TNO report

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Instrumentation report for Lichteiland Goeree
LiDAR measurement campaign

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Management Summary

In order to better understand the wind conditions at the North Sea for future offshore wind farms a LEOSPHERE WINDCUBEv2 LiDAR was installed at the Lichteiland Goeree (LEG) platform in 2014. This report describes the background of the measurement campaign, the Lichteiland Goeree (LEG) platform itself, the used LiDAR system, data sources and operational aspects.

Title: Instrumentation report for Lichteiland Goeree LiDAR measurement campaign
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1 Introduction

An import step to achieve the renewable energy targets of the Netherlands is working on more offshore wind energy towards 2050. The Offshore Wind Energy Act gives the government the option of issuing lots for the development of offshore wind farms. In line with these policy intentions to arrive at 3,500 MW from the first roadmap for offshore wind energy, lots have been issued in the wind energy areas Borssele and the Dutch coast (‘Hollandse Kust Noord’ (HKN) and ‘Hollandse Kust Zuid’ (HKZ)).

The commissioning of wind farms within these plots - as described in the Roadmap 2023 - meets the objective of the Energy Agreement for offshore wind energy, namely approximately 4,450 MW in 2023 [1].
To gain more knowledge of the meteorological conditions for the future offshore wind farms the Dutch Government set up a measurement campaign on strategic points in the designated areas to collect the wind conditions at these locations. This helps developers to make accurate offshore wind farm business plans for the indicated lots. The three running campaigns within the Wind @ Sea – measurement campaign funded by the Dutch Ministry of Economic Affairs and Climate Policy are LiDAR measurements at Lichteiland Goeree (LEG), Europlatform (EPL) and K13-a.

An important measurement campaign which was stopped in 2013 were the Meteorological Mast IJmuiden (MMIJ) measurements. Data collected during this campaign still proofs to be of great value and can also be retrieve via the Wind @ Sea website (www.WindOpZee.net). This, as well as the meteorological mast measurements at the Offshore Wind farm Egmond aan Zee (OWEZ) and the various floating LiDAR measurements in the offshore zones: Borssele, HKN and HKZ

As part of the Wind @ Sea measurement campaign, ECN part of TNO started a LiDAR measurement campaign on Lichteiland Goeree in 2014. This report describes the instrumentation for the LEOSPHERE WINDCUBEv2 LiDAR measurement campaign at Lichteiland Goeree (LEG). Chapter 2 describes the platform Lichteiland Goeree (LEG), its location and use. Chapter 3 describes the used instrumentation (eq. LEOSPHERE WINDCUBEv2 LiDAR). Chapter 4 presents the mechanical as well as the electrical installation and gives the important information like measurement heights, North orientation, data format etc. Chapter 5 describes the data handling from measurements to checking and exporting of the generated data. Chapter 6 finally describes the operation and maintenance (O&M) aspects regarding the measurement campaign.
2 Lichteiland Goeree (LEG)

At a distance of about 30 km south-west from Hoek van Holland the platform Lichteiland Goeree (LEG) is situated. The exact location of the platform can be seen in figure 2.

![Figure 2: Location of Lichteiland Goeree](image)

The platform serves as a beacon for ships on the North Sea. Also, meteorological measurements and wave measurements are being performed on the platform. A picture of the platform can be seen in figure 3.

![Figure 3: Lichteiland Goeree (LEG)](image)
Lichteiland Goeree is part of the North Sea Monitoring Network which purpose is to collect up-to-date information on the air and the seawater. This meets the need for data of the meteorological and oceanographic conditions on the North Sea. The North Sea Monitoring Network consists of several permanent monitoring locations in and around the North Sea. Some of them are in the English section of the North Sea.

Some specific data concerning Lichteiland Goeree are:

RD coordinates        36779, 438793 (Rijksdriehoeksmeting X,Y in meters)
Degrees                51.92503 , 3.66844 (Notation DD.dddddd°)
Degrees and Minutes    N 51 55.502, E 3 40.106 (Notation DD°MM.mmmm’)
Degrees, minutes & seconds N 51 55 30.1, E 3 40 6.4) (Notation DD°MM’S’S.s”)

LAT = MSL -115 cm
NAP = LAT + 92 cm (Hoek van Holland)
References for this information can be found in [2] and [3].

The platform consists of a helicopter deck on a height of 24.58 meter above MSL with an accommodation deck below. The floor of this accommodation deck is on 20.04 meter above MSL [4].

A top view of the platform can be seen in Figure 4 while Figure 5 shows the rear view.

Figure 4: Top view of Lichteiland Goeree
Figure 5: Rear view of Lichteiland Goeree

To perform wind speed measurements on the platform on higher altitudes (up to 220m above sea level), ECN part of TNO installed a LEOSPHERE WINDCUBE V2 LiDAR on the platform.

Chapter 4 describes the selected measurement heights in more detail.
The LEOSPHERE WINDCUBE V2 is a LiDAR instrument used for wind profile measurements which can measure up to 200 meter. The principle of the LiDAR is that it sends infrared pulses into the atmosphere. Four beams are sent successively in four defined directions along a 28° scanning cone. The laser pulses are backscattered by aerosol particles in the air (such as dust, water droplets, aerosol etc.) that move with the wind speed. The collected backscattered light contains information on wind speed and wind direction which can be calculated by using a Doppler induced laser wave length shift [5]. The LiDAR can measure up to 10 different range gates allowing to measure wind speed and wind direction at 10 different heights.

Figure 6 shows the LEOSPHERE WINDCUBE V2. The specifications of the LEOSPHERE WINDCUBE V2 can be found in Appendix A.

The WINDCUBEv2 is a class 1M laser product and the system should be handled with caution. It is important not to stare directly into the beam with optical instruments like telescopes or binoculars. The laser beam is eye-safe according IEC EN 60825-1, January 2008 (see Appendix B)
4 Installation LEOSPHERE WINDCUBE V2 LiDAR

This chapter describes the installation of the LEOSPHERE WINDCUBE V2 LiDAR. The location as well as the mechanical and electrical installation are described, together with the limitations in placement. Furthermore the applied LiDAR settings are given. The installation is described in more detail in [6]

4.1 Installation limitations

The installation possibilities of the LiDAR are limited by the following conditions:
- The top of the platform is a helicopter landing. It is not possible to install the LiDAR on top of the platform, as no objects are allowed to protrude above the helicopter platform.
- Next to the helicopter platform, on the North corner of the platform, a lighthouse is present. Unfortunately it is not possible to install the LiDAR close to this lighthouse, as on top of the lighthouse a radar is rotating, which would hinder the laser beam of the LiDAR.

4.2 Installation possibility

The only possible installation location for the LiDAR was the side of the helicopter platform, far away enough from the lighthouse not to hinder the LiDAR's laser beam. A suitable place for this has been found just beside the cage-ladder on the north-west side of the platform, about 3 meters away from the West corner of the platform. In figure 7 the position of the LiDAR on the platform is shown.

Figure 7 Lichteiland Goeree with location of LiDAR
4.3 Mechanical installation

On 6 October 2014 the first LiDAR has been installed under the helicopter platform. Pictures of the installed LiDAR can be found in Figure 8 and Figure 9.

Figure 8 Installed LiDAR (side view with safety net removed)

Figure 9 Installed LiDAR (bottom view with safety net installed)
4.4 Orientation of the LiDAR

The LiDAR has been oriented in such a way that the ‘North’ marker of the LiDAR is on the left side of the LiDAR (pointing away from the lighthouse) looking at Figure 7. This means that the North marker is also on the left side of the LiDAR in Figure 10. This means that the wind direction signals measured by the LiDAR have a directional offset of exact -135 degrees.

4.5 Safety net adjustment

After the installation the laser of the LiDAR was hindered too much by the safety netting above the LiDAR lens. To overcome this, in consultation with Rijkswaterstaat a temporary replacement safety net has been manufactured, with a hole in the safety net just above the LiDAR lens. The installation of the replacement safety net can be seen in Figure 10.

![Modified replacement safety net installed](image)

4.6 Electrical installation

4.6.1 Electrical power

To be able to operate, the LiDAR needs a 24V DC power supply. The power requirements of the LiDAR can be found in Appendix A. From the LiDAR, an electrical cable has been run along diagonal brace and has been attached with tie-wraps (see Figure 9). From the bottom of this tube the cable has been lead through a cable duct and through a hole in the wall to enter the computer room of the platform. In this computer room the power supply unit has been installed, which was plugged into a 230V AC wall outlet.


4.6.2 Communication

To be able to transfer the data measured by the LiDAR to ECN part of TNO, a 3G/4G modem has been installed in the computer room of the platform. From this router an Ethernet cable was routed to the LiDAR along the installed power cable.

4.7 LiDAR settings

The settings for the LiDAR are easy to adjust. In the following figure an example of the configuration screen is given.

![Figure 11: Example of setting screen LiDAR](image)

The correct settings for the LiDAR are as follows

<table>
<thead>
<tr>
<th>No</th>
<th>LiDAR height configuration</th>
<th>True measurement height (MSL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>63</td>
</tr>
<tr>
<td>2</td>
<td>68</td>
<td>91</td>
</tr>
<tr>
<td>3</td>
<td>93</td>
<td>116</td>
</tr>
<tr>
<td>4</td>
<td>118</td>
<td>141</td>
</tr>
<tr>
<td>5</td>
<td>143</td>
<td>166</td>
</tr>
<tr>
<td>6</td>
<td>168</td>
<td>191</td>
</tr>
<tr>
<td>7</td>
<td>193</td>
<td>216</td>
</tr>
<tr>
<td>8</td>
<td>218</td>
<td>241</td>
</tr>
<tr>
<td>9</td>
<td>243</td>
<td>266</td>
</tr>
<tr>
<td>10</td>
<td>268</td>
<td>291</td>
</tr>
</tbody>
</table>

Table 4.1 LiDAR configuration and true measurement height (icw MSL)

Please note that since the LiDAR is located at 23m above LLWS [12] the LiDAR heights are corrected to retrieve the true measurement heights. The LiDAR is approx. 0.5 meter below helicopter platform.
5 Data handling

In this chapter we will consider the three important data sources / flow, namely
- Standard produced LEOSPHERE data files STA (10 minute statistical data) and RTD (1 second data)
- ECN part of TNO database handling and checking
- ECN part of TNO data export via www.WindOpZee.net

5.1 LEOSPHERE WINDCUBE V2 LiDAR data files

The LEOSPHERE WINDCUBE V2 LiDAR delivers two data sets: the 10 minute statistical data (STA output file) and the 1 second data (RTD output file)

For each altitude the measurements are grouped in 18 columns and each line in the STA file represents the averaged data acquired during the past 10 minutes (for the given date and time).

![Figure 12 File format WINDCUBE V2 STA file](image)

All the produced STA and RTD data are transferred on a daily bases from each measurement location to the data server at ECN part of TNO.
The file name are time stamped as described below:

WLS7-XXXX_YYYY_MM_DD_hh_mm_ss
- WLS7-XXXX: WINDCUBEv2 serial number
- YYYY: year of data
- MM: month of data
- DD: day of data
- hh_mm_ss: time of the first registered in file.

5.2 ECN part of TNO – WDMS data

After the data transfer action the data will be inserted in the ECN part of TNO WDMS data base and processing starts. The Lead Engineer will evaluate the data and can perform a post-validation if additional actions are required.

The Lead Engineer will do this based on a daily plot of the previous day. A daily plot for the LEG measurement campaign looks as follows.

Figure 13: Daily plot for LEG measurement campaign

Before the data will be exported we will first check whether the orientation is correct (the North-cap correction). Moreover, the wind direction will be compared with
nearby stations (this can be either LiDAR measurements or standard KNMI measurements on LEG or EPL which are described in paragraph 5.4).

5.3 Data export Lichteiland Goeree

ECN part of TNO makes the 10 minute statistical data available via the www.WindOpZee.net website. 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.

**LEG-yyyy-mm.CSV** for the previous month(s).

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

After the year is completed the quarterly files will be replaced by a yearly file like **LEG-yyyy.CSV**

5.4 Additional data sets

Besides the ECN part of TNO LiDAR measurements, both KNMI and Rijkswaterstaat also performing measurements on Lichteiland Goeree. They can be divided in Meteorological Measurements (KNMI) and Oceanographic measurements (Rijkswaterstaat)

Meteorological parameters include:
- Air pressure
- Wind speed / Wind direction
- Air temperature
- Relative humidity
- Visibility

Oceanographic parameters include:
- Water level
- Water temperature
- Wave height

The oceanographic parameters are measured with a Radac WaveGuide Radar F08 free space type which is installed on tube construction 8 meter above M.S.L.

The measurements are not carried out by ECN part of TNO but they are important reference measurements [7].
6 Operational and maintenance aspects

The LEOSPHERE WINDCUBE V2 was first installed on October 10th, 2014. According to ECN part of TNO quality system the LiDAR should be replaced every two years and should ideally also be serviced every year. All operational aspects with respect to installing and maintaining the LiDAR are recorded in the Logbook [8].

In the following table, an overview is given of the used LiDAR’s and the period that they were operational. It should be noted that before the LiDAR was installed at the LEG platform it was first calibrated at the ELCF [9,10,11]

Table 6.1 Overview of applied LiDAR @ LEG

<table>
<thead>
<tr>
<th>LiDAR</th>
<th>ECN part of TNO code</th>
<th>Period</th>
<th>Reason for replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>127</td>
<td>DELI</td>
<td>06-10-2014 to 10-04-2015</td>
<td>Satellite communication</td>
</tr>
<tr>
<td>258</td>
<td>DELI</td>
<td>10-04-2015 to 28-09-2015</td>
<td>GSM communication (OK!)</td>
</tr>
<tr>
<td>127</td>
<td>DELI</td>
<td>28-09-2015 to 05-10-2017</td>
<td>Periodically replacement</td>
</tr>
<tr>
<td>577</td>
<td>DELI</td>
<td>05-10-2017 to 24-10-2019</td>
<td>Periodically replacement</td>
</tr>
<tr>
<td>258</td>
<td>DELI</td>
<td>24-10-2019 to …</td>
<td></td>
</tr>
</tbody>
</table>

To check if the LiDAR still runs well the manufacturers Windsoft software package (version 1.1.15) is used, which can be accessed via a web based tool. For further details we refer to the manual of the LEOSPHERE WINDCUBE V2.

The following figure shows the standard screenshot of the WINDCUBE V2

![Screenshot WINDCUBE V2](image-url)
7 References

[1] Kamerbrief routekaart windenergy op zee 2030
Den Haag, Kamerbrief 27 maart 2019, kenmerk DGETM-E2020/17177527


[4] Informatieblad LEG - Rijkswaterstaat

LEOSPHERE

[6] Installation report for Lichteiland Goeree LiDAR measurement campaign


[8] Logbook of WOZ – LEG Campaign (Internal document)

[9] Instrumentation LiDAR Calibration Facility at EWTW


[12] Het lichtplatform Goeree (Ontwerp, bouw en installatie op zee)
ir. P.J. Hoogenberk – Bouwen met staal 21, september 1972
### Appendix A

**Specification of the WINDCUBE V2 LiDAR**

**Specifications**

<table>
<thead>
<tr>
<th>MEASUREMENTS</th>
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<tr>
<td>Range</td>
<td>40m to 200m</td>
</tr>
<tr>
<td>Data sampling rate</td>
<td>1s</td>
</tr>
<tr>
<td>Number of programmable heights</td>
<td>12</td>
</tr>
<tr>
<td>Speed accuracy</td>
<td>0.1 m/s</td>
</tr>
<tr>
<td>Speed range</td>
<td>0 to +60 m/s</td>
</tr>
<tr>
<td>Direction accuracy</td>
<td>2°</td>
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<table>
<thead>
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<tbody>
<tr>
<td>Power supply</td>
<td>18-32V DC / 93 to 264 VAC 50-60 Hz</td>
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<td>Power consumption</td>
<td>45W</td>
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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Temperature range</td>
<td>-30°C to +45°C / -22 °F to 108°F</td>
</tr>
<tr>
<td>Operating humidity</td>
<td>0...100 %RH</td>
</tr>
<tr>
<td>Housing classification</td>
<td>IP67</td>
</tr>
<tr>
<td>Shocks &amp; vibration</td>
<td>ISTA / FEDEX BA</td>
</tr>
<tr>
<td>Safety</td>
<td>Class 1M EC/EN 60825-1</td>
</tr>
<tr>
<td>Compliance</td>
<td>CE</td>
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</table>

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<tbody>
<tr>
<td>Size</td>
<td>System: 543 x 552 x 540 mm</td>
</tr>
<tr>
<td></td>
<td>Transport case: 665 x 745 x 685 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>System: 45 kg</td>
</tr>
<tr>
<td></td>
<td>Transport case: 21 kg</td>
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</thead>
<tbody>
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<td>Data format</td>
<td>ASCII</td>
</tr>
<tr>
<td>Data storage</td>
<td>SSD and compact flash [backup storage]</td>
</tr>
<tr>
<td>Data transfer</td>
<td>LAN/USB</td>
</tr>
<tr>
<td>Standard WINDSOFT™ Software</td>
<td>Configuration &amp; control</td>
</tr>
<tr>
<td></td>
<td>Real time display</td>
</tr>
<tr>
<td></td>
<td>Diagnostic</td>
</tr>
<tr>
<td>Output data</td>
<td>1s/10 min horizontal &amp; vertical wind speed</td>
</tr>
<tr>
<td></td>
<td>Min &amp; max. direction, SNR</td>
</tr>
<tr>
<td></td>
<td>Quality factor [data availability]</td>
</tr>
<tr>
<td></td>
<td>GPS coordinates</td>
</tr>
</tbody>
</table>
B Declaration of Eye safety compliance

Declaration of Eyesafety compliance

The Wednesday, June 16, 2010
at Orsay, France

I, Alexandre Sauvage, CEO of Leosphere Corporation, hereby testify that the WINDCUBE Lidar technology is compliant with the Laser safety IEC EN 60825-1, January 2008.

The tests of compliance have successfully been passed at the LNE, Laboratoire national de métrologie et d’essais, LNE Paris, 1, rue Gaston Boissier, 75724 Paris Cedex 15.

The compliance certification document reference is #LU207508, dated March 19, 2010.

Alexandre SAUVAGE, President

Leosphere SAS au capital de 61,752 euros - SIRET : 492 812 849 00019
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