Validation of the Triton Performance Upgrade

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Revision History

Issue	Date	Author	Nature And Location Of Change
01	15 Mar 2013	Iain Campbell	First Created
02	09 Apr 2013	Iain Campbell	Speaker Array Naming Convention Changed

CONTENTS

1.0 INTRODUCTION

This report reviews the recent speaker and electronics upgrade applied to the Triton SoDAR by the manufacturer, Second Wind. The report primarily investigates what impact the upgrade has had on qualified data capture.

2.0 BACKGROUND

The recent hardware upgrade is designed to improve the Triton signal quality without any increase in power consumption. The result of this increased signal quality should be improved levels of qualified data capture at higher measurement heights and at heights above 100 m in particular[1]. The upgrade involved the replacing of the existing speaker array with a new and improved speaker array including new electronics. The new array is called the Triton Performance Upgrade[2].

3.0 TESTING

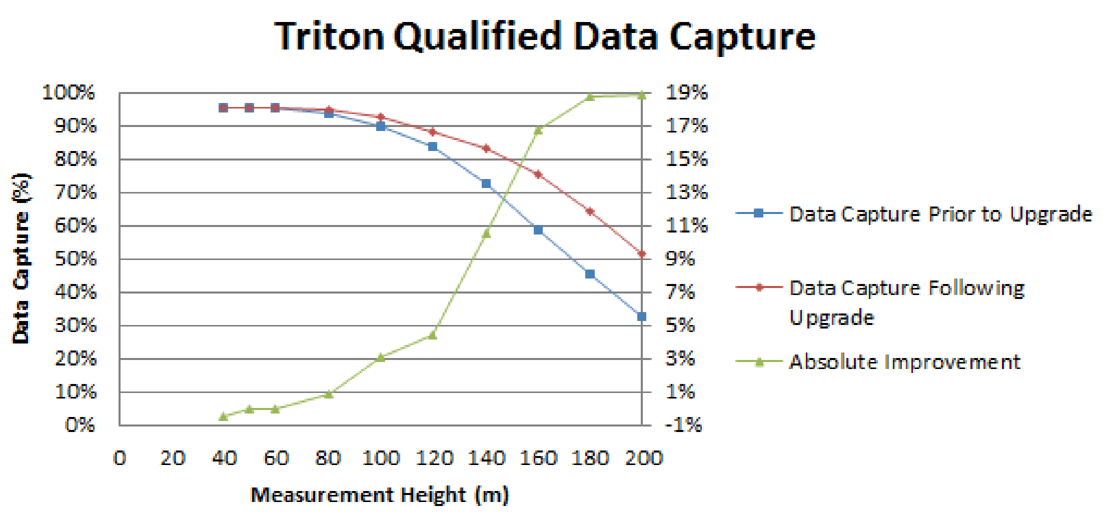
Testing of the hardware upgrade was carried out at Woolley Hill wind farm, England, between September and December 2012. Prior to the hardware upgrade and in order to establish a baseline of performance, Triton 241 was initially deployed beside the site assessment mast ENGwohM46. This initial deployment ran from 08 September 2012 until 07 October 2012. Following the upgrade, Triton 241 continued to operate beside M46 with the test data period running from 09 October 2012 until 04 December 2012.

The Triton performance during the test period [1] was then compared (including a statistical analysis) [2] with that of the baseline period [3].

[1] It is also possible that, as a result of the increased signal quality, correlations between the fixed mast data and Triton data will also be improved.
[2] The array that was installed and tested is a beta version of the Triton Performance Upgrade and is the precursor to a fully commercial production version.

4.0 RESULTS OF ANALYSIS

The following Figure and Table show the qualified data capture (the percentage of data remaining after the necessary filters have been applied) for both the baseline period and the test period. The absolute improvement is also shown.



Triton Qualified Data Capture			
Height (m)	Data Capture Prior to Upgrade	Data Capture Following Upgrade	Absolute Improvement
40	95.6%	95.2%	-0.4%
50	95.2%	95.2%	0.0%
60	95.2%	95.1%	0.0%
80	93.7%	94.5%	0.8%
100	89.7%	92.8%	3.1%
120	83.9%	88.4%	4.5%
140	72.5%	83.0%	10.5%
160	58.5%	75.1%	16.7%
180	45.5%	64.2%	18.7%
200	32.8%	51.7%	18.9%

It can be seen that following the hardware upgrade, the Triton qualified data capture experiences an absolute increase of up to 19 % at 200 m. This suggests that the upgrade has had the desired effect in improving the qualified data capture at upper measurement heights.

It is possible that the observed improvement could be due to seasonal variation. However, after considering the variation in shear between the baseline and test periods, this is not thought to be the case. A brief discussion on seasonal variation can be found in Appendix A.

It is important to ensure that, following the upgrade, other aspects of the device's performance have not been adversely affected. From the analysis of the Triton data, it would appear that the hardware upgrade has had no detrimental effect on any aspect of the Triton performance. Further information on this can be found in Appendix B.

In order to conduct this analysis, it was necessary to first ensure the quality of the Triton data used. This was done by filtering the Triton data to remove any data not deemed to be of sufficient quality. Data filtering criteria can be found in Appendix C.

5.0 STATISTICAL ANALYSIS

In order to ascertain the statistical significance of the observed variations between the two test periods, it was necessary to conduct a statistical analysis of the data [2]. The observed variations in qualified data capture, correlation coefficient and the distribution of points in the correlations (leading to the variation in correlation slope) were tested for significance.

5.1 Qualified Data Capture

For measurement heights from 80 m, the increase in qualified data capture, following the Triton Performance Upgrade, is significant. That is to say, the hypothesis, that the proportions of qualified data capture before and after the Triton Performance Upgrade are the same, is rejected.

It is to be expected that for the lower measurement heights (40, 50 & 60 m) the qualified data capture might not vary between the test periods. It is likely that at these lower measurement heights the signal strength was already sufficient. What is clear, however, is that the Triton Performance Upgrade has significantly increased the qualified data capture for measurement heights from 80 m.

It is likely, that these results, the actual values of qualified data capture and the absolute improvement in qualified data capture, will be site dependent. Nevertheless, it is expected that, at all sites, a significant increase in the qualified data capture will be observed.

5.2 Correlation Coefficient

Using a suitable test to compare two correlation coefficients, the correlation between the Triton 80 m measurement and the fixed mast 80.3 m anemometer, was compared for the two test periods. The results show that the observed increase in correlation coefficient (see Appendix B), following the Triton Performance Upgrade, is significant.

That is to say, the hypothesis, of equal correlations before and after the Triton Performance Upgrade, is rejected.

The Triton Performance Upgrade has therefore significantly increased the correlation coefficient between the fixed mast and the Triton.

5.3 Distribution of Points in the Correlations

The F-test was used to compare the differences, between the 10-minute mean wind speed values from the Triton and the fixed mast, for the two test periods. The results show that, although the correlation slope increases following the Triton Performance Upgrade, the two sets of data are not significantly different.

That is to say, the hypothesis, that the two sets of data come from the same distribution, cannot be rejected.

The Triton Performance Upgrade has therefore not significantly affected the level of agreement between the fixed mast and the Triton.

6.0 CONCLUSION

In conclusion, the Triton Performance Upgrade has had a significant, positive, impact on the Triton data.

It can be seen that, following the hardware upgrade, the Triton continues to operate as expected. In addition, and as a result of the upgrade, the Triton shows increased qualified data capture and reduced scatter.

Further, the Triton Performance Upgrade has significantly increased the qualified data capture at heights from 80 m and significantly increased the correlation coefficient between the fixed mast and the Triton. Moreover, the upgrade has not significantly affected the agreement between the fixed mast and the Triton.

7.0 REFERENCES

1. CAMPBELL, RI (2013), 'ENGwohM826 Device Verification - Prior to Charonia Array Upgrade', RES CALCULATION TC01-028038 Issue 01, dated 14 March 2013.

2. CAMPBELL, RI (2013), 'Baseline and Test Period Statistical Comparisons - Charonia Speaker (Beta) Array Upgrade', RES CALCULATION TC01-028043 Issue 01, dated 14 March 2013.

3. CAMPBELL, RI (2013), 'ENGwohM826 Device Verification - Following Charonia Array Upgrade', RES CALCULATION TC01-028039 Issue 01, dated 07 January 2013.

APPENDIX A - SEASONAL VARIATION

Figure A.1 Concurrent Shear Prior to Hardware Upgrade

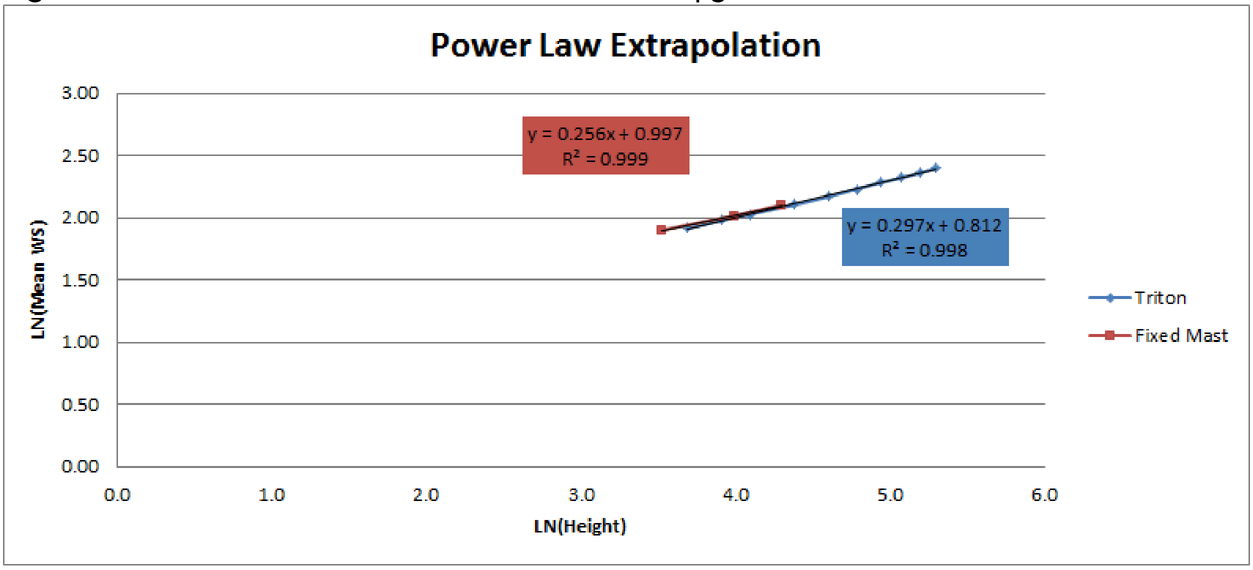
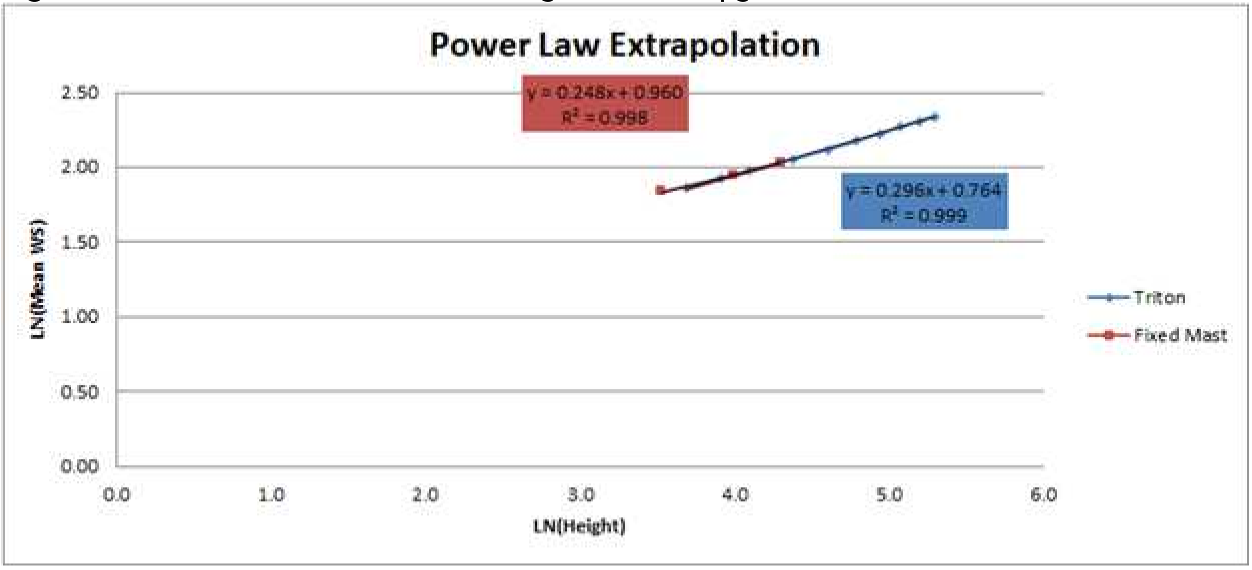


Figure A.2 Concurrent Shear Following Hardware Upgrade



It can be seen that, for both the baseline and test periods, the Triton multi-point measured shear is in broad agreement with the fixed mast multi-point measured shear. Moreover, shear remains consistent between the two test periods. Therefore, it is not expected that seasonal variation has been a factor in the improved qualified data capture observed between the two periods.

APPENDIX B - WIND SPEED CORRELATIONS

Figure B.1 Wind Speed Correlation Prior to Hardware Upgrade

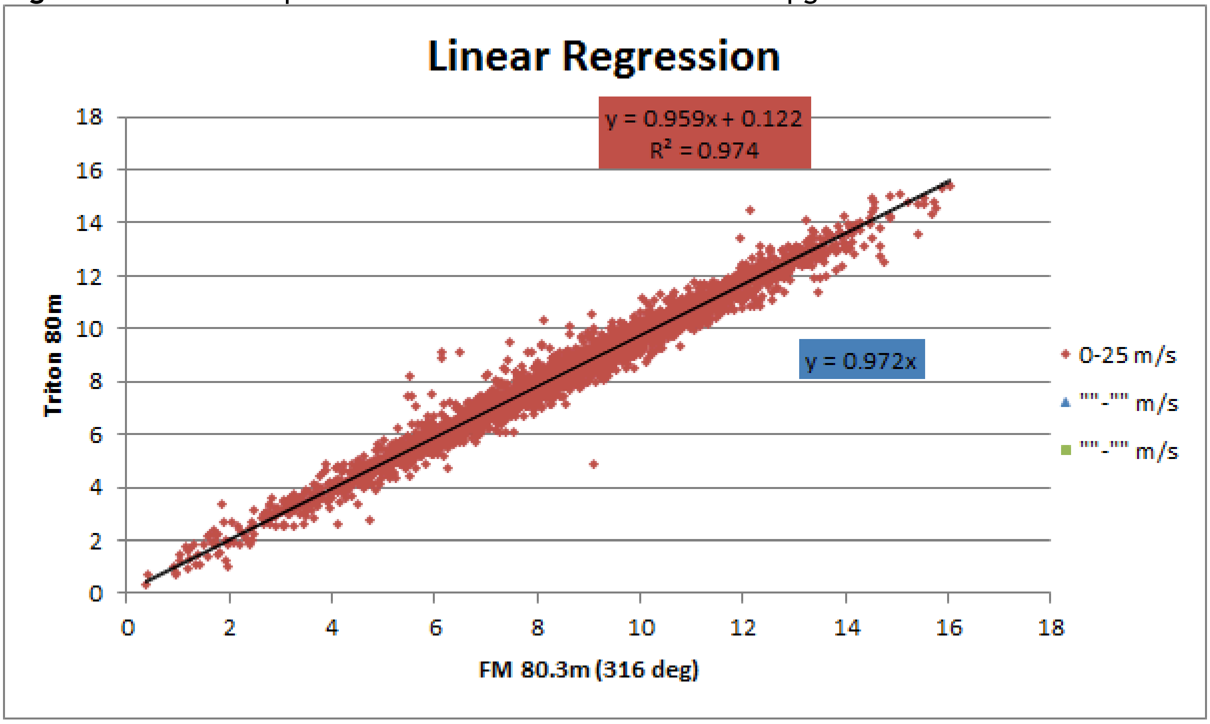
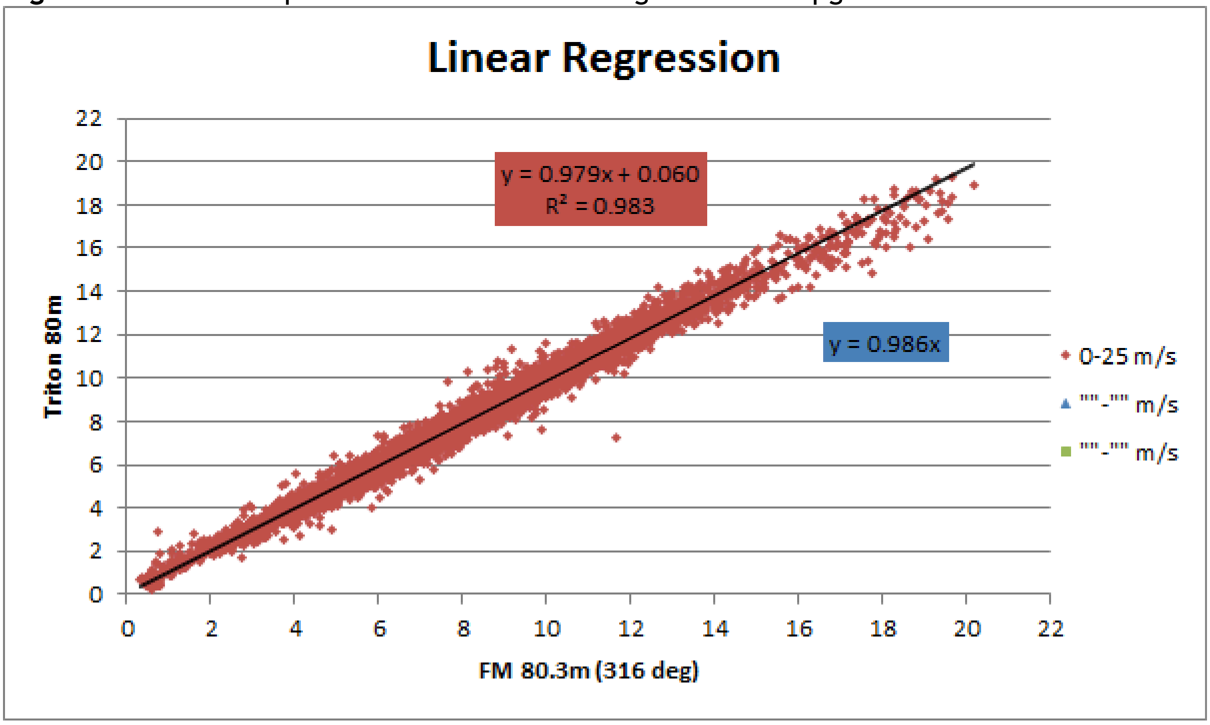


Figure B.2 Wind Speed Correlation Following Hardware Upgrade



It can be seen that, for both the baseline and test periods, the wind speed correlation between the Triton and the fixed mast is reasonably stationary, with 2 % improvement in the gradient of the correlation between the two periods. In addition, the scatter has improved. Therefore, it is not expected that other aspects of the Triton performance have been adversely affected by the Triton Performance Upgrade.

APPENDIX C - DATA FILTERING CRITERIA

Prior to the analysis of data from remote sensing devices, it is important to apply data filters to remove any data that cannot be said to be representative of any given time period. For the Triton the two key filters are a vertical wind speed censor and the quality factor filter. These filters remove data which are not deemed to be of suitable quality or have been affected by precipitation. Table C.1 shows the filters that have been applied to the Triton data [1, 3].

Table C.1 Triton Filters

Triton Filters	
Vertical wind speed censor ($m.s^{-1}$)	1.5
Quality Factor	90
Low wind speed censor ($m.s^{-1}$)	N/A