ZX Lidars

Wind speed at light speed

# ZX 300e Introduction & Performance Credentials

24 September 2025

PUBLIC RELEASE

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# Contents

# Executive Summary

## The ZX 300e represents the latest evolution in ground-based wind Lidar technology, extending the proven performance of ZX Lidars' Continuous Wave (CW) design to new industry-first heights.

This document consolidates the independent IEC 61400-50-2 Classification results and comprehensive Performance Verifications for ZX 300e, providing clear evidence of accuracy, reliability, and acceptance across the wind energy industry up to 300 m.

Key highlights include:

- World-first IEC Classification from 21 to 200 m, with a uniquely broad range extending from 21 m to 200 m, delivering the most comprehensive Classification available today.
- Performance Verification by leading independent test sites, confirming low measurement uncertainty, high data availability, and suitability for finance-grade assessments in both benign and complex terrain.
- Novel extended Performance Verification using Midar technology to provide relative accuracy and availability performance of ZX 300e up to 300 m
- Continuity of proven ZX design principles: rugged construction, 10-year design life, minimal servicing requirements, and unrivalled field track record built on the global ZX 300 fleet.

Together, these results establish ZX 300e as a finance-grade, globally accepted Lidar solution for modern wind resource assessment and operational wind farm applications — meeting the increasing need to measure at the extremes of potential tip heights on today's larger rotor turbines.

**With ZX 300e, we raise the benchmark again.**

# 1 Introduction

Accurate, independent validation is the cornerstone of trust in wind measurement technology. Accuracy of wind measurement technology is critical for trusting and accepting the data - independent verifications and validations allow for this. For more than two decades, ZX Lidars has worked with industry consultants, developers, wind turbine OEMs and financiers to build that trust through a robust programme of factory validations, third-party verifications, and global fleet experience.

The ZX 300e continues this tradition, while advancing it further:

- IEC Classification now extends measurements from 21 m to 200 m, enabling accurate data capture from near-ground turbulence zones to the highest modern hub-heights and rotor tips.
- Independent Performance Verifications demonstrate the system's accuracy, data availability, and consistency, with comparisons against calibrated met masts and acceptance by all leading consultants.

By providing validated measurements at the very heights where today's turbines operate, ZX 300e equips developers, operators, and investors with the data confidence required to reduce project risk and optimise performance.

This document brings together the full body of evidence:

- Detailed IEC Classification findings across the 21–200 m range.
- Verified performance comparisons from multiple third-party campaigns.
- Context on methodology, independent oversight, and practical field deployment.

In doing so, it provides a transparent and consolidated reference point for all stakeholders seeking independent assurance of ZX 300e's capability.

# 2 IEC Classification Results

Details of the ZX 300e lidar classification to the IEC 61400-50-2 standard can be found in *Summary of Classification of ZX 300e Algorithm Version 3.10, ZX Lidars, 16 Sept 2025* which outlines the method and results of an internal study. The classification includes measurements from 21 m to 200 m across 5 campaigns using 3 lidars at 3 sites. The classification criteria are met for all heights from 40 m to 200 m with two campaigns featuring measurements down to 21 m. No significant environmental variables were found which results in a final accuracy class and resulting standard uncertainty of 0% at all heights as shown in Table 1.

**Table 1: Final Accuracy Class of ZX 300e**

| Height (m) | Class (%) | Std Uncertainty (%) |
|---|---|---|
| **200** | 0 | 0 |
| **190** | 0 | 0 |
| **180** | 0 | 0 |
| **170** | 0 | 0 |
| **160** | 0 | 0 |
| **150** | 0 | 0 |
| **140** | 0 | 0 |
| **130** | 0 | 0 |
| **120** | 0 | 0 |
| **110** | 0 | 0 |
| **100** | 0 | 0 |
| **90** | 0 | 0 |
| **80** | 0 | 0 |
| **70** | 0 | 0 |
| **60** | 0 | 0 |
| **50** | 0 | 0 |
| **40** | 0 | 0 |
| **30** | 0 | 0 |
| **21** | 0 | 0 |

# 3 Performance Verifications

## 3.1 Horizontal Wind Speed

In the following sections, the results of the performance verifications of ZX 300e units, at a range of sites, are documented for the contracted measurement heights. The verifications conducted are based on the 10-min horizontal wind speed statistics generated by the unit under test. In total, there are ten campaigns with five lidars at five sites. Two of the sites feature 200 m met masts. One of the sites features highly complex terrain. For this complex site, CFD-conversion factors obtained from the independent engineering consultancy, Deutsche WindGuard GmbH, Germany, were applied to the horizontal wind speed measurements. In all cases, each campaign lasted a period of three months.

In the following sections, analysis of the mast-lidar wind speed regression parameters and data availabilities are presented. In all the plots, the green dashed lines are the DNV recommended best practice acceptance criteria while the orange dotted lines represent the DNV minimum acceptance criteria. Tables of these results can be found in Appendix A.1.

### 3.1.1 Hanover (Geo-Net)

#### 3.1.1.1 Unit No: ZX6003

**Deployment Period:** 21 June - 23 September 2024

**Figure 1: Gradients**


**Figure 2: Coefficients of Determination**

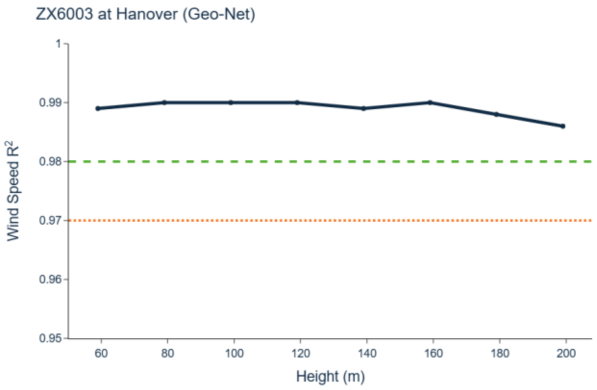
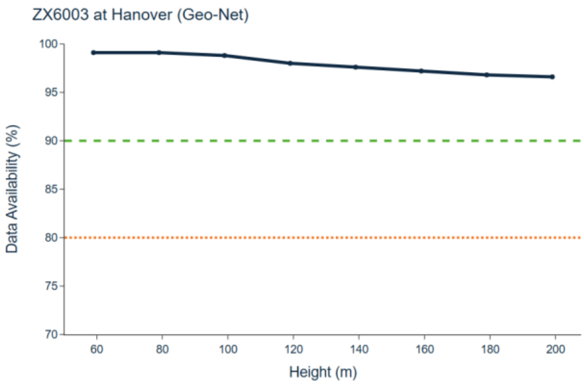



**Figure 3: Data Availability**




**Summary**

At all heights, the gradients are within +/-1% of unity and the coefficients of determination are greater than 0.985. Data availability is also greater than 95% and well above the DNV best practice acceptance criteria at all heights.

### 3.1.1.2 Unit No: ZX6004

**Deployment Period:** 26 May – 25 August 2025

**Figure 4: Gradients**

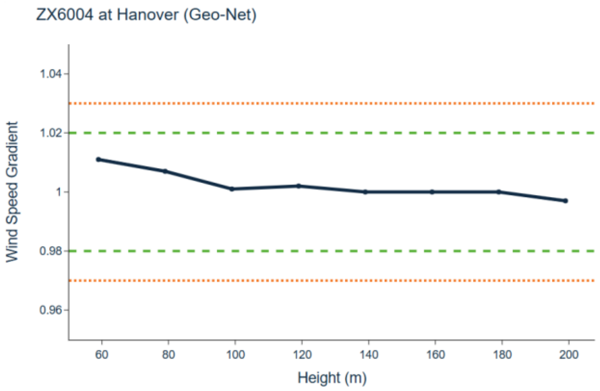



**Figure 5: Coefficients of Determination**

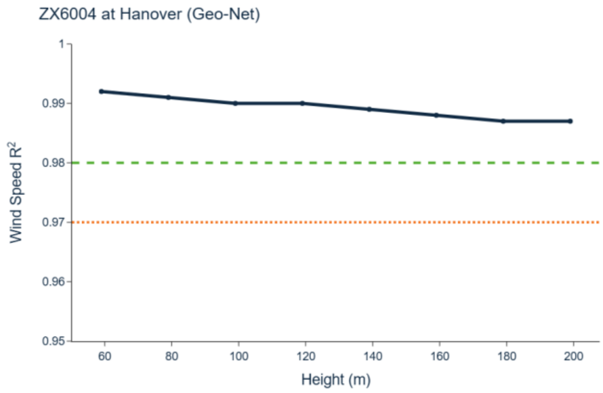
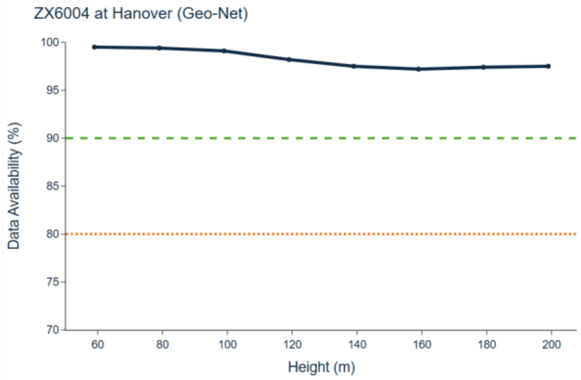



**Figure 6: Data Availability**




**Summary**

At all heights, the gradients are within +/-1% of unity and the coefficients of determination are greater than 0.985. Data availability is also greater than 95% and well above the DNV best practice acceptance criteria at all heights.

### 3.1.2 Janneby (Pavana)

#### 3.1.2.1 Unit No: ZX6002

**Deployment Period:** 17 February - 18 May 2025

**Figure 7: Gradients**

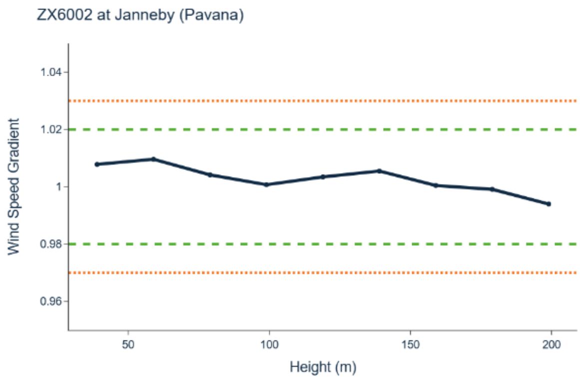



**Figure 8: Coefficients of Determination**

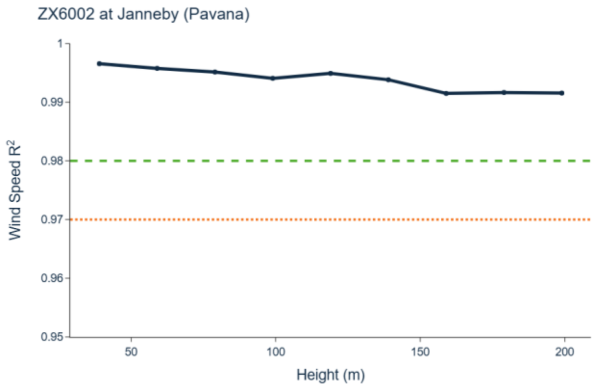
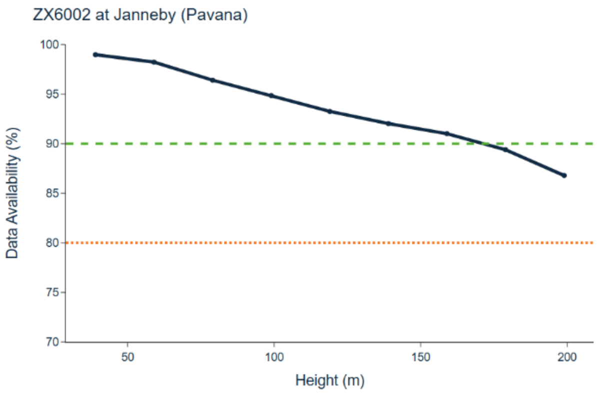



**Figure 9: Data Availability**




**Summary**

At all heights, the gradients are within +/-1% of unity and the coefficients of determination are greater than 0.985. Data availability is also greater than 85% and well above the DNV minimum acceptance criteria at all heights.

### 3.1.2.2 Unit No: ZX6003

**Deployment Period:** 19 February - 20 May 2025

**Figure 10: Gradients**

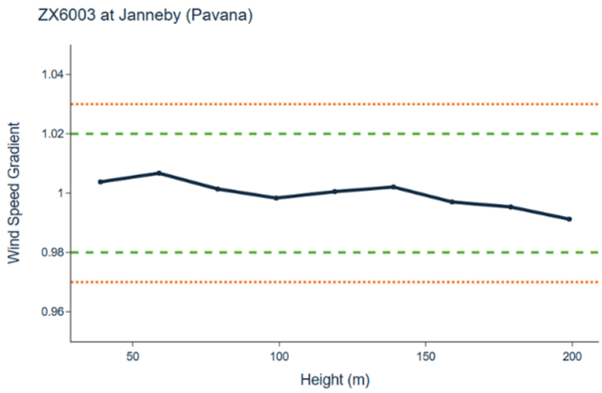



**Figure 11: Coefficients of Determination**

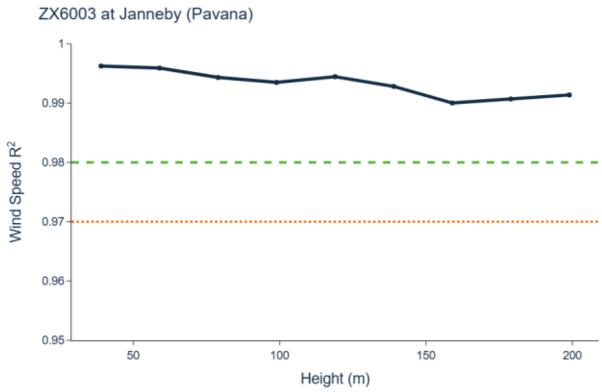
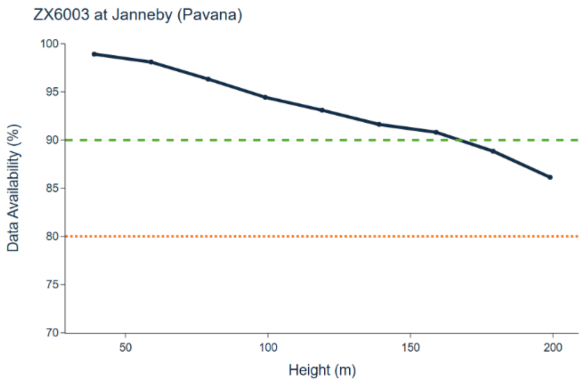



**Figure 12: Data Availability**




**Summary**

At all heights, the gradients are within +/-1% of unity and the coefficients of determination are greater than 0.985. Data availability is also greater than 85% and well above the DNV minimum acceptance criteria at all heights.

### 3.1.3 Janneby (DNV)

#### 3.1.3.1 Unit No: ZX6101

**Deployment Period:** 26 May – 25 August 2025

**Figure 13: Gradients**

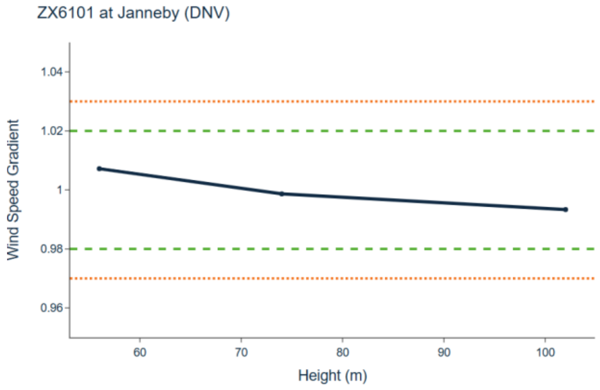



**Figure 14: Coefficients of Determination**

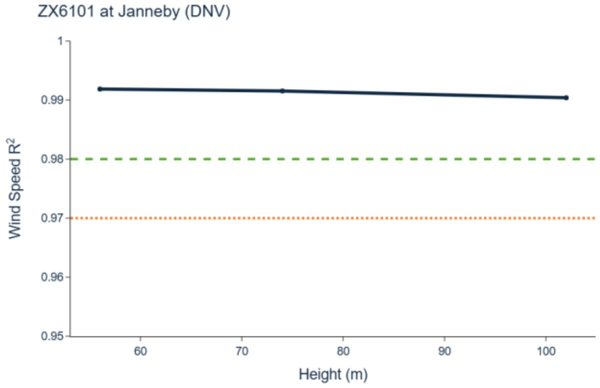
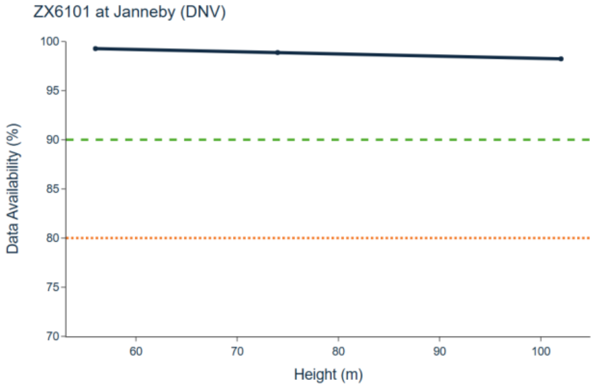



**Figure 15: Data Availability**




**Summary**

At all heights, the gradients are within +/-1% of unity and the coefficients of determination are greater than 0.99. Data availability is also greater than 98% and well above the DNV best practice acceptance criteria at all heights.

## 3.1.4 UK Remote Sensing Test Site (ZX Lidars, DNV)

### 3.1.4.1 Unit No: ZX6101

**Deployment Period:** 10 October 2024 – 8 January 2025

**Figure 16: Gradients**

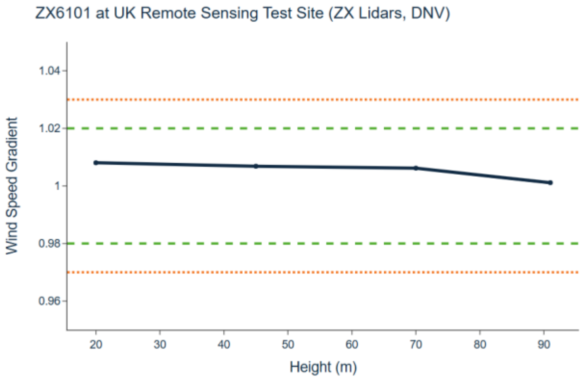



**Figure 17: Coefficients of Determination**

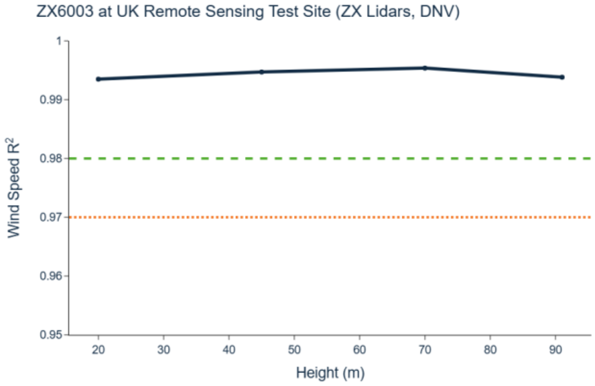
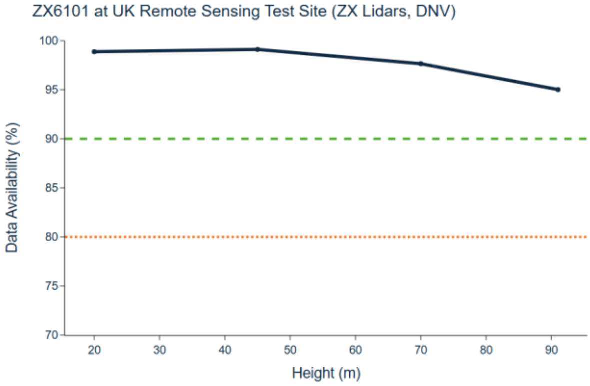



**Figure 18: Data Availability**




### Summary

At all heights, the gradients are within +/-1% of unity and the coefficients of determination are greater than 0.99. Data availability is also greater than 95% and well above the DNV best practice acceptance criteria at all heights.

### 3.1.4.2 Unit No: ZX6104

**Deployment Period:** 25 May – 24 August 2025

**Figure 19: Gradients**

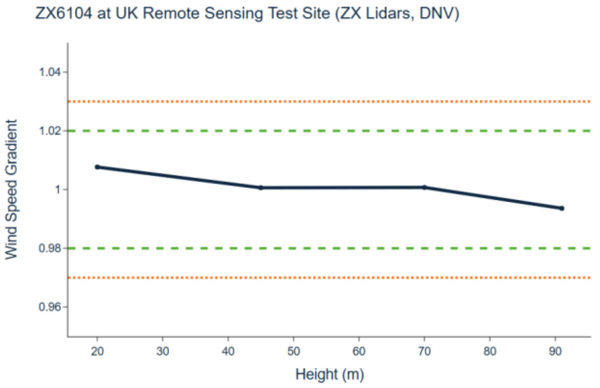



**Figure 20: Coefficients of Determination**

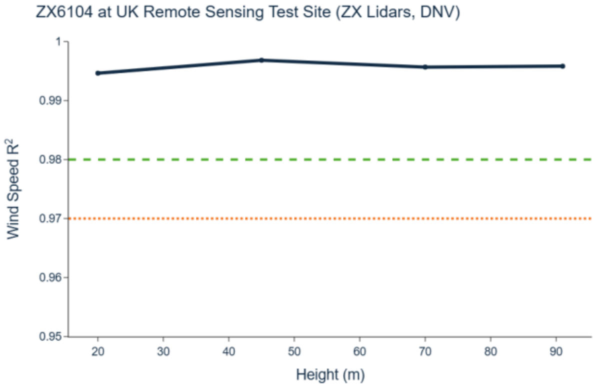
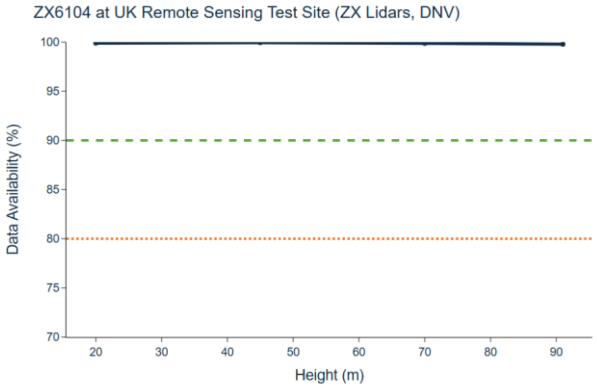



**Figure 21: Data Availability**




**Summary**

At all heights, the gradients are within +/-1% of unity and the coefficients of determination are greater than 0.99. Data availability is also greater than 99% and well above the DNV best practice acceptance criteria at all heights.

### 3.1.4.3 Unit No: ZX6003

**Deployment Period:** 17 May - 2 June 2024; 12 June – 24 August 2025

**Figure 22: Gradients**

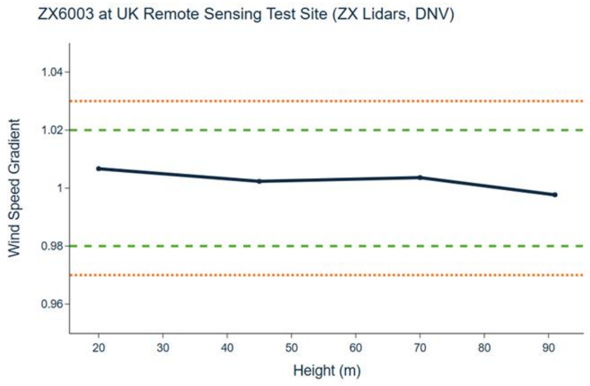



**Figure 23: Coefficients of Determination**

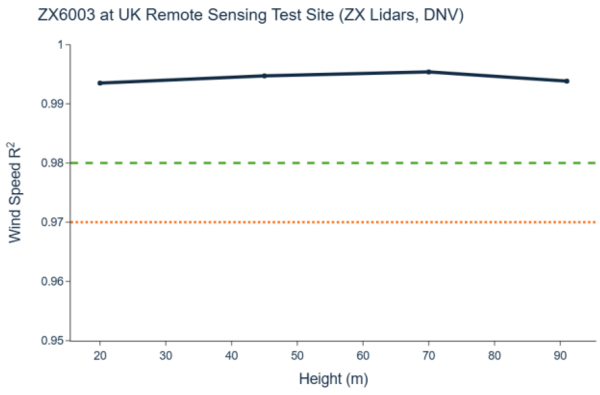
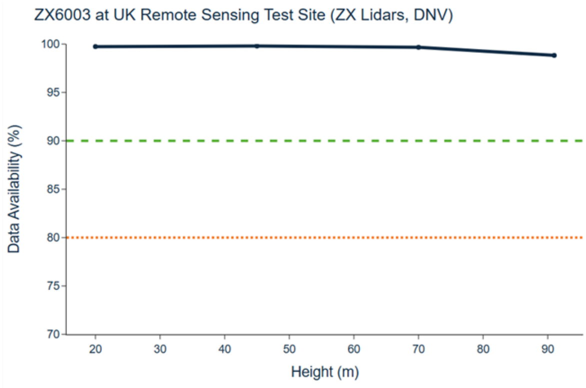



**Figure 24: Data Availability**




**Summary**

At all heights, the gradients are within +/-1% of unity and the coefficients of determination are greater than 0.99. Data availability is also greater than 98% and well above the DNV best practice acceptance criteria at all heights.

## 3.2 Highly complex terrain

A ZX 300e unit was deployed to a highly complex site for a 3-month period. Computational Fluid Dynamics (CFD) wind-speed correction factors were provided by Deutsche Windguard GmbH, Germany. In the sections below, plots of the pre-CFD and post-CFD regression parameters are presented. Furthermore, the ZX Quality Score data recovery method was applied to the data and the results shown in Section 3.3.2. Tables of these results can be found in Appendix A.1.5.

### 3.2.1 Horizontal Wind Speed

**Unit No: ZX6104**

**Deployment Period:** 1 January – 1 April 2025

#### 3.2.1.1 Uncorrected correlations

ZX 300e's inherent 50 Hz sampling and CW architecture make its data output representative and particularly resilient in complex flow conditions. These design features allow the system to capture both horizontal and vertical wind components with minimal distortion, reducing either the immediate need, or eventual magnitude of corrections needed as shown in Figures 25 and 26.

**Figure 25: Gradients**

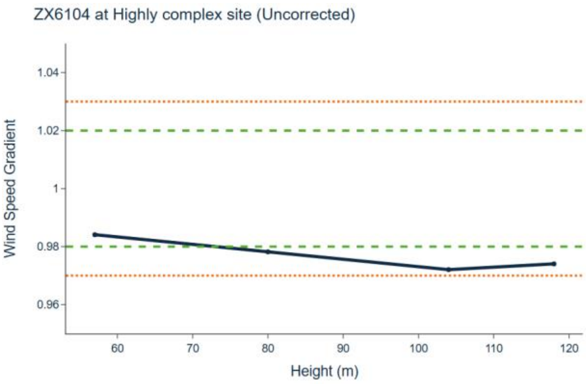
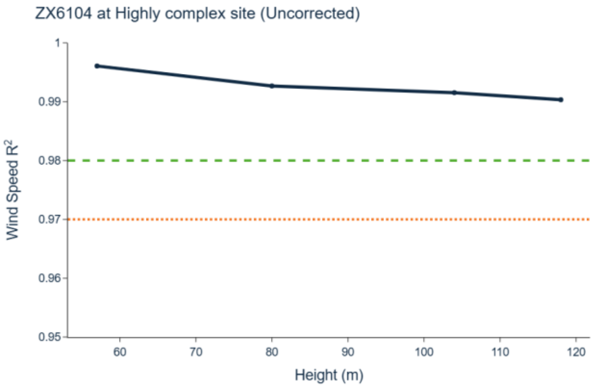



**Figure 26: Coefficients of Determination**




**Summary**

Even without the CFD wind speed corrections, the gradients meet the DNV minimum acceptance criteria while the coefficients of determination are greater than 0.985.

### 3.2.1.2 CFD-Corrected correlations

Deutsche WindGuard GmbH, Germany specialize in the use of Computational Fluid Dynamics (CFD) to calculate wind speed and direction correction factors which account for flow features like flow separation and wind inclination that arise from complex terrain. The wind speed correction factors are both height and wind direction-dependent and can be applied to either the 1s or 10-minute averaged measurements. For this campaign, the correction was applied to the 1s measurements. See *Using Wind Lidars in Complex Terrain: A Best Practice Guide, ZX Lidars, 07 January 2025* for more details.

The regression parameters after the application of the correction factors to the wind speeds are shown in Figures 27 and 28.

**Figure 27: Gradients**

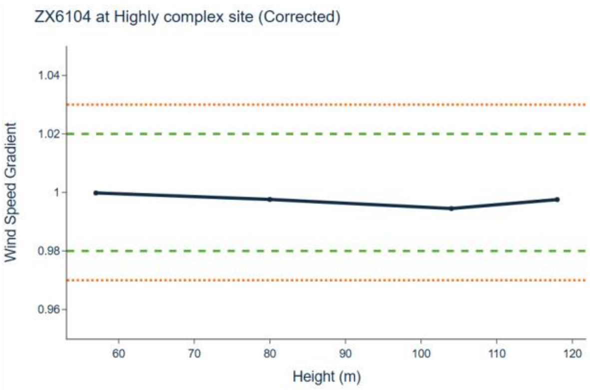



**Figure 28: Coefficients of Determination**

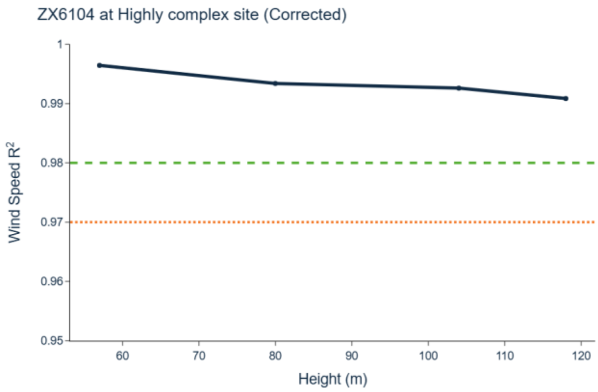
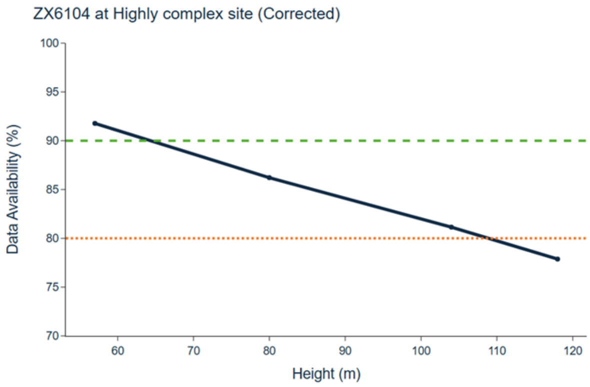



**Figure 29: Data Availability**




**Summary**

At all heights, the corrected gradients are now within +/-1% of unity and the coefficients of determination are greater than 0.99. Data availability is also greater than 80% at all but the highest height.

### 3.2.2 ZX Quality Score Data Recovery method

The ZX Quality Score Data Recovery method employs a post-processing approach to re-evaluate 10-minute averaged data filtered by the number of packets in average. Using interpolation methods, an estimate of the quality of the filtered measurements (quality score) is made based on the adjacent unfiltered measurements. Finally, a validated threshold on the quality score is used to recover some of the filtered measurements. See *ZX Quality Score: Post-processing method for increasing lidar data availability, ZX Lidars, 24 Oct 2024* for more details.

**Figure 30: Gradients**

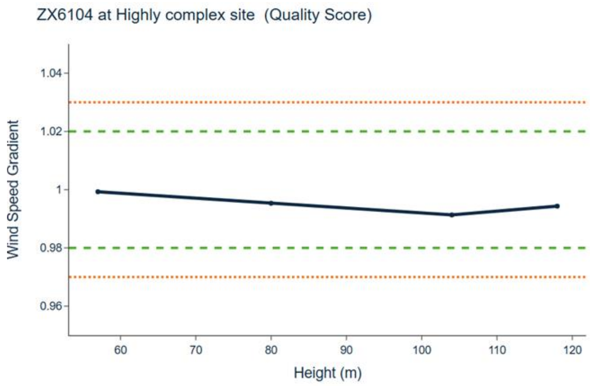



**Figure 31: Coefficients of Determination**

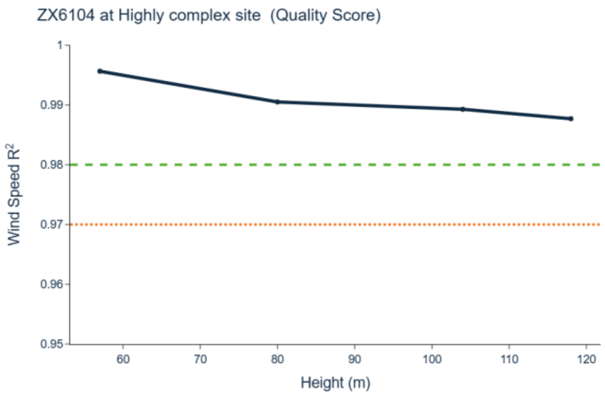
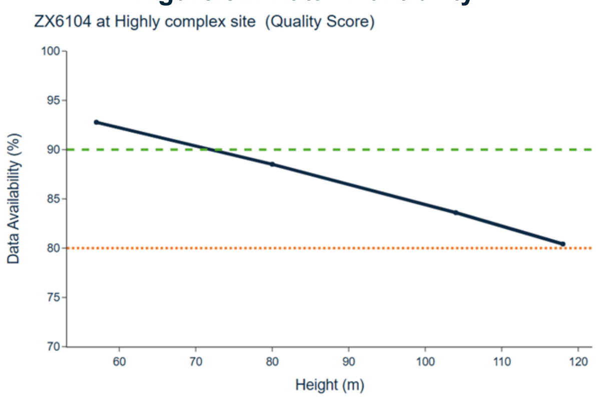



**Figure 32: Data Availability**




**Summary**

After the application of the ZX Quality Score Data Recovery method, the gradients are still within +/-1% of unity and the coefficients of determination are greater than 0.985. Data availability is now greater than 80% at all heights including the highest height.

# 4 Fleet Verifications with the Midar

## 4.1 21 m-180 m verifications

A fleet of 25 ZX 300e units were deployed to the 92 m mast at the UK Remote Sensing Test Site (ZX, DNV) for three weeks.

The reference measurement heights were extended above 92 m by mounting a lidar, already validated to 92 m, at the top of the mast. This configuration called the Midar ('Mast' + 'Lidar') allowed the ground-based lidars verifications to be traceable against a verified reference up to 181 m. ZX 300e measurements up to 200 m and beyond were also verified with Midar.

**Number of units**: 25 (all displayed on the plots below)

**Deployment Period:** 6 August – 1 September 2025

### 4.1.1 Horizontal Wind Speed

**Figure 33: Gradients**

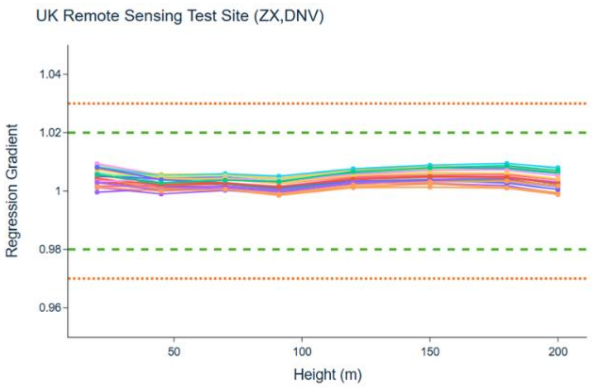



**Figure 34: Coefficients of Determination**

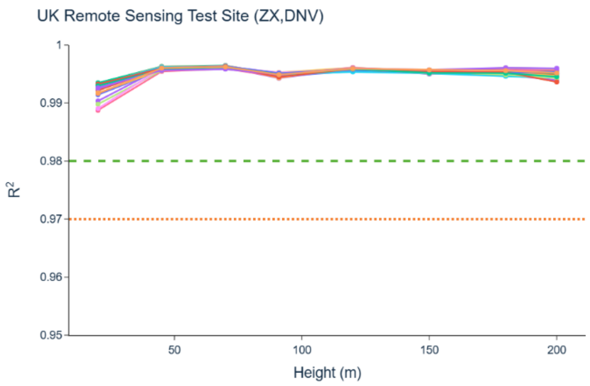
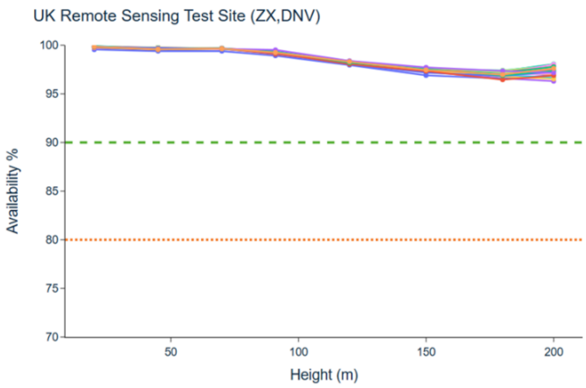



**Figure 35: Data Availability**




**Summary**

At all heights, the gradients are within +/-1% of unity and the coefficients of determination are greater than 0.985. Data availability is also greater than 95% at all heights.

### 4.1.2 Wind Direction

Using the mast as a reference and after correcting for offsets, the differences between the 10-minute averaged wind directions measured by the mast and the fleet of lidars were computed and are shown in Figures 36-38 as wind roses.

**Figure 36: Wind Rose at 21 m**

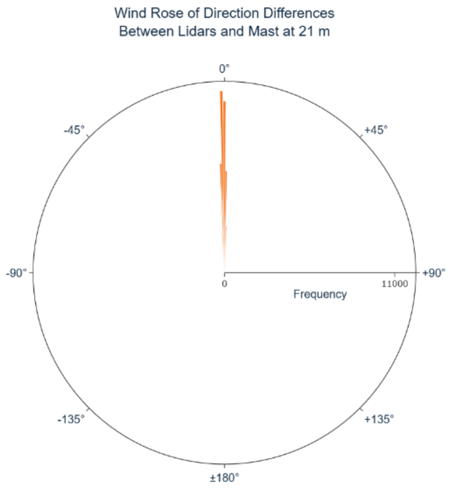



**Figure 37: Wind Rose at 46 m**

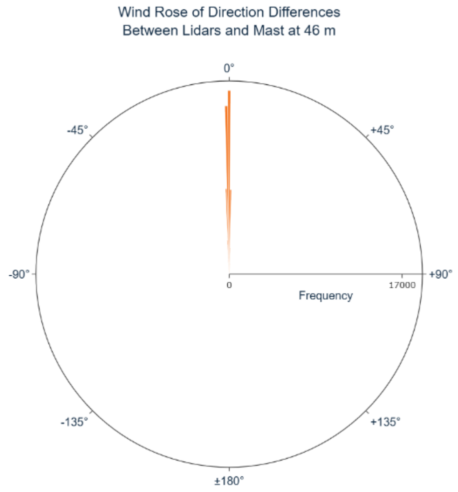
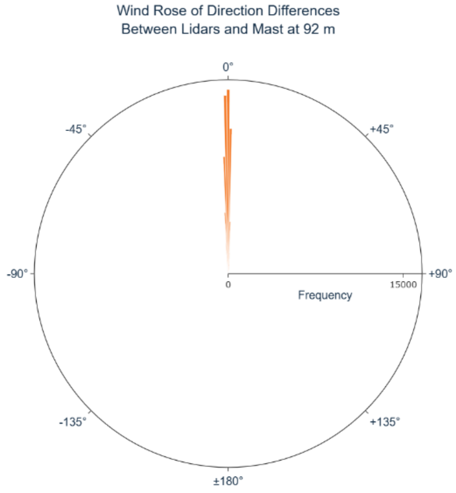



**Figure 38: Wind Rose at 92 m**




**Summary**

As can be seen, the differences between the mast and lidar wind directions are all tightly clustered around 0 degrees at the three mast heights.

## 4.2 Beyond 200 m measurements

Using the Midar as a reference, the measurements heights were extended up to 300 m for the 25 ZX 300e units deployed to the UK Remote Sensing Test Site (ZX, DNV).

**Number of units**: 25 (all displayed on the plots below)

**Deployment Period:** 6 August – 1 September 2025

### 4.2.1 Fleet-wide correlations

**Figure 39: Gradients**

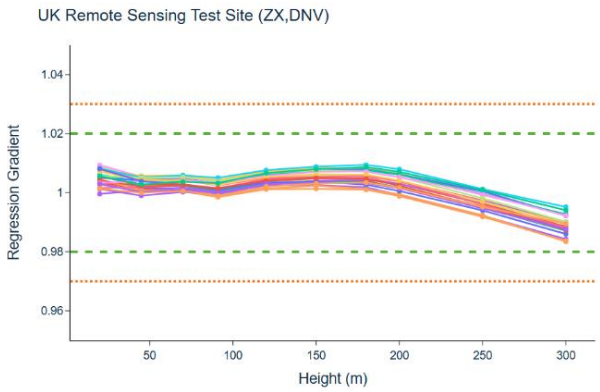



**Figure 40: Coefficients of Determination**

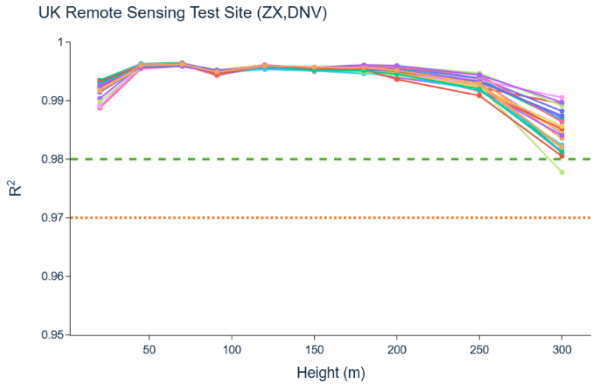
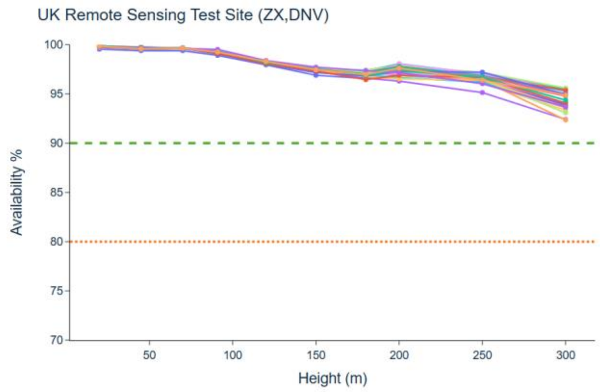



**Figure 41: Data Availability**




**Summary**

At all heights up to and including 300 m, the gradients are within +/-2% of unity (DNV best practice acceptance criteria). Furthermore, the coefficients of determination are greater than 0.98 (DNV minimum acceptance criteria) except for one unit at 300 m. Data availability is also greater than 92% at all heights.

### 4.2.2 Fleet-averaged correlations

**Figure 42: Gradients**

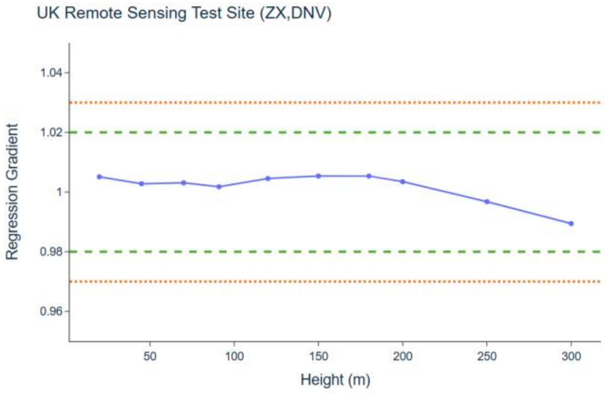



**Figure 43: Coefficients of Determination**

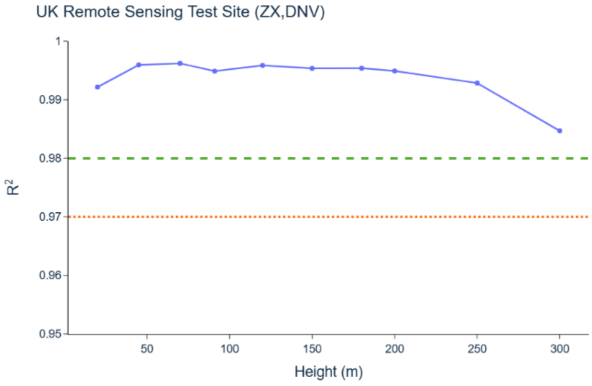
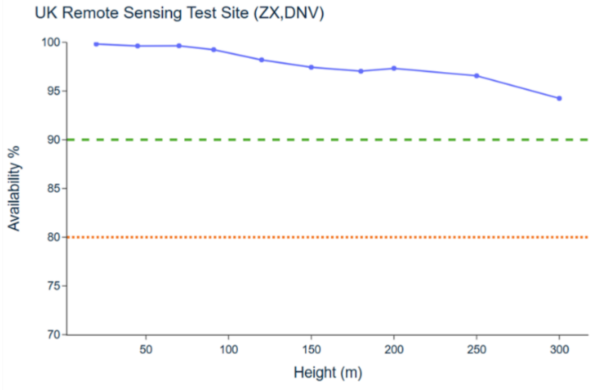



**Figure 44: Fleet-averaged data availability**




**Summary**

At all heights up to and including 300 m, the fleet-averaged gradients are within +/-2% of unity (DNV best practice acceptance criteria) and the averaged coefficients of determination are greater than 0.985. The averaged data availability is also greater than 94% at all heights.

# 5 Turbulence Intensity

In this section, the results of the turbulence intensity validations of ZX 300e units at a range of sites are documented. The turbulence intensities from the lidar are cup-equivalent measurements generated by the Multi-site Ensemble Turbulence Intensity Cup Equivalent (METICE) algorithm.

In the following section, the METICE algorithm is introduced, and the verification results are presented.

## 5.1 Verification of the ZX 300e METICE algorithm

METICE is a machine learning algorithm that uses ensemble predictions from multiple site-specific neural network models and Gaussian Mixture models to estimate TI. The ensemble is made up of 7 sites with measurement heights ranging up to 200 m.

The algorithm was validated with data from 16 sites and 64 measurement heights in total. The Consortium for Advancing Remote Sensing (CFARS) criteria were used to assess the mean bias error of the TI estimates and the Representative TI. The green dashed lines represent the CFARS best practice Acceptance Criteria while the orange dotted lines represent the minimum acceptance criteria.

**Figure 45: Mean Bias Error**

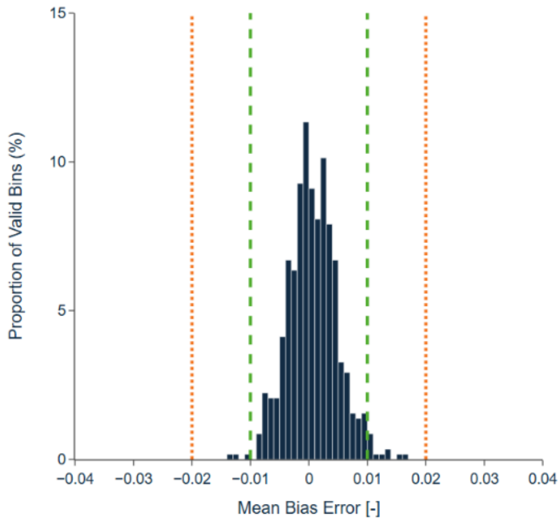
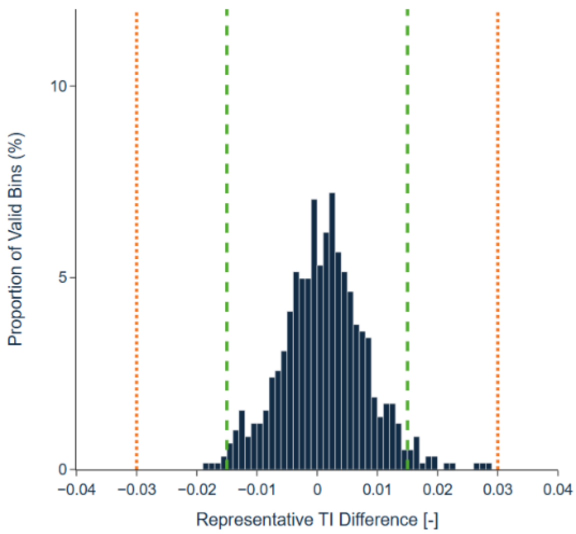



**Figure 46: Representative TI**




### Summary

Across all the sites and measurement heights, 97.6% of the binned data meets the defined ±1% best practice acceptance criteria for Mean Bias Error with 100% meeting the ±2% minimum acceptance criteria. Furthermore, 95.9% of the binned data meets the ±1.5% best practice acceptance criteria for Representative TI with 99.8% within ±3%. These findings support METICE's suitability for cup-equivalent turbulence corrections at simple sites.

# 6 Conclusions

The ZX 300e conclusively retains the benchmark for ground-based wind Lidar. With world-first IEC Classification from 21 m to 200 m and extended fleet-wide verifications up to 300 m, it delivers the most comprehensive body of independent evidence ever assembled for finance-grade wind measurements.

Across a wide range of campaigns, the ZX 300e consistently demonstrated:

- **Accuracy and certainty** – Wind speed gradients within ±1% of unity up to 200 m, and within ±2% to 300 m, with coefficients of determination consistently above 0.985, confirming exceptional correlation with met mast references.
- **High data availability** – Routinely above 95% and fleet-averaged above 94% even at 300 m, surpassing industry acceptance criteria and reinforcing reliability under real-world operating conditions.
- **Proven resilience in complex terrain** – CFD-corrected results at highly complex sites confirmed ZX 300e's suitability in the most challenging environments, with data recovery methods further strengthening availability at high elevations.
- **Validated turbulence intensity** – The METICE algorithm achieved 99.3% compliance with CFARS best-practice criteria for Mean Bias Error and 98.9% compliance for Representative TI, enabling robust cup-equivalent turbulence reporting at scale.

ZX 300e is the first and only Lidar to deliver independently verified performance across the entire operating envelope of modern wind turbines — from near-ground turbulence zones to the highest tip heights now being deployed.

For developers, operators, and financiers, this establishes ZX 300e as the definitive standard for met mast replacement and project wind data. With its rugged design, extended service intervals, and global acceptance, ZX 300e provides the clearest pathway yet to de-risking projects, optimising operational performance, and financing the next generation of wind energy.

**With ZX 300e, the benchmark has been raised — permanently.**

# Appendices

# A Tables of Results

## A.1 Wind Speed Regression Parameters and Data Availability

### A.1.1 Hanover (Geo-Net)

**Table 2: ZX6003 21 June - 23 September 2024**

| Height (m) | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 |
|---|---|---|---|---|---|---|---|---|
| Wind Speed Gradient | 1.008 | 1.005 | 1.000 | 1.002 | 0.999 | 0.999 | 0.996 | 0.992 |
| Wind Speed R-squared | 0.989 | 0.990 | 0.990 | 0.990 | 0.989 | 0.990 | 0.988 | 0.986 |
| Availability (%) | 99.1 | 99.1 | 98.8 | 98.0 | 97.6 | 97.2 | 96.8 | 96.6 |

**Table 3: ZX6004 26 May – 25 August 2025**

| Height (m) | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 |
|---|---|---|---|---|---|---|---|---|
| Wind Speed Gradient | 1.011 | 1.007 | 1.001 | 1.002 | 1.000 | 1.000 | 1.000 | 0.997 |
| Wind Speed R-squared | 0.992 | 0.991 | 0.990 | 0.990 | 0.989 | 0.988 | 0.987 | 0.987 |
| Availability (%) | 99.5 | 99.4 | 99.1 | 98.2 | 97.5 | 97.2 | 97.4 | 97.5 |

### A.1.2 Janneby (Pavana)

**Table 4: ZX6002 17 February - 18 May 2025**

| Height (m) | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 |
|---|---|---|---|---|---|---|---|---|---|
| Wind Speed Gradient | 1.008 | 1.010 | 1.004 | 1.001 | 1.003 | 1.005 | 1.000 | 0.999 | 0.994 |
| Wind Speed R-squared | 0.997 | 0.996 | 0.995 | 0.994 | 0.995 | 0.994 | 0.991 | 0.992 | 0.992 |
| Availability (%) | 99.0 | 98.2 | 96.4 | 94.9 | 93.3 | 92.0 | 91.0 | 89.4 | 86.8 |

**Table 5: ZX6003 19 February - 20 May 2025**

| Height (m) | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 |
|---|---|---|---|---|---|---|---|---|---|
| Wind Speed Gradient | 1.004 | 1.007 | 1.001 | 0.998 | 1.001 | 1.002 | 0.997 | 0.995 | 0.991 |
| Wind Speed R-squared | 0.996 | 0.996 | 0.994 | 0.993 | 0.994 | 0.993 | 0.990 | 0.991 | 0.991 |
| Availability (%) | 98.9 | 98.1 | 96.3 | 94.4 | 93.1 | 91.6 | 90.8 | 88.8 | 86.1 |

### A.1.3 Janneby (DNV)

**Table 6: ZX6101 26 May – 25 August 2025**

| Height (m) | 57 | 75 | 103 |
|---|---|---|---|
| Wind Speed Gradient | 1.007 | 0.999 | 0.993 |
| Wind Speed R-squared | 0.992 | 0.992 | 0.990 |
| Availability (%) | 99.3 | 98.9 | 98.2 |

### A.1.4 UK Remote Sensing Test Site (ZX Lidars, DNV)

**Table 7: ZX6101 10 October 2024 – 8 January 2025**

| Height (m) | 21 | 46 | 71 | 92 |
|---|---|---|---|---|
| Wind Speed Gradient | 1.008 | 1.007 | 1.006 | 1.001 |
| Wind Speed R-squared | 0.996 | 0.998 | 0.997 | 0.996 |
| Availability (%) | 98.9 | 99.1 | 97.7 | 95.0 |

**Table 8: ZX6104 25 May – 24 August 2025**

| Height (m) | 21 | 46 | 71 | 92 |
|---|---|---|---|---|
| Wind Speed Gradient | 1.008 | 1.001 | 1.001 | 0.994 |
| Wind Speed R-squared | 0.995 | 0.997 | 0.996 | 0.996 |
| Availability (%) | 99.9 | 99.9 | 99.9 | 99.8 |

**Table 9: ZX6003 17 May - 2 June 2024; 12 June – 24 August 2025**

| Height (m) | 21 | 46 | 71 | 92 |
|---|---|---|---|---|
| Wind Speed Gradient | 1.007 | 1.002 | 1.004 | 0.998 |
| Wind Speed R-squared | 0.993 | 0.995 | 0.995 | 0.994 |
| Availability (%) | 99.7 | 99.8 | 99.7 | 98.8 |

### A.1.5 Highly complex terrain

**Table 10: ZX6104 1 January - 1 April 2025 (Uncorrected correlations)**

| Height (m) | 21 | 46 | 71 | 92 |
|---|---|---|---|---|
| Wind Speed Gradient | 0.984 | 0.978 | 0.972 | 0.974 |
| Wind Speed R-squared | 0.996 | 0.993 | 0.992 | 0.990 |
| Availability (%) | 91.7 | 86.2 | 81.1 | 77.9 |

**Table 11: ZX6104 1 January - 1 April 2025 (CFD-Corrected correlations)**

| Height (m) | 21 | 46 | 71 | 92 |
|---|---|---|---|---|
| Wind Speed Gradient | 1.000 | 0.998 | 0.994 | 0.998 |
| Wind Speed R-squared | 0.996 | 0.993 | 0.993 | 0.991 |
| Availability (%) | 91.8 | 86.2 | 81.1 | 77.9 |

**Table 12: ZX6104 1 January - 1 April 2025 (ZX Quality Score Data Recovery)**

| Height (m) | 21 | 46 | 71 | 92 |
|---|---|---|---|---|
| Wind Speed Gradient | 0.999 | 0.995 | 0.991 | 0.994 |
| Wind Speed R-squared | 0.996 | 0.991 | 0.989 | 0.988 |
| Availability (%) | 92.8 | 88.5 | 83.6 | 80.4 |

### A.1.6 UK Remote Sensing Test Site (ZX Lidars, DNV): Midar Reference

**Table 13: 25 Units 6 August – 1 September 2025**

| Height (m) | 21 | 46 | 71 | 92 | 120 | 150 | 180 | 200 | 250 | 300 |
|---|---|---|---|---|---|---|---|---|---|---|
| Mean Wind Speed Gradient | 1.005 | 1.003 | 1.003 | 1.002 | 1.005 | 1.005 | 1.005 | 1.003 | 0.997 | 0.989 |
| Mean Wind Speed R-squared | 0.992 | 0.996 | 0.996 | 0.995 | 0.996 | 0.995 | 0.995 | 0.995 | 0.993 | 0.985 |
| Availability (%) | 99.8 | 99.6 | 99.6 | 99.2 | 98.2 | 97.4 | 97.0 | 97.3 | 96.6 | 94.2 |

## A.2 Turbulence Intensity Regression Parameters

### A.2.1 Janneby (Pavana)

**Table 14: ZX6002 17 February - 18 May 2025**

| Height (m) | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 |
|---|---|---|---|---|---|---|---|---|---|
| TI Gradient | 0.990 | 0.983 | 1.007 | 1.011 | 0.998 | 1.002 | 1.030 | 1.024 | 1.020 |
| TI R-squared | 0.901 | 0.907 | 0.879 | 0.852 | 0.847 | 0.821 | 0.777 | 0.765 | 0.744 |

**Table 15: ZX6003 19 February - 20 May 2025**

| Height (m) | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 |
|---|---|---|---|---|---|---|---|---|---|
| TI Gradient | 0.998 | 0.993 | 1.013 | 1.019 | 1.005 | 1.014 | 1.039 | 1.032 | 1.031 |
| TI R-squared | 0.893 | 0.907 | 0.883 | 0.844 | 0.844 | 0.812 | 0.783 | 0.758 | 0.735 |

### A.2.2 Hanover (Geo-Net)

**Table 16: ZX6003 21 June - 23 September 2024**

| Height (m) | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 |
|---|---|---|---|---|---|---|---|---|
| TI Gradient | 1.000 | 1.004 | 1.001 | 0.988 | 0.987 | 0.962 | 0.960 | 1.000 |
| TI R-squared | 0.934 | 0.925 | 0.904 | 0.884 | 0.876 | 0.770 | 0.718 | 0.785 |

**Table 17: ZX6004 26 May – 25 August 2025**

| Height (m) | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 |
|---|---|---|---|---|---|---|---|---|
| TI Gradient | 1.001 | 1.001 | 1.010 | 0.999 | 0.994 | 0.995 | 0.995 | 1.015 |
| TI R-squared | 0.922 | 0.919 | 0.903 | 0.894 | 0.875 | 0.832 | 0.810 | 0.761 |

### A.2.3 Janneby (DNV)

**Table 18: ZX6101 26 May – 25 August 2025**

| Height (m) | 57 | 75 | 103 |
|---|---|---|---|
| TI Gradient | 0.959 | 0.960 | 0.965 |
| TI R-squared | 0.850 | 0.857 | 0.832 |

### A.2.4 UK Remote Sensing Test Site (ZX Lidars, DNV)

**Table 19: ZX6101 10 October 2024 – 8 January 2025**

| Height (m) | 21 | 46 | 71 | 92 |
|---|---|---|---|---|
| TI Gradient | 0.998 | 0.985 | 0.990 | 1.006 |
| TI R-squared | 0.792 | 0.879 | 0.861 | 0.817 |

**Table 20: ZX6104 25 May – 24 August 2025**

| Height (m) | 21 | 46 | 71 | 92 |
|---|---|---|---|---|
| TI Gradient | 0.986 | 1.014 | 1.027 | 1.052 |
| TI R-squared | 0.853 | 0.898 | 0.902 | 0.882 |

**Table 21: ZX6003 17 May - 2 June 2024; 12 June – 24 August 2025**

| Height (m) | 21 | 46 | 71 | 92 |
|---|---|---|---|---|
| TI Gradient | 0.989 | 1.016 | 1.031 | 1.050 |
| TI R-squared | 0.830 | 0.893 | 0.902 | 0.874 |

## A.3 Horizontal Wind Speed: Selection of scatterplots

### A.3.1 Verification sites

**Figure 47: 200 m at Hanover (Geo-Net)**

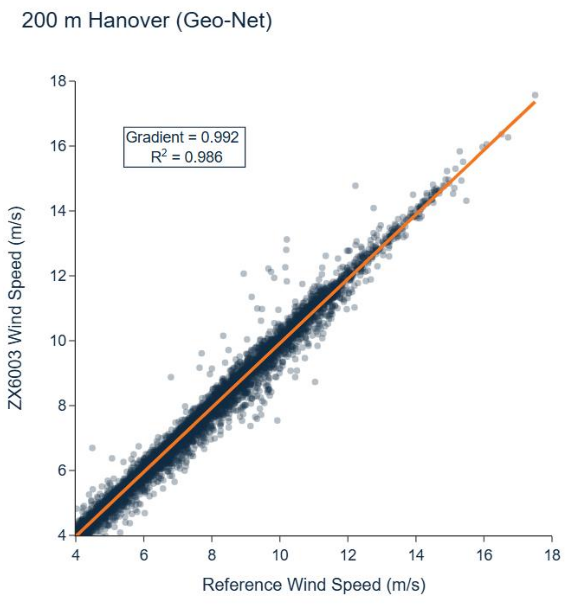



**Figure 48: 200 m at Janneby (Pavana)**

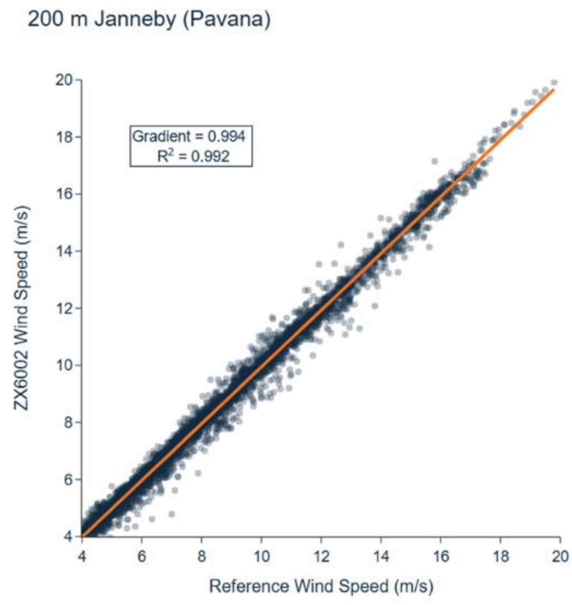



**Figure 49: 103 m at Janneby (DNV)**

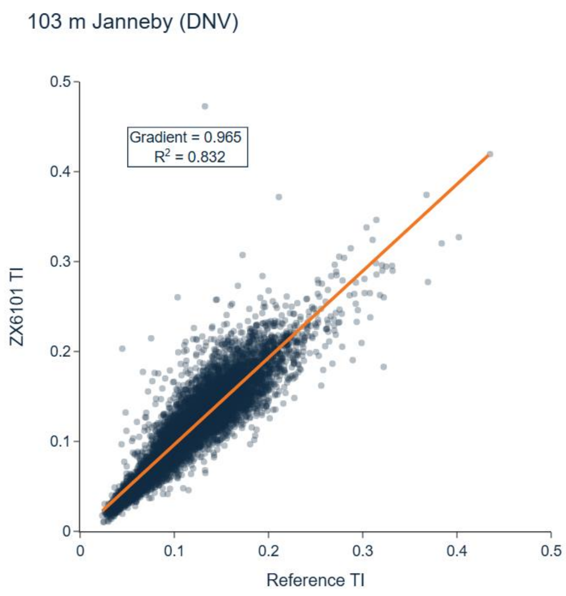
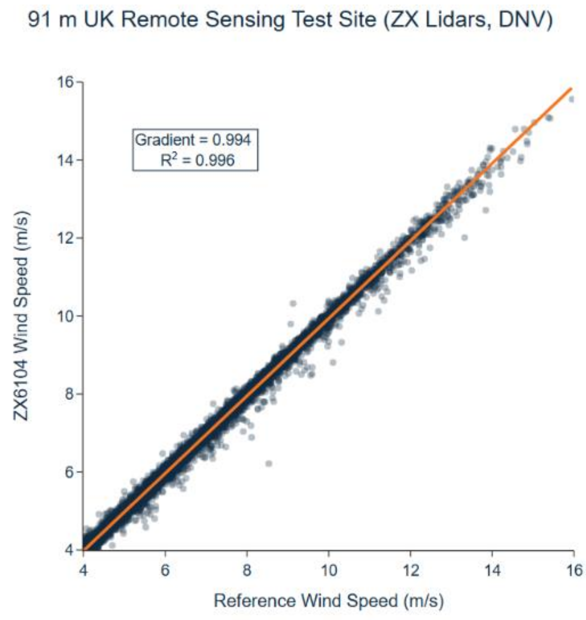



**Figure 50: 92 m at UK Test Site (ZX, DNV)**



### A.3.2 Highly complex terrain

**Figure 51: 118 m at a highly complex site (Uncorrected)**

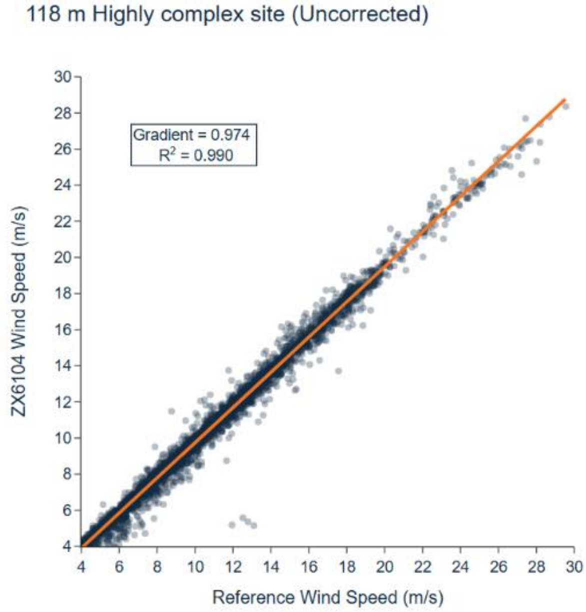



**Figure 52: 118 m at a highly complex site (CFD-Corrected)**

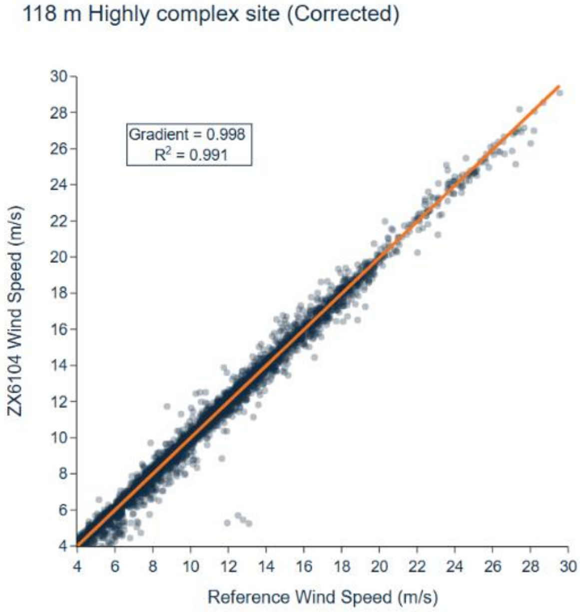
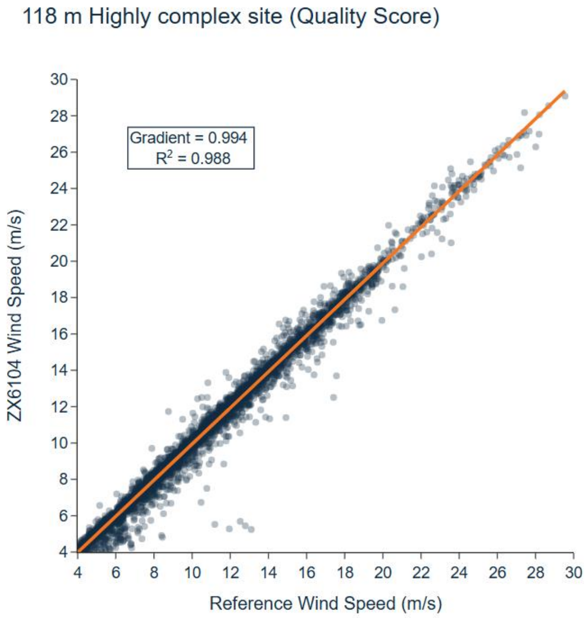



**Figure 53: 118 m at a highly complex site (ZX Quality Score)**



## A.4 Turbulence Intensity: Selection of scatterplots

**Figure 54: 200 m at Hanover (Geo-Net)**

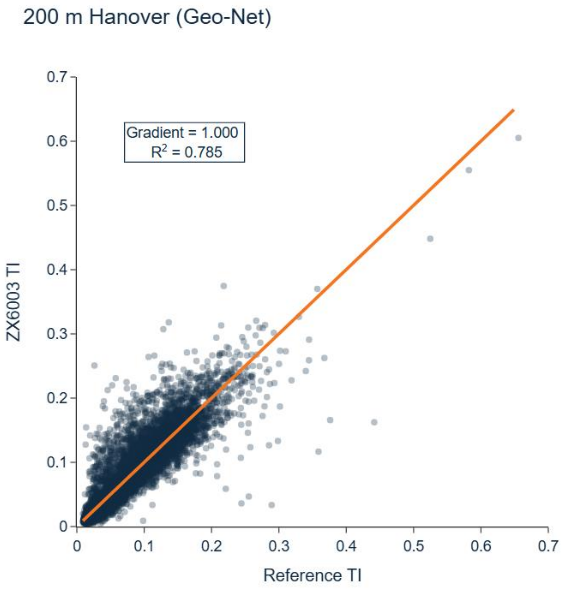



**Figure 55: 200 m at Janneby (Pavana)**

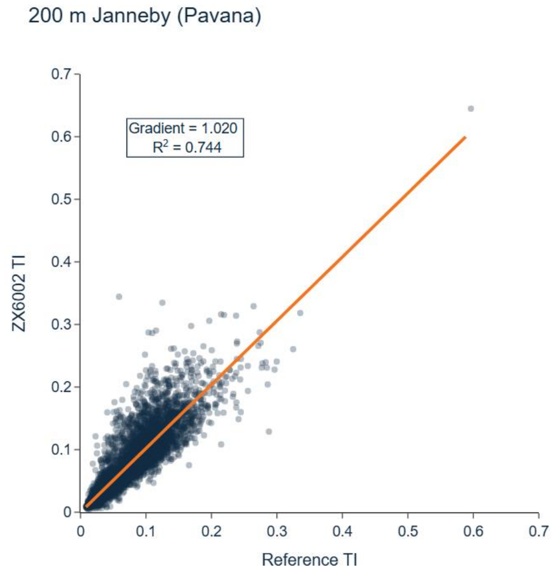



**Figure 56: 103 m at Janneby (Pavana)**

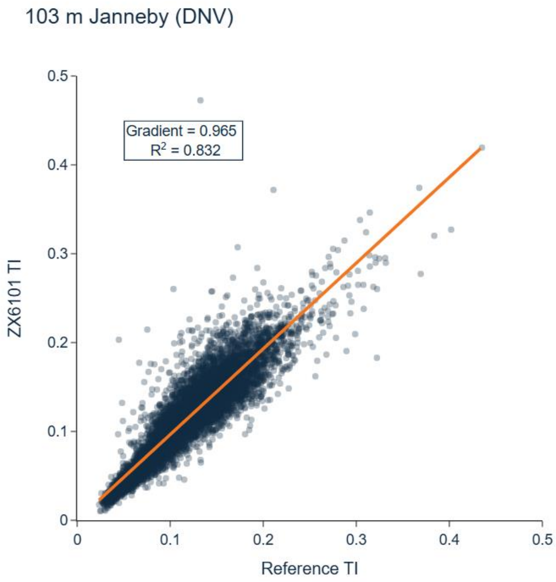
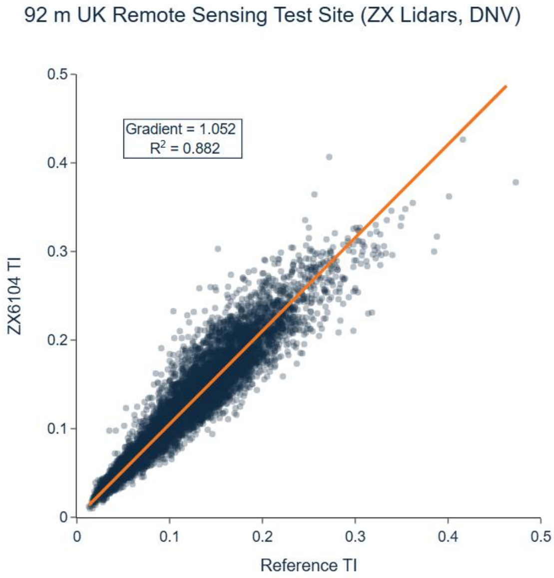



**Figure 57: 92 m at UK Test Site (ZX, DNV)**



# About Us

In 2003 we released the first commercial wind lidar, pooling decades of fibre laser research from the science, security and energy industries. Designed specifically for the wind industry our Lidar has paved the way for many of the remote sensing devices seen in the market today. Our original lidar technology continues to innovate with world firsts such as taking measurements from a wind turbine spinner and being the first to deploy an offshore wind lidar, both fixed and floating. Our Lidars have also now amassed millions of hours of operation across 15,000+ deployments globally spanning two decades of commercial experience. Some of our proudest achievements are listed below; these are the earliest reported examples that we are aware of from open publications.

**2003** - The first wind lidar to make upwind measurements from a turbine nacelle
**2004** - The first and original commercially available lidar for the wind industry
**2004** - The first wind lidar to investigate the behaviour of turbine wakes
**2005** - The first wind lidar to be deployed offshore on a fixed platform
**2007** - The first wind lidar to take measurements from a turbine spinner
**2008** - The first wind lidar to be signed off against an industry-accepted validation process
**2009** - The first wind lidar to be deployed offshore on a floating platform
**2010** - The first wind lidar to re-finance and re-power a wind farm
**2011** - The first wind lidar to be proven in a wind tunnel
**2012** - The first wind lidar to be used with very short masts and secure project financing
**2012** - The first wind lidar to be accredited for use with no or limited on-site anemometry for project financing by DNV GL
**2014** - The largest batch of single-type lidar verifications against an IEC met mast
**2015** - The first lidar designed specifically for offshore use, with the longest warranty available - 3 years as standard
**2016** - The first wind lidar to support safe lifting on a jack-up vessel
**2016** - The first wind lidar SCADA integrated on operational wind farms in replacement of site met masts
**2017** - The first wind Lidar to be installed across a wind farm on a Lidar-per-turbine basis, uniquely mapping wakes across a wind farm
**2018** - The first wind Lidar to satisfy all criteria for IEC Classification
**2019** - The first wind Lidar to take wind measurements from a drone
**2020** - The first wind Lidar to be accepted for bankable energy assessments in complex terrain standalone (without a met mast)
**2021** - The first wind Lidar to attract more than £150bn+ of investment into wind energy projects
**2022** - The first wind Lidar to be fully integrated into a retrofit wind turbine controller for Lidar Assisted Control
**2023** - ZX Lidars moves to Willow End!
**2024** - The first wind Lidar with a 5 year warranty and 5 year planned service interval as standard
**2025** - The first wind Lidar to achieve 20 – 200 m IEC Classification and 300 m Performance Verifications

# Our Products & Services