Instrumentation report 2024

K13-A lidar measurement campaign

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Contents

Abbreviations

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
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 ZX300M lidar was installed at the offshore platform K13-A of Wintershall Noordzee B.V.. 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 Ministry of Climate Policy and Green Growthmeasurement 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 K13-A. A description of the K13-A 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 K13-A starting from 2016 until now are available.

2 Platform K13-A

The K13-A offshore platform owned by Wintershall Noordzee B.V. is located northwest of Den Helder, 101 kilometres from the coast, see fig. 1.1. The platform serves as a production platform for natural gas. Since November 2016 wind measurements are carried out by TNO using a platform-mounted ZX300M wind lidar, see fig. 3.1 (35 m above MSL). The platform is part of the North Sea Monitoring Network consisting of several permanent monitoring locations. The platform serves as a measurement station for oceanographic (Rijkswaterstaat) and meteorological (KNMI) measurements. An aerial picture of the platform can be seen in fig. 2.1.

Figure 2.1: K13-A platform.

Some specific data concerning K13-A are:

- Coordinates (WGS 84): 53°13′4.3″N, 3°13′6.6″E
- Water depth: 28 m to MSL
- K13-A platform heading: Platform North is 35° west to true North

A top view and side view drawing of the K13-A platform can be seen in fig. 2.2 and fig. 2.3.

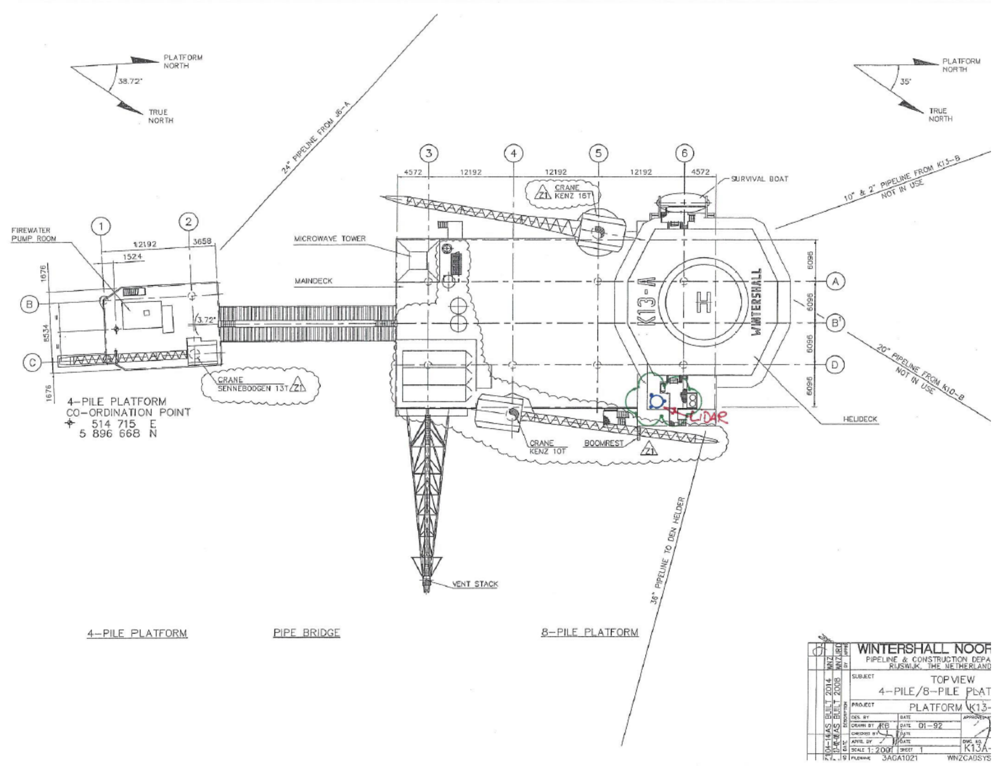

Figure 2.2: Top view the K13-A.

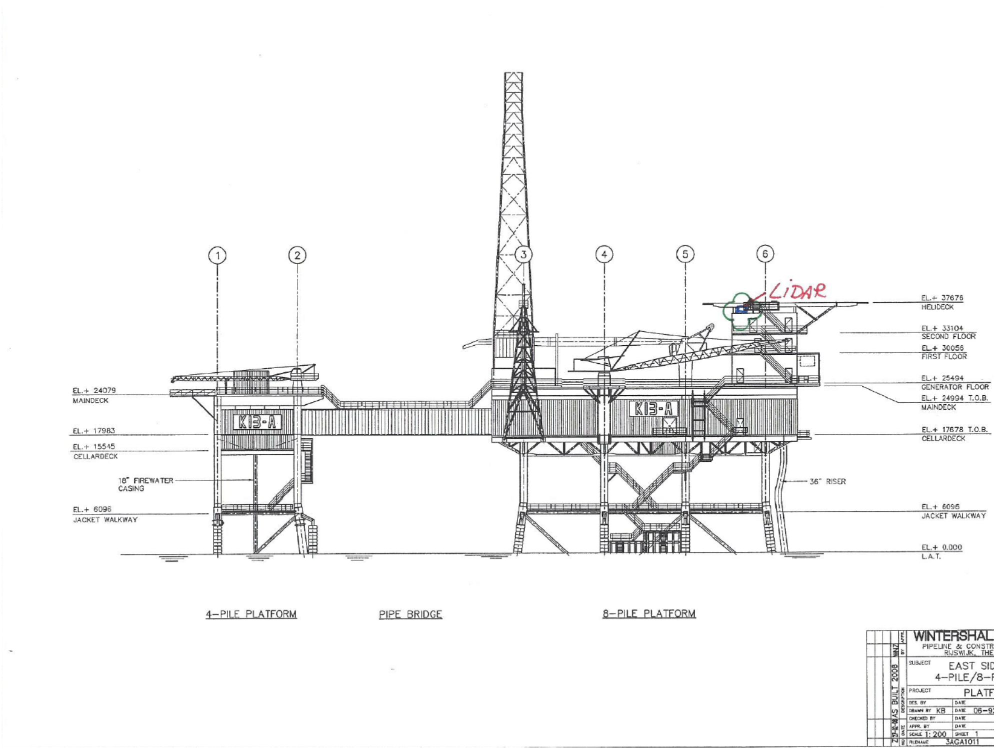

Figure 2.3: Side view the K13-A helideck.

3 Lidar ZX300M

The ZX Lidars 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.

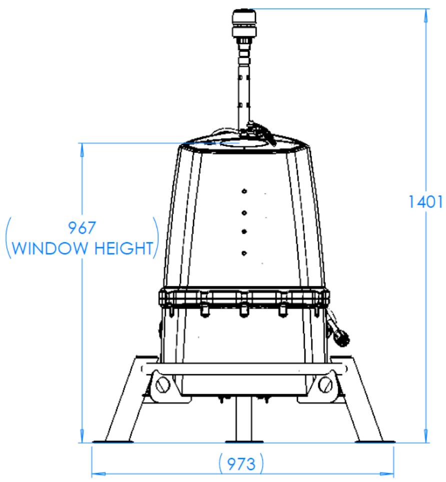

Figure 3.2: ZX Lidars ZX300M dimensions.

4 Installation lidar ZX300M

In November 2016 a ZX300M lidar is installed at K13-A on top of the accommodation building, east of the helideck. The lidar is mounted on top of the accommodation building with six bolts on three hard plastic mounting blocks, see fig. 4.1.

4.1 Electrical installation

To lidar is powered by 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. The power requirements of the lidar is 55 Watt, see appendix A.

4.1.1 Communication

To be able to transfer the data measured by the lidar to TNO, a laptop is installed in the computer room, located close to the lidar. The laptop is connected to the internet by local wireless network and satellite connection, see fig. 4.2.

4.2 Orientation of the lidar

The lidar is installed with the 'north' marker aligned to the platform North. As seen in fig. 2.2 the platform North is orientated 35 degrees west to true North. Therefore a 360-35=325 degrees bearing is configured in the lidar settings, see fig. 4.3.

4.3 Obstacles

The ZX300M lidar is installed just below the helicopter deck on a the accommodation building east of the helicopter deck, see fig. 2.2 and fig. 2.3, therefore the lidar experiences free sight for the complete scan circle of the laser beam with an opening angle of 30 degree to the vertical.

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

The chosen measurement heights are in line with the, at the time of installation, already operational TNO offshore lidar locations like Lichteiland Goeree and the Europlatform. These measuring heights are based on the meteorological mast IJmuiden (MMIJ) measurement height configuration, which performed measurements from November 2011 to March 2016.

The lens of the lidar is around 36 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 325° to true North. The measuring heights and bearing to the

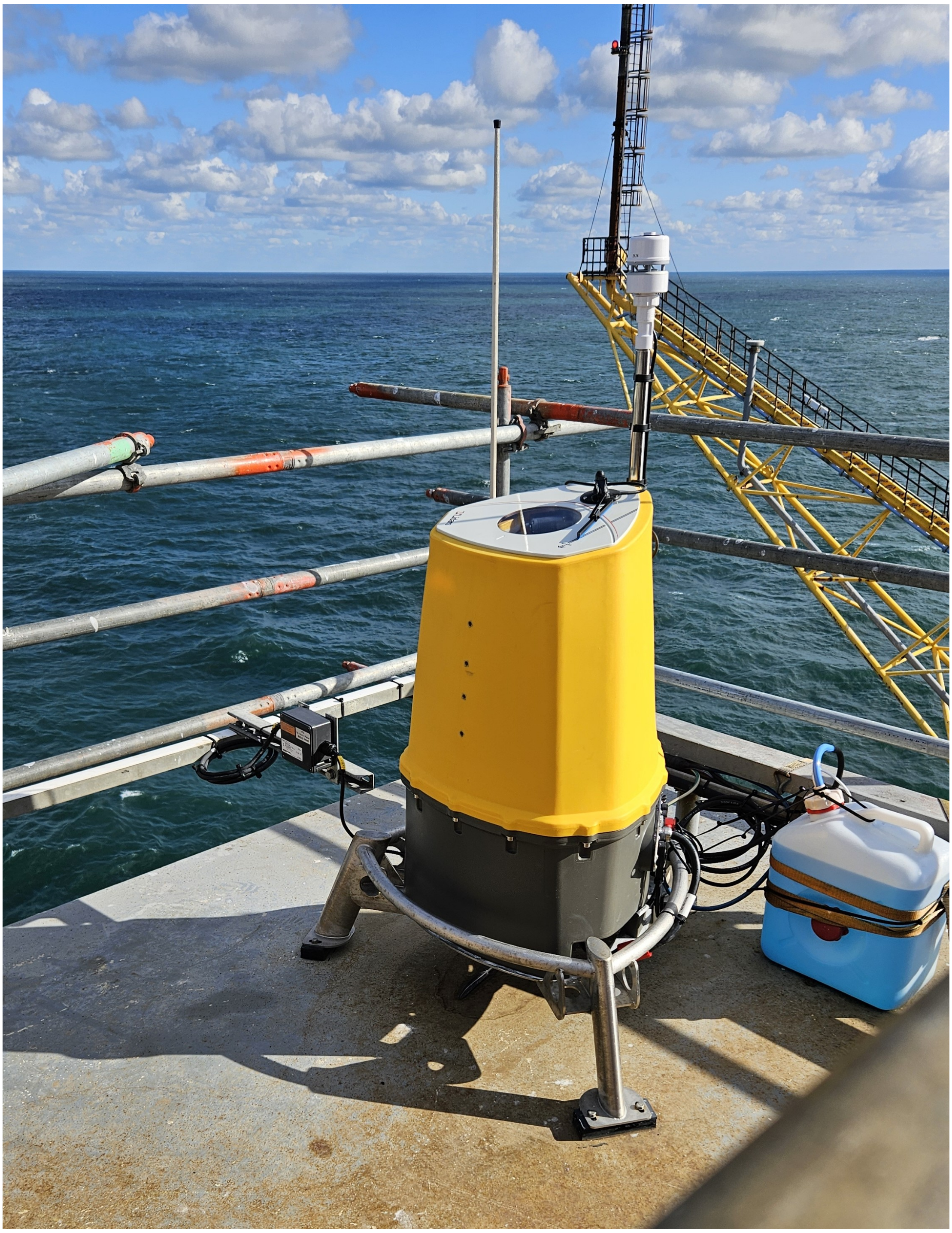

Figure 4.1: ZX300M lidar mounted on top of the accommodation building at K13-A.

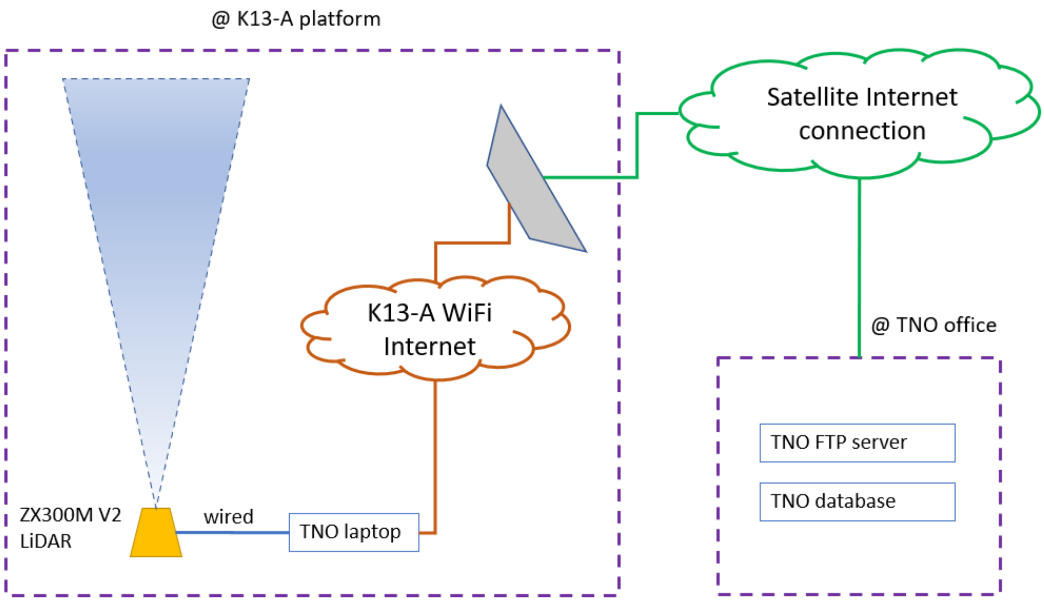

Figure 4.2: K13-A lidar campaign network layout.

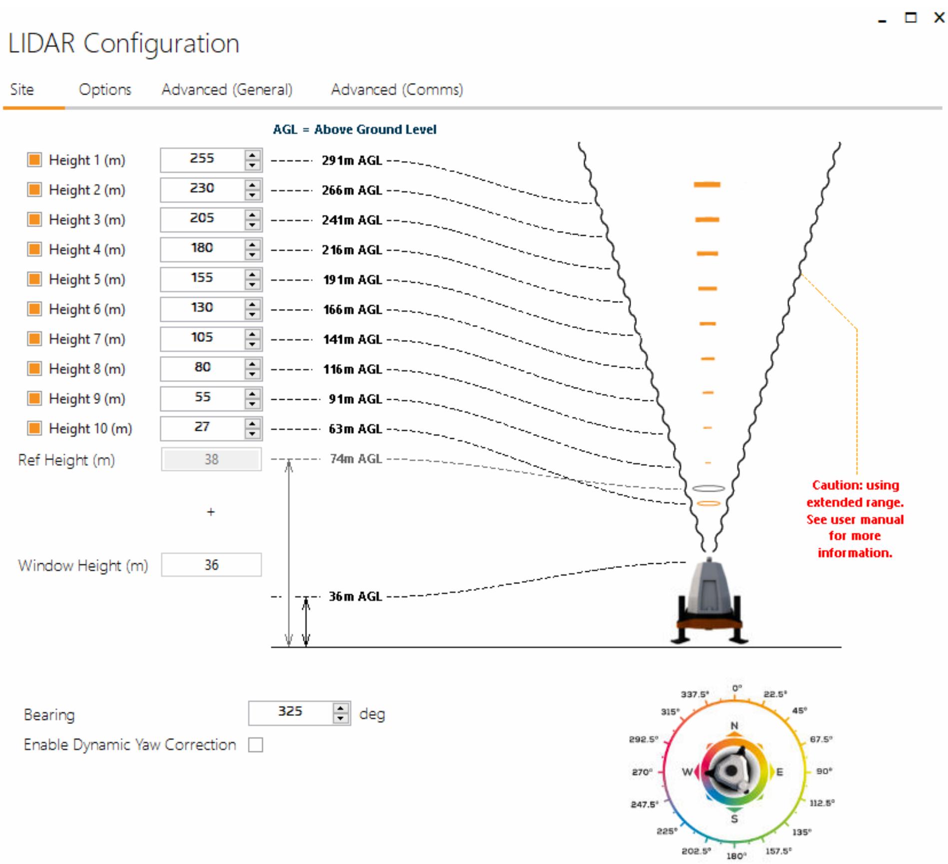

Figure 4.3: Height and bearing configuration of the ZX300M lidar.

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	measurement height to MSL
	[m]	[m]
1	27	63
2	55	91
3	80	116
4	105	141
5	130	166
6	155	191
7	180	216
8	205	241
9	230	266
10	255	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 K13-A data from RWS and KNMI
- Wind direction correction of the 180° shifts

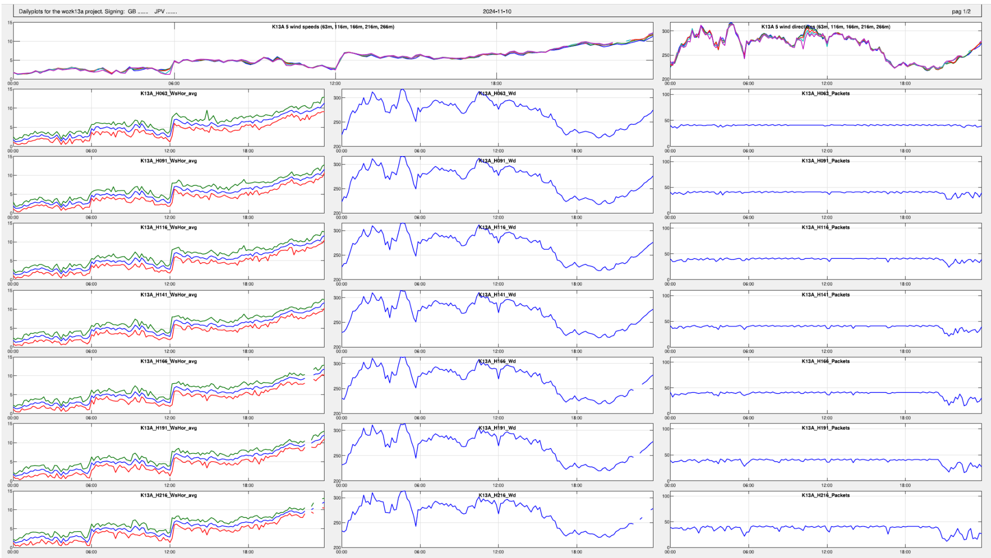

Figure 5.1: Automatically generated and distributed 'daily-plot' example of the K13-A measurement signals.

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 K13-A

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:
K13A-STAT-yyyy-mm.CSV for the previous month(s).

After a quarter is completed the monthly files will be replaced by:
K13A-STAT-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:
K13A-STAT-yyyy-Y.CSV

5.4 Additional data sets

Besides the TNO lidar measurements, both KNMI and Rijkswaterstaat also perform measurements on K13-A. 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 K13-A 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 lidars at the K13-A platform.

lidar	TNO code	Period	Reason for replacement
ZX563	94012687	01-11-2016 to 11-11-2022	Periodically replacement
ZX1524	22003515	11-11-2022 to 11-10-2024	Periodically replacement
ZX2126	24002232	11-10-2024 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.

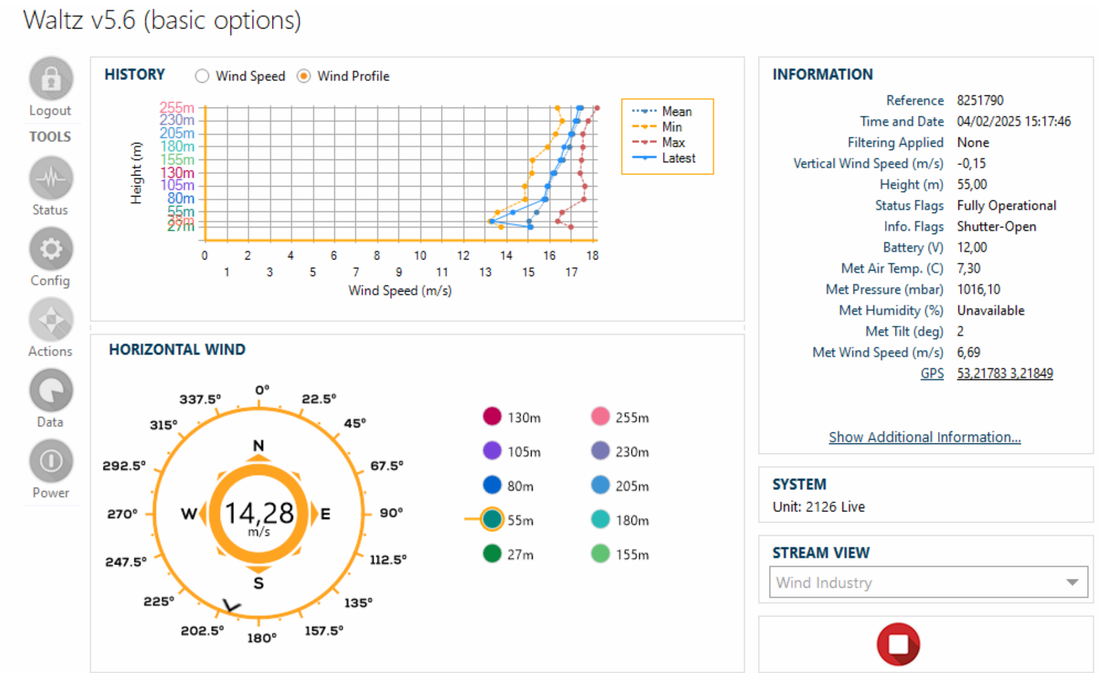

Figure 6.1: Screenshot of ZX Lidars software Waltz.

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] H. Rogoll, R. Menke, and R. Fruehmann. *Independent analysis and reporting of ZX Lidars performance verification executed by ZX Lidars at the UK Remote Sensing Test Site. ZX Lidars*. ZX2126. 10488072-A-14-A. Version A. DNV - Energy, Feb. 14, 2024.

Signature

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Programme(s)	Wind Energy	

Abstract

As part of the '2024 Wind Conditions @ North Sea' project the ZX Lidars ZX300M lidar at offshore location K13-A is periodically replaced. This report describes the measurement location, lidar system, installation, data handling and operation and maintenance of K13-A.

Task	Name	Role	Signature
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Expert review	J.P. Verhoef	Project manager	ValidSigned by Hans Verhoef on 2025-03-18 09:00:01
Generic review	C.B.H. Eeckels	Project manager	ValidSigned by Catherine Eeckels on 2025-03-21 16:50:06
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Authorization	E.D. Nennie	Research manager	ValidSigned by Erik Nennie on 2025-03-20 09:12:18

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	K13-A	K13A_Battery_avg	ZXLidars ZX300M V2	V	TNO	10-min stat	Wind@Sea
Lower temperature inside Lidar		K13A_Lower_Temp_avg		deg C			
Upper temperature inside Lidar		K13A_Upper_Temp_avg		deg C			
Relative humidity inside Lidar		K13A_Pod_Humidity_avg		%			
Relative humidity inside Lidar		K13A_Met_Air_Temp_avg		deg C			
Lidar met station bearing		K13A_Met_Compass_Bearing_avg		deg			
Lidar met station relative humidity		K13A_Met_Humidity_avg		%			
Lidar met station air pressure		K13A_Met_Pressure_avg		hPa			
Lidar met station tilt angle		K13A_Met_Tilt_avg		deg			
Lidar met station wind direction		K13A_Met_Wind_Dir_avg		deg			
Lidar met station wind speed		K13A_Met_Wind_Speed_avg		m/s			
External supply voltage		K13A_Generator_avg		V			
LiDAR status flags		K13A_Status_Flags_avg		-			
LiDAR info flags		K13A_Info_Flags_avg		-			
Proportions of packets		K13A_Proportion_Of_Packets_with_Rain_avg		#			
Error flags		K13A_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	K13-A	K13A_Hxxx_Ws_avg	ZXLidars ZX300M V2	m/s	TNO	10-min stat	Wind@Sea
Horizontal wind speed std deviation		K13A_Hxxx_Ws_std		m/s			
Horizontal wind speed minimum		K13A_Hxxx_Ws_min		m/s			
Horizontal wind speed maximum		K13A_Hxxx_Ws_max		m/s			
Vertical wind speed average		K13A_Hxxx_WsV_avg		m/s			
Wind direction		K13A_Hxxx_Wd_avg		deg			
Turbulence intensity		K13A_Hxxx_TI_avg		-			
Package in average		K13A_Hxxx_Packets_avg		#			

Figure B.1: ZX300M measured signals.

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