Verification of Nacelle-based LiDAR systems

A comparison of Black box and White box approach

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Summary
Especially offshore, nacelle-based LiDAR systems are a cost-effective and robust tool for different applications in the wind industry. For the verification of nacelle-based LiDAR systems two approaches are discussed (Black box and White box) [1]. Direct comparisons of both approaches are rare, and the validity is highly limited to the test site [2, 3, 4]. DNV GL established a new test site to perform both approaches under very similar conditions, which allows a direct comparison. In the presentation, both approaches will be compared and evaluated considering metrological and economical aspects.

1. Introduction

Nacelle-based LiDAR systems are becoming more and more important in the wind industry.
Especially offshore, they are a cost-effective and robust tool for different applications such as power curve verification (PCV) or turbine optimization studies [1].
For traceable field campaigns, the accuracy of the LiDAR system should be determined and evaluated in accordance with international standards and guidelines [1]. In general, the verification of nacelle-based LiDAR systems can be carried out by using two different approaches, the so-called black box and the white box approach [2]. Both approaches have their advantages and disadvantages, but their reliable evaluation is difficult because direct comparisons are rarely available and the validity is limited due to different test setups and conditions [2, 3, 4].

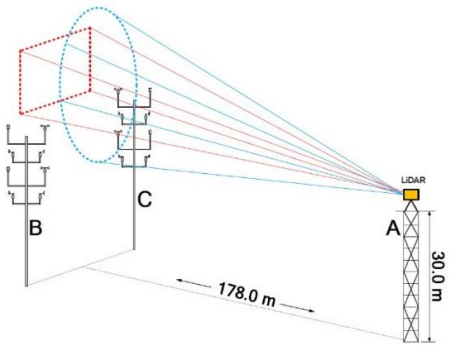

Fig. 1: DNV GL test site in Janneby, Germany

2. Black box and White box approach

Using the black box concept, the performance of the LiDAR system is verified by comparing its outputs (e.g., horizontal wind speed) with an equivalent reference measurement [2].
In contrast, the white box concept follows an approach where all relevant input parameters (e.g., radial wind speed) used by the LiDAR algorithm are verified independently [2].

3. DNV GL test site

DNV GL established a new test site to perform verifications of nacelle-based LiDAR systems (see Fig 1). The test site consists of two 30 m reference masts which are equipped with calibrated reference sensors, such as cup anemometers and wind vanes. Additionally, a lattice tower is used to install the nacelle-based LiDAR system at the height of 30 m.
The specially designed test setup opens the possibility to align the LiDAR system in nearly the same way as it is installed on a turbine during a real field campaign.

4. Black box vs. White box

Due to the particular design of the test site, it allows performing both, black box and white box verification. As both can be performed under very similar conditions, it is possible to carry out a direct comparison between the two approaches. The presentation will consist of several comparisons studies between the two approaches. Additionally, both approaches will be compared by using both metrological and economical aspects (e.g. costs and time).

5. References

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[3] Wagenaar J.W., Wind Iris nacelle LiDAR calibration at ECN test site, 2016
[4] Franke K., Albers A., White box vs. Black box – Calibration of a 2-beam Nacelle LiDAR, Poster from Wind Europe Conference, 2017