Zandmotor LiDAR Survey

Field Report

Shore
Monitoring & Research

Shore
Monitoring & Research

Adres: Shore Monitoring & Research BV
2e Zeesluisdwarsweg 8
2583 DW, Den Haag
Nederland

Telefoon: +31(0)681280230
E-mail: info@shoremonitoring.nl
Website: www.shoremonitoring.nl
IBAN: NL89RABO0150660405
KvK: Den Haag 63003112
BTW: NL 855049431B01

Field Report

Stichting Deltares
Delivered by email to:
Bas.huisman@deltares.nl

Project: Zandmotor LiDAR Survey
Subject: Field Report
Author: L. Veltman MSc.
Internal reviewer: R.C. de Zeeuw MSc.
Reference: N201910-02_DLTRS_ZMLiDAR
Version: v1

Revision	Date	Revision Details	By	Approved
v1	24-10-2019	First Draft	LV	RZ

Contents

1 Introduction

1.1 Context

Numerous aspects of the Sand Motor project are monitored, researched and evaluated. One aspect is (juvenile) dune formation and vegetation development. Bas Arens (Bureau voor stand en duinonderzoek) and Kees Vertegaal (Vertegaal ecologisch advies en onderzoek) are researching this since 2011 for Stichting Deltares. Last year was the first year UAV LiDAR and orthophoto imagery was obtained as input for their research. SHORE is requested to prolongue the dataset.

This report describes the measurements, the instruments, and results of the measurements.

1.2 Terminology

Table 1.1: Terminology

Abbreviation:	Meaning:
SHORE	Shore Monitoring & Research BV.
SWMS	Safe Work Method Statement
PPE	Personal Protective Equipment
KNRM	Koninklijke Nederlandse Redding Maatschappij
RNLI	Royal National Lifeboat Institution
VHF	Very High Frequency
SBES	Single Beam Echo Sounding
RTK	Real Time Kinematic
PPK	Post-processed kinematics
BM	Benchmark (marker with known coordinates)
Base	GNSS receiver positioned over a BM for PPK and RTK
Rover(s)	moving GNSS receiver for positioning of platform or position measurements
LiDAR	Light Detection And Ranging
DTM	Digital Terrain Model
DSM	Digital Surface Model

1.3 Project Scope of Work

Stichting Deltares has commissioned SHORE to execute measurements with UAV LiDAR to obtain a high resolution DTM and orthophoto at the Sand Motor for research into dune development. The research will be carried out by Bas Arens and Kees Vertegaal.

1.4 Area of Interest

The area of interest consists of 5 areas perpendicular to the first dune row. For efficient measurements and processing the envelop of the 5 areas is measured (Fig. 1.1).

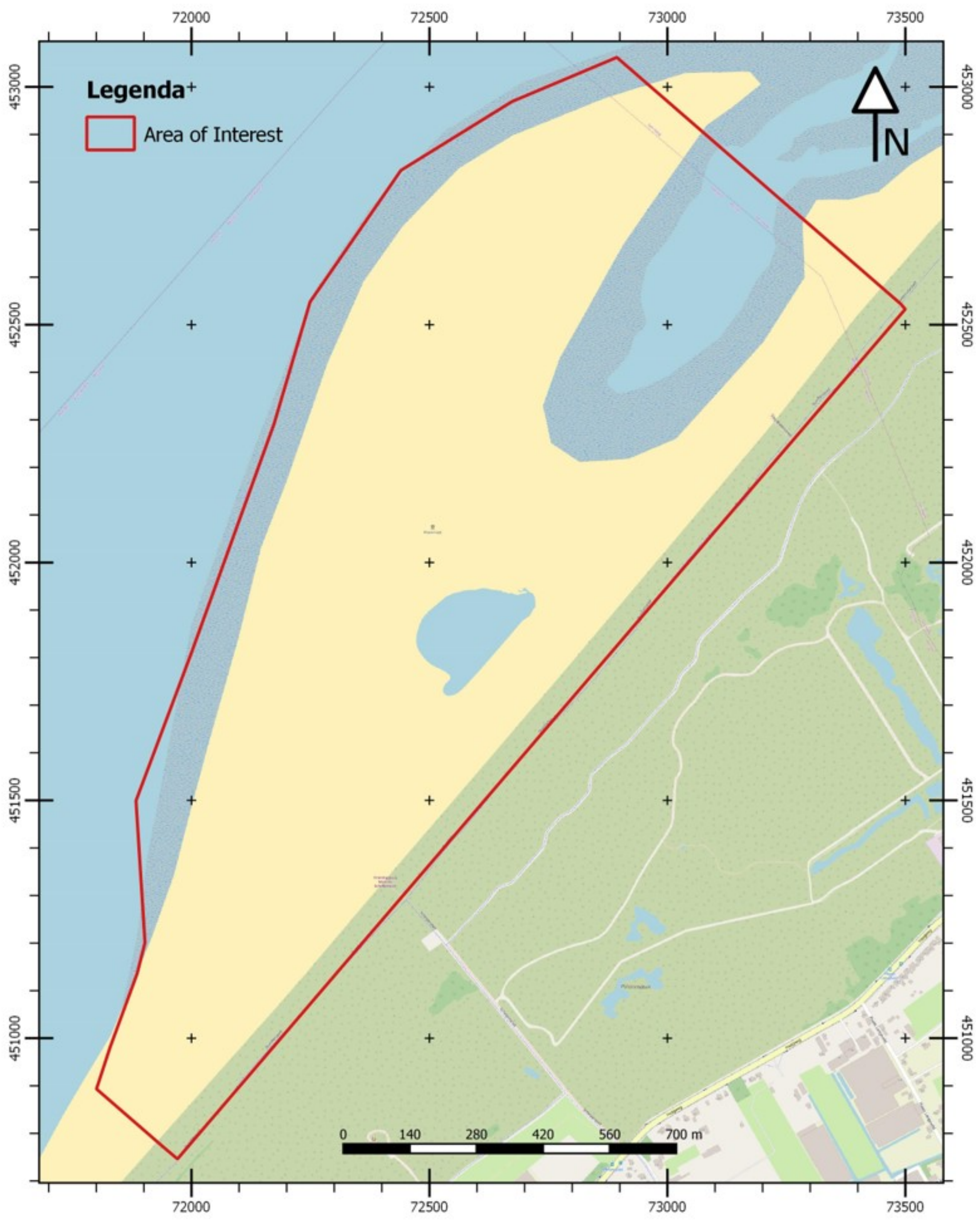


Figure 1.1: Survey area

2 Deliverables

The following deliverables are agreed upon with the client:

- DTM of 25x25 cm resolution in RDNAP
- Orthophoto of 1.5 cm and 5 cm resolution in RD

3 Survey Strategy

This chapter describes the executed survey strategy and survey plans designed to obtain the desired data:

- A local benchmark is used to provide rovers with GNSS correctoins
- Ground Control Points are placed and installed to georeference the orthophoto in the desired CRS
- A UAV equipped with a mobile LiDAR system and RGB camera is used to measure the topography and shoot the images for the orthophoto.
- A GNSS on a wheel is used to obtain height validation data in the AOI

3.1 Topography and orthophoto with UAV LiDAR survey system

3.1.1 Flight plan

The flight plan for the UAV LiDAR flights is presented in Fig. 3.1. Altitude, lines spacing, velocity and overlap are designed to meet the desired deliverables (Tab 3.1).

Table 3.1: Flightplan specifications

Parameter	**Value:**
Altitude	50 m
Velocity	8 m/s
Line spacing	35 m
Lateral overlap images	60 %

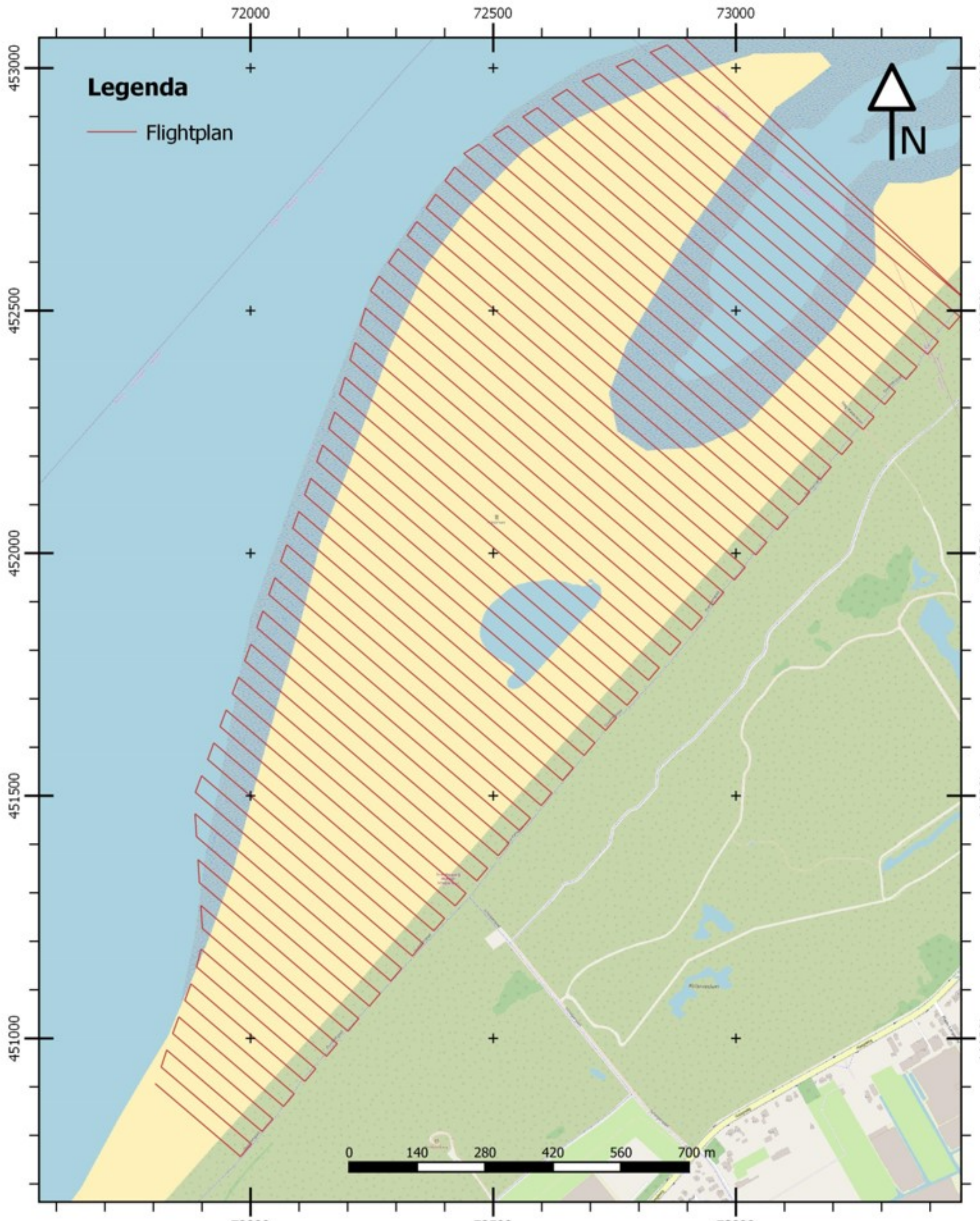


Figure 3.1: Flightplan

3.1.2 GCP plan

Ground control points are placed according to the plan visualised in Figure 3.2

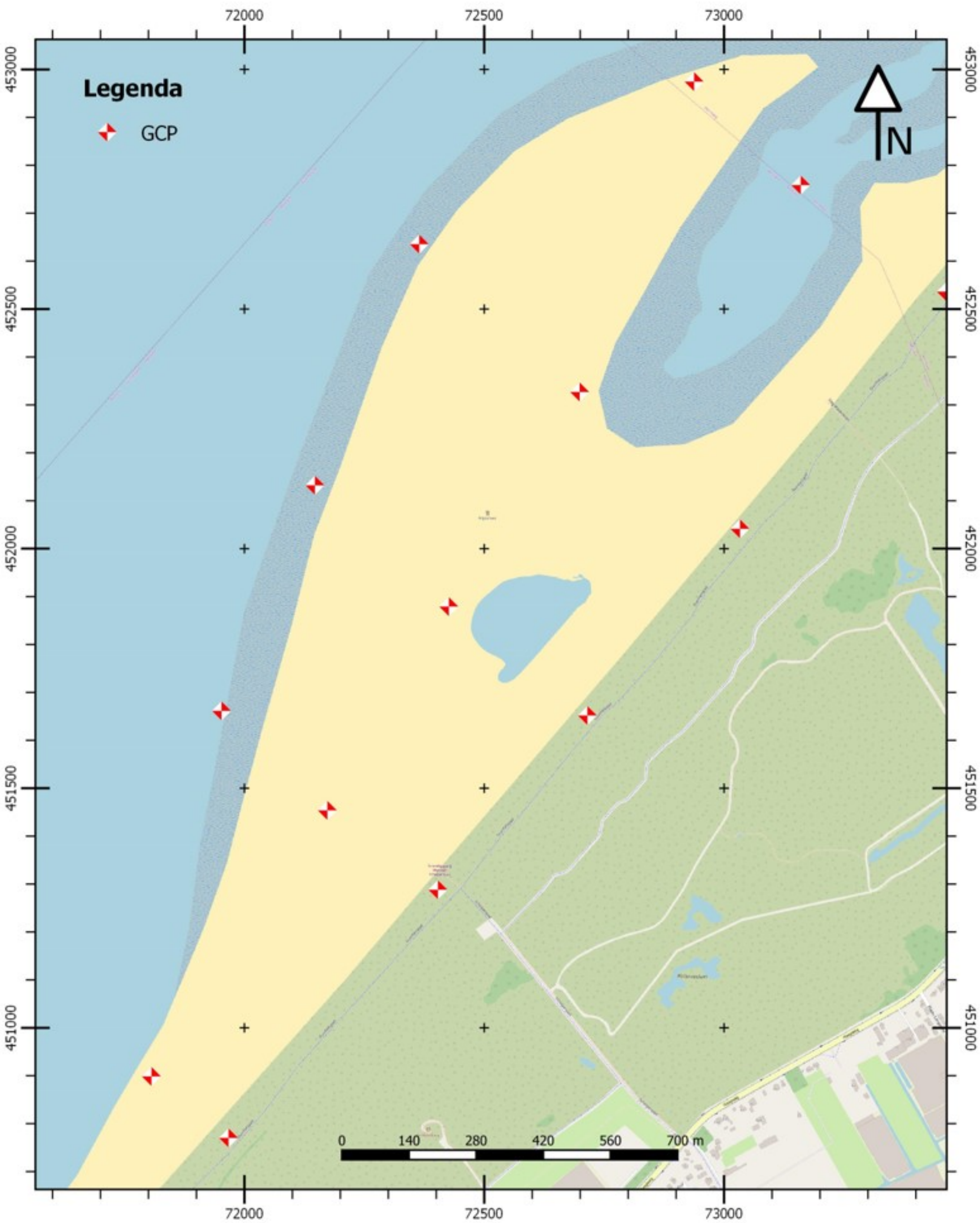


Figure 3.2: GCP plan

4 Survey Equipment

The survey equipment used for the project is:

- AL3-32 mobile LiDAR system on a UAV
- Leica GX1230GG GNSS base station on a tripod
- Leica GS14 GNSS rover for validation data

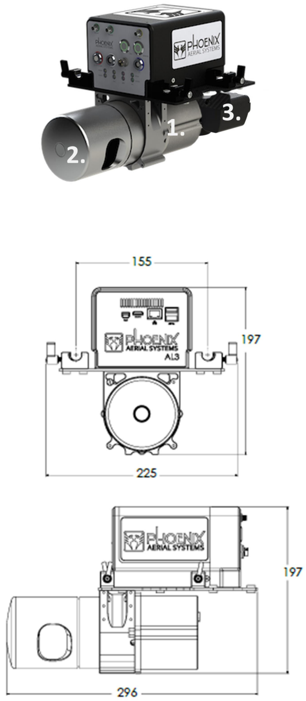
For detailed information on the equipment and general methodology, reference is made to the associated appendices. The equipment is briefly discussed below.

4.1 UAV LiDAR system

SHORE uses the AL3-32 mobile LiDAR system by Phoenix LiDAR Systems Inc. The system is usually mounted to a UAV, car or boat. Operation of the systems sensors is independent of the platform it is attached to. Figure 4.1 shows the system on an M600pro, with annotations of the different components.

Figure 4.1: Mobie LiDAR system on DJI M600pro. Components annotated.

The system consists of a KVH1750 Fiber Optic Gyro IMU (Fig. 4.2 annotation 1), Velodyne HDL32e laserscanner (Fig. 4.2 annotatio 2), Sony A6000 RGB-camera (Fig. 4.2 annotation 3) and a mini Linux computer which controls and collects instrument data. The IMU forms the heart of the system. Translations and angular offsets between GNSS antenna, camera and laserscanning were measured and preset into the systems software.



PLATFORM	
OVERALL DIMENSIONS	296 x 225 x 197 mm
OPERATING VOLTAGE	12-28 V
POWER CONSUMPTION	~40 W
WEIGHT	3.2 kg
1. NAVIGATION SYSTEM	
DUAL-ANTENNA / HEADING	Optional
CONSTELLATION SUPPORT	GPS[2], GLONASS[2], Galileo[1], BeiDou[1] [1] Single frequency, dual-frequency optional [2] Dual-frequency
SUPPORT ALIGNMENT	Kinematic, Dual-Antenna
OPERATION MODES	Real-time, Postprocessing optional
ACCURACY POSITION	1cm + 1ppm RMS horizontal
ACCURACY PITCH/ROLL	0.015 deg RMS
ACCURACY HEADING	0.08 deg RMS
2. LiDAR SENSOR (HDL-32e)	
LASER POWER	Class 1 (safe eye)
LASER WAVELENGTH	905 nm
MIN RANGE	1.0 m
MAX RANGE	120 m
MAX RANGING ERROR	20 mm
RANGE RESOLUTION	2 mm
SCAN RATE	700k shots/s, up to 1.4 million points/s
FIELD OF RANGE	+10°, -30° Vertical FOV / 360° Horizontal FOV
MULTIPLE ECHOES	2
POWER CONSUMPTION	12 W
DIAMETER/HEIGHT	85.34 * 144.24 Mm
WEIGHT	1,050 g
OPERATING TEMPERATURE	-10° / 60° C
INGRESS PROTECTION	IP 67
NUMBER OF LASERS/ PLANES	32
RECOMMENDED SCANNING HEIGHT AGL (m)	20 - 60 m

Figure 4.2: Factsheet AL3-32 Mobile LiDAR system.

4.1.1 Calibratie

The system is annually calibrated (boresighted) in a test environment of Phoenix LiDAR Systems.

4.1.2 Real time data link and sensor control

The system can be operated via WiFi or 3G (ethernet in case of a car/boat set up) to which the ground station and mobile system are connected. RTK-GNSS corrections can be streamed via ntrip, UHF, WiFi or 3G. The operator controls the sensors with the ground station. Sensor status and real time building of the point cloud are monitored throughout the flights.

4.2 Base station equipment

SHORE uses a Leica GX1230GG GNSS receiver on a tripod as base station (Fig. 4.3). Manufacturers specifications are presented in Table 4.1.

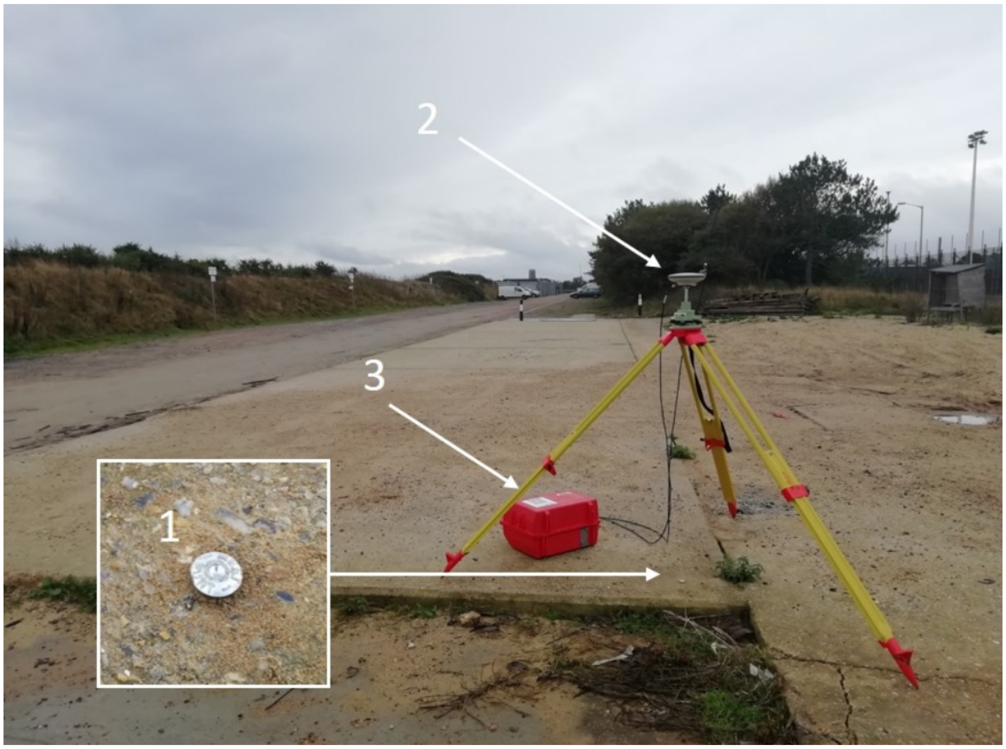


Figure 4.3: Typical base station set-up

Table 4.1: Base station GNSS specifications based on the manufacturer's declaration.

Instrument:	Brand and type:	Accuracy:
GNSS	Leica GX1230GG	± 2 cm + 1 mm/km

Receivers and antennas are checked on fixed RD points in the Netherlands on a yearly basis.

4.3 Topography GNSS rover equipment

SHORE uses several Leica Viva GNSS receivers for GNSS measurements (Fig. 4.3). Manufacturers specifications are presented in Table 4.2.

Figure 4.4: Typical rover set-up

Table 4.2: GNSS rovers specifications based on the manufacturer's declaration.

Instrument:	Brand and type:	Accuracy:
RTK-GNSS	Leica GS10/GS14	$\pm$ 2 cm + 1 mm/km

Receivers and antennas are checked on fixed RD points in the Netherlands on a yearly basis.

5 Results

Results of the measurements and delivered products are presented below.

5.1 LiDAR Results

The results of the LiDAR measurements are presented in the following figures:

1. Orthophoto of the AOI, including the location of the gcps. (Fig. 5.1).
2. DSM of the AOI, including vegetation, buildings, objects etc. (Fig. 5.2).
3. DTM of the AOI, based on only ground point, so excluding vegetation, buildings, objects etc. (Fig. 5.3).

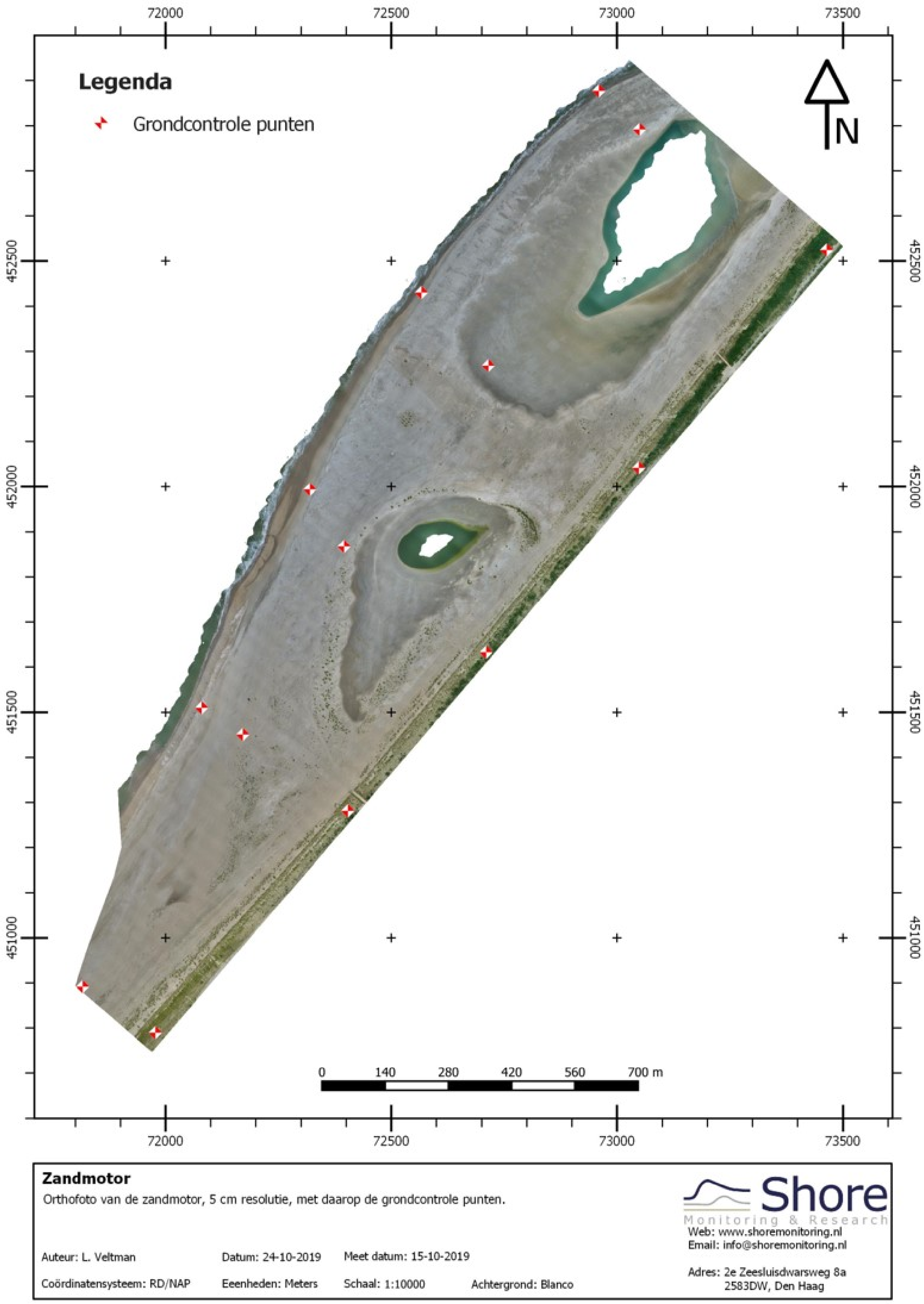


Figure 5.1: Orthophoto with ground control points

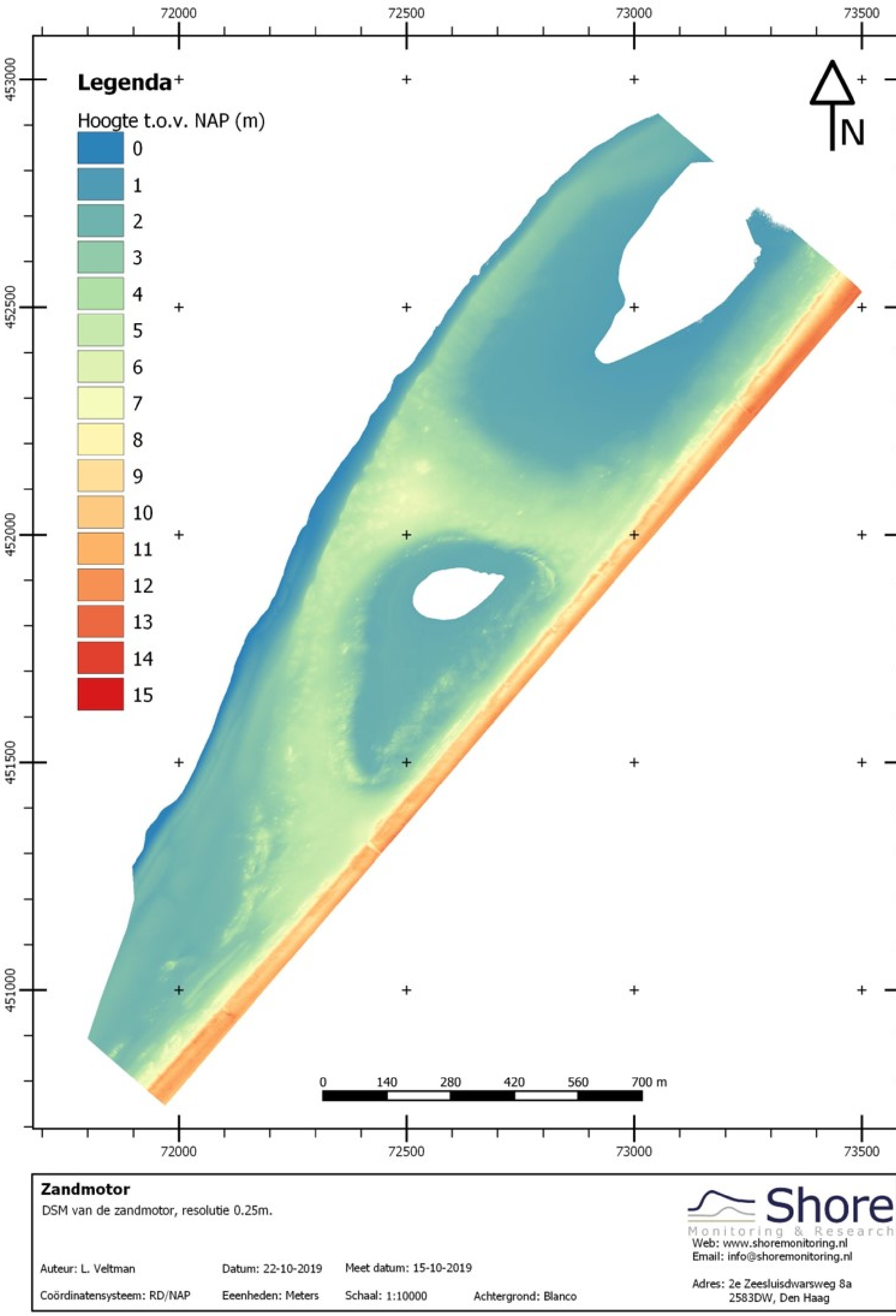


Figure 5.2: Digital Surface Model (**no** classification of ground points)

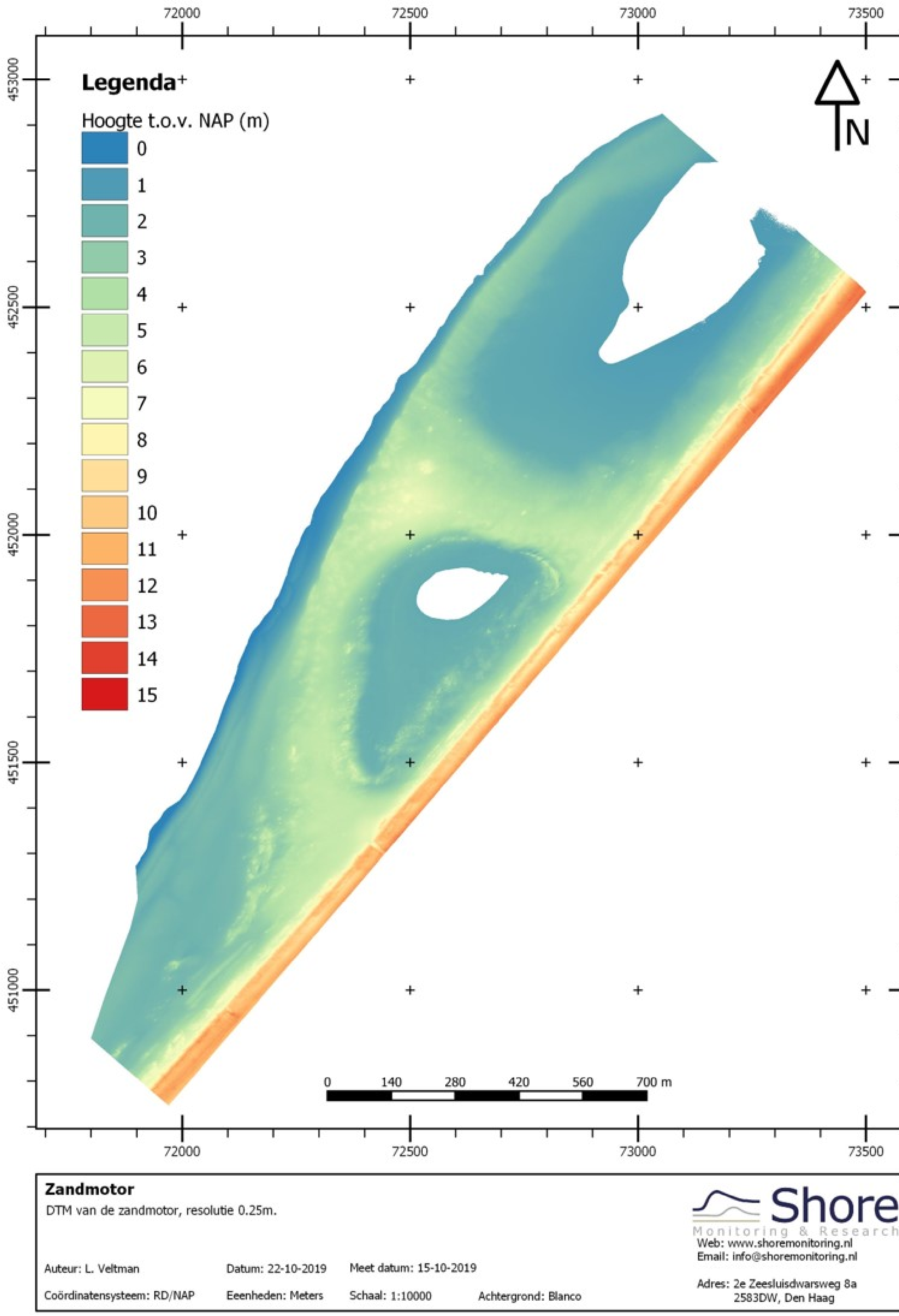


Figure 5.3: Digital Terrain Model (classification of ground points)

6 Quality assurance checks in the field

Strict quality assurance procedures are used to assure the quality of the final data products. Checks are performed in four stages:

1. Preparation of instruments before deployments/survey
2. Deployment/execution of survey
3. Post-processing of collected data
4. Validation of the collected data with requirements

To assure all necessary checks are performed (e.g. check on sensor-status, entered parameters etc.) checklists are used and completed with a photo or print screen. These are uploaded and processed to Quality Assurance reports for internal use and control by the Lead Surveyor and Project Manager during operations.

Results of specific QA checks are presented below:

6.1 Validation results of topographic UAV LiDAR and RGB-orthophoto measurements

Validation results are shown in the figures below.

- Height validation: elevation difference between DTM and GNSS measurements (Fig. 6.1)
- Planimetric validation: comparison of GNSS and LiDAR measurements of 3D objects (Fig. 6.2).

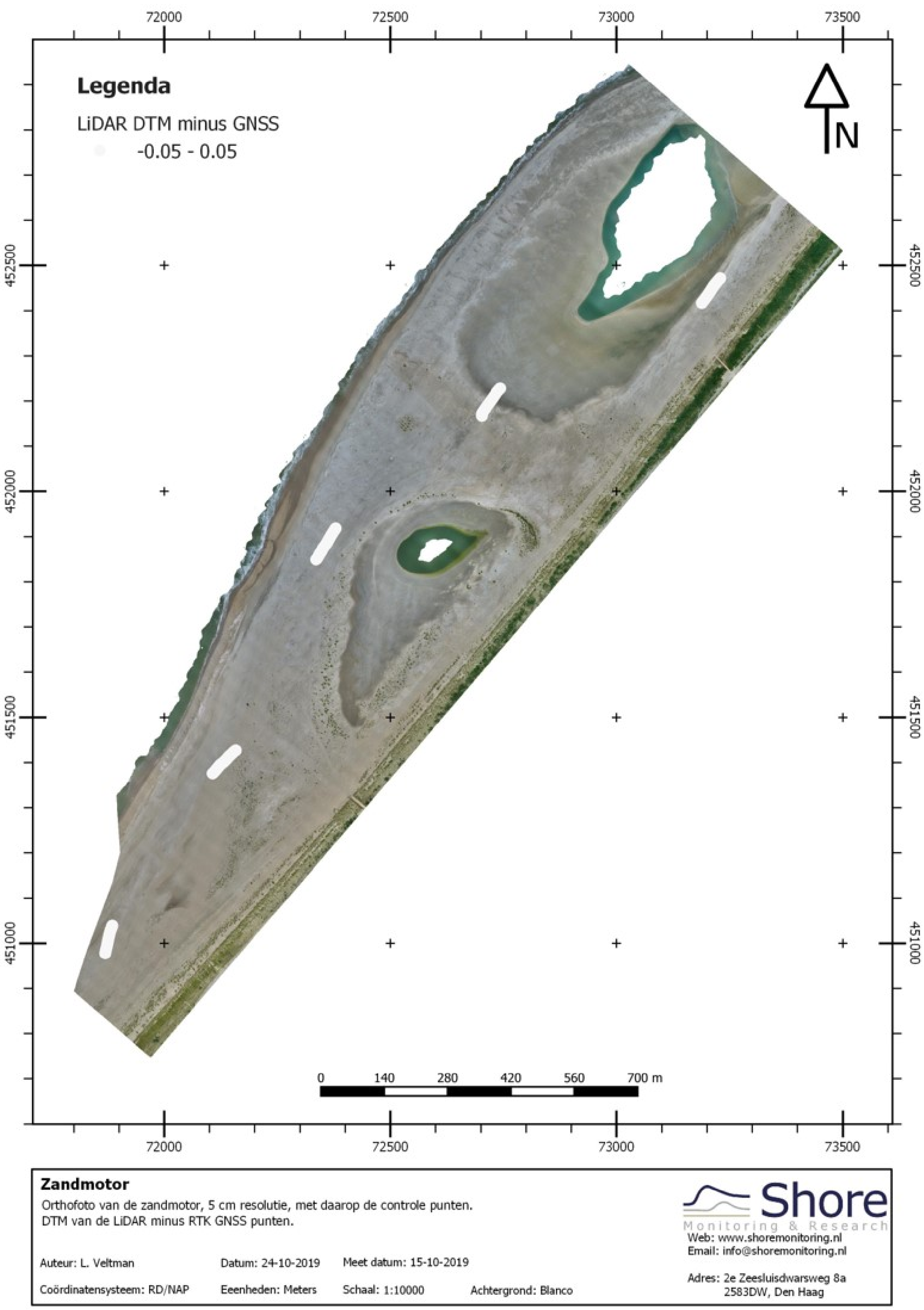


Figure 6.1: Orthophoto with coloured dots, indicating elevation difference DTM - GNSS

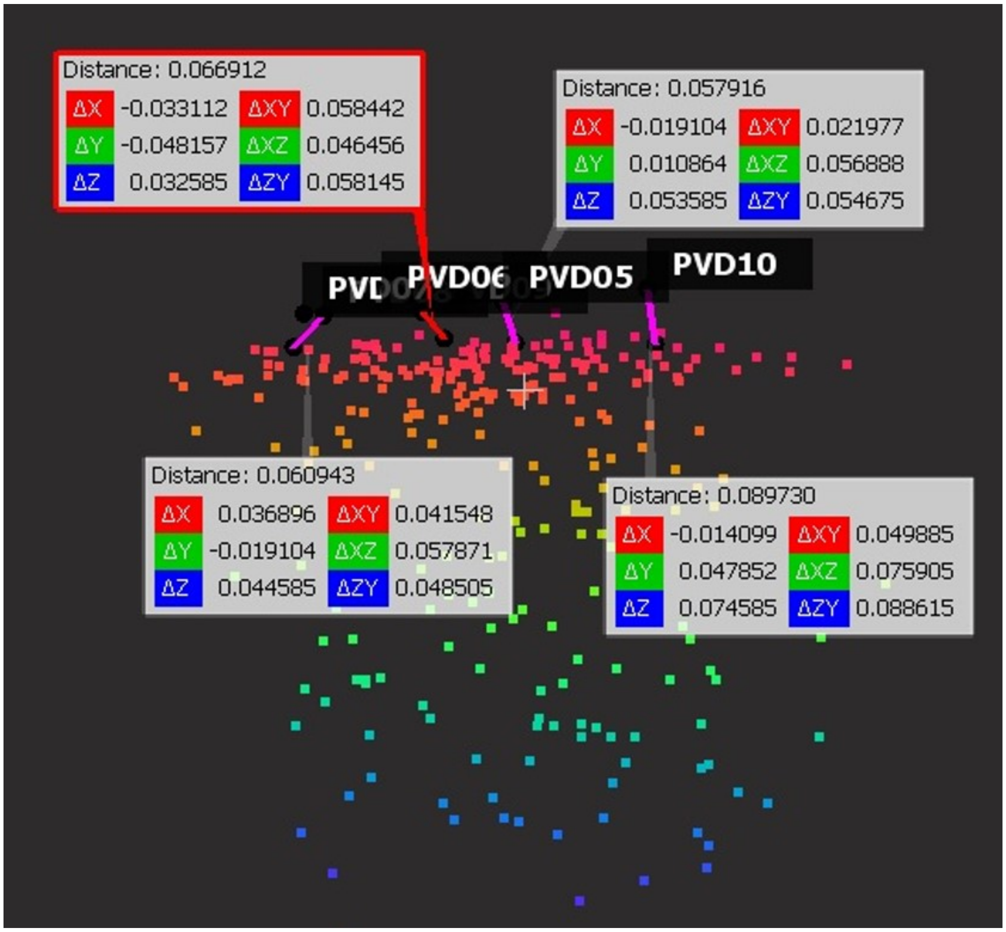


Figure 6.2: Planimetric result: GNSS and LiDAR measurement of 3D object.

7 Deviations from deliverables

Deviations from the agreed deliverables are documented here below, if any.

8 Observations

Photos are included below to provide an impression of the measured area and measurements.

Figure 8.1: Recently developed embreyo dunes. Strong autumn winds and 'sea rocket' start the creations of new sand dunes. Photo taken close to the dunelake.

Figure 8.2: Near the southern end of the area, on the big open fields a stroke of 'beach grass' is visible. Surrounded by car tracks, the new vegation still manages to survive.