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Commentary on the steps required to adopt remote sensing devices for the measurement of the wind regime at potential wind farm sites and an appraisal of the status of the Second Wind Triton device within this context

Second Wind has developed the Triton SODAR remote wind speed sensing device. GL Garrad Hassan has been asked to comment on the use of remote sensing wind measurements in the context of the development and financing of wind farm projects. This note presents GL Garrad Hassan's position on the steps that GL Garrad Hassan considers are required before a new remote sensing system may be considered to be a proven device in the context of the wind energy industry. The current status of the Second Wind Triton SODAR system within this process is discussed here.

Cup anemometers are the current industry standard for measuring wind speed at wind farm sites. Measurements from cup anemometers therefore must be considered the norm against which any new measurement device must be judged.

GL Garrad Hassan considers that the process whereby a new remote sensing device may be considered to be a proven device is as follows:

> ***Stage 1***
> *During this stage a remote sensing device is commercially available and the device can routinely provide measurements of wind speed and direction with height. However, either limited measurements are available to validate the data produced against conventional measurements or validation data indicates that error bars on remote sensing measurements are substantially higher than those which could be obtained from conventional measurements. During this stage data from a remote sensing device can be useful in providing qualitative but not quantitative data. Remote sensing may assist with understanding the wind flow at a given site but the data may not be used quantitatively in a formal wind speed and energy production analysis used to support the financing of a project.*
>
> ***Milestone 1***
> *GH consider a milestone is reached when a remote sensing device has been successfully tested at suitable relatively simple terrain test locations against conventional wind speed measurements over a range of heights relevant to wind energy applications. The tests will have demonstrated that the accuracy achieved through remote sensing is broadly similar to that which would have been achieved with conventional anemometry. The results of the test will have been presented in suitable technical papers.*
>
> ***Stage 2***
> *A device gains increasingly wide use on a range of sites with different meteorological characteristics. A device gains more operational experience and more is learned about the set up, robustness and consistency of the measurement equipment. Confidence is gained that the device provides robust, continuous and accurate data over a wide range of operational conditions. Alternatively specific conditions where the device does not provide robust data become well understood and can be excluded from analyses. Data from the remote sensing device may be used quantitatively within a formal wind speed and energy assessment provided for relatively simple terrain sites.*
>
> ***Milestone 2***
> *A device has been used extensively over a range of sites with different environmental and topographic characteristics with high data capture levels and numerous validations which demonstrate close agreement with data derived from conventional measurements.*

Stage 3
A device is considered proven for use in the assessment of wind farm sites. The data may be used quantitatively within formal wind speed and energy assessments with only limited or no site specific validation against conventional anemometry.

GL Garrad Hassan considers that the majority of remote sensing devices currently have not achieved Milestone 1 and therefore may only be considered to be at "Stage 1" as defined above.

Second Wind has supplied a technical paper [1] which presents the results of an independent validation test of the Triton device. Triton measurements have been carried out in parallel with a meteorological mast at a height of up to 100 m over a period of approximately 99 days. The separation distance between the Triton SODAR device and the nearby meteorological mast is 220 m [1]. Measurements at the mast were obtained using a Risø P2546A anemometer that was top-mounted on a meteorological mast at 100 meters above ground level. It is noted that the anemometer was mounted in accordance with the recommendations of the standard IEC 61400-12 [2]. The results of the experimental campaign demonstrate that the Triton is capable of reproducing cup anemometer measurements to within 0.6% at 100 m in uniform terrain. However, somewhat less ideal agreement was observed at the 60 m and 80 m measurement heights where the Triton system overestimated wind speeds by 2.8% at each height. It is noted that the boom mounting arrangement at each of these heights was not consistent with the recommendations of the IEC. Additionally, inherent in these observations is the assumption that the wind conditions are the same at the location of the Triton and the mast.

It is understood that periods of diverse weather conditions and nearby turbine operation were present during the measurements and that the data recorded during these periods were filtered according to the practices recommended by Second Wind [3]. The observed agreement between the mast and the Triton is within the range of uncertainty which is typically assigned to data recorded with cup anemometry, with the slight exception of the lower heights where the level of agreement is marginally lower than would be expected from a "best practice" cup anemometer mounting arrangement. Uncertainties within the validation process include the difference between the positions of the mast and the Triton, as well as the non-ideal mounting arrangements of the 60 m and 80 m cup anemometers. Nevertheless, the test may be considered as a meaningful validation which demonstrates the ability of the Triton to reproduce conventional wind speed measurements to a reasonable degree of accuracy in relatively simple terrain at heights between 60 m and 100 m.

GL Garrad Hassan has reviewed results from another Triton measurement campaign performed in West Texas [4]. This campaign was performed over a period of approximately 198 days where the Triton device was located approximately 200 m away from an 80 m conventional meteorological mast. The test site was located near an operating wind farm in relatively simple terrain with uniform vegetation growth. Concurrent Triton and anemometer measurements were carried out at 80 m in a variety of environmental conditions. Wind speed measurements at the mast were carried out using a calibrated Risø P2546A anemometer mounted at 80 m in accordance with the standard IEC 61400-12 [2]. Similar measurements were carried out at the 50 m measurement height, but overall mean wind speeds were not reported at this height. Thus, the results of this report are limited to the 80 m measurement height. In order to eliminate the flow disturbance from the neighboring wind farm, the concurrent mast and Triton data were direction sector limited to ensure free stream comparisons. The average wind speed recorded by the Triton system was found to agree to within 2.1% of the mean wind speed recorded by the cup anemometer. Given the 200 m separation between mast and Triton, some level of disagreement between mean wind speeds may occur, as material wind flow variation can develop over this distance in the terrain conditions present at the site. Nevertheless, the results of this validation campaign provide confidence in the ability of the Triton SODAR system to reproduce traditional wind speed measurements within the approximate uncertainty bounds expected for cup anemometer measurements.

From the results in [1] and [4], it is GL Garrad Hassan's opinion that the Triton device may be considered to have achieved Milestone 1, as defined above, and may now be considered to be in Stage 2 of its commercial exploitation. There is expected to be a growing body of additional validation data sets which will further demonstrate the ability of the Triton to reproduce conventional wind measurements at relatively simple terrain sites. It is considered that when results from additional validation campaigns become available, GL Garrad Hassan should review these in order to establish further detail on the level of consistency and repeatability of the results exhibited in [1] and [4]. It is noted that GL Garrad Hassan has experience of working with other data sets recorded by the Triton device than those reported here. However, while these other data sets have been useful to build a body of experience in working with data from the Triton device, as they were from earlier models or software versions of the device those results have not been directly considered here.

The validation data sets summarized herein demonstrate that the Triton wind speed profiler is capable of adding value to wind farm developments with project finance requirements. The two measurement campaigns summarized in [1] and [4] have been performed in flat terrain conditions that are ideal for this measurement technique. As discussed in [5] there are reasons to expect the level of agreement between remote sensing devices and conventional anemometry may be lower for complex terrain sites or sites with particularly complex flow patterns. The validation results within [5] are not considered to be relevant in the context of this document which addresses the Triton device. For complex sites or wind regimes, it is therefore currently recommended that the Triton device be used in combination with conventional anemometry and the obtained results are interpreted with some caution.

Wind data recorded on a wind farm site are used to make important commercial decisions. Great care is therefore required before data from remote sensing devices are relied upon for use in such analyses. For a device that has completed Milestone 1, as defined above, GL Garrad Hassan considers that the following will maximize the weight that can be assigned to the data recorded by a remote sensing device.

1. Before shipment to site the device is validated at a test site with a suitable tall mast to confirm that the device is operating within acceptable limits over a range of measurement heights. The test mast should be equipped with high quality, traceable and calibrated anemometry. Alternative test regimes may also be acceptable.

2. In addition to any pre-shipment testing it is important that commissioning tests are carried out each time a device is installed at a site to ensure no issues have occurred during transport to the site or while setting up the device at a site. Suitable on-site commissioning tests should be undertaken and documented. Effective tests will increase the confidence in the data recorded.

GL Garrad Hassan places a high value on measured, on-site wind data and considers the Triton SODAR technology to offer material value to the estimation of hub height wind speeds in many situations. Thus, such data may be utilized in a quantitative sense for many wind farm sites. Depending on the specific characteristics of the wind farm site under evaluation, there may be concerns that the aforementioned relatively simple terrain validations of the device may not be representative of what may be expected at the site under consideration. In such situations the Triton data recorded at a site would be used in a qualitative sense only but may well still add value to an analysis.

Due to disparities associated with volume versus point measurements, the Triton SODAR device is known to report both turbulence and extreme wind speed values in a fundamentally different way yielding significantly different results when compared to traditional methods using cup anemometry. Thus, this remote sensing measurement technique should be used with care for the assessment of site suitability.

In addition, data coverage rates reduce with height, and therefore care is needed in interpreting the results. Special care is also needed in case bias in the measured wind speed is introduced through data not being captured during certain specific meteorological conditions.

GL Garrad Hassan will currently use a pragmatic approach, based on results within the literature, to define the uncertainty in measurements made with the Triton device. It would be advisable to build up a body of Triton to Triton and Triton to conventional met mast data which will allow a more statistical approach to defining the uncertainty in the measurements to be undertaken in the future.

In summary, GL Garrad Hassan considers that the Second Wind Triton system is within Stage 2 operation as defined within this note and is in the process of building a body of data to allow it to enter Stage 3 operation. It is expected that for relatively simple terrain sites—provided that the guidance within this note is followed—data from the Triton device may be used in a quantitative sense with reasonable error bars for the purpose of the assessment of the wind regime at a potential wind farm site. For other sites a site specific view will be taken on how Triton data will be used depending on the characteristics of that site. Until a greater knowledge database is built up about the performance of the Triton in different conditions, it is recommended that Triton data are used to compliment conventional met towers as a part of the design of an overall monitoring campaign rather than to replace conventional met towers entirely. It remains important to include, at a minimum, one met tower per site as part of a well executed resource assessment campaign for the purpose of providing a reference for wind speed correlations and to capture turbulence and extreme wind speed information.

This note does not provide comment on the cost effectiveness or robustness of the Triton device compared with other devices or measurement systems.

References

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