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The Commercialisation of Floating LiDAR

Chris McConville / Andy Paterson
Babcock International Group

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Abstract

As areas in deeper water and farther from shore are investigated for the development of offshore wind farms the use of novel technologies such as floating LiDAR provide an efficient method of collecting valuable development data.

While Floating LiDAR offers several clear advantages over traditional meteorological measurement systems, including cost and versatility, it is imperative that the data collected is consistently of a high quality, comparable with that of a fixed installation.

Babcock's FORECAST floating LiDAR system underwent a trial deployment, in cooperation with the Carbon Trust OWA, in order to prove that floating LiDAR can provide consistently high quality data. This would provide the confidence needed for developers to utilise the technology in commercial applications where the data is critical in wind farm design, yield assessments and financial negotiations.

Objectives

The primary objective of this validation project was to prove the ability of floating LiDAR to collect wind data which is of comparable quality to that of a fixed met mast, the current industry standard method. In particular it is important to prove the quality of wind speed and direction measurements at a variety of heights across the span of a typical turbine. Additionally, proving the ability of the system to operate continuously in a range of weather and sea conditions is important to provide confidence in the technology's ability to provide a data set which fully represents site conditions.

Beyond these key objectives, the effect of motion on measurements would be investigated, as well as identifying operational aspects of the system which could be optimised for remote monitoring and offshore maintenance

Technology

Babcock's FORECAST floating LiDAR system is based around a low motion, shallow draft spar buoy which is designed to minimise the wave, wind and tidal current induced pitch and roll.

This provides a very stable platform from which the proven ZephIR 300 wind LiDAR system is able to operate accurately and reliably without the need for any motion compensation.

Specially designed power and communications systems are also integrated into the platform in order to provide a reliable power supply and facilitate remote data transmission and system monitoring.

The stability of the platform also allows safe access offshore for maintenance and repair tasks

Methods

In order to determine the quality of the data collected by Babcock's FORECAST the system was deployed 150m South East of an IEC compliant fixed met mast within the Gwynt Y Mor offshore wind farm development. Data from both systems was then provided directly to a third party consultant who an independent analysis of performance.

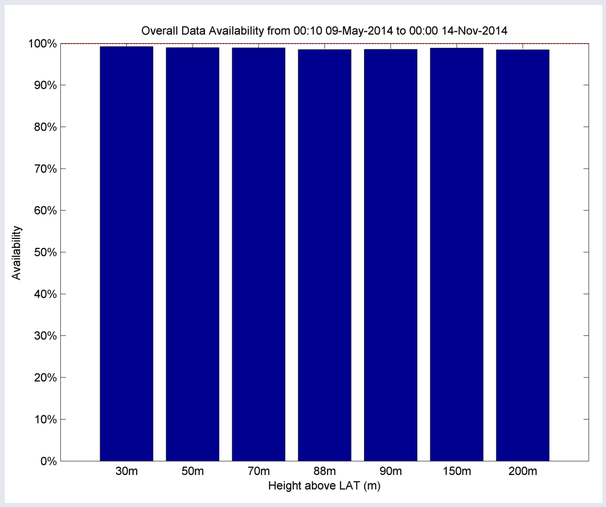
The data sets from both systems were compared by plotting the individual entries for wind speed and direction from the floating LiDAR against the identically timestamped entry from the met mast. A regression line was then found for these plots to determine the systems accuracy. For wind speed a single variant regression line, constrained through the origin, was used while a two variant regression line was used for wind direction. The gradient and regression coefficient of these lines could then be compared to the values recommended by the Carbon Trust's Roadmap[1].

The deviation of measurements could also be plotted against wave height to identify any effect that wave induced motion might have on the quality of the results. This, although not a primary objective, is of interest as Babcock's system differs from others tested as it does not have any form of motion compensation either through mechanical means or through data post processing, instead relying purely on the provision of a stable platform.

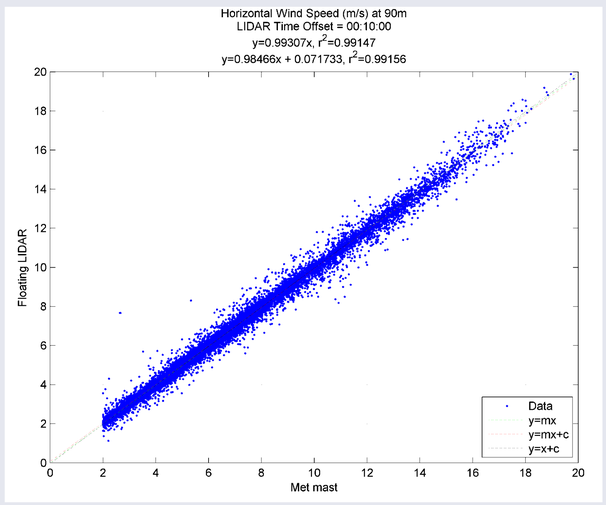
A calibrated LiDAR unit was also installed on the fixed met mast platform which allowed comparisons on data to be performed up to 200m above LAT, as well as providing an additional measurement reference.

Results

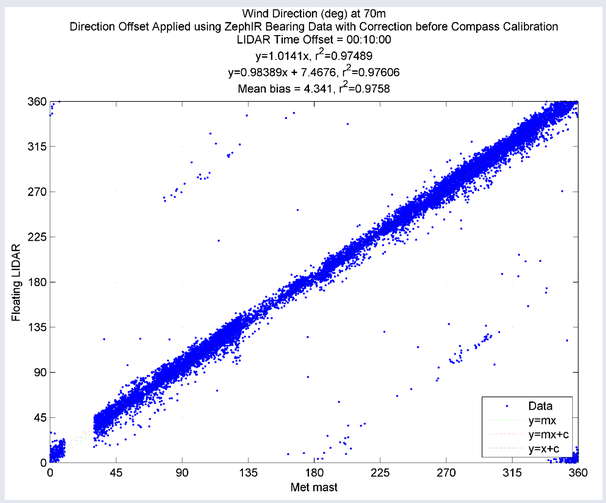
The results[2] of the trial show excellent system and data availability at over 99% and 98% overall respectively. Similarly, wind speed accuracy is excellent, providing a gradient and regression coefficient very close to unity and well within the Roadmap's best practice recommendations. Wind Direction accuracy was good, although affected slightly by magnetic forces on the systems compass. This has now been addressed by using a DGPS compass to provide even better accuracy.



Availability Metric	Value
Overall System Availability	99.86%
Data Availability at 30m above LAT	99.22%
Data Availability at 50m above LAT	98.93%
Data Availability at 70m above LAT	98.90%
Data Availability at 88m above LAT	98.51%
Data Availability at 90m above LAT	98.53%
Data Availability at 150m above LAT	98.84%
Data Availability at 200m above LAT	98.45%



Measurement Height above LAT	Measurement Reference	Regression Slope	Regression r^2
90m	Cup anemometer	0.993	0.991
50m	Cup anemometer	0.997	0.991
50m	Fixed LIDAR	0.999	0.940
90m	Fixed LIDAR	0.997	0.985
150m	Fixed LIDAR	0.996	0.985
200m	Fixed LIDAR	0.996	0.985



Measurement Height above LAT	Measurement Reference	Regression Slope	Regression y-Intercept	Regression r^2
30m	Wind vane	0.989	3.69°	0.972
70m	Wind vane	0.984	7.47°	0.976
70m	Fixed LIDAR	0.986	4.25°	0.983
90m	Fixed LIDAR	0.988	3.71°	0.979
150m	Fixed LIDAR	0.989	3.40°	0.973
200m	Fixed LIDAR	0.991	3.06°	0.968

The deviation between FORECAST data and fixed met mast measurements was also investigated in respect to wave height, period and steepness to identify any adverse impact on accuracy. The results from this trial show that there was no noticeable effect on the accuracy of data with increasing wave states.

Conclusions

The results of the trial show that the Babcock FORECAST floating LiDAR is capable of collecting wind speed and direction data which is comparable to that collected by traditional fixed met masts. In addition the system has proven it's ability to survive and operate in seas of over 8m H_{max}, measuring wind speeds up to 100kph.

This has resulted in FORECAST being the second system to formally reach Stage 2 of the Roadmap, further providing confidence that floating LiDAR in general is capable of replacing, or at least augmenting, fixed met masts.

The results also show that the measurements are not affected by sea state, proving the suitability of FORECAST's low motion design philosophy, allowing the system to be utilised in a variety of sites without extensive validation campaigns. Instead the motion of the platform simply has to be monitored to ensure that it remains within that experienced within this validation campaign.

References

1. Roadmap to Commercial Acceptance of Floating LiDAR, The Carbon Trust / DNV-GL, 2013
2. OWA Floating LIDAR Evaluation – Results of Babcock Trial, FNC, 2015