Abstract
Especially for offshore measurements, the use of nacelle-mounted LiDAR systems becomes more and more important in the wind industry. For traceable field measurements it is recommended to assess the performance of the LiDAR system against a well known reference sensor, e.g. cup anemometer. For nacelle-mounted LiDAR systems two verification methodologies are discussed:
• White box approach
• Black box approach

The results of several verification campaigns for both the black box and white box methodology are summarized. The campaigns were conducted at two different test sites, whereby two different LiDAR types were verified. The methodologies are compared and the pros and cons are discussed.

Methods

White Box (WB):
The WB methodology is based on the assessment of different input quantities which are used by the LiDAR to reconstruct the wind field characteristics. In general, the WB approach includes the verification of the following parameter:
• Scan geometry
• Measurement range
• Uncertainty assessment

Black Box (BB):
The BB methodology is based on the assumption that the total functionality of the LiDAR system is represented by the output quantities provided by the LiDAR system (e.g. horizontal wind speed). Therefore, a separate consideration of single input quantities, e.g. scan geometry or measurement position, which are used by the LiDAR algorithm, is not done.

Test specifications
The comparison between black and white box approach is based on six verification campaigns. The campaigns were conducted at two different test sites, whereby two different LiDAR types (CW and pulsed) were verified. For the six tests, the following test configuration were applied:

Unit 1-4
• Horizontal setup (platform test)
• Test setup according to figure below:

Unit 5-6
• Inclined test setup (slant test)
• Inclination angles: 12-25°
• Comparison against 100m mast
• Measurement range: 130-180m

Results of linear regression analysis

Uncertainty assessment for White Box methodology

Differences in uncertainty assessment
• Less complex for BB methodology.
• Different uncertainty components, depending on the test site and test setup.
• Slightly higher statistical uncertainty for BB methodology, but not that much higher

DNV GL internal KPIs and ACs for accuracy assessments

In practice, further KPIs and ACs, e.g. for data coverage, system and data availability should be considered for both methodologies. Additionally, KPIs and ACs for other verification parameters of the white box methodology (e.g. Scan geometry) should be defined.

Conclusions

White Box
• Most proven method for verification of nacelle LiDARs
• Generic method for verification of Line-of-sight velocity
• Longer campaign duration (about 6-12 weeks)
• More complex • More experience needed

Black Box
• Shorter campaign duration (about 4-6 weeks)
• Less costly (about 70 % of WB)
• Less complex • Less experience needed
• Higher statistical uncertainty, due to higher scatter
• Specific for each type of device/Reliability on manufacturer algorithm

Different methodologies for different applications?

Different KPIs and ACs for assessment of LiDAR performance needed

White Box (left) and Black Box (right) results (Unit 1)

• Comparable results for both test sites and both LiDAR types.
• Slopes close to unity for both WB and BB.
• Squared correlation coefficient:
  - WB: 0.991 – 0.997
  - BB: 0.980 – 0.989
• For most analysis rel. mean WS difference below 1%.

References
3. IEC 61400-12-1: Power performance measurements of electricity producing wind turbines, Ed. 2., Apr. 2017

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