Instrumentation report 2024

Europlatform lidar measurement campaign

TNO Public ⟩ TNO 2024 R10960
28 June 2024

Energy & Materials
Transition
www.tno.nl
+31 88 866 50 65
info@tno.nl

TNO 2024 R10960 – 28 June 2024

Europlatform lidar measurement campaign

Instrumentation report 2024

Author(s)	G. Bergman and J.P. Verhoef
Classification report	TNO Public
Number of pages	22 (excl. front and back cover)
Number of appendices	2
Sponsor	Dutch Ministry of Economic Affairs and Climate Policy
Project name	MinvEZ 2024 Windconditions@northsea
Project number	060.59137

Revision

Rev.	Date	Description
1.0	28-06-2024	First release.

Archiving

`https://365tno.sharepoint.com/teams/P060.59137/`

Contents

Abbreviations

EPL	Europlatform
IEC	International Electrotechnical Commission
IECRE WE	IEC system for certification to standards relating to equipment for use in Renewable Energy applications - Wind Energy
KNMI	Royal Netherlands Meteorological Institute
LEG	Lichteiland Goeree
Lidar	Light Detection And Ranging
MSL	Mean Sea Level
OWEZ	Offshore Wind farm Egmond aan Zee
RWS	Rijkswaterstaat
TNO	Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek (Netherlands Organisation for applied scientific research)
TNW	Ten Noorden van de Wadden
VPN	Virtual Private Network
WGS 84	World Geodetic System 1984

Summary

In order to better understand the wind conditions at the North Sea for future offshore wind farms a ZX Lidars ZX300 lidar was installed at the offshore platform Europlatform (EPL) of Rijkswaterstaat (RWS) in 2016. In 2024 the ZX300 is replaced by the offshore version ZX300M. This report describes the background of the measurement campaign, the platform itself, the used lidar system and installation, data handling and operational aspects.

1 Introduction

1.1 Offshore wind energy deployment

The Netherlands has set clear ambitions to accelerate the energy transition and wind energy plays an essential role. The energy agreement outlines the route for implementation of offshore wind energy and by 2032 an installed capacity of 21.5GW needs to be achieved. Upscaling the offshore wind capacity is happening across all North Sea countries and this agreement is established in the Esbjerg Offshore Wind declaration[1].

The Offshore Wind Energy Act gives the government the option of issuing lots for the development of offshore wind farms. Recently the Dutch Government has planned to open 5 new areas for offshore wind farm development to accommodate these revised ambitions and targets [2], see fig. 1.1.

To enhance these developments, TNO performs offshore wind measurements at different platforms across the Dutch North Sea.

Figure 1.1: Locations of existing wind farms (yellow), wind farms under development (green) and TNO offshore measurement locations (red).

1.2 TNO leading role on offshore measuring campaigns

Before the integration of lidars in offshore wind resource assessments, meteorological masts (met mast) have been widely used by TNO. Notable examples include the met mast IJmuiden (MMIJ), as well as the met mast at Offshore Wind farm Egmond aan Zee (OWEZ).

Since 2014, TNO is performing for the Dutch Ministry of Economic Affairs and Climate Policy measurement campaigns with lidars at four strategically locations in the North Sea. These campaigns are part of the 'Wind op Zee' project to support the Dutch wind offshore roadmap. These four locations are: Lichteiland Goeree (LEG), Europlatform (EPL), K13-A and L2-FA-1, see fig. 1.1.

This report focusses on the upgrade of the instrumentation on the offshore platform EPL. A description of the EPL platform is found in chapter 2 and in chapter 3 detailed information can be found on the ZX lidars ZX300M lidar. The installation is elaborated on in chapter 4 and chapter 5 focusses on the data handling. Finally, chapter 6 covers the operation and maintenance aspects.

1.3 Open-access and public datasets

Since 2020 TNO has published annually reports on the wind conditions for each measurement campaign location. These reports are available at the TNO offshore wind measurements website: https://offshorewind-measurements.tno.nl/en/ [3]. Here the data sets from EPL starting from 2016 until now are available.

2 Europlatform (EPL)

The Europlatform (EPL) is an offshore platform of Rijkswaterstaat (RWS) located at a distance of about 60 km west from Hoek van Holland, see fig. 1.1. The platform serves as a measurement station for among others water level and wave height measurements. Also, meteorological measurements are being performed on the platform. A photo of the platform can be seen in fig. 2.1.

Figure 2.1: EPL platform.

Some specific data concerning EPL are:

- Coordinates (WGS 84): 51°59′52.5″N, 3°16′29.3″E
- Water depth: 32 m to MSL
- EPL platform heading: Platform North is 8° East to True North

The platform consists of a helicopter deck at a height of 19 m above MSL, with an accommodation deck below. The floor of this accommodation deck is 16.2 m above MSL. A top view drawing of the EPL platform can be found in fig. 2.2.

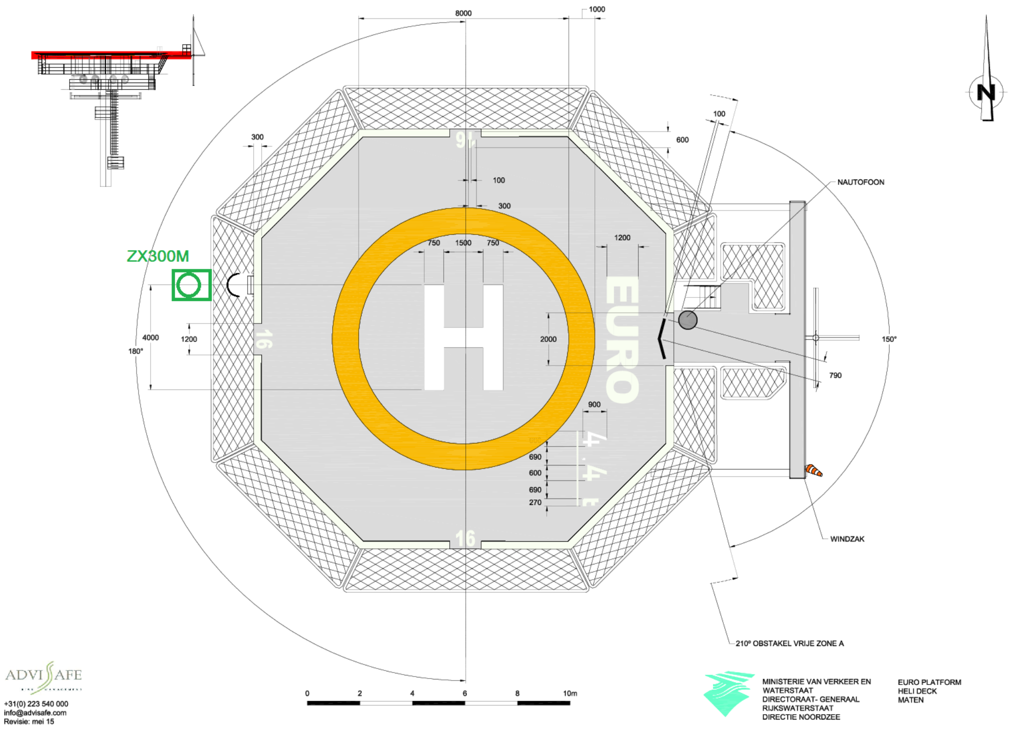

Figure 2.2: Top view the EPL helideck, in green the lidar position.

3 Lidar ZX300M

The ZX Lidar ZX300M(v2) consists of a tripod-shaped housing, with dimensions of ca. 90 x 90 x 90 cm. The inclined top of the housing contains the lens through which the laser beam is projected upwards. A picture of the system can be seen in fig. 3.1 and the dimensions in fig. 3.2.

Figure 3.1: Lidar ZX300M (v2).

The laser beam of this lidar points up with an angle of 30° with respect to the vertical, and sweeps to describe full circles, as can be seen in fig. 4.3.

The ZX300M(v2) version is the successor of the ZX300M initial version and improved the offshore robustness of the lidar by, among other, applying a single user connector panel with MacArtney Subconn connectors.

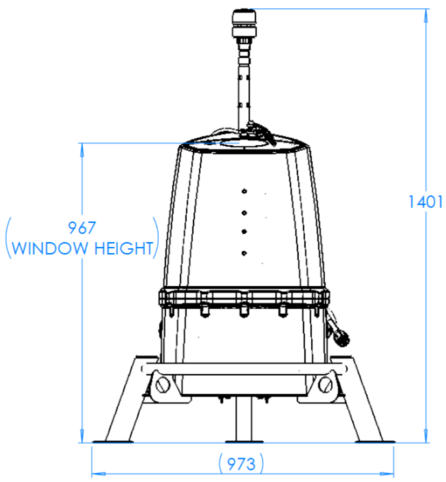

Figure 3.2: ZX Lidars ZX300M dimensions.

4 Installation lidar ZX300M

In May 2016 a ZX300 lidar is installed at EPL on an extension platform at the West side of the accommodation deck with a height of 16.2 m, just below helideck. In 2024 the ZX300 lidar is replaced by the offshore version, ZX300M. The lidar ZX300M is bolted onto a mounting plate using six bolts, see fig. 4.1.

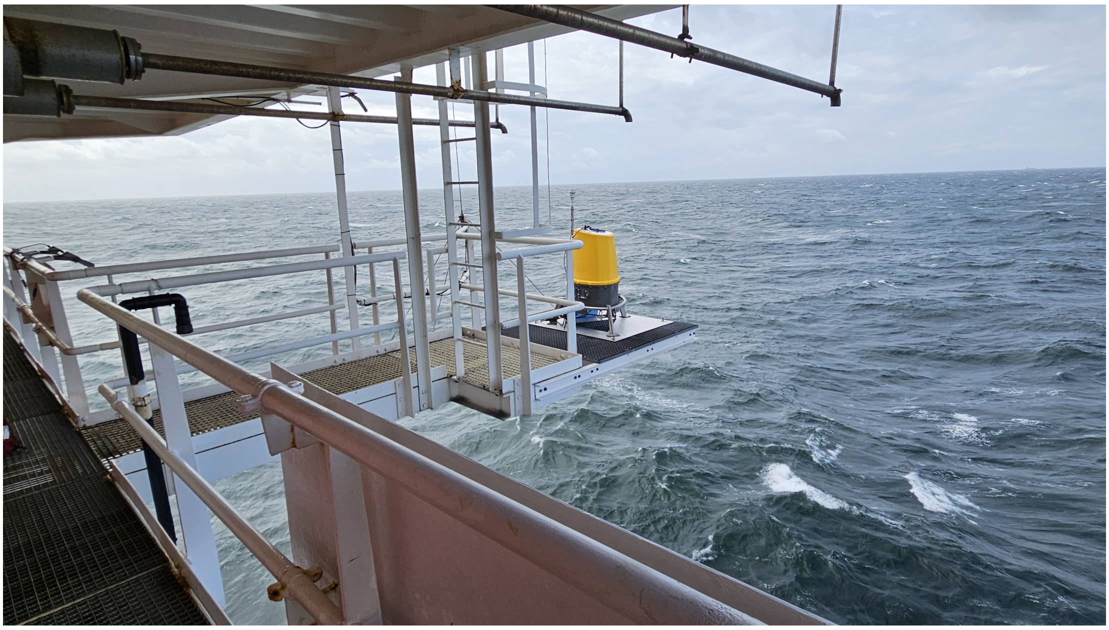

Figure 4.1: ZX300M lidar mounted on top of the accommodation building at EPL.

4.1 Electrical installation

4.1.1 Power supply

To be able to operate, the lidar needs a 12VDC power supply. At the lidar platform a power cable is available with 230VAC power supply. The 230VAC is converted to 12VDC by the AC-DC converter mounted at the bottom of the lidar. In the computer room a power relay, accessible by web interface, is installed between the platform supply power and the lidar power supply cable. This allows a remote reset of the lidar in case necessary. The power requirements of the lidar is 55 Watt, see appendix A.

4.1.2 Communication

To be able to transfer the data measured by the lidar to TNO, a TNO 4G VPN router is installed inside the computer room. This router is connected to the KPN internet by 4G network. From the TNO office a VPN connection is setup. Using this connection the local web relay and lidar can be accessed. An overview of the network layout can be found in fig. 4.2.

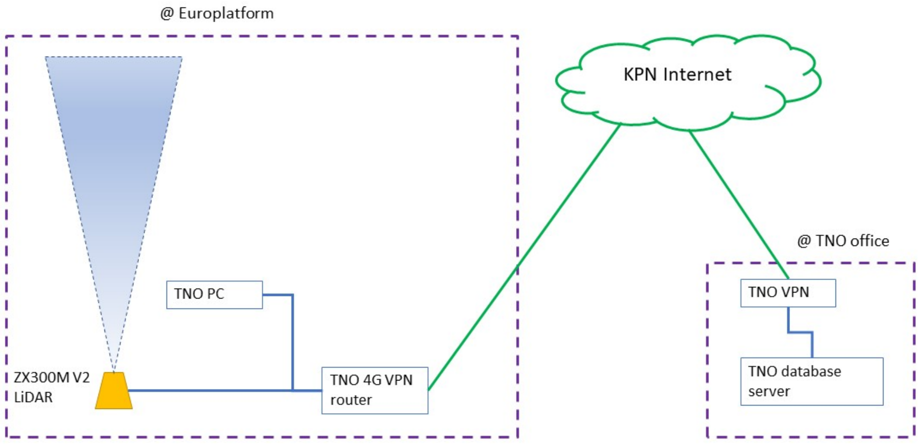

Figure 4.2: EPL lidar campaign network layout.

4.2 Orientation of the lidar

The lidar is installed with the ‘north’ marker of the lidar 30° West to the platform North, therefore a 330° offset is configured in the lidar configuration, see fig. 4.3. According to drawings TNO received of EPL, the platform is aligned to True North. However, data analysis show an directional offset to the nearby offshore platform Lichteiland Goeree data. Platform orientation measurement, using a GNSS compass, are planned to validate the orientation of the EPL platform.

4.3 Obstacles

The ZX300M lidar is installed about 2 m below the helicopter deck on the accommodation deck to the side of the helicopter deck, see fig. 2.2 and fig. 4.1 Although the lidar ZX300M is installed on an extended platform of ca. 1.75 m x 1.75 m, see fig. 4.1, the laser scanning circle is still partially blocked by the helicopter deck and netting.

The ZX300M lidar is equipped with a sonic wind direction sensor. This measurement is used by the lidar to more reliably determine the wind direction. Due to wind blockage effects caused by the platform, the wind direction measurements by the sensor can be affected and therefore not always reliable. In some cases this results in an 180° offset on the lidar wind directions, see section 5.5.

4.4 Lidar settings

We have chosen to configure the measurement heights (MSL) at the EPL platform identical to the heights measured at the Lichteiland Goeree platform. These are based on the meteorological mast IJmuiden (MMIJ) measurement height configuration, which performed measurements from November 2011 to March 2016.

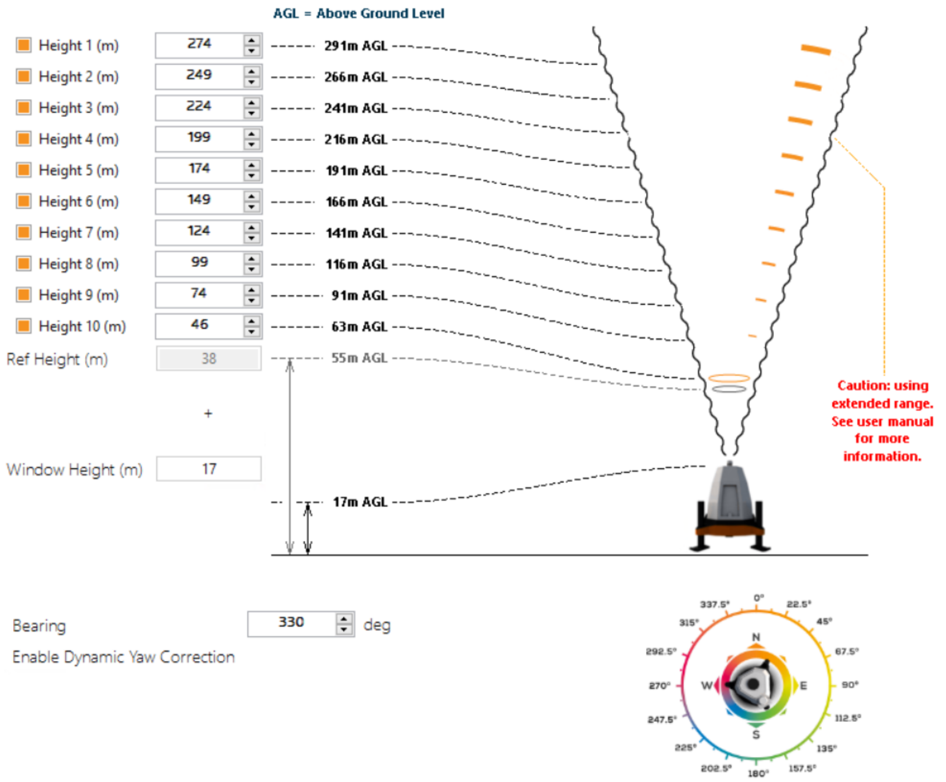

Figure 4.3: Height and bearing configuration of the ZX300M lidar.

The lidar lens height is about 17 m above MSL. The heights configuration in the lidar is relative to the lens height. Based on the orientation of the lidar as elaborated on in section 4.2 the bearing of the lidar amounts to 338° to True North. This consists of the 330° offset to the platform North and the additional offset as found during the orientation validation measurement using a GNSS compass of about 8°. The measuring heights and bearing to the platform North as configured in the lidar can be seen in fig. 4.3. table 4.1 gives the corresponding measurement heights above MSL as well.

Table 4.1: Lidar configured heights and measurement height to MSL.

No.	lidar height configuration [m]	measurement height to MSL [m]
1	46	63
2	74	91
3	99	116
4	124	141
5	149	166
6	174	191
7	199	216
8	224	241
9	249	266
10	274	291

5 Data handling

In this chapter we will consider the following:

- Standard produced ZX300M data files, 10-minute statistical data and fast data
- TNO database handling, checking, correction and filtering
- TNO data export via https://offshorewind-measurements.tno.nl/en/
- Additional EPL data from RWS and KNMI
- Wind direction correction of the 180° shifts

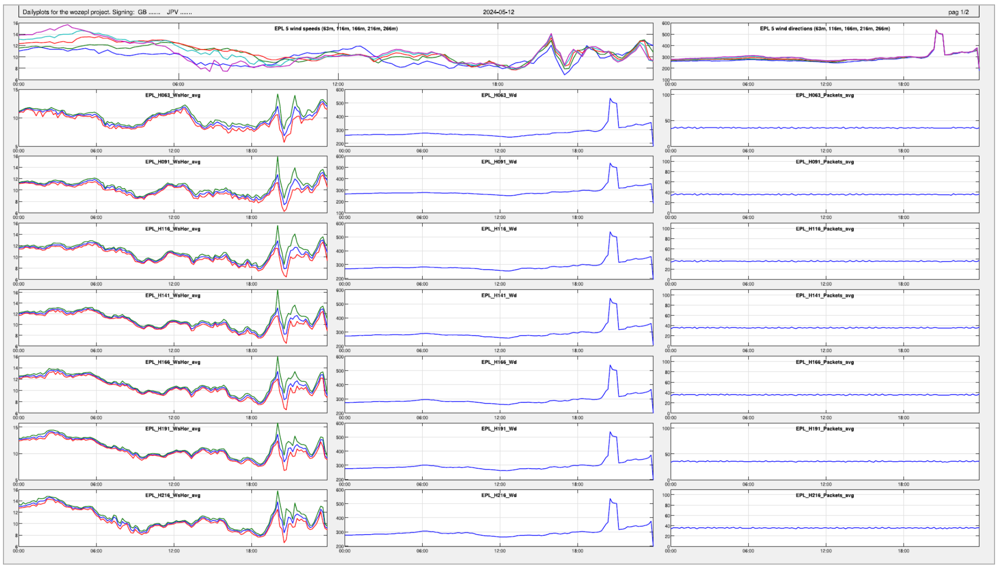

Figure 5.1: Automatically generated and distributed ‘daily-plot’ example of the EPL measurement signals.

5.1 Lidar ZX300M data files

The ZX300M lidar delivers data files in CSV format. Two different files are created by the lidar on a daily basis, one file with the 10-minute statistical data, recognized from the prefix ‘Wind10_’ and one file containing the fast data with prefix ‘Wind_’. Approximately every 1.5 s one height is measured. So with 10 configured measuring heights the refresh rate is close to 15 s. All produced CSV files are transferred on a daily basis to the data server at TNO. Only the 10-minute statical data is imported into the project database and processed. The fast data is stored and available for further processing when requested.

The complete filename is build up as described below:

Wind10_”ID”@Yyyyy_Mmm_Ddd.CSV (Wind_”ID”... in case of the fast data file)
“ID”: ZX300M serial number
yyyy: year of data
mm: month of data
dd: day of data

For an overview of the measured signals see Appendix B.

5.2 TNO data base

After data transfer, the data is imported into the project data base and then an automated 'daily-plot', see fig. 5.1, of the measured signals is created. This is distributed by email to the project team as PDF file who evaluate the signals on a daily basis. If needed TNO can perform a post-validation on the data in the database so that a specific data period is marked 'invalid' and is no longer visible.

The wind directional signals are manually corrected for the 180° shifts, see section 5.5.

5.3 Data export EPL

TNO makes the 10-minute statistical data available via the TNO offshore wind measurements website: https://offshorewind-measurements.tno.nl/en/. Here you can find the historical data of the lidar measurement campaign.

The order for export and presentation on the website will be as follows:
EPL-yyyy-mm.CSV for the previous month(s).

After a quarter is completed the monthly files will be replaced by:
EPL-yyyy-Qx.CSV (where x stands for the actual quarter)

After the year is completed the quarterly files will be replaced by a yearly file:
EPL-yyyy.CSV

5.4 Additional data sets

Besides the TNO LiDAR measurements, both KNMI and Rijkswaterstaat also perform measurements on EPL. Those measurements can be divided into Meteorological Measurements (KNMI) and Oceanographic measurements (Rijkswaterstaat), summarized table 5.1.

Table 5.1: Measurement Parameters from other organizations.

Parameter	Meteorological (KNMI)	Oceanographic (Rijkswaterstaat)
Air pressure	X	
Wind speed / Wind direction	X	
Air temperature	X	
Relative humidity	X	
Visibility	X	
Water level		X
Water temperature		X
Wave height		X
Wave period		X

The oceanographic parameters are measured with a Radac WaveGuide Radar F08 free space type which is installed on the jacket construction.

The measurements are not carried out by TNO but they are important reference measurements. Together with the lidar data the availability and plausibility is checked on a daily basis.

5.5 Wind direction correction

The ZX300M is based on the continuous wave technology. It changes focus point for every measurement height. Using the doppler shift in the backscattered data the wind speed can be determined but the direction of the doppler shift cannot be determined, which can result in a 180° shift. For this the ZX300M is equipped with an sonic anemometer mounted at a pole near the lidar, used as a reference wind direction. However when installed at the side of this platform, the sonic wind direction measurement is disturbed. This results in periods where the wind direction is shifted 180°. These shifts are most of the time easy identifiable by looking into the wind direction data. Comparing the data to the available reference wind direction of KNMI can help to identify the shifted periods.

For the wind direction correction a TNO developed tool is used, which helps to identify the shifted periods and efficiently convert the identified periods to wind direction corrections in the project database. This correction is done on a monthly basis before the data is made publicly available.

6 Operational and maintenance aspects

The first TNO lidar at the EPL platform was installed on 2016. In Table 3 an overview is given of the used lidars and the period that they were operational. Before installation the lidar is verified against an IEC compliant meteorological mast [4]. As defined by TNO's ISO17025:2017 quality system, the lidar should be replaced every three years. Additionally on a yearly basis the condition of the lidar is checked, the wiper is replaced and wiper fluid replenished. All operational aspects with respect to installation and maintenance of the lidar are recorded in the logbook.

Table 6.1: Overview of the installed lidar (s) at the EPL platform.

lidar	TNO code	Period	Reason for replacement
ZX308	94012680	10-05-2016 to 10-08-2018	Periodically replacement
ZX315	94012681	10-08-2018 to 23-10-2019	Power failure
ZX308	94012680	23-10-2019 to 22-03-2022	Periodically replacement
ZX315	94012681	22-03-2022 to 19-04-2024	Periodically replacement
ZX563	94012687	19-04-2024 to	

The quality of the signals is checked on a daily basis via the automatically distributed 'daily-plot', see fig. 5.1. Using the manufacturers software Waltz, we can directly connect to the lidar and monitor the measurements and status, see fig. 6.1.

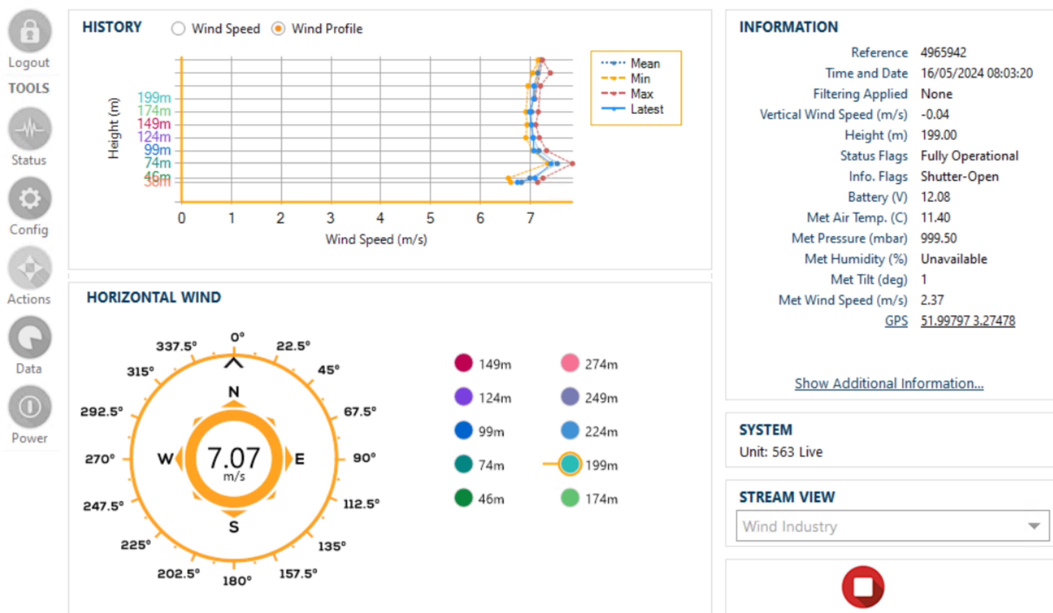

Figure 6.1: Screenshot of ZX Lidars software Waltz.

References

[1] *THE ESBJERG DECLARATION. on The North Sea as a Green Power Plant of Europe*. Rijksoverheid.

[2] *Kamerbrief aanvullende routekaart windenergie op zee 2030, Den Haag*. DGKE-E / 22235501.

[3] *https://offshorewind-measurements.tno.nl/en/*.

[4] C. Liu and G. Bergman. *Verification of the Wind@Sea LiDAR system ZX563 at the EWTW test site near meteorological mast MM6*. TNO 2024 P10316. TNO, 2024.

Signature

	Date: 28 June 2024	**Report number:** TNO 2024 R10960
Title	Europlatform lidar measurement campaign Instrumentation report 2024	
Author(s)	G. Bergman and J.P. Verhoef	
Principal(s)	Dutch Ministry of Economic Affairs and Climate Policy	
Project number	060.59137	
Programme(s)	Wind Energy	

Abstract

As part of the ‘2024 Wind Conditions @ North Sea’ project the ZX Lidars ZX300 lidar at offshore location Europlatform is replaced by the offshore version ZX300M. This report describes the measurement location, lidar system, installation, data handling and operation and maintenance.

Task	Name	Role	Signature
Author	G. Bergman	Lead Engineer	ValidSigned by Gerben Bergman on 2024-07-02 10:30:55
Expert review	J.P. Verhoef	Project manager	ValidSigned by Hans Verhoef on 2024-07-05 09:35:25
Generic review	C.B.H. Eeckels	Project manager	ValidSigned by Catherine Eeckels on 2024-07-02 10:44:17
Approval	R.H.M. Giepman	Deputy research manager	ValidSigned by Rogier Giepman on 2024-07-02 10:30:56
Authorization	E.D. Nennie	Research manager	ValidSigned by Erik Nennie on 2024-07-02 10:41:51

Appendix A
ZX Lidars ZX300M specifications

Range	10 – 300 metres (Lidar measurement) 0 – 10 metres (onboard met weather station)
Probe length	± 0.07 metres @ 10 metres ± 7.70 metres @ 100 metres
Height measured	10 User configurable 1 Additional met weather station measurement
Sampling rate	50Hz (up to 50 measurement points every second)
Averaging rate	True 1-second averaging 10 Minute averaging
Accuracy wind speed	0.1 m/s*
Direction variation	< 0.5°

Figure A.1: Measurement specifications.

Service interval	36 months from new
Size	805 x 845 x 966mm
Weight	53.4kg
IP Rating	IP68
Power consumption	55W
Power input	12V
Temperature range	-40 to +50°C
Warranty	3 years
Maintenance	No annual maintenance or calibration in this period

Figure A.2: Product specifications.

Appendix B
ZX300M measured signals

Name	Location	Short name (Signal name)	Sensor	Unit	installed	Freq	Campaign
Height independent signals							
Battery Voltage	Europlatform	EPL_Battery_avg	ZXLidars ZX300M V2	V	TNO	10-min stat	Wind@Sea
Lower temperature inside Lidar		EPL_Lower_Temp_avg		deg C			
Upper temperature inside Lidar		EPL_Upper_Temp_avg		deg C			
Relative humidity inside Lidar		EPL_Pod_Humidity_avg		%			
Relative humidity inside Lidar		EPL_Met_Air_Temp_avg		deg C			
Lidar met station bearing		EPL_Met_Compass_Bearing_avg		deg			
Lidar met station relative humidity		EPL_Met_Humidity_avg		%			
Lidar met station air pressure		EPL_Met_Pressure_avg		hPa			
Lidar met station tilt angle		EPL_Met_Tilt_avg		deg			
Lidar met station wind direction		EPL_Met_Wind_Dir_avg		deg			
Lidar met station wind speed		EPL_Met_Wind_Speed_avg		m/s			
External supply voltage		EPL_Generator_avg		V			
LiDAR status flags		EPL_Status_Flags_avg		-			
LiDAR info flags		EPL_Info_Flags_avg		-			
Proportions of packets		EPL_Proportion_Of_Packets_with_Rain_avg		#			
Error flags		EPL_Proportion_Of_Packets_with_Fog_avg		#			
For every measuring height (m):		xxx : 63, 91, 116, 141, 166, 191, 216, 241, 266, 291					
Horizontal wind speed average	Europlatform	EPL_Hxxx_Ws_avg	ZXLidars ZX300M V2	m/s	TNO	10-min stat	Wind@Sea
Horizontal wind speed std deviation		EPL_Hxxx_Ws_std		m/s			
Horizontal wind speed minimum		EPL_Hxxx_Ws_min		m/s			
Horizontal wind speed maximum		EPL_Hxxx_Ws_max		m/s			
Vertical wind speed average		EPL_Hxxx_WsV_avg		m/s			
Wind direction		EPL_Hxxx_Wd_avg		deg			
Turbulence intensity		EPL_Hxxx_TI_avg		-			
Package in average		EPL_Hxxx_Packets_avg		#			

Figure B.1: ZX300M measured signals.

Energy & Materials Transition

Westerduinweg 3
1755 LE Petten
www.tno.nl