



Fulcrum3D Sodar

State-of-the-art
remote sensing



Introduction

The portable Fulcrum3D Sodar measures wind speed, direction and inflow angle up to 200m above ground level

A complete wind monitoring system:

- ▶ Reliable, flexible & cost-effective
- ▶ Optimised for the operating range of modern wind turbines
- ▶ Excellent performance in complex terrain

The Fulcrum3D Sodar is a fully integrated, user friendly wind monitoring system and is delivered complete with its own trailer, solar power supply and communications.

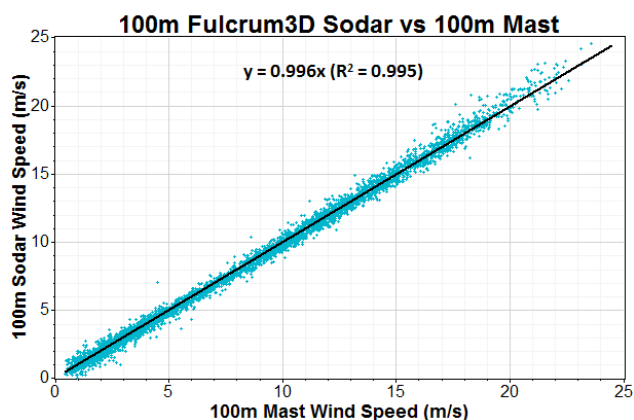
Fulcrum3D's *FlightDECK* data management system allows easy remote access, download and analysis of data.

Proven Performance

The Fulcrum3D Sodar has been independently verified in different climates, topography, locations and elevations by internationally recognised wind energy experts. DNV GL accepts the Fulcrum3D Sodar for use in formal wind energy assessments including bankable wind energy studies.

Correlation coefficients against high quality tall met masts are typically >0.98 at IEC Class 1 Terrain sites, with slopes comparable to cup anemometry in both simple and complex terrain.

The Fulcrum3D Sodar has demonstrated higher accuracy and availability than its competitors in side by side trials.



Market Leading Accuracy

Key Applications

Development sites:

- ▶ Low cost site prospecting on early stage sites
- ▶ Infill for 'bankable' wind studies
- ▶ Verification of wind shear above an existing met mast
- ▶ Accurate inflow angles to confirm turbine suitability
- ▶ Low cost measurements for noise assessments

Operating sites:

- ▶ Power curve verification tests
- ▶ Measures power performance of operating wind turbines, e.g. for O&M diagnostics

An Innovative Design

Compact-Beam Design

The compact-beam design of the Fulcrum3D Sodar maximises performance in highly turbulent or complex terrain by using a narrow beam angle to address 'flow curvature' effects. The Fulcrum3D Sodar uses physically fixed beam angles rather than electronic beam steering which requires constant frequency adjustments for local atmospheric conditions.

Full Spectrum Data Retrieval for Traceability

The Fulcrum3D Sodar stores full signal and noise data on the unit and transmits this entire dataset to Fulcrum3D's secure servers for processing into wind speed data. This approach allows a consistent and fully traceable dataset to be provided to third parties for verification & analysis.

Multi-Beam Sampling

The three independent beams of the Fulcrum3D Sodar can be pulsed simultaneously ('multi-beam sampling'), providing more data samples per 10min period and higher data quality and availability, especially at greater heights.

Cold Climate Option

Fulcrum3D's cold climate option is operationally identical to the standard Fulcrum3D Sodar. It includes a thermal management system to ensure battery reliability, snow and ice melt capability, and additional power supply options to ensure operation throughout the coldest months.

Key Benefits for your Projects

Low Cost, Flexible Deployment

- ▶ Significantly lower costs of installation, operation and removal than met masts and lidar systems
- ▶ Faster deployment with minimal delays as planning approval and construction lead time is not required
- ▶ Lower maintenance costs than met masts which are prone to lightning damage and require maintenance
- ▶ Standalone turnkey solution

Lower Site Yield Uncertainty

- ▶ Lower cost allows more monitoring locations to be assessed on site
- ▶ Reduced errors introduced via wind flow modelling which usually dominate uncertainty assessments
- ▶ Higher accuracy and hence lower site uncertainty and greater bankability

More Accurate Wind Data

- ▶ Wind measurements right to the turbine tip height eliminate extrapolation errors from met masts which often only cover ~20% of the turbine swept area
- ▶ Directly measure inflow angles to confirm turbine suitability and to improve site modelling accuracy
- ▶ Direct measurement of wind shear characteristics which occur above mast height
- ▶ User selectable measurement heights to match turbine hub heights, met mast or other measurement

Stable and Consistent Measurements

- ▶ Full signal and noise data is permanently stored
- ▶ No electronic beam steering means consistency between locations and more accurate measurement
- ▶ Calibration not required during monitoring campaign



Fulcrum3D Sodar Specifications

Design Parameters

Phased array	3 phased arrays each with 37 Piezoelectric transducers 100% acoustic fill factor
Sound beam tilt	Physically set at 9° and 12.7° from vertical Beam tilt independent of frequency and temperature
Sound beam frequency	Range 3.5 – 7.5kHz, nominally 5kHz. Simultaneously sampled beams separated by 500Hz.
Sound level	<90dBA at 10m, <70dBA at 50m

Data Capture and Storage

Sampling rate	Nominally 2 seconds between pulses
Integration time	Adjustable, default 10 minutes.
Data upload	Every 10 minutes (3G/4G/GSM systems)
Memory storage	32 GB Micro SD card records a minimum of 6 months full noise and signal data. Expandable to 128GB.

Wind Measurements

Measurement range	40 - 200m in 10m height bands centred on nominal height (40, 50m...), user defined heights available.
Measurement accuracy	Typical correlation coefficient >0.98 and <2% bias compared to mast (dependent on-site conditions)
Horizontal wind speed	0 to 40m/s, resolution 0.01m/s
Horizontal wind direction	0 to 360°, resolution 0.1°
Inflow angle / Vertical wind speed	-20 to +20°, resolution 0.1° -8.0 to +8.0 m/s, resolution 0.01 m/s
Fixed echo removal	Automatic for wind speeds > 2m/s

Additional Sensors

GPS output	Location (WGS 84) <5m RMS horizontal position accuracy Altitude (m)
Temperature ¹	Naturally aspirated radiation shield, -40°C to +60°C range with ±0.6°C accuracy
Humidity ¹	±3% between 10% to 90%, ±5% between 0% to 100%
Hardware support	1x RS232/422/485, 1x USB, 1x Ethernet

Power and Communications

Average power consumption	15W operating (single beam sampling) 25W operating (multi-beam sampling)
Power supply	Standard: 2 x 220W solar panel and 3x 12V 120AH AGM batteries providing in excess of 7 days storage. Optional: Solar expansion pack; Mains power supply kit; Fuel cell power kit.
Communications	3G/4G/GPRS/GSM Optional: Satellite/Wi-Fi/Ethernet

Environmental Conditions

Operating temperature	Standard: -10° to 50°C Cold Climate version: -30° to 50°C
Lightning protection	Multi-strike lightning protection fitted to communications equipment. All chassis wiring has transient voltage suppressors, all instruments chassis grounded.

Safety Standards

Warning signage	Hearing protection warning signs on all sides visible in compliance with AS 1319:1994.
Applicable standards	AS 4086.2:1997 <i>Secondary batteries for use with stand-alone power systems - Installation and maintenance</i> AS 1319:1994 <i>Safety signs for the occupational environment</i> AS/NZS 5033:2005 <i>Installation of photovoltaic (PV) arrays</i> AS/NZS 3000:2007 <i>Electrical installations (known as the Australian/New Zealand Wiring Rules)</i>

Transportation

Dimensions	Skid mounted: 1000 x 2600 x 1500 mm fully assembled. Trailer mounted: Fits in standard 7'x4' trailer for transport.
Weight	~400kg including battery, solar panels and skids (skid mount, excluding trailer)
Material	Marine grade aluminium, resin encased rock-wool acoustic insulation.
Transportation	7'x4' trailer with stabilising anchors. Five Fulcrum3D FS1 skid mounted units fit in a standard 20' shipping container.

Configurations

Standard configuration	Skid mounted SODAR installed in 7'x4' box trailer with stabilising anchors 440W/360Ah solar power supply Installation tool kit
Cold climate version	660W/360Ah upgraded solar power supply battery heating, thermal management and snow melt capability 45 / 110 W fuel cell power supply options
Options	Additional sensors (e.g. pressure, rain gauge, solar radiation, pyranometer etc) Solar expansion pack (to 660W) Mains power supply kit Satellite / WiFi / Ethernet communications

Notes:

- ▶ NIST traceable and NATA calibrated sensors available on request.
- ▶ Actual performance of instrument depends on local atmospheric conditions.
- ▶ These specifications may change without notice.