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Scanning LiDAR Installation and Operation Offshore: Offshore Wind Accelerator Wake Study

E. Brown[1],C. Arnott[1], A. Oldroyd[1], N. Adams[2], B. Gribbens[2], B. Gellatly[3], J. Moffat[4], M. Jiminez[5], N. Connell[6], C. Pearce[7]
1 Oldbaum Services, Stirling, United Kingdom; 2 Frazer Nash Consultancy, Bristol, United Kingdom; 3 Carbon Trust, London, United Kingdom; 4 E.ON, Nottingham, United Kingdom; 5 DONG Energy, London, United Kingdom; 6 Mainstream Renewable Power, London, United Kingdom; 7 RWE Npower Renewables, Swindon, United Kingdom

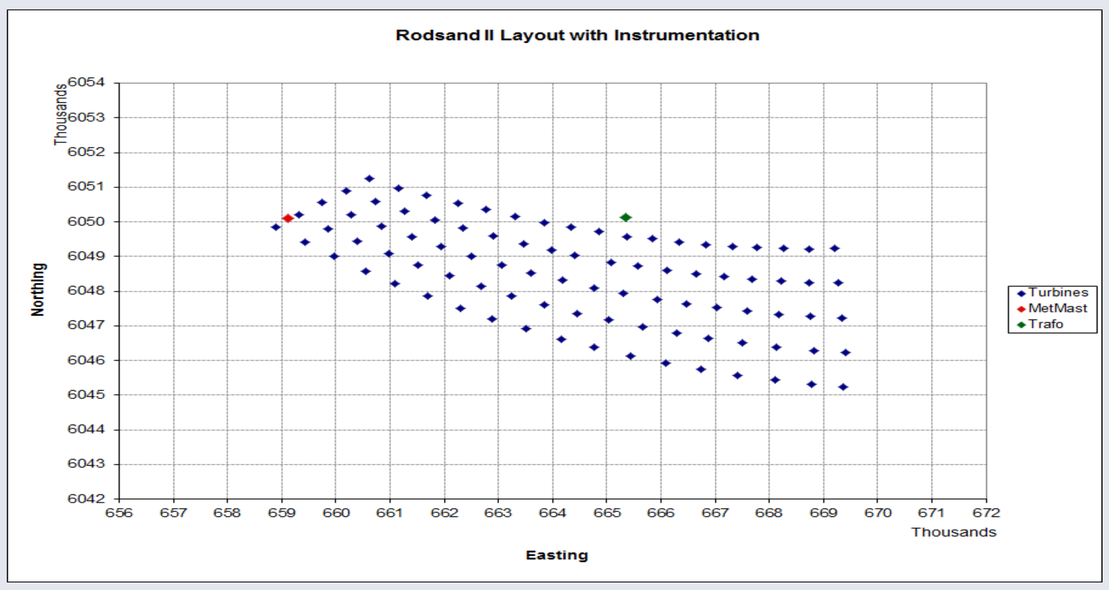
Abstract

As part of the Carbon Trust's 'Offshore Wind Accelerator' program, a study into offshore wakes and turbulence is to be carried out using the innovative combination of four nacelle mounted LiDARs and two long range scanning LiDARs. The scanning LiDARs selected are the Windcube 200s by Leosphere. This campaign is the foremost industrial study into complex wakes and has a number of campaign aims to better understand offshore wakes and their implications on power delivery and turbine loads.

The Windcube 200s scanning LiDAR uses a single pulsed laser beam and optical head allowing it to scan distances up to 12km. This then means that understanding the alignment of the system is of utmost importance as any small deviation in will have a significant impact on the data returned. This is also critical to the campaign goals as matching the scan patterns to accurate locations around the wind farm are key to surveying wakes throughout the farm.

Location

The Windcube scanning LiDARs were installed in two locations within E.ON's Rødsand offshore wind farm in Denmark. The first is located to the north of the farm on a transformer platform, and the second on a met mast to the South West corner of the farm. Both locations allow for measurement of the free stream inlet conditions to the farm, and allow for measurement of wake interactions under varying conditions depending on wind direction.



Scanning LiDAR locations – indicated by green and red markers

Installation

Prior to offshore installation and operation the LiDARs used in this project were validated at the DTU Høvsøre site. Each LiDAR had to meet certain criteria for data availability and in regression coefficients in comparison with the 116m met mast at the testing facility.

Upon transportation to Denmark each system was assembled and checked for operation onshore prior to final installation. This helped to reduce the spent offshore, which was beneficial for both safety and project costs.
Once installed in their final locations the systems were then checked to ensure the levelling of the units and the orientation with respect to the wind farm.

Windcube located on Met Mast platform

Given the measurement range of 6km that the LiDARs can achieve, an inclination error of 0.5º results in an error of 52m in the measurement location at the maximum range. It is clear therefore that careful levelling and verification is essential.

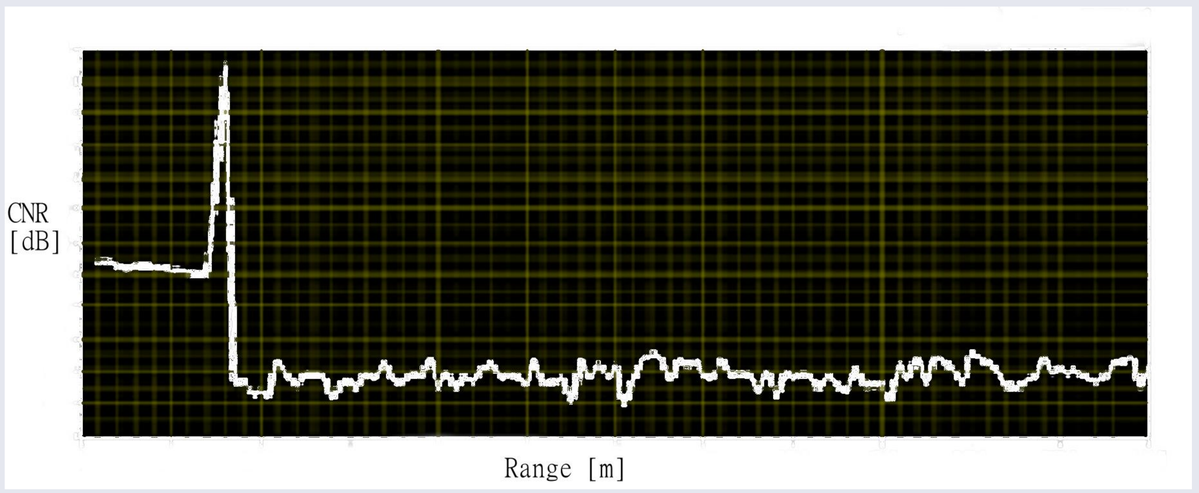
Verification

Using the known positions of turbines within the farm the precise location and orientation of the systems could be calculated. This involved using the line of sight mode of the LiDAR in which the beam stares in a fixed direction. The direction and range to turbines in the vicinity could therefore be measured.

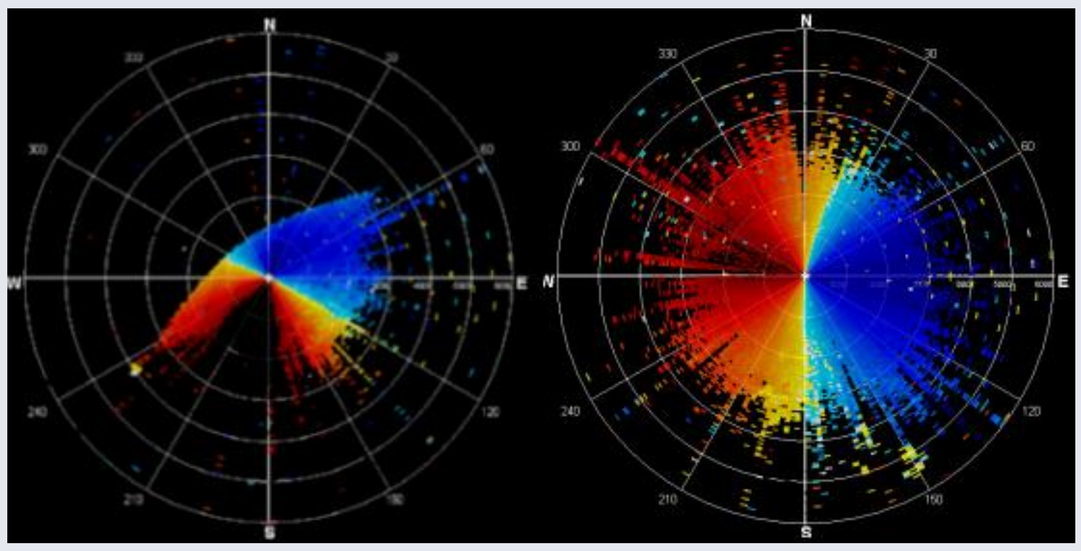
Through examination of the return signal from the scanning LiDARs it was possible to determine that the systems were level.

In order to further reduce the uncertainty of these measurements the use of a high accuracy GPS device would be recommended to find the exact location of the hard return targets.

Installation of Windcube 200s by helicopter.



Line of sight mode of LiDAR to find range to nearby turbines



Windcube 200s LiDAR before and after levelling

Further investigation was also carried out in order to inspect the returned data for sectors in which there was a physical blockage to the return of a signal. This is not only advantageous for future data analysis but also helps to confirm that the calculated orientation of the systems correlate with the position of known elements of the platforms that would introduce a blockage to the beam.

Conclusions

Windcube 200s scanning LiDARs have been successfully installed in two separate locations within an offshore wind farm. Particular attention has been given to the installation of the systems, with respect to the leveling and orientation of the LiDARs. With this preparatory work completed the systems are gathering data which should help to fulfill the project objectives of developing understanding of offshore wakes.

References

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