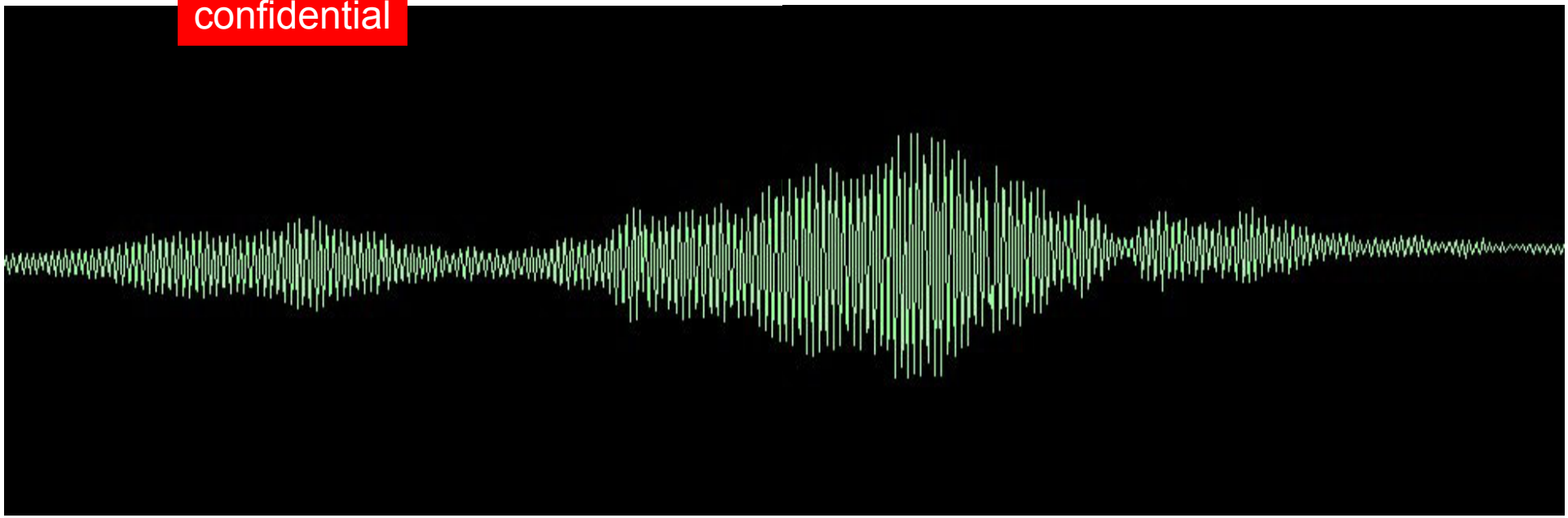
Doppler Radar Data Exploitation in Scanning Mode(45° with 8°/s)

DOPPLER WAKE VORTEX SIGNATURE IN SCANNING MODE

Doppler Spectrum are confidential

Wake Vortex Radar Signature
Without Rain



Time = angle (8°/s)

Scanning Mode on 45° (scan rate : 8°/s)

Same Performances as in Staring Mode

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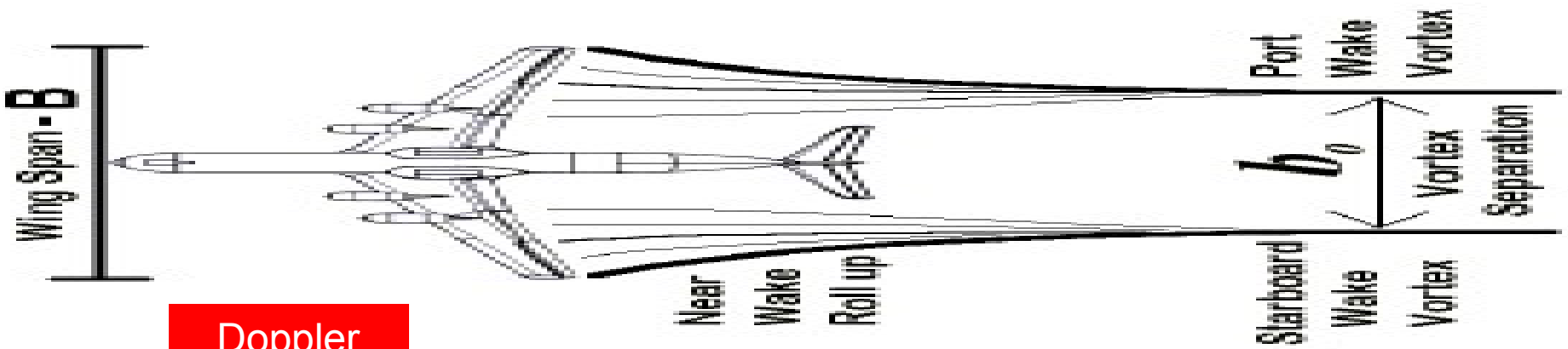
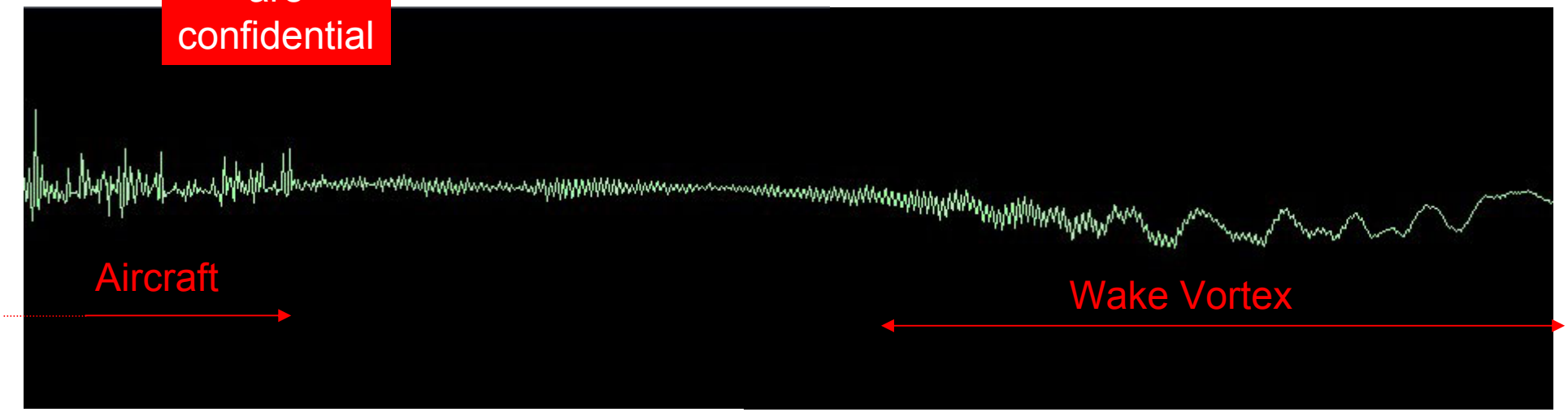
DOPPLER WAKE VORTEX SIGNATURE IN SCANNING MODE



Doppler Spectrum are confidential



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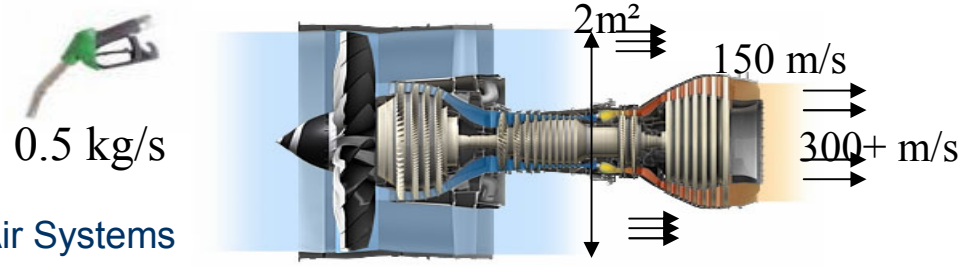
RADAR REFLECTIVITY OF WAKE VORTEX IN CLEAR AIR

CLEAR AIR RADAR REFLECTIVITY OF WAKE VORTEX

- **"Analysis of the Radar Reflectivity of Aircraft Vortex Wakes" by Karim SHARIFF and Alan WRAY, J. Fluid Mech., vol. 463, pp.121-161,Cambridge University Press, 2002**
  - **Tests have revealed radar echoes from aircraft wakes in clear air.**
  - **Two mechanisms causing refractive index gradients are :**
    - **Radial Pressure (and therefore density) gradient in a columnar vortex arising from the rotational flow**
    - **Adiabatic transport of atmospheric fluid within a descending oval surrounding a vortex pair**
  - **The role of Engine Exhaust :**
    - **At approach, the exhaust of a heavy aircraft has a temperature of 477 K and each engine emits 1200-6000 lb/h of water vapour. If we consider the temperature contribution alone, this is roughly two orders of magnitude greater than for the density variation in each vortex. But due to turbulent mixing of the exhaust with the ambient, wake RCS doesn't change when the engine run at idle or full power. Diversion of some engine exhaust into the laminarizing flow of the vortex cores may allow the exhaust to maintain its heat further downstream.**
    - **Exhaust diameter of 2 m yields a partial pressure of vapour and a contribution which is much smaller than that due to temperature.**



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BOR-A550 Radar for Safety Cases on Airports & Operational Use in a "Wake Vortex Alerts System"

FOLLOW-ON STUDY : PARIS CDG SAFETY CASE

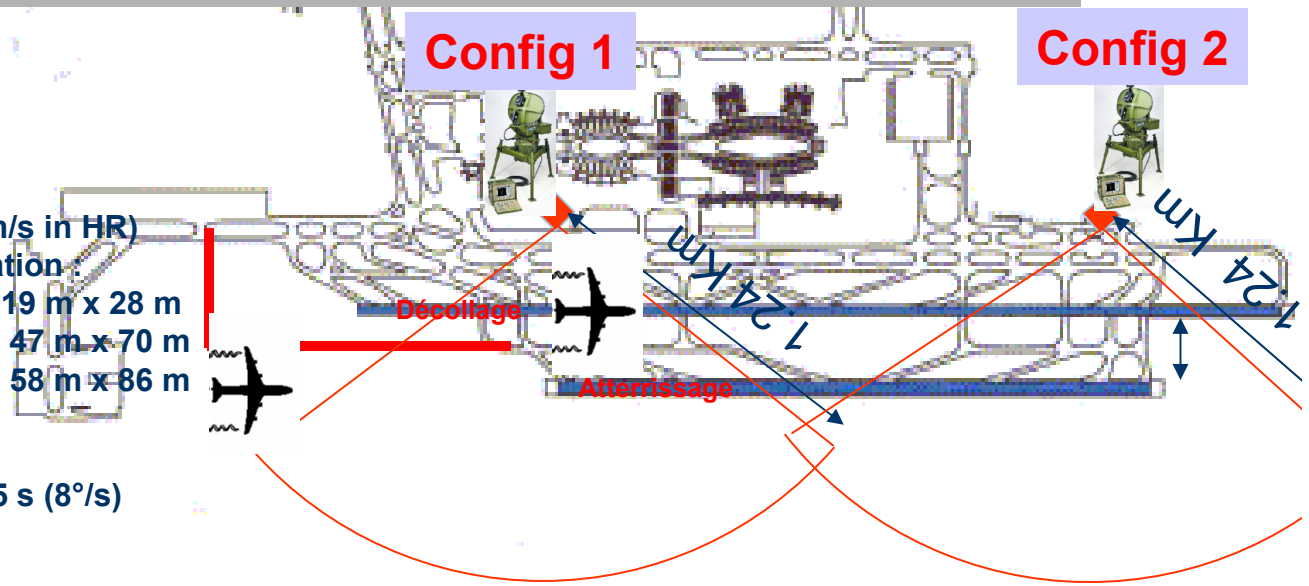
***WAKE VORTEX ALERTS SYSTEM* ARCHITECTURE IS DESCRIBED ON A POSTER OF *THALES AIR SYSTEMS S.A* DURING WAKENET CONFERENCE**

X-BAND BOR-A550 RADAR CAN BE DEPLOYED , AS SOON AS 2007, ON LARGE EUROPEAN AIRPORTS FOR SAFETY CASES (CDG, Francfort, Heathrow, Schiphol, Zürich,…)

MODE : SCANNING
OBSERVATION AREA :
- **Azimuth : 90°**
- **Range : from 400 m to 1240 m**
- **Resolution :**
  - **Doppler : 0.2 m/s (0.04 m/s in HR)**
  - **Cell range/azimuth/elevation :**
    - **at 400 m : 40 m x 19 m x 28 m**
    - **at 1000 m : 40 m x 47 m x 70 m**
    - **at 1340 m : 40 m x 58 m x 86 m**

RADIAL VELOCITY RANGE :
- **+/- 26 m/s**

UPDATE RATE OF 90° SECTOR : 11.25 s (8°/s)



- **Range until first runway : 400 m**
- **Range between Runways : 340 m**
- **Runway Width : 50 m**

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Thank you for your attention

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Acknowledgements

DSNA & ADP Team (ORLY)

- **Jean-Paul Lecorre**
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- **Daniel Duong**
- **Gilbert Herbulot**

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- **Alfred Harter**

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- **Gérard Batistella**

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- **Jean-Pierre Nicolaon**