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Yaw misalignment study for neighbouring turbines using nacelle mounted LiDARs

E Brown'; A Oldroyd'
[1]Oldbaum Services Ltd., Stirling, United Kingdom

Abstract

A yaw misalignment study has been carried out with in-situ measurements taken by two Wind IRIS nacelle mounted LiDARs located on neighbouring turbines offshore. Comparison has been made with wind direction data taken from a nearby met mast, and also with yaw angle data recorded by turbine SCADA system.

The nature of the Wind IRIS' 2 beam measurement technique it is an excellent and proven tool for studying the direction of the wind as it comes onto a turbine. This can give us an idea of the how the turbines control system is operating and whether there are any opportunities for improvement.

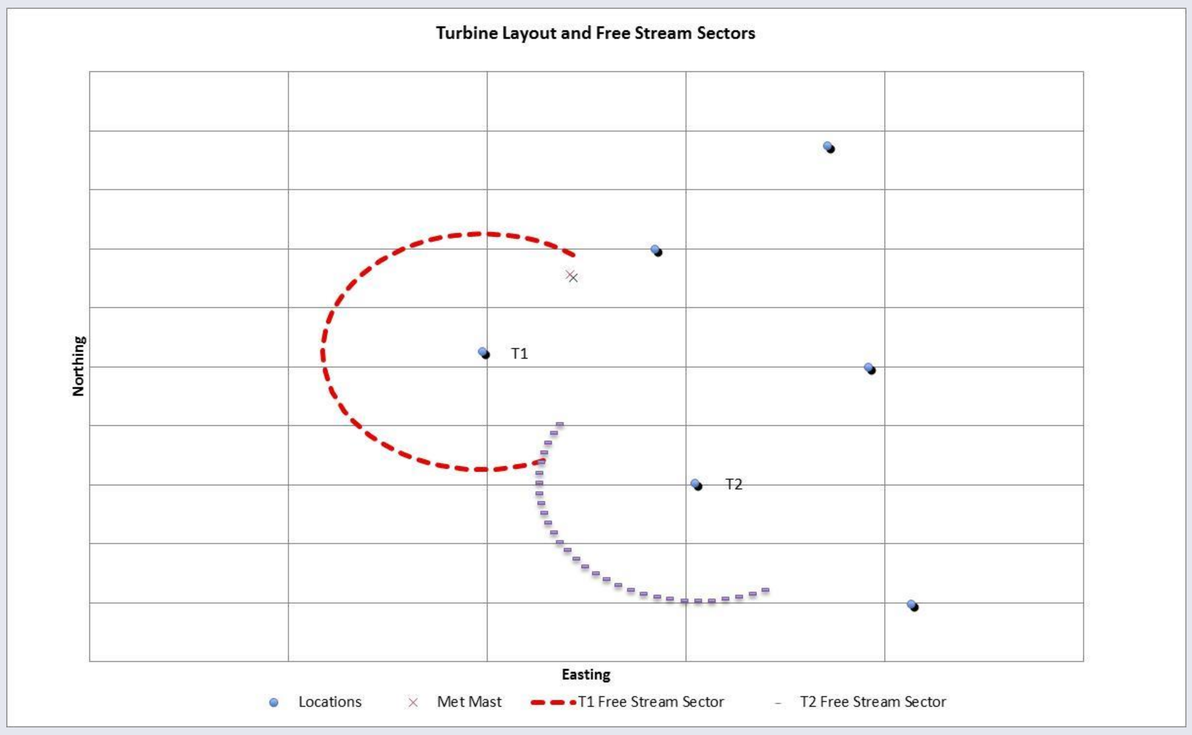
Of particular interest in this study is the behaviour of the turbines in the free stream and wake effected cases. The differences between the cases are quantified and the causes investigated.

Objectives

The objectives of this study are to:

1. Identify whether a yaw misalignment exists on both turbines;
2. Investigate whether the observed misalignment is static or dynamic with respect to wind speed;
3. To identify whether this relationship changes when the turbine is out of the free stream;
4. Comment on the suitability of using reconstructed data in a complex flow field.

Methods



The relative positions of the turbines studied, T1 and T2, are shown above. Their freestream sectors have been defined as above with the red and purple dashes. There is a met mast located to the north of both turbines and wind direction measurements are taken from this in addition to the turbine yaw data from the SCADA system.

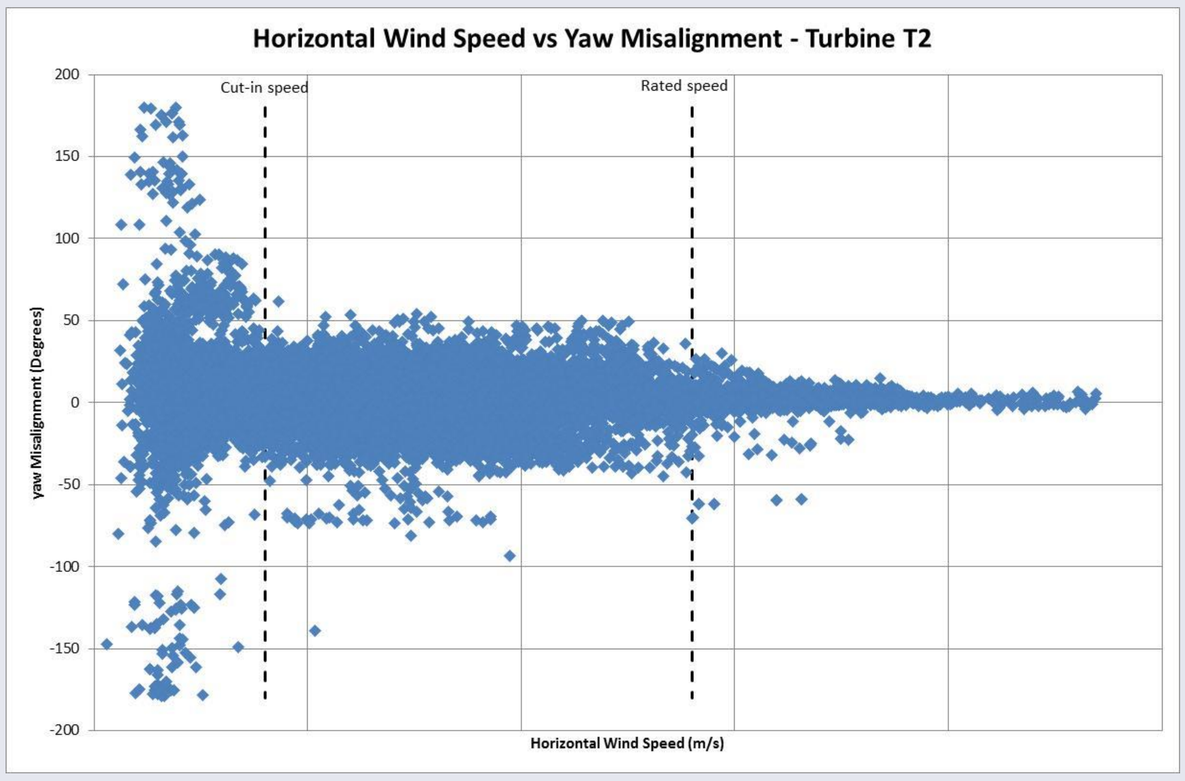
The following considerations have been made when examining the data from these 4 sources:

1) Concurrent timestamps for mast, SCADA, and both Wind IRIS;
2) Wind speeds above cut in speed;
3) Measurement range of 160m = 2RD;
4) Turbulence Intensity measured by both beams within 1.5% of each other;

This method has been applied so that distance between each beam is within the rotor diameter. Additionally by only considering cases where the wind speed is above cut in we can be more confident that the turbine has not been stopped for maintenance, however it cannot be completely ruled out as access to the turbine status indicators were not available for this study.

To help give confidence in using the wind direction values measured by the Wind IRIS in the non-freestream sectors, we have only used records where each beam has recorded a similar turbulence intensity. This has been used as a proxy to ensure that the readings from each beam can be used to reconstruct a valid value for wind direction.

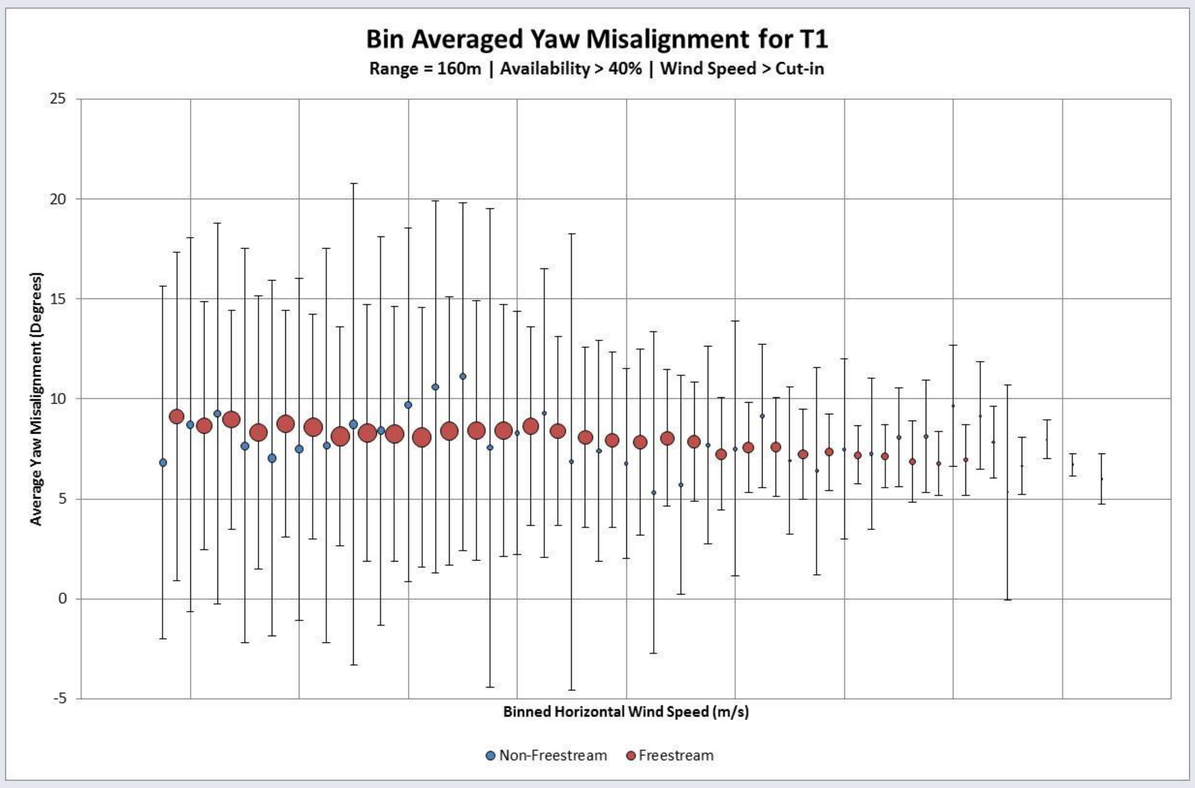
Results



Shown above is horizontal wind speed and yaw misalignment for turbine T2 with all wind speeds with the cut in and rated speeds highlighted.

It was found that both turbines exhibited a significant yaw misalignment, and that there was a definite positive bias in the recorded data. The average yaw misalignment in the freestream for turbine T1 was **8.28º** and for T2 **5.37º**. In the wake affected sectors T1: **8.16º** and T2: **5.12º**. **These translate to wind speed losses in the freestream / wake affected sectors of 3.09% / 3.01% for T1 and 1.31% / 1.19% for T2.**

After filtering and bin averaging the data, it was found for both turbines that the yaw misalignment was dynamic and decreased with wind speed whereas in the wake affected sectors the misalignment remains static. This indicates that the input ot the SCADA system may have become less reliable in this environment. This was found to be the case for both turbines investigated.



Shown above is average yaw misalignment vs binned horizontal wind speed for the freestream and non-freestream cases on turbine T1. The error bars display the standard deviation within each bin.

Conclusions

A study of neighboring turbines using nacelle mounted LiDAR has been carried out, and shown that the behavior of SCADA systems in wake affected wind flow may require a different correction approach than the freestream case.

References

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3. In-depth presentation of turbine after turbine performance
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