

On the use of Radar Wind Profiler Data for Wind Farm Site Selection

Hands-On with Degreane Horizon PCL-1300

Baptiste Domsps*, J. Marmain, C. Melnotte and T. Pugliesi

Degreane Horizon – Radar and Scientific Applications Department

* Corresponding author: baptiste.domsps@degreane-horizon.fr

Specialist Meeting on Electromagnetic Waves and Wind Turbines
École Nationale de l'Aviation Civile, 5-6 Dec 2019



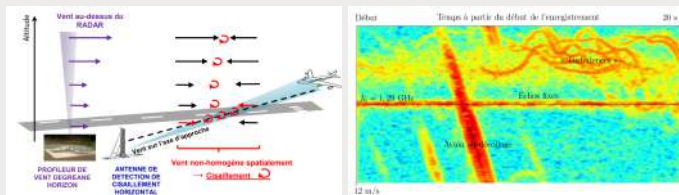
AGENCE
INNOVATION
DÉFENSE



Research Topics

Degreane Horizon Wind Profiler: measures wind speed and direction on a vertical axis (meterological agencies, airports)

Our 'usual' research topic: wind shear detection



Our 'wind energy' research topic: wind assessment using radar system

- Early stages
- Marketing studies, requirements

Outline

- Research Topics

1 Background

- Degreane Horizon
- VINCI group
- Wind energy and VINCI Énergies

2 Degreane Wind Profiler

- System overview
- Wind remote sensing with radar
- Processing overview

3 Wind Potential Assessment

- Generalities
- Issues with classical instruments
- Wind Assessment with Wind Profiler

4 Summary

- Appendix

Degreane Horizon

- Based in Toulon (French Riviera)
- 70 people, sales: €10m

Our expertises



Degreane Horizon

- Based in Toulon (French Riviera)
- 70 people, sales: €10m



Our expertises



A full range of worldwide-trusted weather sensors, e.g.:



Degreane Horizon

- Based in Toulon (French Riviera)
- 70 people, sales: €10m



Our expertises



Defence



Space surveillance radar



Air-droppable met system



Underwater acoustics

Degreane Horizon

- Based in Toulon (French Riviera)
- 70 people, sales: €10m



Our expertises



Energy/transport

Remote alarm systems, Data transmission, Remote control,
Galvanic Isolation Devices

Degreane Horizon

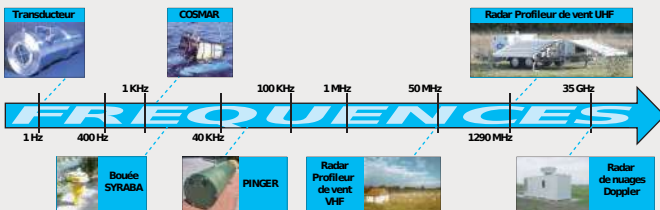
- Based in Toulon (French Riviera)
- 70 people, sales: €10m



Our expertises




A wideband knowledge





VINCI group

Global player in concessions and construction

Degreane Horizon is part of VINCI , itself part of VINCI group



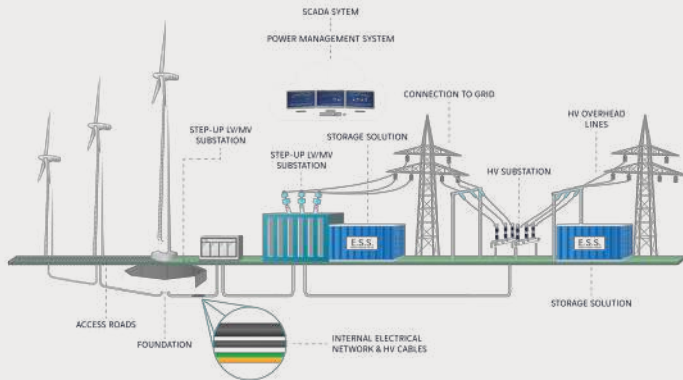
- Investor, builder and operator of buildings and infrastructure
- Worldwide business (≈ 100 countries)
- At the heart of today's challenges



Wind energy and VINCI Énergies

Dedicated brand for energy transition: **OMEXOM**

- 21k people, 33 countries
- Power (wind & solar), transmission, substations, distribution, territories



System overview

Degreane Horizon Wind Profiler: measures wind speed and direction on a vertical axis



- L-band ($\approx 1,3$ GHz)
 - 3 to 5 arrays of dipoles
 - Range from 75 m to 5 km
 - 75 m max resolution
 - 2 min temporal resolution
-
- Deployed on > 50 sites worldwide, many references in the meteorological literature as a reliable instrument
 - Optional temperature profile with RASS system

System overview

Setup example

Wind Profiler



(hard or mobile installation)



data (wired, LTE)



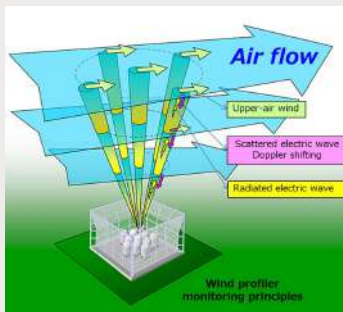
Remote Data Analysis

- Custom-setup: hard or mobile
- Turnkey solution (including civil engineering if needed)
- Robust system with autonomous and continuous operation under all weather conditions
- Remote data analysis
- Life span > 10 years, low operating costs

Wind remote sensing with radar

Detection of irregularities of the refractive index of particle-free clear air

These irregularities are caused through variations in the temperature, pressure and moisture that affect the propagation of electromagnetic waves and backscattering

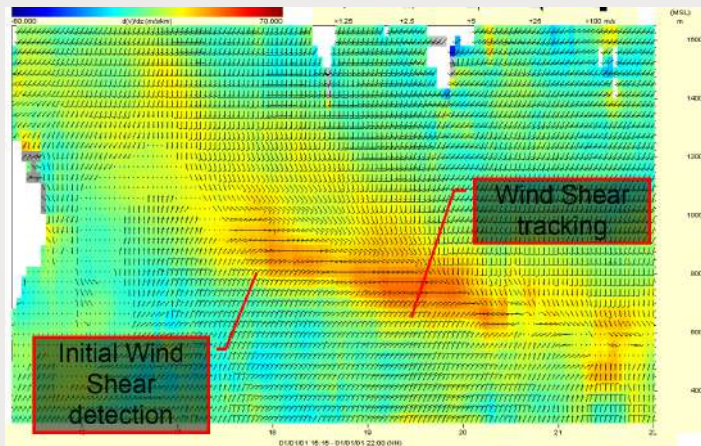


Japan Meteorological Agency

- Doppler Beam Swinging technique to compute wind vector
- Applications: Aeronautic safety, Meteorological forecasting, Study of atmosphere's dynamic, etc.

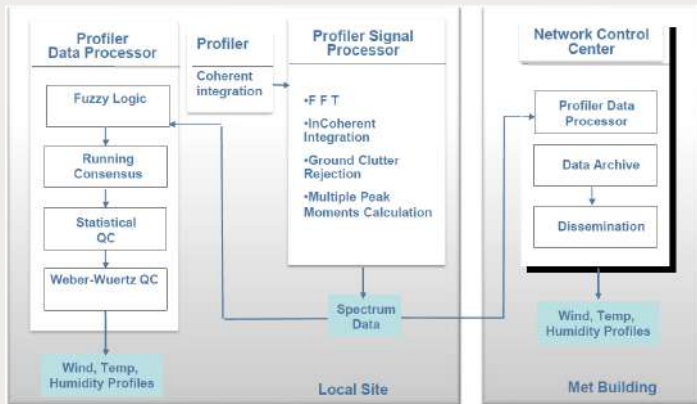
Wind remote sensing with radar

Case study: Wind Shear & Wind Barb display (3 min
sampling, 7 hours data)



Time vs Altitude

Processing overview



- Own software tailored to customer's requirements
- Full quality control functionality is provided at all stages of signal and data processing

Generalities about Wind Potential Assessment

- One of the first step when designing a Wind Farm Project
- Ensures economic viability of the farm:
 - 1 identification of wind site (mesoscale wind atlases);
 - 2 preliminary evaluation;
 - 3 assessment of site and micrositings.

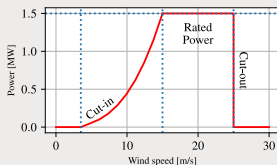
Wind Potential depends on w :

$$P_W = \frac{1}{2} \rho A w^3$$

Probabilistic model for w :

$$f(w) = \frac{k}{\lambda} \left(\frac{w}{\lambda} \right)^{k-1} \exp \left(-\frac{w}{\lambda} \right)^k$$

Power Curve is non-linear



Goal: Find the most realistic $(\lambda; k)$ parameters

Issues with classical instruments

Masts

3 different Meteorological Towers:

- ❶ Site Selection: 40 m, 2 years data, 1/site
 - Measures Wind direction & speed, humidity, temperature
 - Verify Wind Atlases Data
 - Wind at the rotor's height is **estimated** with the Wind profile power law
- ❷ Micrositing: 100 m, 2 months, 1/Wind Turbine
 - Validation of Wind Turbine position
- ❸ Operation: 100 m, during all Wind Farm's life, 1/site
 - Met Monitoring

Expensive, Civil engineering required, No errors permitted,
Height limitation

Issues with classical instruments

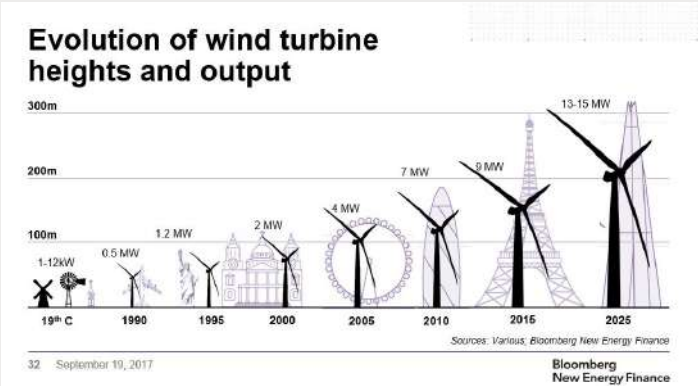


There are even
offshore met masts!
FINO-1: 80 m

D. Muñoz-Esparza, F. Miceli

Issues with classical instruments

Masts are becoming too short



- WTG's rotor is now outside the radar's blind zone

Issues with classical instruments

Anemometer/Lidar/Radar

Anemometer mounted on Met Masts: sensitive to
Aerodynamics Effects because of the mast

Pros for Lidar Very high radial resolution for low altitudes

Cons for Lidar Expensive, Mechanical parts

Pros for Radar All-weather, Reliable, Temperature &
Humidity with RASS

Cons for Radar Lower resolution, Blind zone near ground

Wind Assessment with Wind Profiler

1 Reduce the blind zone:

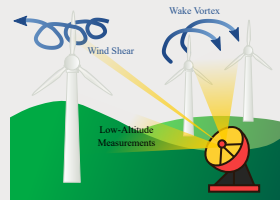
- First gate at 75 m
- Ground noise and fixed-echoes issues

2 Better resolution:

- Resolution depends on Pulse Width: $r = \frac{c\tau}{2}$
- Present shorter Pulse Width is $\tau = 0.5 \mu s$
- Faster switching: less transmit power

Summary

- Promising alternative to met masts
- Wind speed & direction but also temperature with RASS
- I would be happy to discuss further 😊



Baptiste Doms
baptiste.doms@
degreane-horizon.fr



AGENCE
INNOVATION
DÉFENSE



Signal Processing Appendix

