Validation of the Triton SoDAR 2.0 Software Upgrade

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Revision History

Issue	Date	Author	Nature And Location Of Change
01	18 Jan 2013	Iain Campbell	First Created - External Draft Release
02	14 Mar 2013	Iain Campbell	Updated to Include Statistical Analysis

CONTENTS

1.0 INTRODUCTION

This report reviews the recent software upgrade[1] 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 software upgrade is designed to filter out background environmental noise, such as insect noise. The upgrade means that background noise is now filtered at the level of an individual sound pulse or 'chirp'. If there are enough 'good' chirps in a ten-minute interval, the ten-minute average is retained. This is reported to make a dramatic increase in the recovery of quality data in noisy situations [1].

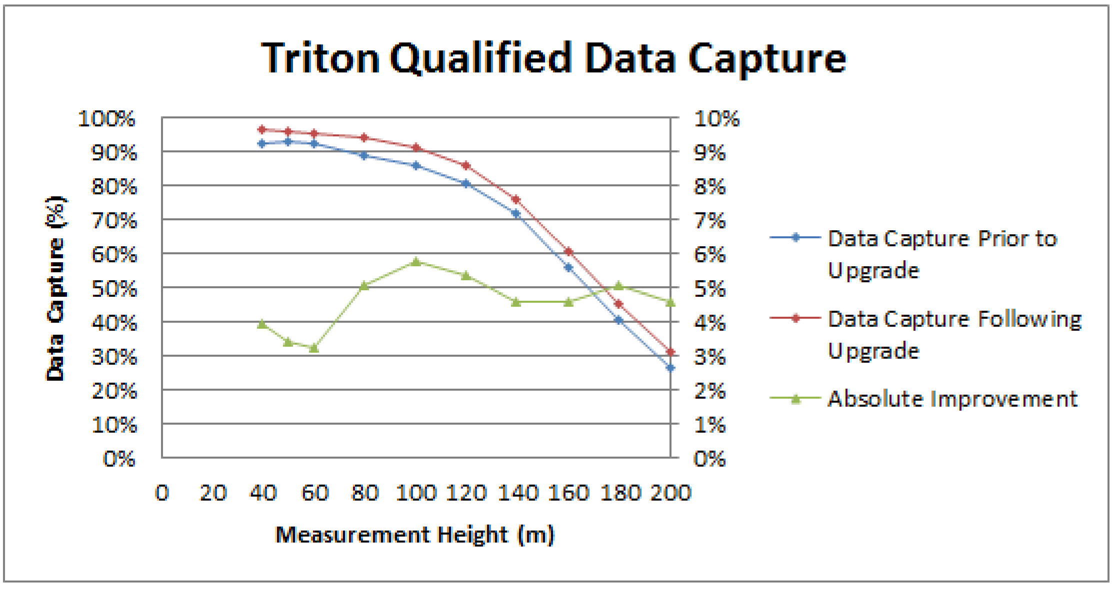
3.0 TESTING

Testing of the software upgrade was carried out at Wadlow wind farm, England, between April and June 2012. Prior to the software upgrade and in order to establish a baseline of performance, Triton 241 was initially deployed beside power performance mast ENGwadM640. This initial deployment ran from 11 April 2012 until 17 May 2012. Following the software upgrade, the upgrade being installed remotely, Triton 241 continued to operate beside M640 with the test data period running from 18 May 2012 until 24 June 2012.

The Triton performance during the test period [2] was then compared (including a statistical analysis) [3] with that of the baseline period [4].

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.



[1] Sodar 2.0: firmware upgrade

Triton Qualified Data Capture			
Height (m)	Data Capture Prior to Upgrade	Data Capture Following Upgrade	Absolute Improvement
40	92.1%	96.0%	3.9%
50	92.5%	95.9%	3.4%
60	92.1%	95.3%	3.2%
80	88.8%	93.8%	5.0%
100	85.5%	91.2%	5.7%
120	80.4%	85.7%	5.3%
140	71.3%	75.9%	4.6%
160	55.9%	60.5%	4.6%
180	40.4%	45.4%	5.0%
200	26.3%	30.9%	4.6%

It can be seen that following the software upgrade, the Triton qualified data capture experiences an absolute increase of between 3.2% and 5.7%. This suggests that the upgrade has had the desired effect in reducing the impact of background noise on the Triton's qualified data capture.

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 software 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 [3]. 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 all measurement heights, the increase in qualified data capture, following the software upgrade, is significant. That is to say, the hypothesis, that the proportions of qualified data capture before and after the software upgrade are the same, is rejected.

The software upgrade has therefore significantly increased the qualified data capture at every height.

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 75.4 m anemometer, was compared for the two test periods. The results show that the observed increase in correlation coefficient (see Appendix B), following the software upgrade, is significant.

That is to say, the hypothesis, of equal correlations before and after the software upgrade, is rejected.

The software 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 decreases following the software 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 software upgrade has therefore not significantly affected the level of agreement between the fixed mast and the Triton.

6.0 CONCLUSION

In conclusion, the Triton SoDAR 2.0 software upgrade has had a significant, positive, impact on the Triton data.

It can be seen that, following the software 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 software upgrade has significantly increased the qualified data capture at every height 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. Second Wind (2012), 'Wind Industry Remote Sensing Update', dated February 2012.

2. CAMPBELL, RI (2012), 'ENGwadM822 Device Verification Prior to Software Upgrade', RES Calculation TC01-023743 Issue 01, dated 14 August 2012.

3. CAMPBELL, RI (2012), 'Baseline and Test Period Statistical Analysis - SoDAR 2.0 Software Upgrade', RES Calculation TC01-027002 Issue 01, dated 14 March 2013.

4. CAMPBELL, RI (2012), 'ENGwadM822 Device Verification Following Software Upgrade', RES Calculation TC01-026990 Issue 01, dated 16 August 2012.

APPENDIX A - SEASONAL VARIATION

Figure A.1 Concurrent Shear Prior to Software Upgrade

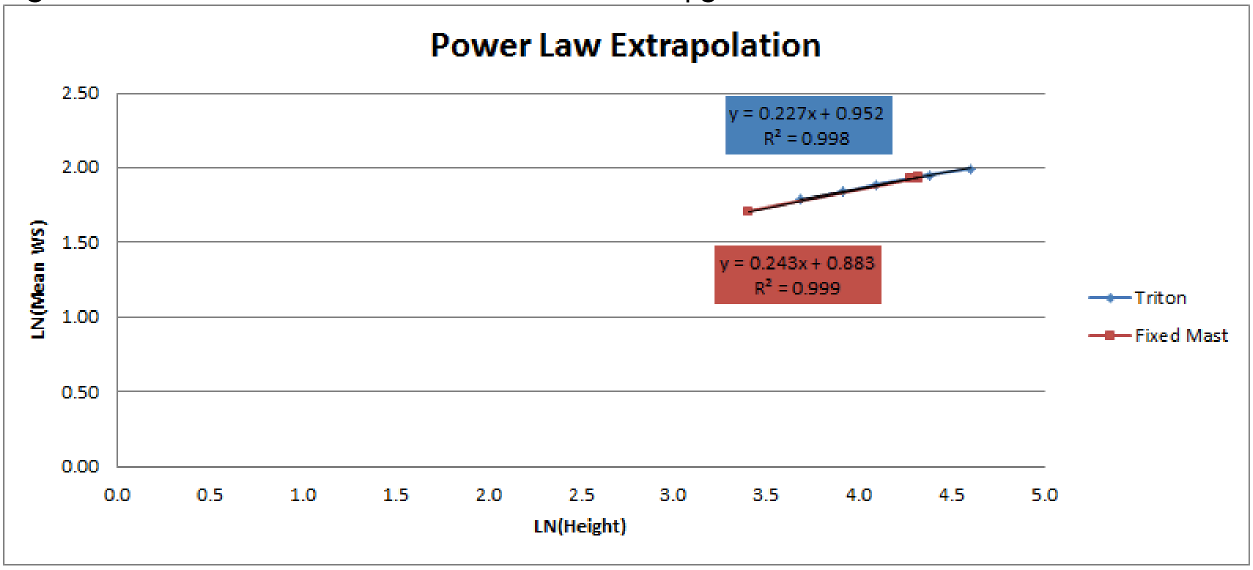
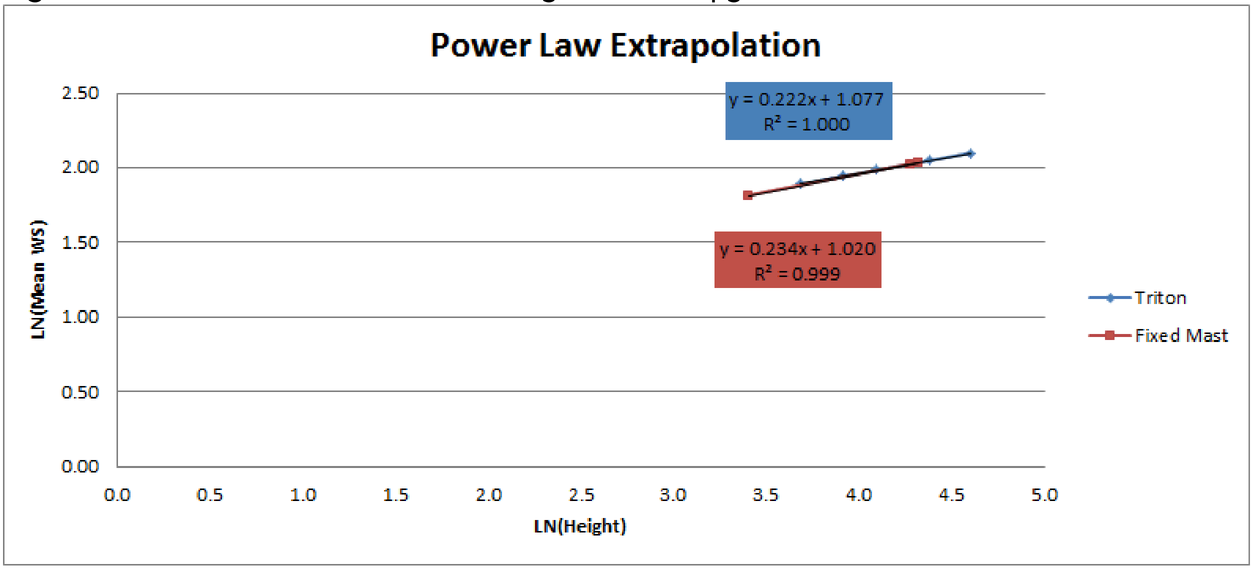


Figure A.2 Concurrent Shear Following Software Upgrade



It can be seen that, for both the baseline and test periods, the Triton multi-point measured shear is in good 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 Software Upgrade

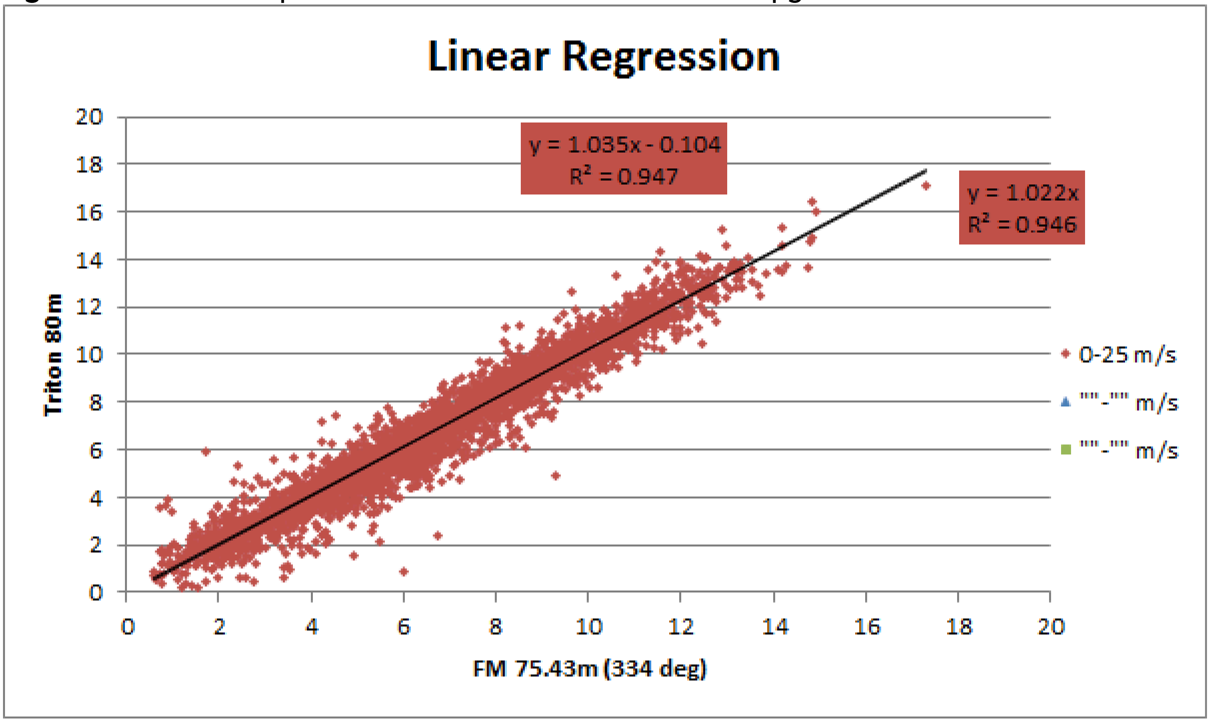
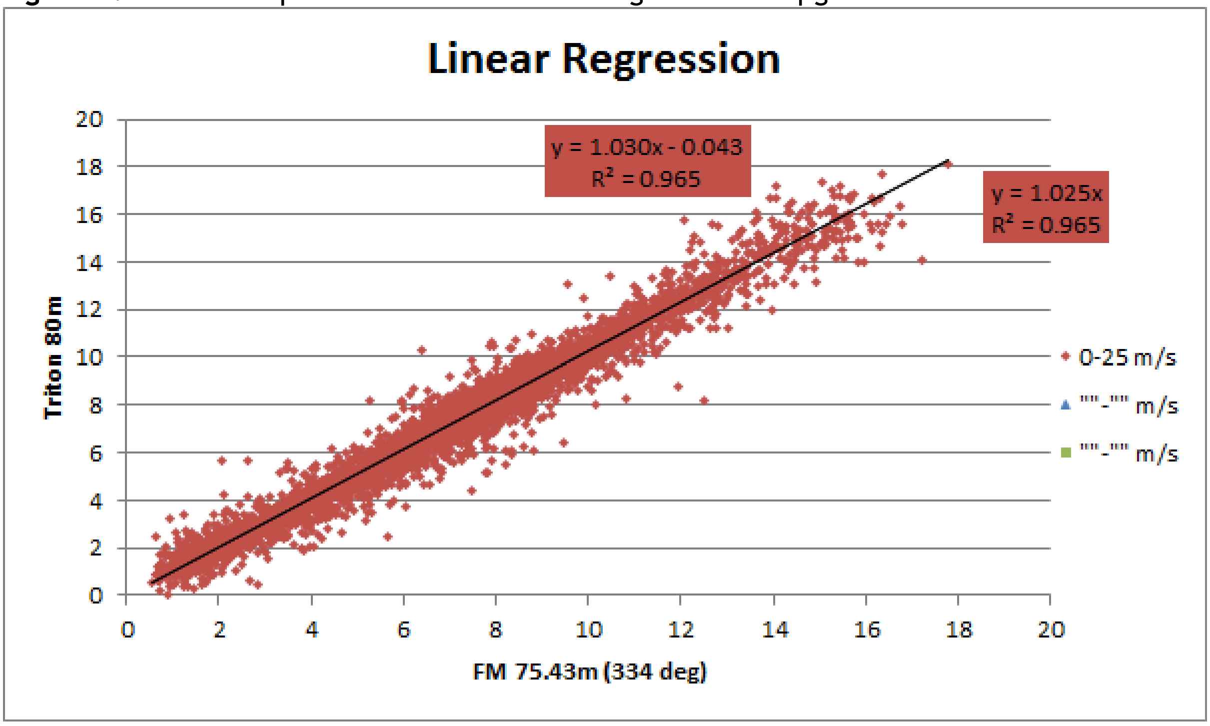


Figure B.2 Wind Speed Correlation Following Software Upgrade



It can be seen that, for both the baseline and test periods, the wind speed correlation between the Triton and the fixed mast is very stationary, with much less than 1% variation 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 software 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 [2, 4].

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