CAMPBELL SCIENTIFIC®
WHEN MEASUREMENTS MATTER

ZephIR Lidar

wind speed at light speed

For info, call or visit: **435.227.9030**

www.campbellsci.com/zephir-lidar

Proven Extreme Operation

Industry-recognized validations

The ZephIR 300 is a lidar measurement system used to make wind speed measurements at user-configurable heights between 10-200 meters. It is a coherent lidar that uses continuous wave technology to gather high quality wind speed data. The ZephIR 300 is well suited for both onshore and offshore campaigns and has a proven design with over three million hours of operation and 650 deployments in extreme conditions across the globe.

ZephIR technology first became commercially available in 2005, founded on decades of Lidar expertise within QinetiQ, one of Europe's largest research and development laboratories. The ZephIR 300 is the latest product evolution and employs the same core technology; the most validated lidar technology on the market today.

Benefits and Features:

- Up to ten programmable measurement heights from 10m up to 200m
- The most validated Lidar
- Proven operation in extreme conditions from -40C to +50C
- Constant high sensitivity at all heights
- High data availability
- Rapid data rate provides 50 measurements per height
- Proven power supply options for deployment in harsh climates
- High quality capture of data across the entire rotor:
    - Wind speed
    - Wind direction
    - Turbulence intensity
    - Wind shear
    - Wind veer
- Multiple communications options enable communication with Campbell Scientific dataloggers or SCADA systems on operational wind farms
- No special permitting required to deploy
- Fast to deploy and re-deploy
- Discrete deployment
- Low maintenance
- Autonomous operation with wireless remote access and data retrieval
- 24 hour monitoring and control
- Does not require calibration

Quick View

- **Remote Wind Profiling**
  across 10 user-defined heights from 10 meters (33 feet) to 200 meters (656 feet)
- **Unparalleled Experience**
  borne across 650+ deployments, 3 million hours of operations and a decade of wind lidar experience globally
- **Finance-Grade Wind Data**
  accepted by Banks' Engineers as part of the formal energy assessment of a wind project
- **Proven Extreme Operation**
  from -40˚C to +50˚C across more than 650 lidar deployments globally
- **Industry-Approved Validations**
  including IEC equivalent power performance measurements, extensive onshore/offshore campaigns and tall met mast verifications

Wind Data & Technical Specifications

Data Heading	Unit	Explanation
Reference	–	Numerical reference of each record
Time and date	–	In text format, to the nearest second
Timestamp	Seconds	Tima and date of the reading as numerical value in seconds
Info.flags	–	Operational mode information
Status flags	–	Internal Zephir status
Battery	Volts	Internal battery voltage
Generator	Volts	External supply voltage, if present
Upper temp/lower temp	Degrees Celsius	Pod temperature
Pod humidity	Percent	Internal Zephir humidity
GPS	Decimal Degrees	GPS location (lat and long)
Zephir bearing	Degrees	Direction of the Zephir wrt True North
Tilt	Degrees	Pitch and roll away from vertical
Air Temp.	Degrees Celsius	Ambient temperature
Pressure	Millibar/ Hectopascals	Ambient pressure
Humidity	Percent	Ambient humidity
MET wind speed	Meters per second	Horizontal wind speed measured by the MET station
MET direction	Degrees	Wind direction measurement by the MET station
Raining	–	Rain sensor detects rain
Horizontal wind speed	Meters per second	Horizontal wind speed measured by Zephir
Vertical wind speed	Meters per second	Vertical wind speed measured by Zephir
Horizontal min/max	Meters per second	Min/max horizontal wind speeds measured by Zephir
TI	–	Turbulence Intensity

Performance	
Range (min.) Range (max.) Extended Range	10 meters 200 meters 300 meters
Lidar Technology	Focused continuous wave
Laser Frequency	1565 nm
Probe length @ 10 meters Probe length @ 100 meters	0.07 meters 7.70 meters
Heights Measured	10 heights, user configurable
Sample Rate	50 Hz
Averaging periods	1 second and 10 minute
Scanning cone angle	30 degrees (other angles available)
Speed accuracy	< 0.5%
Speed range	< 1 m/s to 70 m/s
Direction accuracy	< 0.5 degrees

Data	
Data output format	1 second scan wind data and 10-minute averaged wind data comprising: • Horizontal wind speed • Vertical wind speed • Wind direction • Turbulence Intensity • Height reading • Temperature • Relative Humidity • Barometric pressure
Data quantity: 10-minute Averaged Data 1-second data	 80K / day 4 MB / day

Safety	
Eye safety standard	IEC 60825-1
EMC compliance	EN55022 Class A. ENG1326 Industrial, FCC Radiated & Conducted Emissions

Operations	
Temp range (min.) Temp range (max.)	-40 degrees C +50 degrees C
Power Consumption	69 watts
Power input DC	12 V
Power input AC	90-264 VAC, 0-60 Hz
Weight	55 kg
IP Rating	IP67 (excl. external fans)

Communications	
Internal Modem	GSM Modem with Global SIM Card
Satellite	Iridium backpack available
Protocols Supported	TCP/IP, Modbus TCP/IP
Protocols Supported when used in conjunction with Campbell Scientific Datalogger	TCP/IP, Modbus TCP/IP, PakBus, DNP3, HTTP

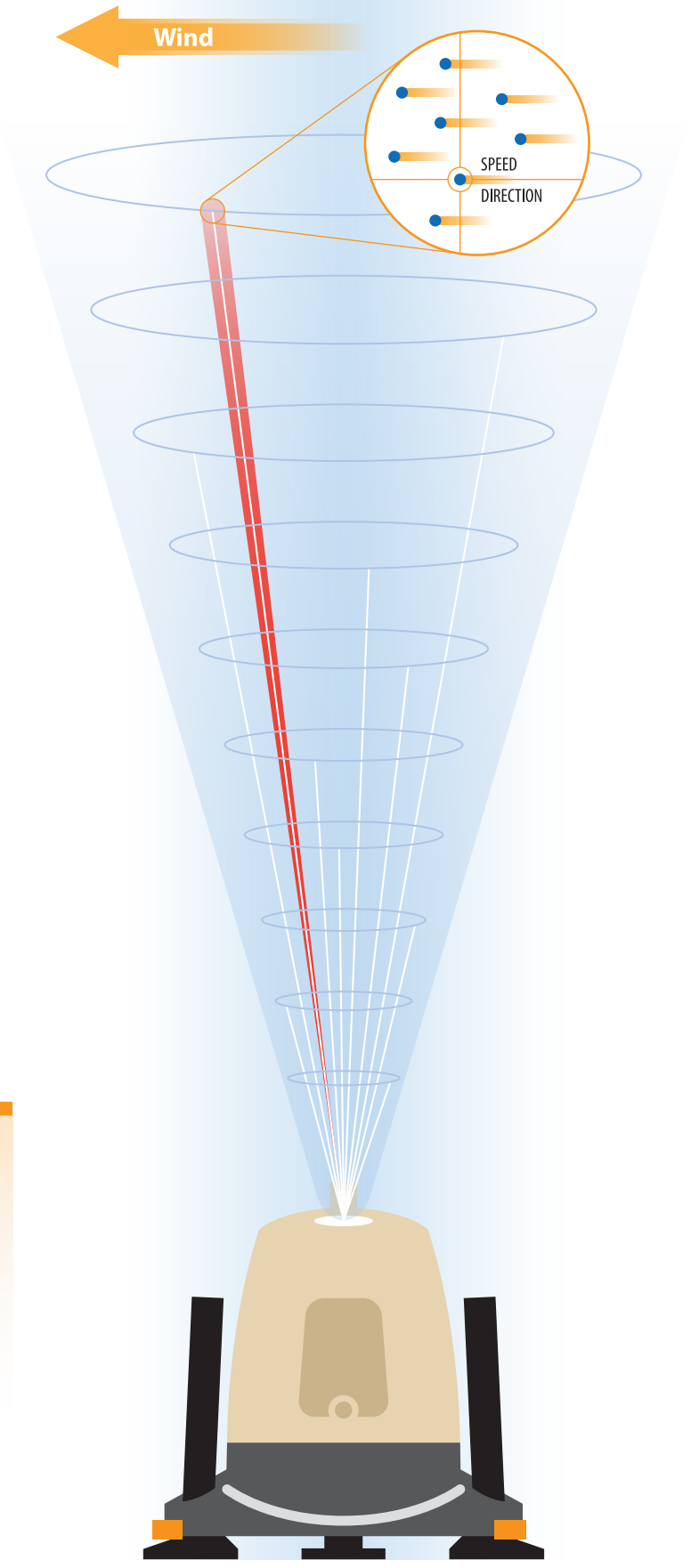
Coherent, Continuous Wave Lidar Technology

The ZephIR 300 is a coherent lidar system that uses unique continuous wave technology. In a Continuous Wave Lidar system, the laser beam is focused using optics at each measurement height required. In the ZephIR 300 system, the focused laser beam is then rotated through a 360 degree scan. Each scan rotation takes 50 measurements, providing a wealth of captured wind data. More real data equals more certainty.

As the Continuous Wave principle involves physically focusing the laser beam at each measurement height of interest, the ZephIR 300 is able to achieve constant sensitivity at each height. As the emitted laser beam is physically focused, the laser power does not change with height, therefore, the sensitivity does not degrade. This constant sensitivity ensures high data availability at all heights and in all conditions, such as areas with clean air containing low concentrations of natural aerosols. The rapid 50Hz data rate of Continuous Wave also offers an advantage in complex terrain where wind flow is fast moving and non-uniform.

Up to 130 meters, the probe depth of the ZephIR 300 is significantly smaller than that of a pulsed system. These lower measurement heights are very applicable to the wind industry. Above 130m a pulsed system does have a smaller probe depth, but the ZephIR 300 gains advantage as the sensitivity remains high and constant at all heights.

Continuous wave technology does not rely on complicated laser charging or timing circuitry in its electronics. Given the remote locations involved when developing wind farms and demanding locations offshore, Continuous Wave has an advantage because it provides high reliability for long periods of autonomous and remote operation. Since its commercial release to market five years ago, ZephIR technology has been operating successfully in over twenty-five countries, enduring very hash and challenging environmental conditions.



Quick View

- **High sensitivity – able to function even in extremely clear air**
- **Constant sensitivity at all heights**
- **Rapid data rate, fast data acquisition, more data**
- **Smaller probe depth at lower heights where wind shear is greater**
- **Robustness and Durability**

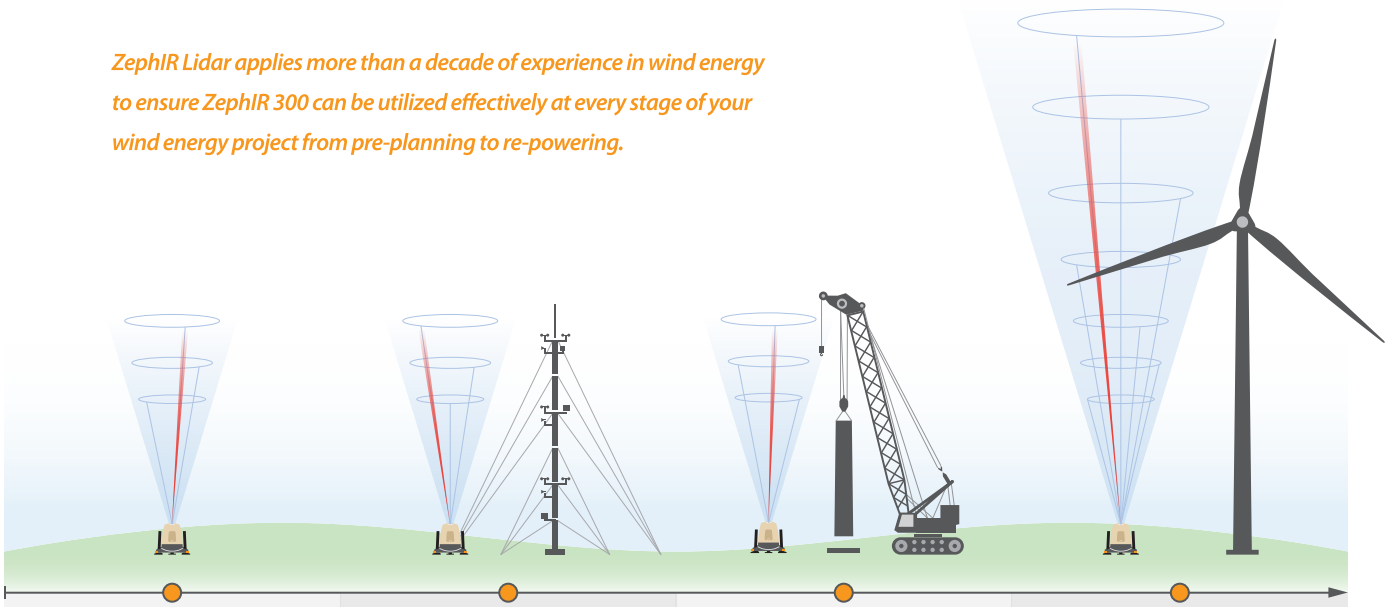
Our Unique Offering

ZephIR is a continuous wave lidar system. This core technology was chosen specifically during the original design of the product due to the unique benefits listed below. Many of these features are a result of the absolute simplicity in system design and add real benefit to the end user.

Feature	Benefit	ZephIR	Met Mast	SODAR	Other Lidar
Range Focussing System	High data availability at all heights; no extrapolation required; continuous data sets; lower uncertainty	●	×	×	×
	Optimized probe measurement length at low heights / close ranges where air flow is rapidly changing; more accurate wind analysis	●	matched performance	×	×
10 Meter (33ft) Low Height Measurement	Correlations with low level instruments; in-situ performance checks; low level measurements even in thick fog for continuous data sets	●	●	×	×
Industry-recognized validation process on all systems against an IEC-compliant met mast	Proven repeatable performance; traceability for finance-grade data sets; alignment to GL Garrad Hassan / Natural Power remote sensing best practice guidelines	●	matched performance	×	×
Up to 50 wind data points collected at each height / range interval with up to 1 second sampling	More accurate capture of data in complex terrain where air flow is rapidly changing	●	×	×	×
	Less sensitivity to obscuration / incomplete view of sky from fixed objects' greater redundancy of sample points	●	×	×	×

Onshore Wind Energy Projects

ZephIR Lidar applies more than a decade of experience in wind energy to ensure ZephIR 300 can be utilized effectively at every stage of your wind energy project from pre-planning to re-powering.



Pre-Planning

Research/Academia
Wind profiling turbine experiments, calibdration of wind sensors, bespoke lidar configurations

Complement to Met Mast
From low 10 metre (33ft) masts up to world-class 200 metre (656ft) research masts

Wind Shear Verification
Across the entire turbine rotor diameter including measurements above and below down to just 10 metres (33ft)

Turbulence

Planning

Wind Resource Assessment, Site Classsification & Micro-Siting
Accurate siting of wind turbines for optimized energy production

Wind Model Verification
In-situ measurements to verify and adjust wind models such as WASP® and VENTOS®

Fixed Reference/Long Term
A continuous data set across measurement heights ranging 10 metres (33ft) to 200 metres (656ft)

Construction/Finance

Safe Operation
Real-time wind speed measurements at hub height during WTG component lifting and assembly

Energy Yield Analysis
Finance-grade wind data for the purpose of Energy Yield reporting and analysis

Operation

WTG Condition Monitoring
Nacelle mounted measurements to monitor condition of WTG against measured wind speed and for performance trouble shooting

Power Perfomance Tesing
Performance Optimization
Nacelle mounted and / or ground based measurements to monitor performance of WTG against measured wind speed

Wind Model Verification
In-situ measurements to verify and adjust wind models

Forecasting
Real-time wind measurements to suport site energy forecast

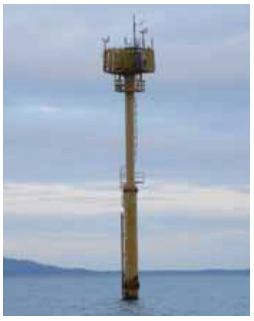
Offshore Wind Energy Projects

Fixed Platform

ZephIR is subject to extensive EMC testing to ensure no interference with other equipment sited on these platforms.

Floating Platform

ZephIR can be integrated onto other floating platforms and there is a track record of integrating the system into a range of solutions for clients.



Designed by Wind Engineers for Wind Engineers

Marine Meteorological Station
providing temperature, pressure and humidity measurements, designed to operate in harsh marine environments and includes a GPS device for data timestamp and location

Automotive Moisture Sensor
for activating wiper arm, designed to operate in exhaustive automotive applications

Marine Wiper System
with silicone wiper blade for extended operation, keeps window surface clear of moinsture and debris, designed to operate in harsh environments, uses industrial spec screenwash capable of subzero operation

Insulated Body Pods
manufactured in twin-skin Polyethylene, operating across all temperature ranges (-40˚C to +50˚C) and with IP seals across all surfaces and connector panels

Carbon Fiber Legs
resistant to horizontal wind loading while keeping overall weight minimized

Quick-Release Handles
for simple levelling adjustments and designed for gloved operation

Marine-Grade Rope
at three locations around waist of product for ease of lifting across uneven terrain

Wide Spread Feet
for stable footing in all terrains and all ground surfaces with security bolt through apertures

User Interface

Wind Speed History and Wind Shear Graphs
show users the wind field live or from recorded data giving insight into the windfield as it evolves

Uncluttered Displays
show wind speed and direction clearly giving users a quick glance into the current or recorded wind field

Define Heights of Interest
from just 10m to 200m either locally or remotely, covering the entire rotor swept diameter, above and below

Waltz Software
allows users to easily configure all ZephIR models and automatically adjusts available options to the type of unit

Detailed Status Outputs
are available both live and in recorded data giving you feedback on the ZephIR system and its environment

Simple Download Interface
gives access to data wherever ZephIR is deployed, over ethernet, wifi, GSM, or satellite comms links

Live and Recorded Data
is available at your fingertips with simple controls to export recorded data into other formats

Communications

The ZephIR 300 has multiple communications options, giving users the flexibility necessary to integrate the ZephIR 300 into their specific applications.

Standard in every ZephIR 300 is a built-in GSM modem and sim card. This allows users to access their lidar data remotely, in areas where cell coverage is available. In areas where a cell modem connection is not possible, satellite communications can be provided via an optional Iridium backpack.

Also standard in every ZephIR 300 is built in WiFi. Users can connect over this WiFi network with their laptops for initial setup, configuration, or data collection.

The ZephIR 300 supports TCP/IP communications and comes standard with an Ethernet port for applications where the ZephIR 300 can be connected to a local network for data collection, or for connection to an external modem.

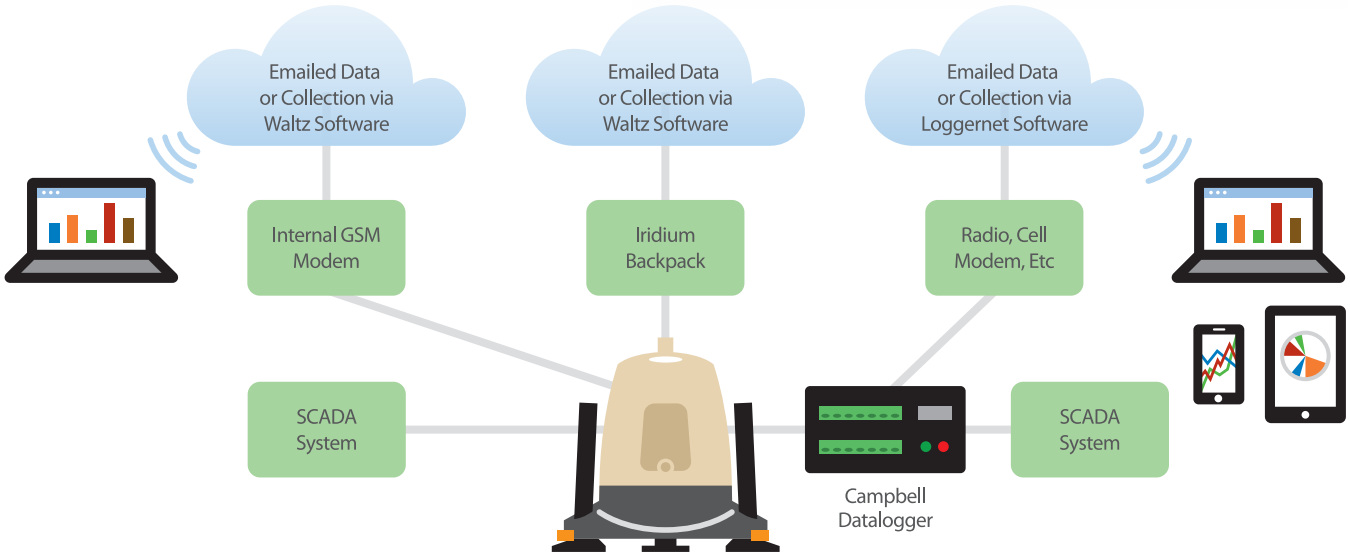
The ZephIR 300 also supports the Modbus protocol, making it compatible with existing SCADA systems on operational wind farms.

Data Retrieval Methods/Protocols
Waltz Software
Modbus
Data Retrieval Methods when Routed through Campbell Datalogger
Loggernet
Pakbus
Modbus
DNP3

The ZephIR 300 and Campbell Scientific Dataloggers

Campbell Scientific Dataloggers, including the CR800, CR850, CR1000, or CR3000 can be used to integrate and synchronize ZephIR 300 lidar data with data from other instruments, such as instrumentation on a meteorological tower.

Using a Campbell Scientific datalogger to gather data from the ZephIR 300 also enables integrated tower and lidar data collection through a single gateway via an external cell phone modem, radio, or direct connection. Campbell Scientific dataloggers support multiple protocols such as Modbus, Pakbus, DNP3, and HTTP, giving users the maximum in flexibility and customization of data retrieval methods.



Power Supply

Selection of a power supply is a critical component of any lidar deployment. Important criteria for power supply selection are:

- Sizing for prolonged autonomous operation
- Performance in harsh environments
- System weight
- Transportation and deployment logistics

ZephIR 300 Power Consumption

	Average (W)	Maximum Instantaneous (W)
Standard Climate (-30°C to +35 °C)	69	111
Cold Climate (-40 °C to -30°C)	105	171
Hot Climate (+35 °C to +45°C)	99	141
Cold Start (below 0°C) estimated maximum 4hrs	140	140

Ampair offers power supply solutions that have been proven in the field with the ZephIR 300, including the:

- Ampair TR-4000/2000
- Ampair HP-1000
- Ampair Minipod

In addition to power supplies from Ampair, there are other 3rd party power supply providers that can offer power supplies to meet the needs of the ZephIR 300, including solutions that incorporate wind, solar, and fuel cell technologies.

Please contact Campbell Scientific for assistance in selecting a power supply that is appropriate for your application.

Validations

The ZephIR 300 is the most validated lidar for wind resource assessment on the market today. ZephIR technology has been evaluated by many independent leading authorities in the wind industry, repeatedly demonstrating the excellent correlation with cup anemometry; which is still considered the industry norm. These correlation studies form the basis of why Banks engineers will accept ZephIR data as part of a bankable study, and why more frequently it is being used as the only form of anemometry. Every ZephIR 300, as part of its quality assurance sign-off process, is verified against an IEC 61400-12-1 compliant mast. ZephIR 300 is a CE Marked product, which guarantees that the product is in conformity with the essential requirements of the applicable EC directives.

ZephIR Technology Industry Firsts

- The first and original commercially available wind lidar
- The only continuous wave wind lidar commercially available to date
- The first wind lidar to take measurements from a turbine spinner
- The first wind lidar to be deployed offshore – both on fixed and floating platform
- The first wind lidar to be signed off against an industry accepted validation process
- The first wind lidar to re-power a wind farm
- The first wind lidar to be proven in a wind tunnel

List of Validation Studies

- DTU Wind Energy ZephIR 301 Evaluation Test
- A Comparison of ZephIR Measurements Against Cup Anemometry and Power Curve Assessment
- ZephIR 301 Evaluation Test
- ZephIR Wind Lidar Demonstrates World-First Matched Performance in High-Performance Wind Tunnel

Find studies here

Pre-Deployment Performance Validations

Before ZephIR systems are deployed, they are assessed against a 91.5m mast in flat terrain at UK's Lidar and Sodar test site as part of an industry-approved and well-documented performance validation. The mean and standard deviation of the mast correlation parameters, gradient and R2, have been calculated from a batch of more than 40 ZephIR 300 units to investigate consistency of lidar performance, pre-deployment. The regression slopes show a standard deviation for the ZephIRs of <1% at all heights, with current IEC standards for cup anemometers allowing for almost double that variation, at <2%. The comparisons also include any effects of differing weather conditions in addition to lidar and cup calibration effects.

Performance Results

Height (m)	*Gradient*		*R^2*	
	Mean	StDev	Mean	StDev
91	1.00	0.0066	0.99	0.0061
70	1.00	0.0062	0.99	0.0041
45	1.00	0.0046	0.99	0.0058
20	1.00	0.0046	0.99	0.0047

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