# Scanflow: High-resolution full-scale wind field measurements of the ECN's 2.5 MW aerodynamic research wind turbine using DTU's 3D WindScanner and SpinnerLidar for IRPWind's and EERA's benchmark

**Hasager, Charlotte Bay; Mikkelsen, Torben Krogh; Angelou, Nikolas; Pena Diaz, Alfredo; Giebel, Gregor; Wagenaar, Jan Willem; Schepers, Gerard; Werkhoven, Erwin**

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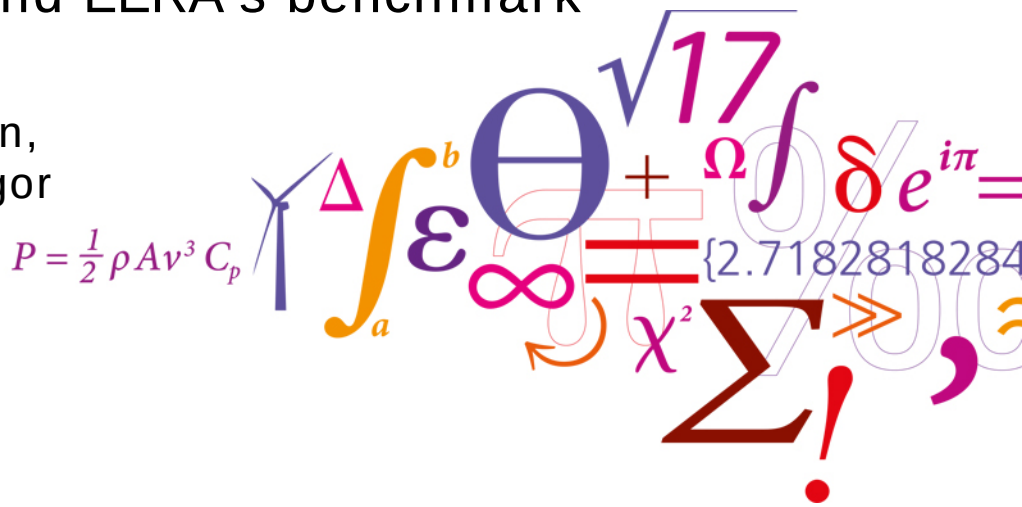
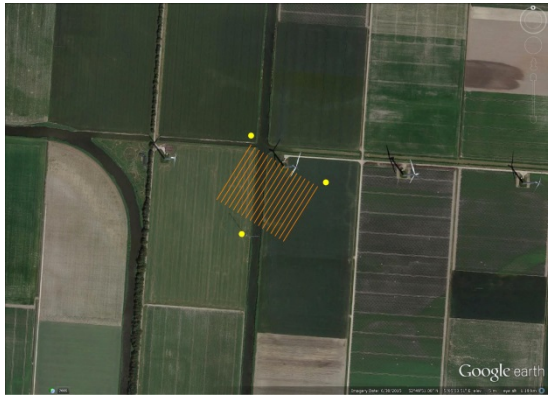



DTU Wind Energy
Department of Wind Energy

# Research topics and originality

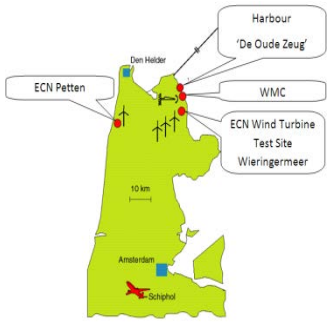
We aim to establish a unique turbine power performance and induction zone benchmark experiment by operating a DTU developed high-resolution nacelle integrated 2D SpinnerLidar installed in a research wind turbine at ECN.

Concurrently, three ground-based short-range WindScanner lidars from DTU will be deployed to perform 3D wind velocity field observations Cf. WindScanner.dk and WindScanner.eu

# ECN Test Site (EWTW)

## *ECN Wind turbine Test station Wieringermeer*

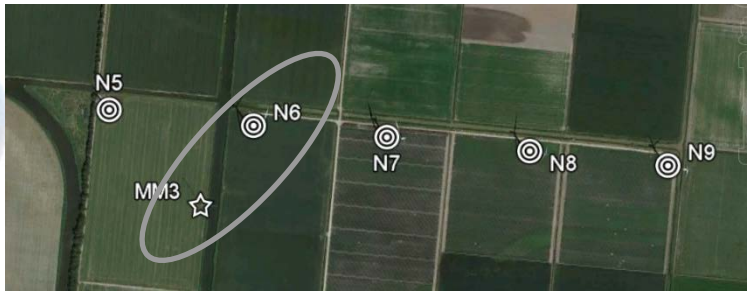


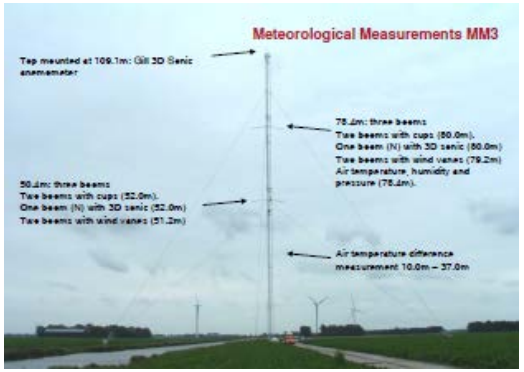

- Prototype turbines and masts
  - 6 prototypes: 2MW-5MW, D=100m-120m
  - 4 IEC compliant meteorological masts
- Research turbines and mast
  - 5 ECN research turbines East-West
  - IEC compliant meteorological mast
- Measurement pavilion
  - Data gathering and transfer to ECN

# ECN test site set-up

- Meteorological mast 3
  - Cups, vanes and sonics @ 52m, 80m, 108m
  - Temperature, pressure, etc
- ECN research turbine
  - Nordex, 2.5MW
  - H=D=80m
- Over 10 years of experiences. High quality measurements

- Installation on N6
  - 2nd in row from West
  - On top of cooler

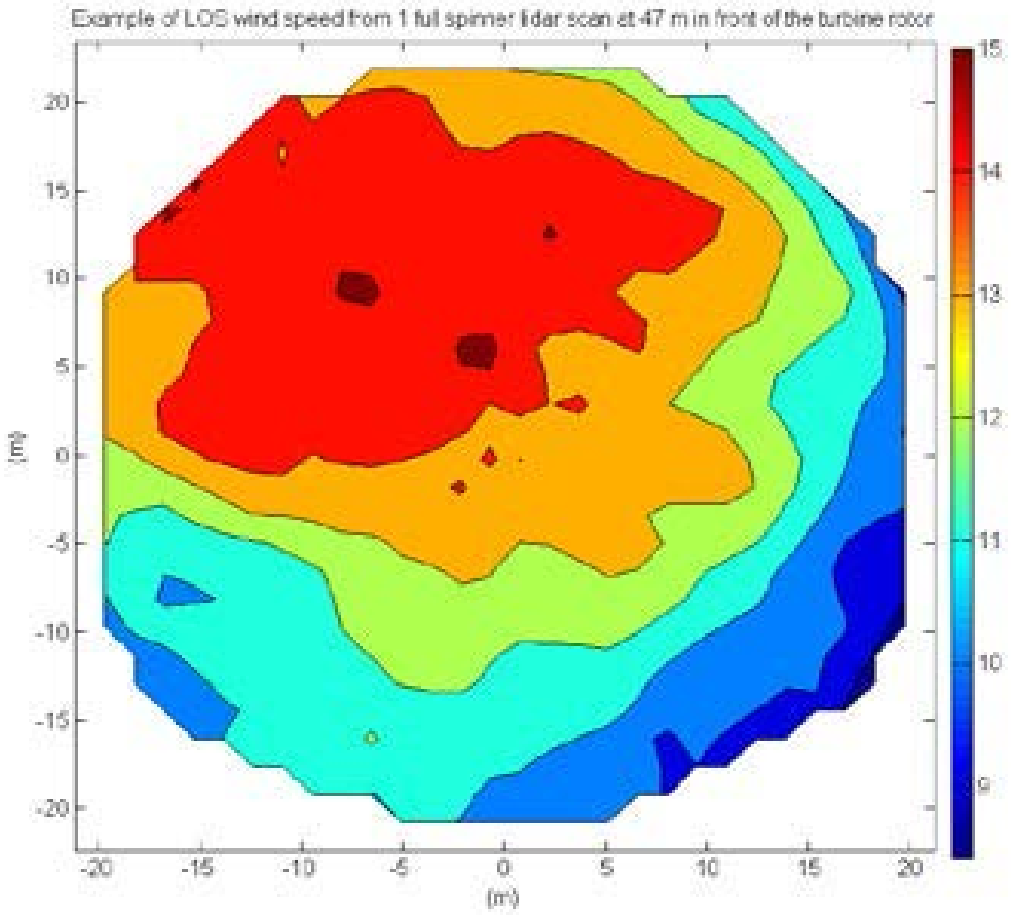


# DTU 2D SpinnerLidar on Risø Campus NordTank during the UniTTE[1] field test 2015


[1]Wagner R, Vignaroli A, Angelou N, Sathe A, Meyer Forsting A R, Sjöholm M, Mikkelsen T 2015 MEASUREMENT OF TURBINE INFLOW WITH A 3D WINDSCANNER SYSTEM AND A SPINNERLIDAR DEWEK 2015 pp 7–10

# A single 2D SpinnerLidar measurement during UniTTE 2015 (4 s sampling period)



# Experimental evaluation ECN 2016: Syncronized 3D scanning short-range WindScanners

# Outcome

- The **ScanFlow** project will provide a **state-of-the-art inflow dataset** useful for evaluation of aerodynamic models ranging from engineering-like up to computational fluid dynamics models, models of the inflow and induction zone.

- A proof-of concept testing of the new advanced software for wind reconstruction using the LINCOM model based on the anti-Cyclop buster methodology program will be applied. The idea of the latter is to extract all three wind components of the **inflow in front of the rotor from a single SpinnerLidar**.

- The result will be compared with the **“true” ground based measurements of the three wind speed components (u,v,w) from the three short-range WindScanner** lidars that will measure from the ground.

- The benchmark will be available through an **open access** e-science platform also beyond project time.

# Main components of ScanFlow

- The **WindScanner SpinnerLidar** from DTU will observe during 6 weeks the inflow approaching the research wind turbine.

- The raw data will be transformed into 3D inflow wind velocity fields upwind the rotor plane by methods developed at DTU and compared against **3D short-range WindScanner** observations from DTU during few weeks; thereby establish a limited dataset proof-of concept demo.

- The turbulence will be assessed from an expression combining the **rotor equivalent wind speed and the power fluctuations of the wind turbine** and will be compared to turbulence observed from the WindScanner and turbulence observed from mast observations.

# Work Packages

- **WP1** (DTU) Preparation of short range WindScanners at DTU
- **WP2** (ECN) Preparation of measurement campaigns
- **WP3** (ECN) 6 week measurement campaign of the SpinnerLidar (nacelle), including installation, dismantling and shipment
- **WP4** (DTU) 2 week measurement campaign of the short range WindScanners (ground based), including installation, dismantling and shipment
- **WP5** (DTU) Post-processing of collected data. Proof of concept three wind components SpinnerLidar
- **WP6** (ECN) Public database with wind turbine, meteorological and WindScanner data. Workshop with database announcement **(18-20 January 2017 EERA DeepWind Conference, Trondheim)**

# Gannt diagram, Deliverables and Milestones

Extension
Feb. 2017

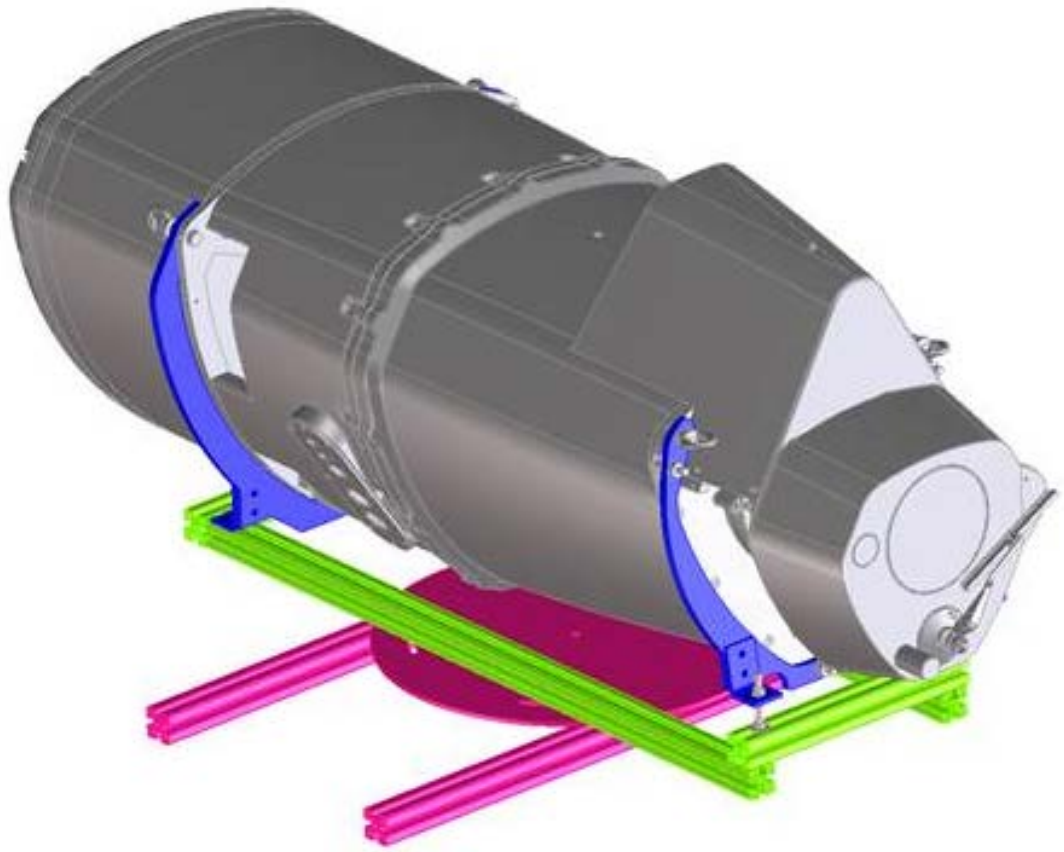
| | June | July | Aug | Sep | Oct | Nov | Dec | Lead |
|---|---|---|---|---|---|---|---|---|
| **WP1:Prepare WindScanners** | X | X | D1 | | | | | DTU |
| **WP2: Experiment detail plan** | | | D2 | | | | | ECN |
| **WP3: Nacelle campaign** | | | | X | M2 | | | ECN |
| **WP4: Ground campaign** | | | | M1 | | | | DTU |
| **WP5: Post-processing data** | | | | | X | X | D3 | DTU |
| **WP6: Database/publication** | | | | X | X | M3 | D4, D5 | ECN |

D3, M3, D4, D5

D1: Nacelle-based and ground-based lidars ready for experiment
D2: Final experimental plan published
D3: Report on the experiment and proof of concept
D4: Final workshop with external colleagues from EERA and industry invited
D5: Final project report

M1: Collected 2-weeks of three ground-based WindScanner data
M2: Collected 6-weeks of nacelle-based WindScanner inflow data
M3: Open database launched

# Progress on the SpinnerLIDAR mounting bracket



# Dissemination

- The dissemination strategy is to produce 100% open access to the benchmarks on inflow conditions. This will include the 10-minute wind turbine information on power production and the collected WindScanner data.

- The Transfer of Knowledge will be through the dedicated web-sites of
  - ✓ IRPWIND http://www.irpwind.eu/
  - ✓ WindScanner.eu http://www.windscanner.eu/
  - ✓ WindBench https://windbench.net/

- Final presentation at EERA DeepWind Trondheim 2017

# Key Performance Indicators (KPIs)

- Obtain 6 weeks measurements with WindScanner SpinnerLidar at ECN wind turbine test field
- Obtain data from three ground-based short-range WindScanner lidars during a two week campaign
- Deliver the wind turbine 10 minute data power production, pitch angle and rotational speed to public database.
- Deliver WindScanner 10 minute data to public database.