TotalControl: Full-Scale Measurements at Lillgrund Offshore Wind Farm

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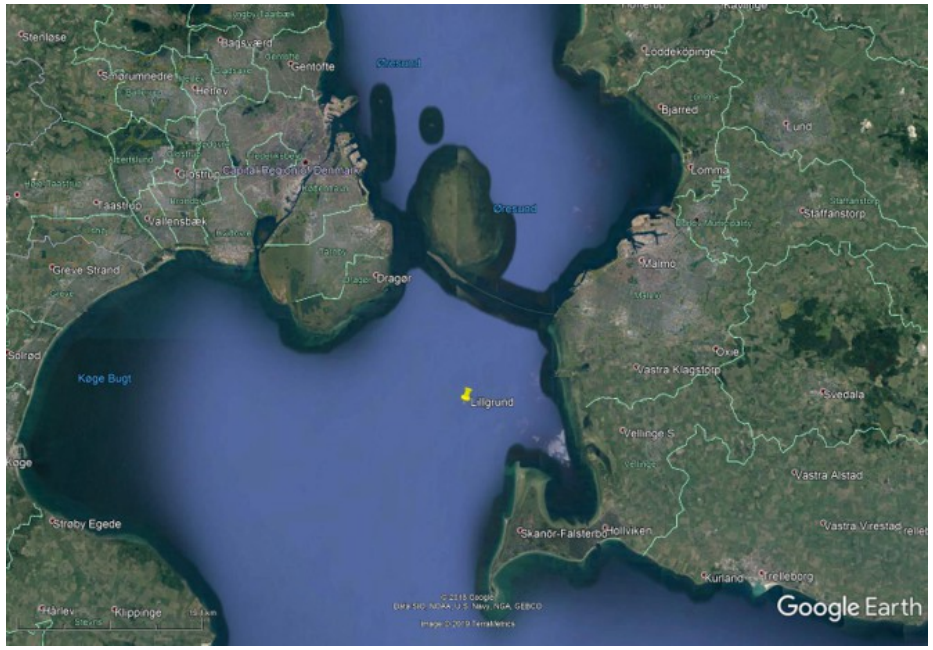
Measurement Systems & Methods

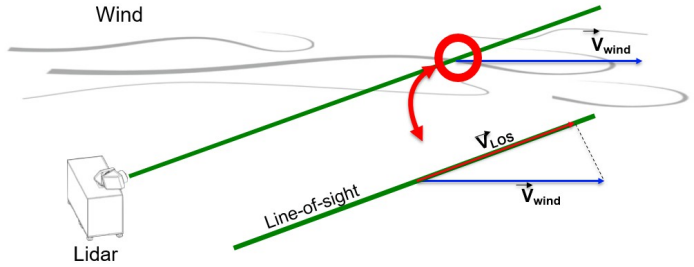
TotalControl test site #1

- Lillgrund offshore wind farm
- Swedish waters in Øresund strait near Copenhagen
- Vattenfall owned & operated
- (110 MW, 48x Siemens SWT-2.3-93)



DTU Long-Range WindScanner System

- Hardware:
  - Pulsed coherent scanning Doppler lidar
  - Measures line-of-sight (aka radial) wind speed which can be reconstructed into wind vector via different methods
  - 2-axis scan head allows arbitrary beam pointing
  - Low laser emission power is eye safe
  - Measurements possible at long range (up to 10 km) with consistent sampling volume
  - Multiple distances (range gates) along beam measured simultaneously



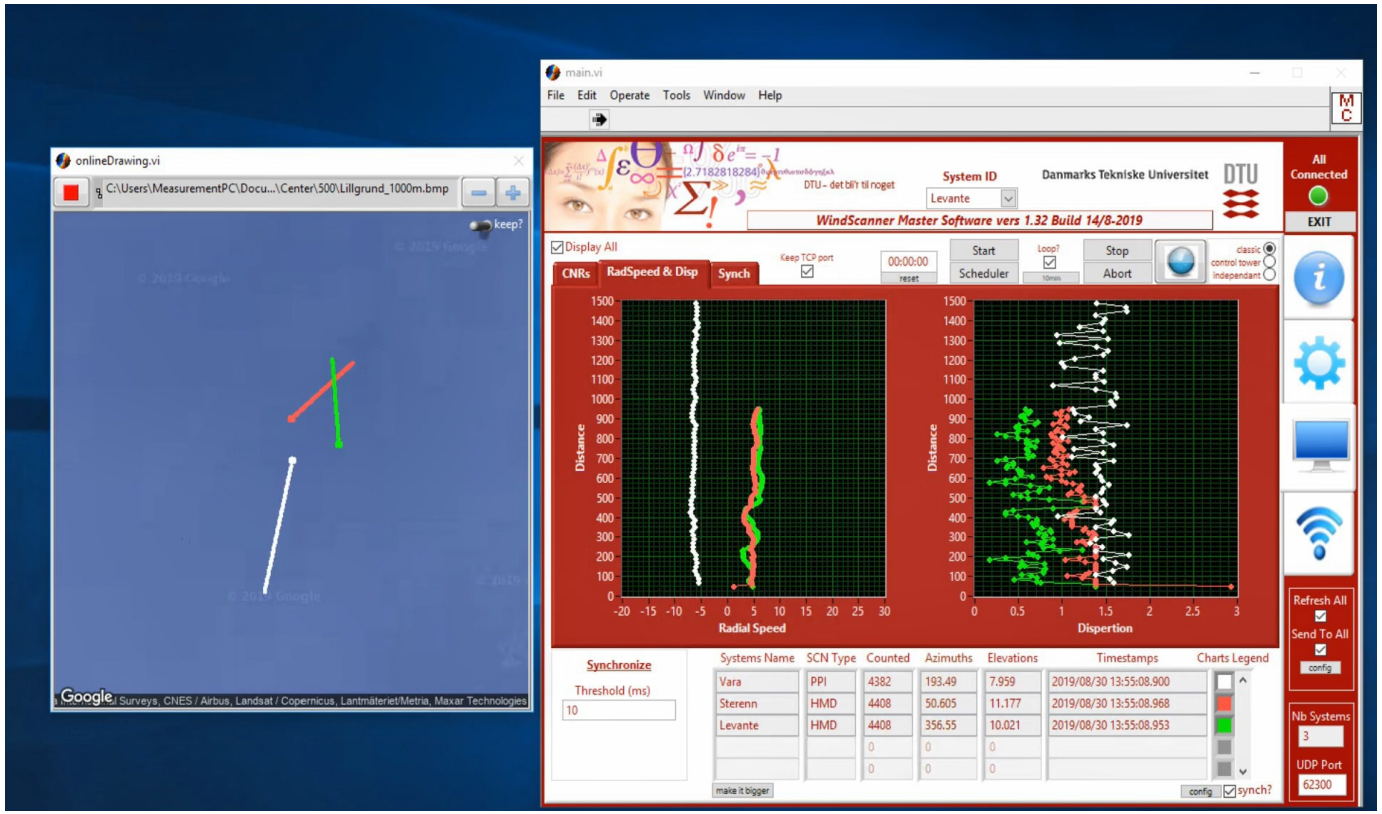
- Software:
  - Complex scan pattern support
  - Multi-lidar synchronization for dual & triple Doppler
  - Unified communication protocol (RSComPro)

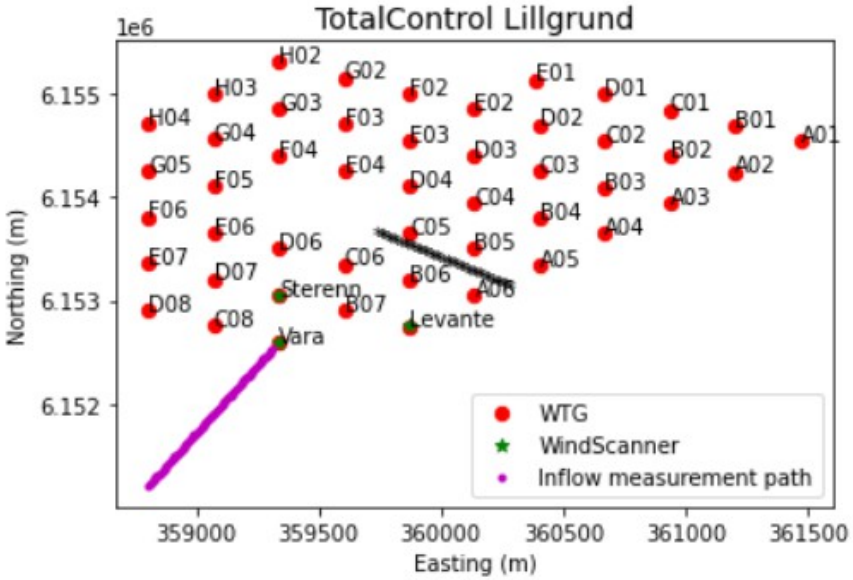
https://www.mdpi.com/2072-4292/8/11/896

TotalControl Lillgrund

- 3 LRWS installed on wind turbine transition pieces
- 1x for wind farm inflow (PPI), 2x for wakes (synchronized dual-Doppler complex trajectory mode)
- Video montages of wind farm operation, high frequency SCADA and load measurements
- Demonstration and full-scale measurements of wind farm control
  (dynamic wake steering & induction control)

Lidar placement and scan patterns





Wake scans:

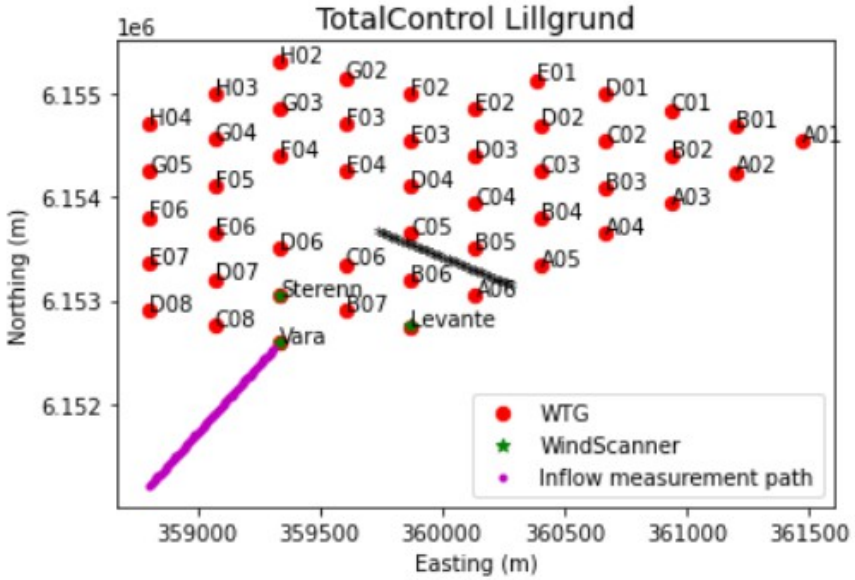
- Space & time synchronized dual Doppler complex trajectory
- Transect centered 6RD downstream of B07 WTG, 8RD wide
- 3 heights measured (6, 70, 130m ASL) in “TV scan” configuration
- Gives synchronized vertical plane (40 points/line x 3 lines) every 60s

Inflow scans:

- 60 degree PPI scans centered upstream of wake transect
- Elevation angle = 7.95 degrees
- 70m-1.5km range, RG every 20m
- Sample rate = 30s
  (2 deg/s, 500ms accumulation time)

Dual-Doppler wake measurements

- Entire overlapping dual-Doppler area reconstructed
  - Animated result shows hub-height plane of horizontal winds during 20 degree yaw test
- Space-time synchronized vertical plane available



Dual-Doppler wake measurements (Arezoo Zamanbin)

The end

- Currently focused on running second full-scale test campaign in Scotland
- Questions?
- You are welcome to contact me later:
  ellsim@dtu.dk
- We are very happy to work together in other research or commercial projects