Analysis

NT : Windfield reconstruction

Ways that wind lidar data can be processed to extract useful data

---

applications

NT : use case
virtual met mast

Ways that wind lidar can be used

Arbitrary trajectory

note : The scanning geometry taxonomy is based on Figure 3 in NREL/TP-5000-64634 https://www.nrel.gov/docs/fy16osti/64634.pdf
BT : Compound scan
TT : measurement principles

Scans can be made where the beam is swept through an arbitrary combination of elevation and azimuth angles to follow a desired trajectory. This could be considered analagous to tracking the path of a flying bird from a fixed location.

Battery

BT : Uninterruptible power supply
TT : design
NT : Battery voltage
Battery capacity

An energy storage component

Battery capacity

BT : Battery
TT : design

The total stored energy in the battery voltage. Units are Amp Hours (Ah).

Battery voltage

BT : Battery
TT : design

The battery voltage. Units are Volts.

~~*Beamsplitter*~~

USE : Beam splitter

Beam splitter

note : Definition based on Wikipedia entry at https://en.wikipedia.org/wiki/Beam_splitter
UF : *Beamsplitter*
BT : Detector
TT : design

An optical assembly to split a laser beam into two or more beams.

Carrier to noise ratio

UF : *CNR*
BT : parameters
TT : parameters

A measure of signal strength

Chassis module

note : Definition based on the OpenLidar module definitions at https://github.com/e-WindLidar/OpenLidarModuleDefinitions
BT : design
TT : design

The Chassis module is responsible for the various mounting solutions for the lidar, including, but not limited to, mounting on a nacelle, a meteorological tower, the ground, a floating platform, or a mobile structure.

~~*CNR*~~

USE : Carrier to noise ratio

Communications module

note : Definition based on the OpenLidar module definitions at https://github.com/e-WindLidar/OpenLidarModuleDefinitions
BT : Control module
TT : design

The system of devices and software that transmit and receive data and commands to and from the lidar device

---

Complete cone

RT : velocity-aziumth display
Sequential scan
BT : Variable azimuth
TT : measurement principles

A scan geometry in which the azimuth angle of the beam is varied over the full 360 degree range of possible azimuth angles. Wind speed and direction values can be obtained through a wind field reconstruction process, for example by assuming a sinusoidal dependence on azimuth angle.

Compound scan

note : The scanning geometry taxonomy is based on Figure 3 in NREL/TP-5000-64634 https://www.nrel.gov/docs/fy16osti/64634.pdf
BT : Single lidar
TT : measurement principles
NT : Arbitrary trajectory
Sequential scan

Compound scans include more degrees of freedom and can follow an arbitrary trajectory or be made up of a sequence of simple scans

---

Cone sector

RT : Sequential scan
BT : Variable azimuth
TT : measurement principles

A scan geometry in which the azimuth angle of the beam is varied over less than the full 360 degree range of possible azimuth angles. Wind speed and direction values can potentially be obtained through a wind field reconstruction process, for example by assuming a sinusoidal dependence on azimuth angle.

Control module

note : **Definition based on the OpenLidar module definitions at https://github.com/e-WindLidar/OpenLidarModuleDefinitions**
BT : **design**
TT : **design**
NT : **Communications module**
Signal processing module
Storage module

The control module is the interface between the external controller (human or machine) and the lidar system .

~~*Crossed RHI*~~

USE : **virtual met mast**

Datum elevation

note : **Sea level should be defined on a project basis and is out of scope of this schema.**
RT : **Datum plane**
BT : **parameters**
TT : **parameters**

The height of the datum plane above sea level

Datum feature

EX : **A measurement window or base of the unit (excluding feet)**
UF : ***Reference marker***
RT : **Datum plane**
BT : **parameters**
TT : **parameters**

A distinguishing feature used to recognise or define the datum plane from which the measurement height is defined

---

Datum plane

UF : ***Reference height***
RT : **Measurement height**
Datum elevation
Datum feature
BT : **parameters**
TT : **parameters**

The horizontal plane from which the measurement height is defined.

~~*DBS*~~

USE : **Doppler beam swinging**

---

design

note : **Definition based on the OpenLidar module definitions at https://github.com/e-WindLidar/OpenLidarModuleDefinitions**
NT : **Chassis module**
Control module
Interlocks
Optics module
Power module
Photonics module
Scanner

Wind lidar generic design structure.

Detector

BT : **Photonics module**
TT : **design**
NT : **photodetector**
Optical amplifier
Beam splitter

An assembly to detect incident light.

---

devices

NT : **windscanner**
Wind Iris

Specific implementations of wind lidar technologies.

Doppler beam swinging

UF : ***DBS***
RT : **Sequential scan**
Measurement height
BT : **Variable azimuth**
TT : **measurement principles**

A scan geometry in which the azimuth angle of the beam is varied by 90 degrees over the full 360 degree range of possible azimuth angles. Wind speed and direction values can be obtained through a wind field reconstruction process, for example by assuming a sinusoidal dependence on azimuth angle.

---

instances

NT : **serial number**
lidar type

Wind lidar instances.

Interlocks

note : **Definition based on the OpenLidar module definitions at https://github.com/e-WindLidar/OpenLidarModuleDefinitions**
BT : **design**
TT : **design**

The interlocks are a dispersed set of safety systems that prevent or mitigate potentially dangerous activities.

Laser diode

BT : **Laser source**
TT : **design**
NT : **Laser wavelength**

A semiconductor component to generate laser light of a defined frequency.

Laser source

BT : **Photonics module**
TT : **design**
NT : **Laser diode**

An assembly to generate and manage laser light.

Laser wavelength

BT : **Laser diode**
TT : **design**

The nominal wavelength of the laser source. This is defined in units of meters, e.g. 1450E-9 m for a near-infrared laser source.

---

lidar type

BT : **instances**
TT : **instances**

The type of lidar device

Maximum azimuthal slew rate

BT : **Servo motors**
TT : **design**

The maximum rate of operation of the servo motor in the azimuthal direction.

Maximum elevation slew rate

BT : **Servo motors**
TT : **design**

The maximum rate of operation of the servo motor in the elevation direction.

Measurement height

RT : **velocity-aziumth display**
Doppler beam swinging
Datum plane
BT : **parameters**
TT : **parameters**

The nominal height above the datum plane at which a windfield reconstruction process returns a wind speed. Often used for vertically-profiling wind lidars for comparison to point wind speed measurements from an anemometer.

---

measurement principles

NT : **scanning geometry**
Time of flight

The means by which a lidar makes a measurement of the wind

Mirrors

BT : **Scanner**
TT : **design**

Mirrors modifying the beam path between the telescope and atmosphere.

~~*Multilidar*~~

USE : **Multi-lidar**

Multi-lidar

UF : ***Multilidar***
BT : **scanning geometry**
TT : **measurement principles**

Coordinated measurements made in the same region by multiple lidar. Measurements may or may not be synchronised in time.

Optical amplifier

note : **Definition based on Wikipedia entry at https://en.wikipedia.org/wiki/Optical_amplifier**
BT : **Detector**
TT : **design**

An assembly to amplify the outgoing laser light signal without coverting it into an electrical signal.

Optics module

note : **Definition based on the OpenLidar module definitions at https://github.com/e-WindLidar/OpenLidarModuleDefinitions**
BT : **design**
TT : **design**
NT : **telescope assembly**

The optics module is designed to alter the original laser beam into radiation with desired specification that can be sent to the target and received by the detector properly.

---

parameters

NT : **Carrier to noise ratio**
Measurement height
Datum elevation
Datum plane
Datum feature

Wind lidar-specific parameters.

---

photodetector

BT : **Detector**
TT : **design**
NT : **Photodetector gain**
Photodetector voltage noise

Semiconductor light sensor.

Photodetector gain

BT : **photodetector**
TT : **design**

The gain of the photodetector transimpedance amplifier.

Photodetector voltage noise

BT : **photodetector**
TT : **design**

The voltage noise of the photodetector transimpedance amplifier.

Photonics module

note : **Definition based on the OpenLidar module definitions at https://github.com/e-WindLidar/OpenLidarModuleDefinitions**
BT : **design**
TT : **design**
NT : **Detector**
Laser source

The photonics module is the source of emitted light that will be used for the measurements.

Power module

note : **Definition based on the OpenLidar module definitions at https://github.com/e-WindLidar/OpenLidarModuleDefinitions**
BT : **design**
TT : **design**
NT : **Uninterruptible power supply**

The Power Module is responsible for supplying power to the entire lidar system, including motors, lasers, sensors, and detectors.

~~*Range-height indicator*~~

USE : **Vertical slice**

~~*Reference height*~~

USE : **Datum plane**

~~*Reference marker*~~

USE : **Datum feature**

~~*RHI*~~

USE : **Vertical slice**

Scanner

note : **Definition based on the OpenLidar module definitions at https://github.com/e-WindLidar/OpenLidarModuleDefinitions**
BT : **design**
TT : **design**
NT : **Mirrors**
Servo motors

The scanner orients the beam with respect to the housing and other parts of the lidar system. The scanner may be capable of one or more degrees of freedom.

---

scanning geometry

EX : **An RHI scan is an example of a scanning geometry**
note : **The scanning geometry taxonomy is based on Figure 3 in NREL/TP-5000-64634 https://www.nrel.gov/docs/fy16osti/64634.pdf**
UF : ***scan pattern***
BT : **measurement principles**
TT : **measurement principles**
NT : **Single lidar**
Multi-lidar

1. The arrangement of a sequence of scanning lidar configurations that require the lidar beam to be scanned or swept between a number of different orientations. The scan geometry ensures measurements are acquired throughout the measurement volume sufficient for wind field reconstruction. The sequence of beam orientations may be repeated to acquire a time series of final data acquired from each iteration. Scans may be performed in stop-stare or sweep-stare mode. 2. The collection of lines of sight / beam orientations along which the lidar is programmed to emit its probe.

~~*scan pattern*~~

USE : **scanning geometry**

Sequential scan

EX : **A low-elevation conical scan is followed by a sector scan. The results from the conical scan are used to estimate large-scale flow characteristics, which are in turn used to constrain the analysis of data from a sector scan.**
note : **The scanning geometry taxonomy is based on Figure 3 in NREL/TP-5000-64634 https://www.nrel.gov/docs/fy16osti/64634.pdf**
RT : **Complete cone**
Cone sector
Doppler beam swinging
Vertical slice
BT : **Compound scan**
TT : **measurement principles**

In a sequential scan, simple and/or compound scans are executed one after another by the same device to reveal flow characteristics.

---

serial number

BT : **instances**
TT : **instances**

A unique identifier of the lidar instance

Servo motors

BT : **Scanner**
TT : **design**
NT : **Maximum azimuthal slew rate**
Maximum elevation slew rate

The servo motor(s) drives the scanner motion

Signal processing module

note : **Definition based on the OpenLidar module definitions at https://github.com/e-WindLidar/OpenLidarModuleDefinitions**
BT : **Control module**
TT : **design**

The signal processing module is used to convert the data acquired by the lidar into a data product.

Simple scan

note : **The scanning geometry taxonomy is based on Figure 3 in NREL/TP-5000-64634 https://www.nrel.gov/docs/fy16osti/64634.pdf**
BT : **Single lidar**
TT : **measurement principles**
NT : **Variable azimuth**
Variable elevation

A simple scan geometry entails variation in beam orientation in a single degree of freedom

---

Single lidar

note : **The scanning geometry taxonomy is based on Figure 3 in NREL/TP-5000-64634 https://www.nrel.gov/docs/fy16osti/64634.pdf**
BT : **scanning geometry**
TT : **measurement principles**
NT : **Simple scan**
Compound scan

Measurements made by a single lidar.

Storage module

note : **Definition based on the OpenLidar module definitions at https://github.com/e-WindLidar/OpenLidarModuleDefinitions**
BT : **Control module**
TT : **design**

The Storage module is responsible for saving data in the lidar system which will be accessed by users at some future time.

---

telescope aperture

BT : **telescope assembly**
TT : **design**
NT : **telescope aperture diameter**

The aperture through which laser light is emitted and received

---

telescope aperture diameter

BT : **telescope aperture**
TT : **design**

Characteristic optical diameter of the lidar telescope

---

telescope assembly

BT : **Optics module**
TT : **design**
NT : **telescope aperture**

The system of lenses, mirrors and other optical and mechanical components that emit and receive laser light

---

Time of flight

UF : ***TOF***
BT : **measurement principles**
TT : **measurement principles**

The time taken for a lidar pulse to be emitted, interact with the atmosphere in a probe volume such that it is backscattered, and return to be detected by the system.

~~*TOF*~~
USE : **Time of flight**

Uninterruptible power supply
BT : **Power module**
TT : **design**
NT : **Battery**

Uninterruptible power supply

---

use case
BT : **applications**
TT : **applications**

The combination of three elements: 1. Outcome-driven data requirements (as opposed to constraint-driven requirements, see 1st generation sensor / 1st generation measurements); 2. The measurement method selected to fulfil them; 3. The operational conditions that determine the performance of the method with respect to accuracy

---

~~*VAD*~~
USE : **velocity-aziumth display**

Variable azimuth
note : **The scanning geometry taxonomy is based on Figure 3 in NREL/TP-5000-64634 https://www.nrel.gov/docs/fy16osti/64634.pdf**
BT : **Simple scan**
TT : **measurement principles**
NT : **Complete cone**
Cone sector
Doppler beam swinging

A simple scan geometry with variable azimuth angle

Variable elevation
note : **The scanning geometry taxonomy is based on Figure 3 in NREL/TP-5000-64634 https://www.nrel.gov/docs/fy16osti/64634.pdf**
BT : **Simple scan**
TT : **measurement principles**
NT : **Vertical slice**

A simple scan geometry with variable elevation angle

---

velocity-aziumth display
UF : ***VAD***
RT : **Measurement height**
Complete cone
BT : **Windfield reconstruction**
TT : **Analysis**

VAD is a method of analyzing data from a complete conical scan whereby many closely spaced azimuthal points may be sampled by the lidar, and the data are used to estimate the wind speed at each height using a statistical fitting method. The VAD method is described in Lhermitte (1966) and Browning and Wexler (1968).

Vertical slice
UF : ***Range-height indicator***
RHI
RT : **Sequential scan**
BT : **Variable elevation**
TT : **measurement principles**

Scans can be made where the beam is swept through a vertical slice by varying the elevation angle but not the azimuth angle. These scans are also known as range-height-indicator (RHI) scans. This scan geometry may be used to look at details in the flow in the cross-sectional surface sampled by the scan

---

virtual met mast
UF : ***Crossed RHI***
BT : **applications**
TT : **applications**

A series of wind measurements made at discrete vertical locations, aping a met mast. These can be implemented using many approaches including Crossed RHI (XRHI) and other dual- or triple-lidar measurement

---

Windfield reconstruction
UF : ***Wind field reconstruction***
BT : **Analysis**
TT : **Analysis**
NT : **velocity-aziumth display**

Approach to processing wind lidar data to estimate a wind vector at one or more points in the domain sampled by the lidar

---

~~*Wind field reconstruction*~~
USE : **Windfield reconstruction**

Wind Iris
note : **Describing a wind lidar unit as 'a Wind Iris' is insufficient information to uniquely describe it's capabilities.**
BT : **devices**
TT : **devices**

Type of free-standing lidar device intended for use as a forward-looking lidar mounted on a wind turbine nacelle.

---

windscanner
note : **Describing a wind lidar unit as 'a windscanner' is insufficient information to uniquely describe it's capabilities.**
BT : **devices**
TT : **devices**

One of many different types of system that can be used to perform convergent scan geometries. Originally referred to the DTU-led windscanner.eu project.

Wind Lidar

Analysis
L Windfield reconstruction
L L velocity-aziumth display

applications
L use case
L virtual met mast

design
L Chassis module
L Control module
L L Communications module
L L Signal processing module
L L Storage module
L Interlocks
L Optics module
L L telescope assembly
L L L telescope aperture
L L L L telescope aperture diameter
L Photonics module
L L Detector
L L L Beam splitter
L L L Optical amplifier
L L L photodetector
L L L L Photodetector gain
L L L L Photodetector voltage noise
L L Laser source
L L L Laser diode
L L L L Laser wavelength
L Power module
L L Uninterruptible power supply
L L L Battery
L L L L Battery capacity
L L L L Battery voltage
L Scanner
L L Mirrors
L L Servo motors
L L L Maximum azimuthal slew rate
L L L Maximum elevation slew rate

devices
L Wind Iris
L windscanner

instances
L lidar type
L serial number

measurement principles
L scanning geometry
L L Multi-lidar
L L Single lidar
L L L Compound scan
L L L L Arbitrary trajectory
L L L L Sequential scan
L L L Simple scan
L L L L Variable azimuth
L L L L L Complete cone
L L L L L Cone sector
L L L L L Doppler beam swinging
L L L L Variable elevation
L L L L L Vertical slice
L Time of flight

parameters
L Carrier to noise ratio
L Datum elevation
L Datum feature
L Datum plane
L Measurement height