

Survey Innovations

**1st FIG Young Surveyors
European Meeting (Lisbon)**

**DRAVOSA Survey Department
17-18 october 2013**



PUMA Survey Innovations




VanOord Survey Department
17 october 2013

PUMA Organization



- Boskalis 50%
- Van Oord 50%



 Koninklijke
Boskalis Westminster nv

Van Oord



Port investments Rotterdam

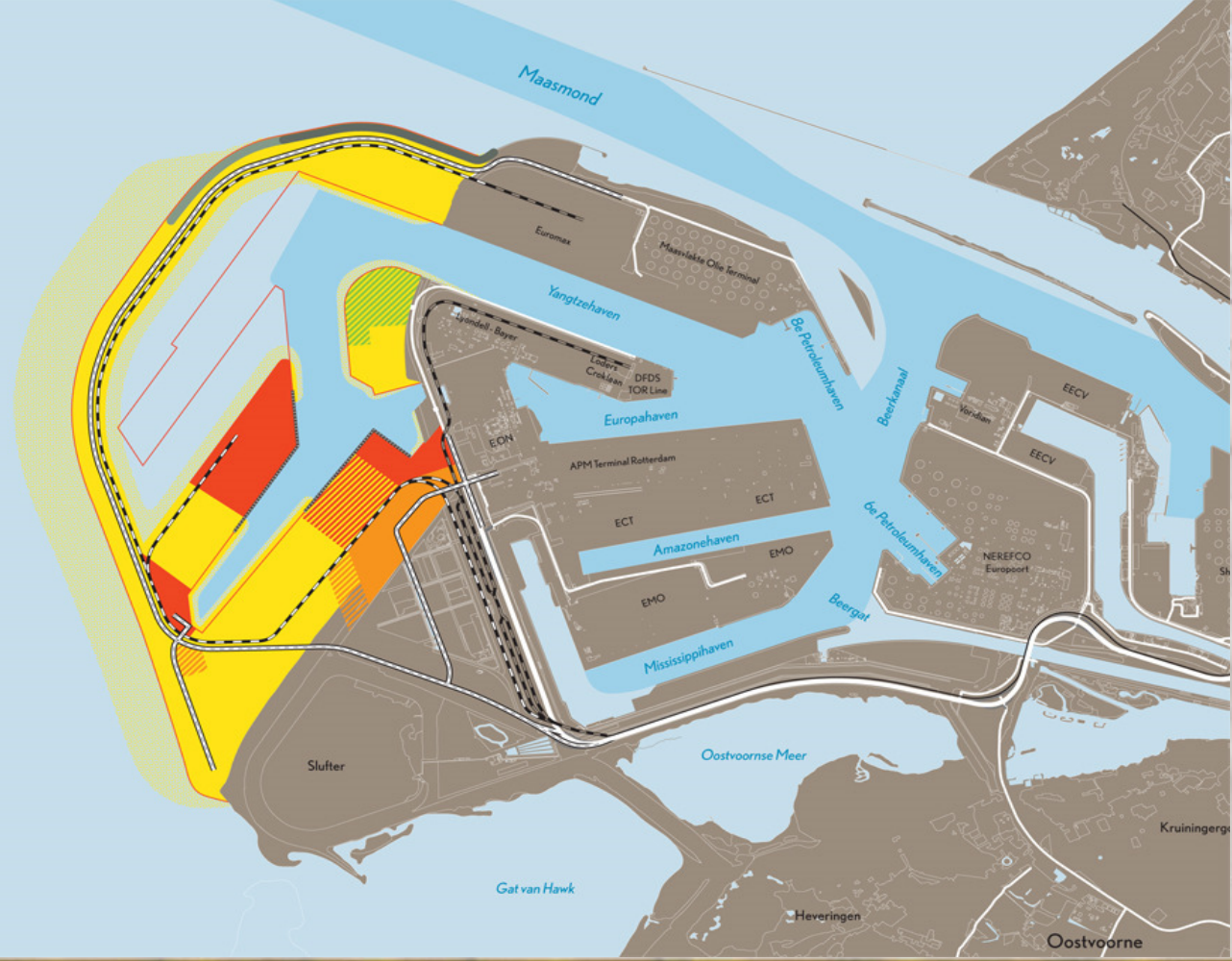
- MV2 2,9 billion (total till 2030)
including connection with MV1,
including PUMA
- Contract PUMA 1,1 billion (Construction 1st fase)
including 200 million BAVO-MV2

Contract 1 – 2013

Seawall Defence and Port Reclamation (Phase 1)

2013

Noordzee



Final Phase - 2030

2030

Noordzee



Maasvlakte 2 in 2030



December 2008



January 2010



January 2011



February 2012



February 2012



July 2012



Contract 1

Seawall Defence and Port Reclamation (Phase 1)

Hard Seawall Defence 3.5 km

Beach and dunes 7.3 km

Harbour basins 530 ha

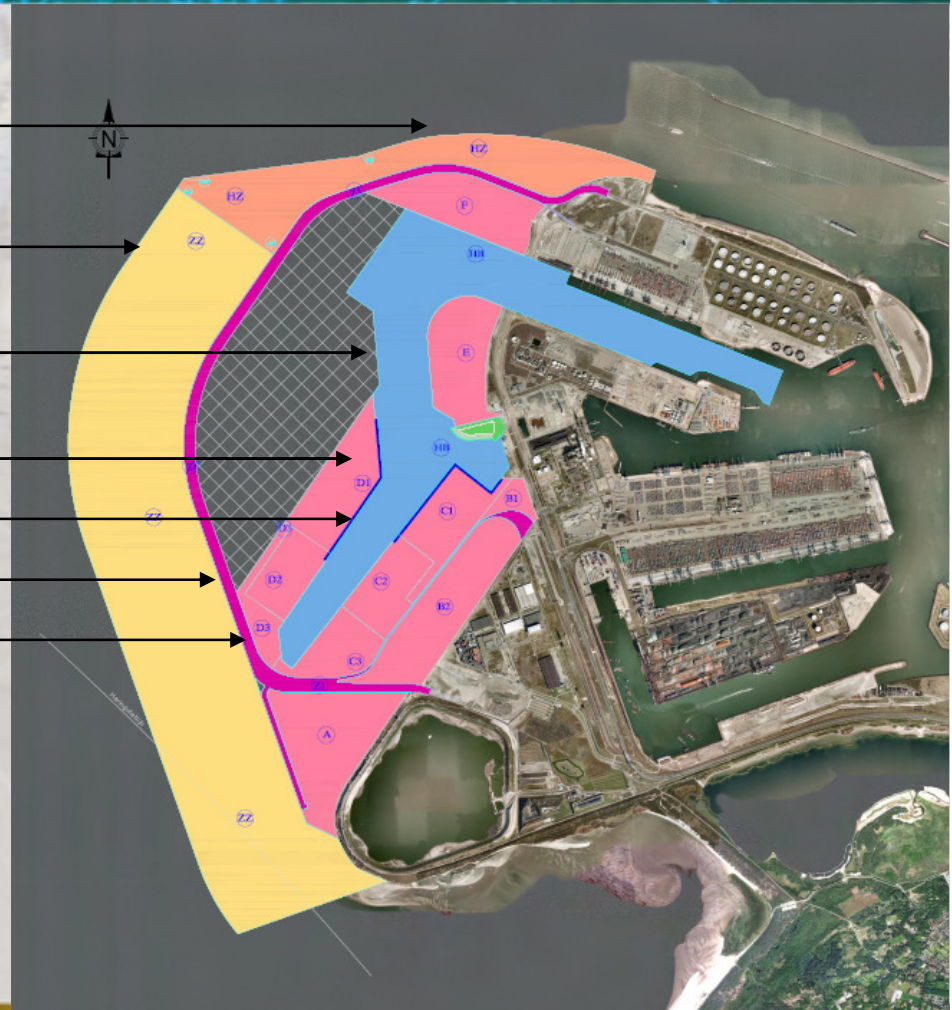
Port Reclamation 700 ha

Quaywalls 3.5 km

Roads 13 km

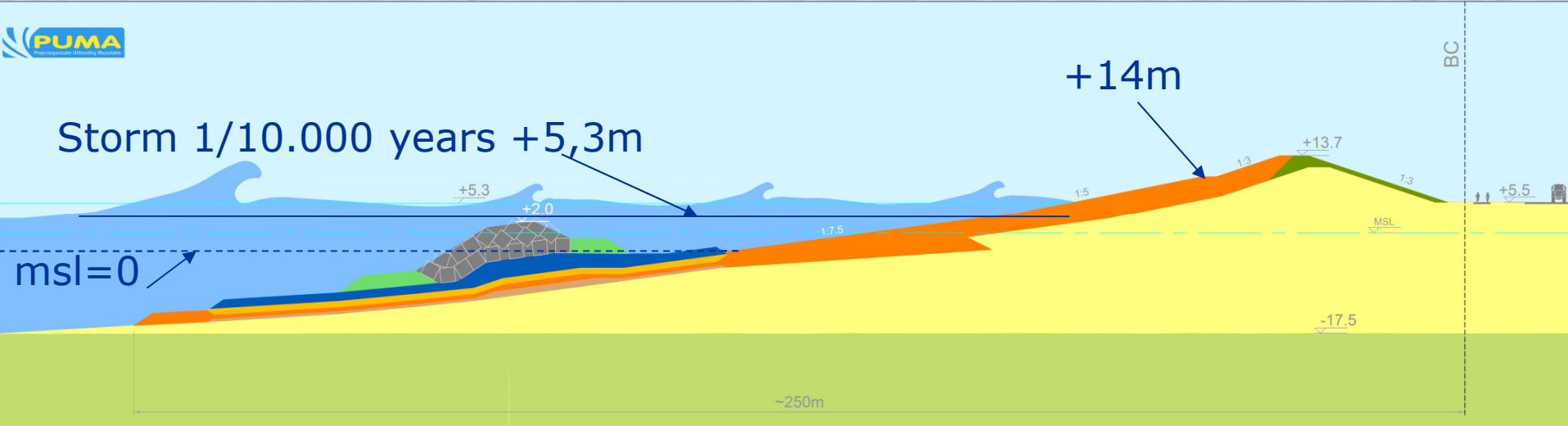
Railroads 14 km

- 240 million m³ sand
- 7 million ton stone
- 20.000 concrete blocks (40T/piece)

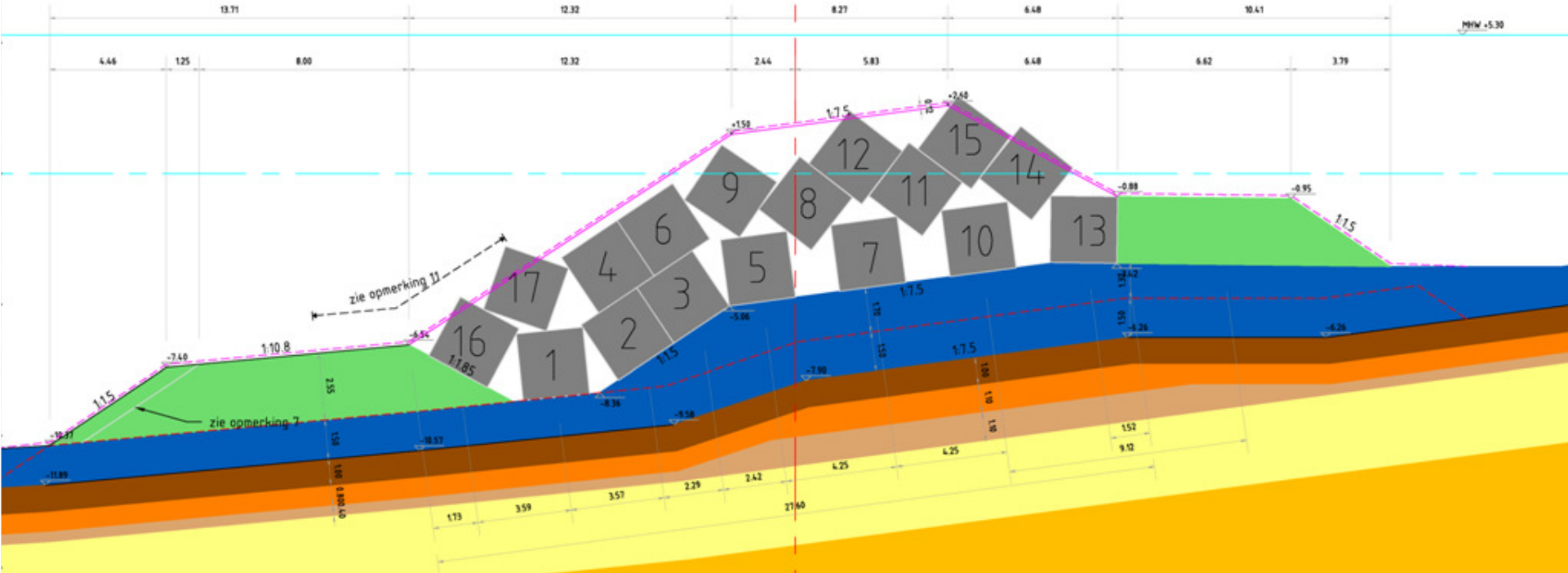


Hard Seawall Defence

Total length 3,5 km



Theo Model



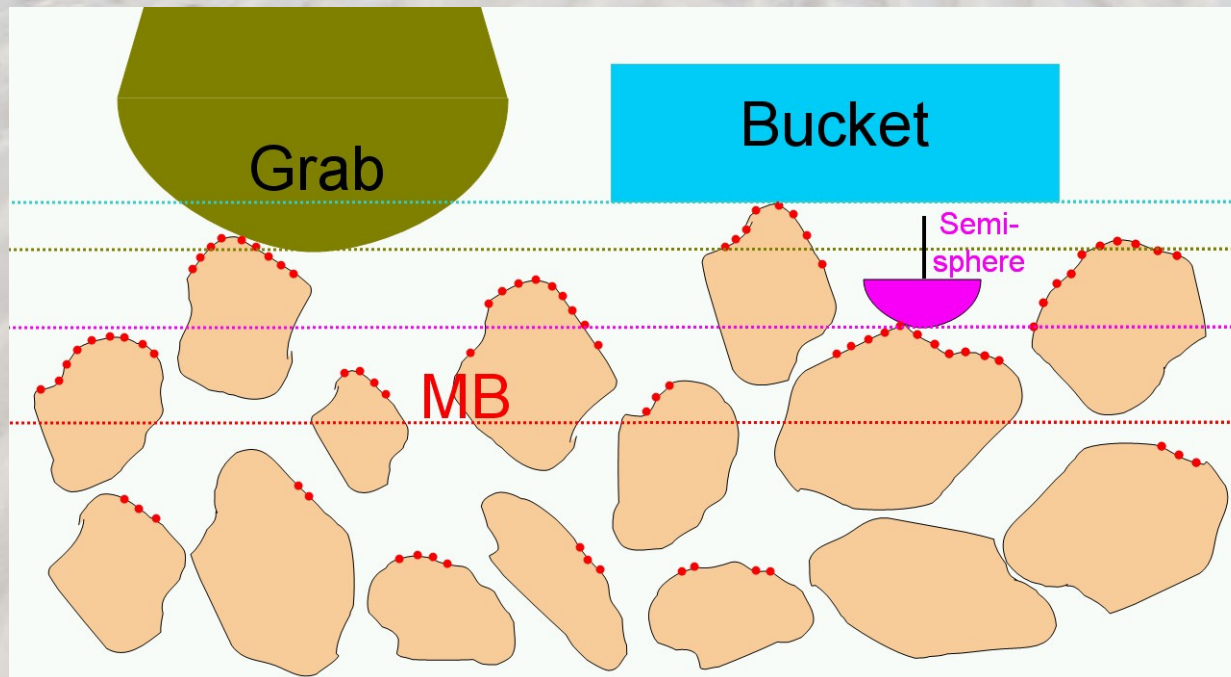
Rock Works

- Approximately 5.5 million tons of rock from european stone quarries.
- About 1.6 million tons of reuse stone from MV1 block dam.
- 9,558 concrete blocks reused from MV1 block dam



Measurement methods on rock placement

Understanding the differences in measurements of the average bed elevation between different measurement systems, that can possibly be used on the construction of the Hard Seawall



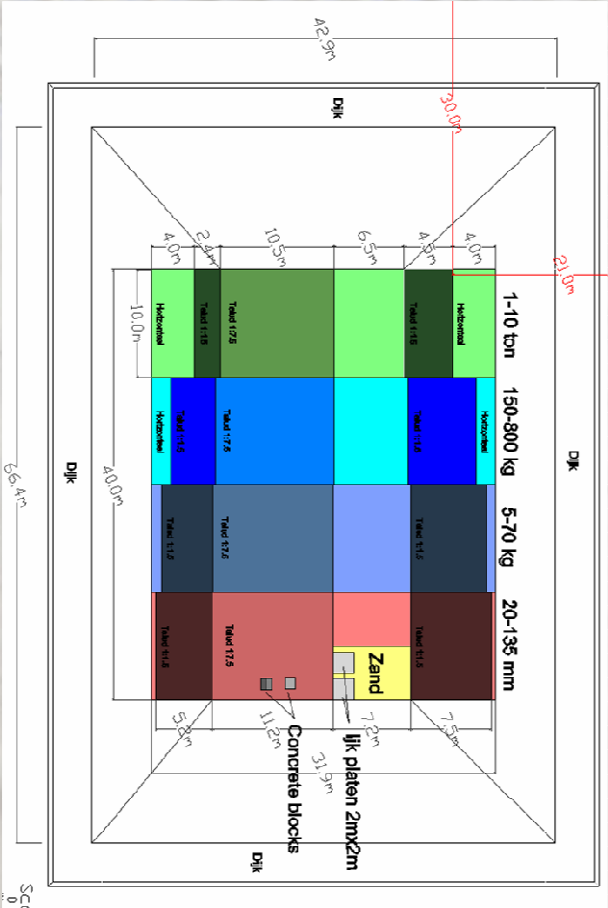
Test Pit

Comparison of different topographical - and contact measurement methods, acoustic measurement techniques, and laser techniques

- Dry Excavation - Hard Seawall 1:1 scale
- Start construction end of 2009



Test Pit PUMA 2010 & Verolme dock 1999



Test Pit – Dry Measurements

- Semi-spherical measurement
 - Diameter of the half-sphere is equal to the half of the nominal stone diameter.
 - Measurements are carried out in a 1m x 1m grid
- Point measurement



Test Pit – Dry Measurements

- Plate measurements
 - 1m x 1m tot 150-800kg
 - 2m x 2m voor 1-10 ton



Test Pit – Dry Measurements

- Grab measurement
- Bucket measurement



Test Pit – Dry Measurements

- One size bigger!



Test Pit – Dry Measurements

- Static Laser Scan measurement
- Mobile Laser Scanning measurement
- Fli-map



FUGRO Fli-map



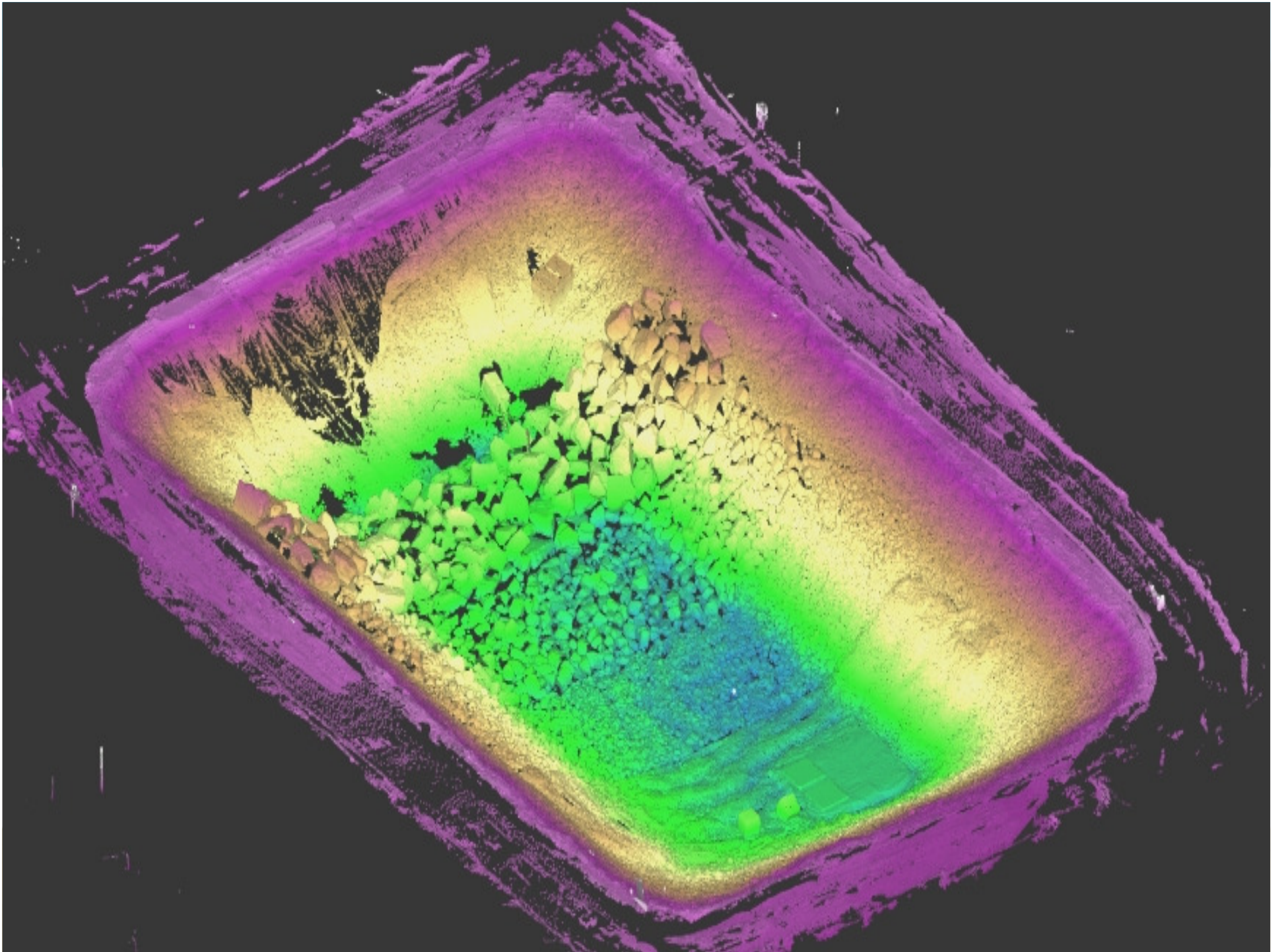
MDL LacerACE



Leica



SICK LMS151



Test Pit – Underwater Measurements

- Multi-beam Reson Seabat 8125
- Multi-beam Reson Seabat 8101
- Multi-beam R2Sonic 2024
- Multi-beam R2Sonic 2022
- Multi-beam Kongsberg EM3002
- Multi-beam Odom ES3
- Echoscope CodaOctopus-II (375 KHz & 610 KHz)
- Single-beam Reson Navisound 215, 200 KHz met 3° en 9° Δ



Test Pit – Underwater Measurements

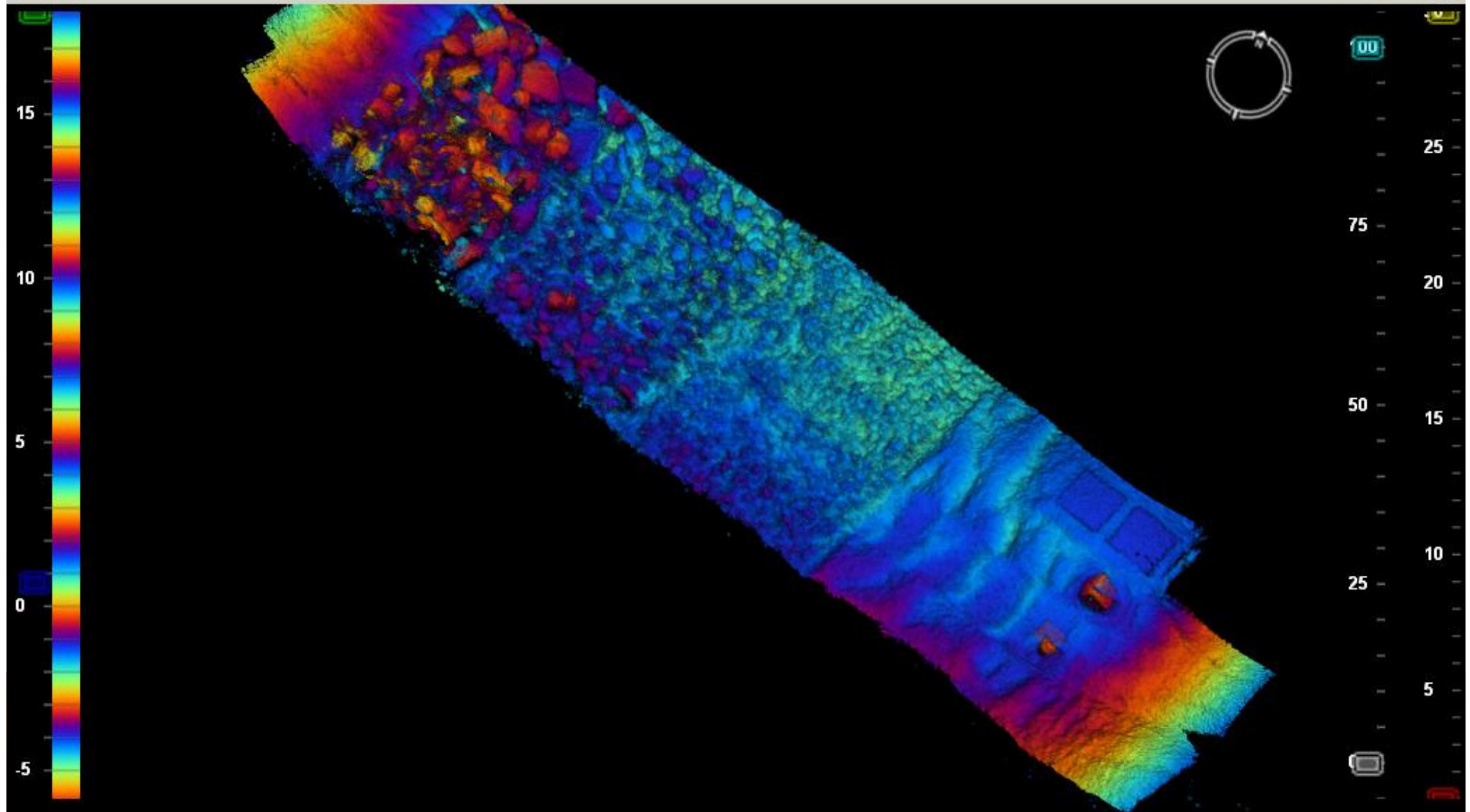
- Setup measurements and Calibration on dry, with different equipment.



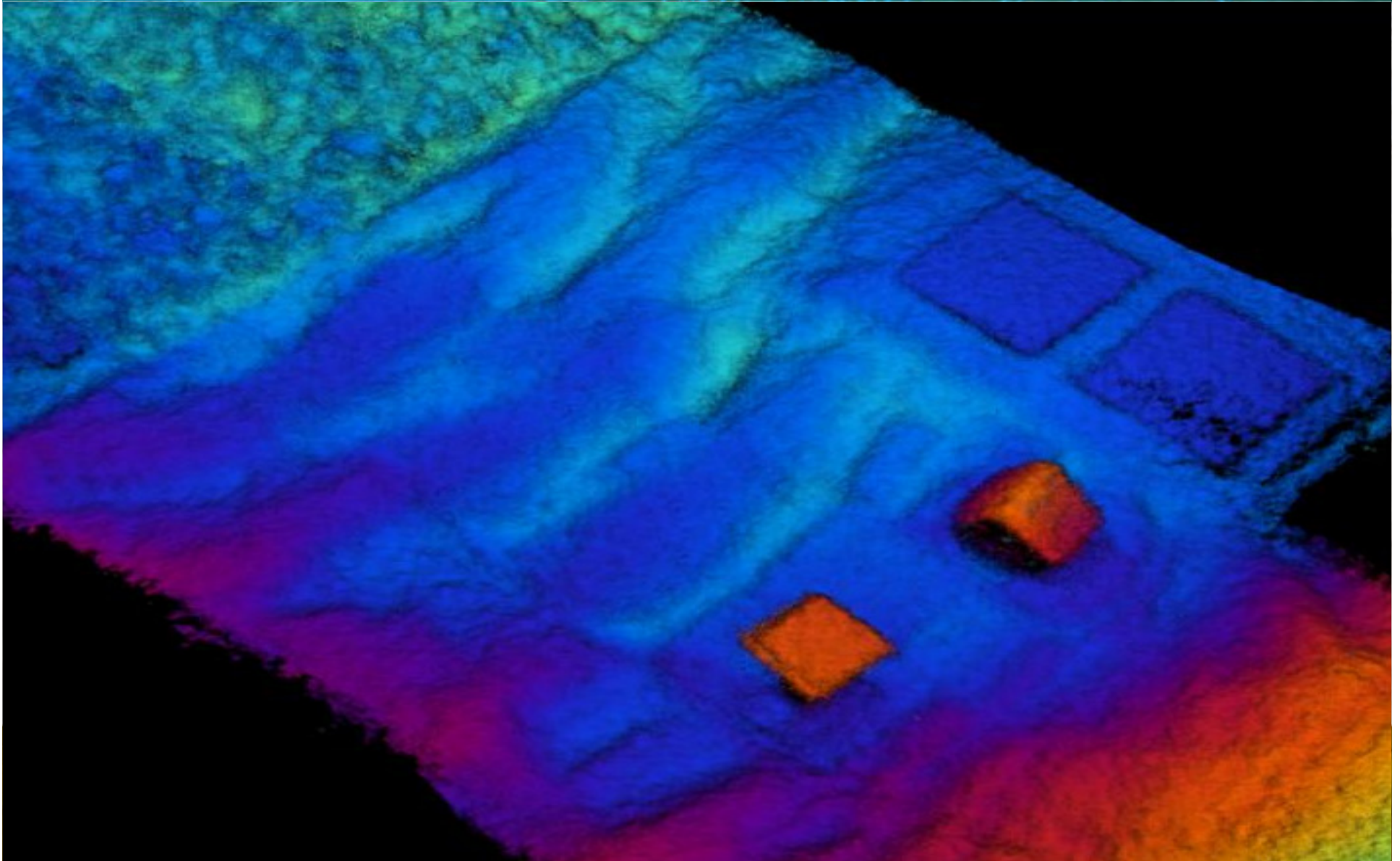
Test Pit – Echoscope data

www.codaoctopus.com

C:\Users\Tom.Barr\Desktop\PUMA3\PICTURES OF DATA\sd3D16.jpg



Test Pit – Echoscope data



Test Pit – Results

Survey System	Sand		20-135 mm		5 - 70 kg		150 - 800 kg		1 - 10 t	
	Systematic Error	Precision	Systematic Error	Precision	Systematic Error	Precision	Systematic Error	Precision	Systematic Error	Precision
Total station – plate	n.a.	n.a.	0.07	0.08	0.12	0.09	0.14	0.15	0.11	0.17
Total station – point	n.a.	n.a.	n.a.	n.a.	-0.07	0.07	-0.13	0.19	-0.27	0.51
Excavator – bucket ¹	n.a.	n.a.	0.17	0.13	0.14	0.15	0.34	0.27	0.32	0.40
Excavator - orange peel ²	n.a.	n.a.	0.17	n.a.	0.08	0.11	0.18	0.21	0.20	0.36
Excavator – sorting	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0.14	0.22	0.18	0.32
Single-beam	0.01	0.03	0.08	0.08	0.08	0.11	0.09	0.18	0.06	0.26
Multi-beam / Echo-scope	-0.01	0.02	-0.03	0.06	-0.11	0.09	-0.19	0.15	-0.38	0.26
Static laser	-0.01	0.05	-0.01	0.06	-0.04	0.10	-0.05	0.15	-0.18	0.23
Crane based laser	0.02	0.05	0.04	0.07	-0.01	0.10	-0.08	0.15	-0.25	0.24
Fli-map laser	0.00	0.06	-0.06	0.09	-0.12	0.10	-0.17	0.18	-0.36	0.27

Test Pit – Final Results

Results are included in the new edition of "Make and Measurement Accuracies in the execution of dredging and rock placement" ”

- **Maak- en Meetnauwkeurigheden** bij de uitvoering van baggerwerken en steenbestorringen



Sand – 240 million m³ for fase 1



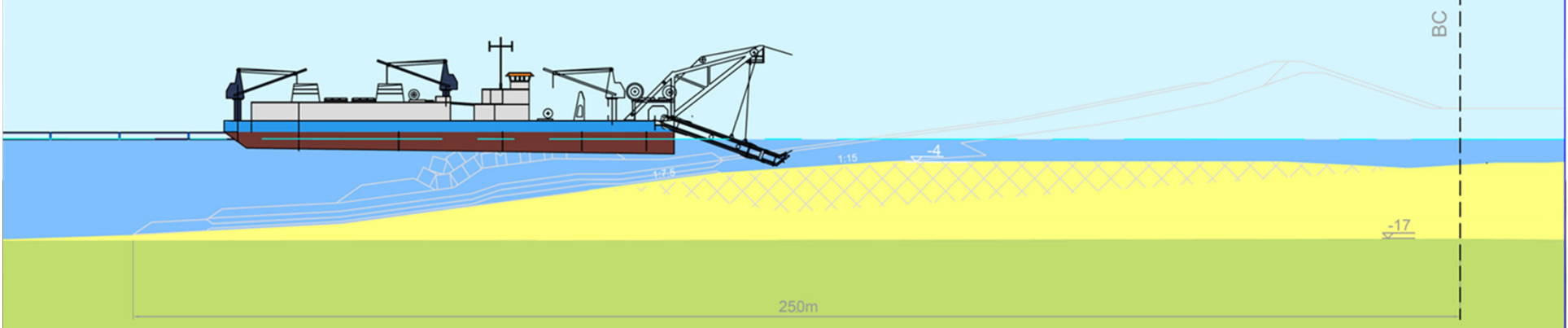
Construction hard seawall

Building sand profile



aanleg zandkern met sleeplopperzuiger + drijvende leiding + sproeiponton

aanleg Harde Zeewering

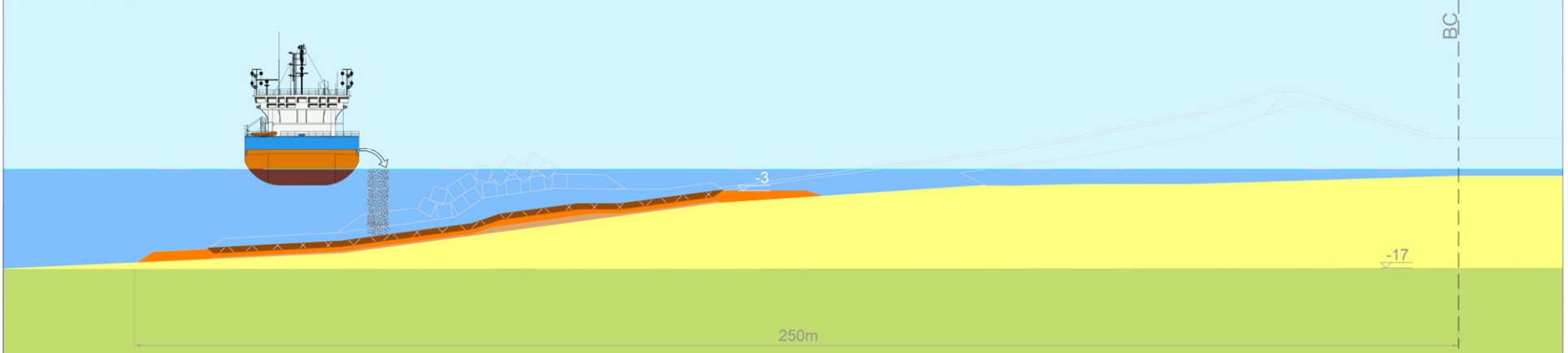


Construction hard seawall Rock dumping underwater

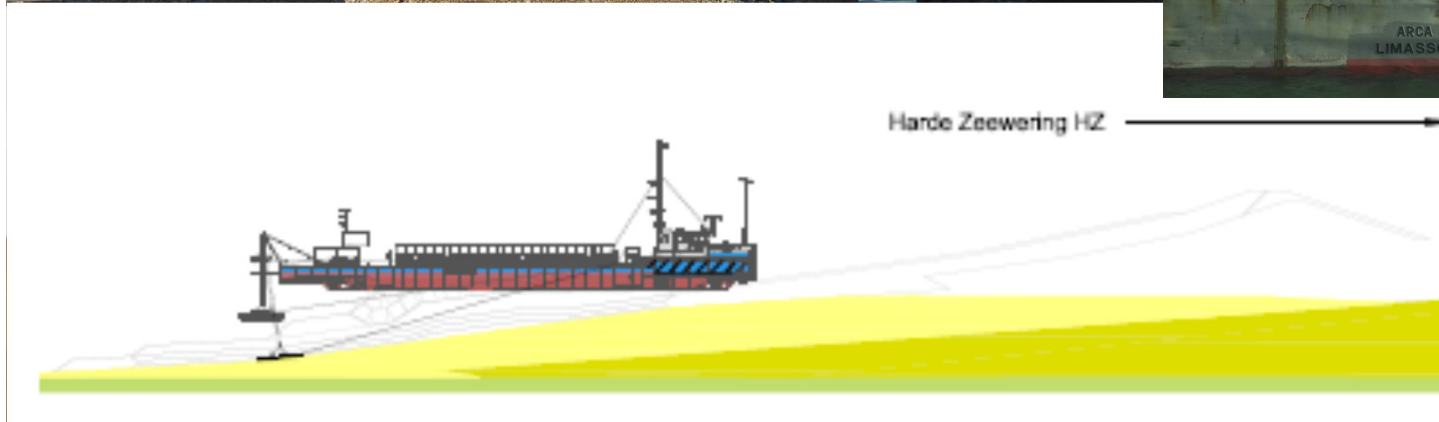


plaatsen breuksteen onderlaag met steenstorter

aanleg Harde Zeewering



Profiling sand and stone Plough Ship – Arca



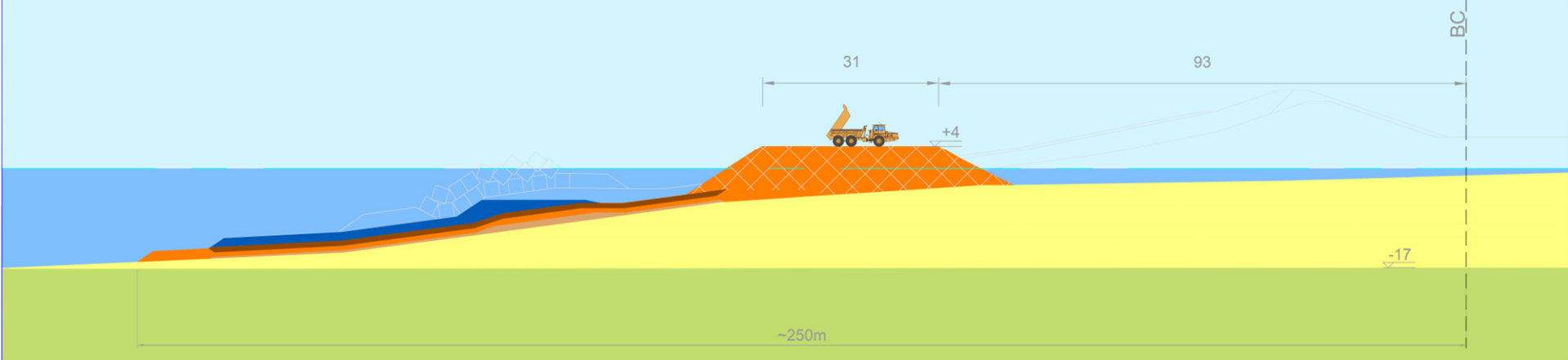
Construction hard seawall

Construction temporary work acces



plaatsen breuksteen werkbaan met dumper trucks

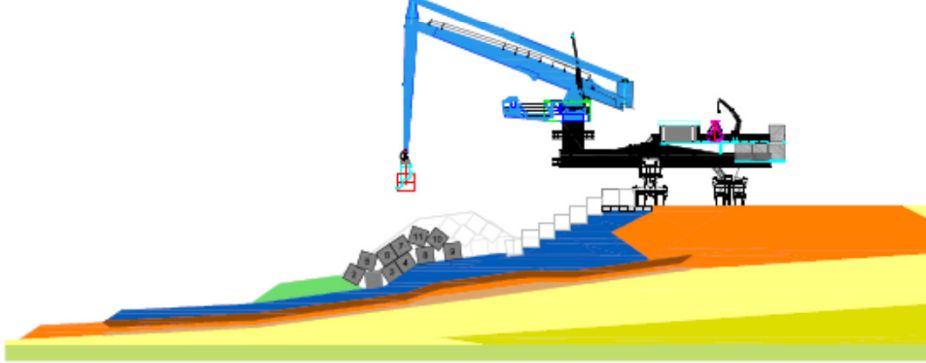
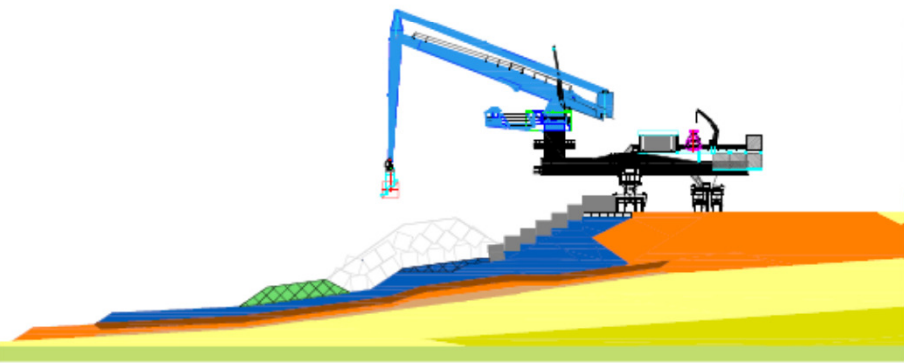
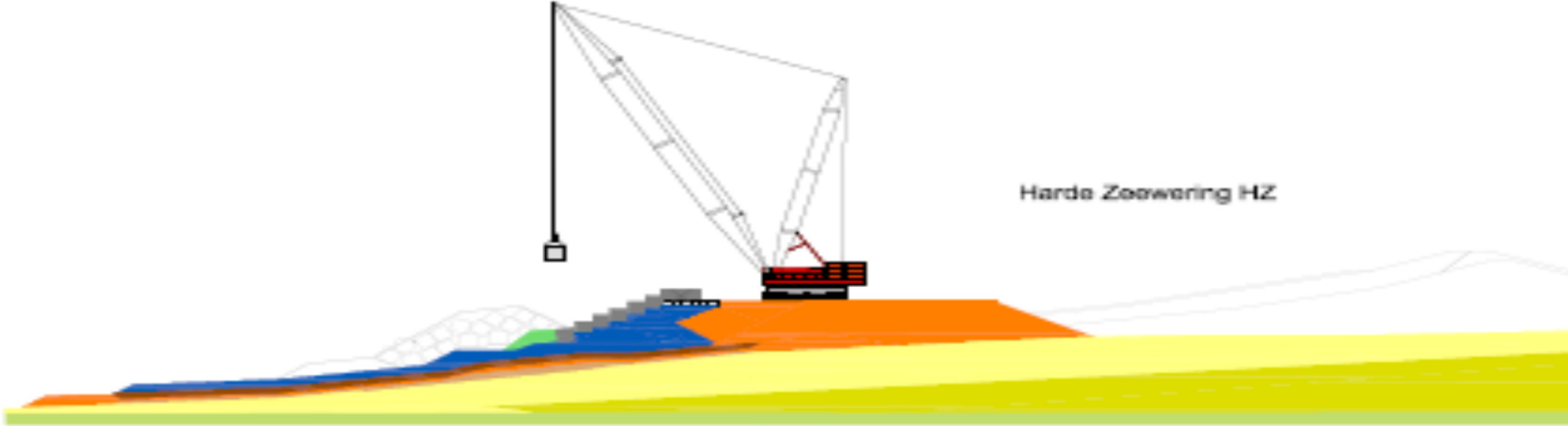
aanleg Harde Zeewering



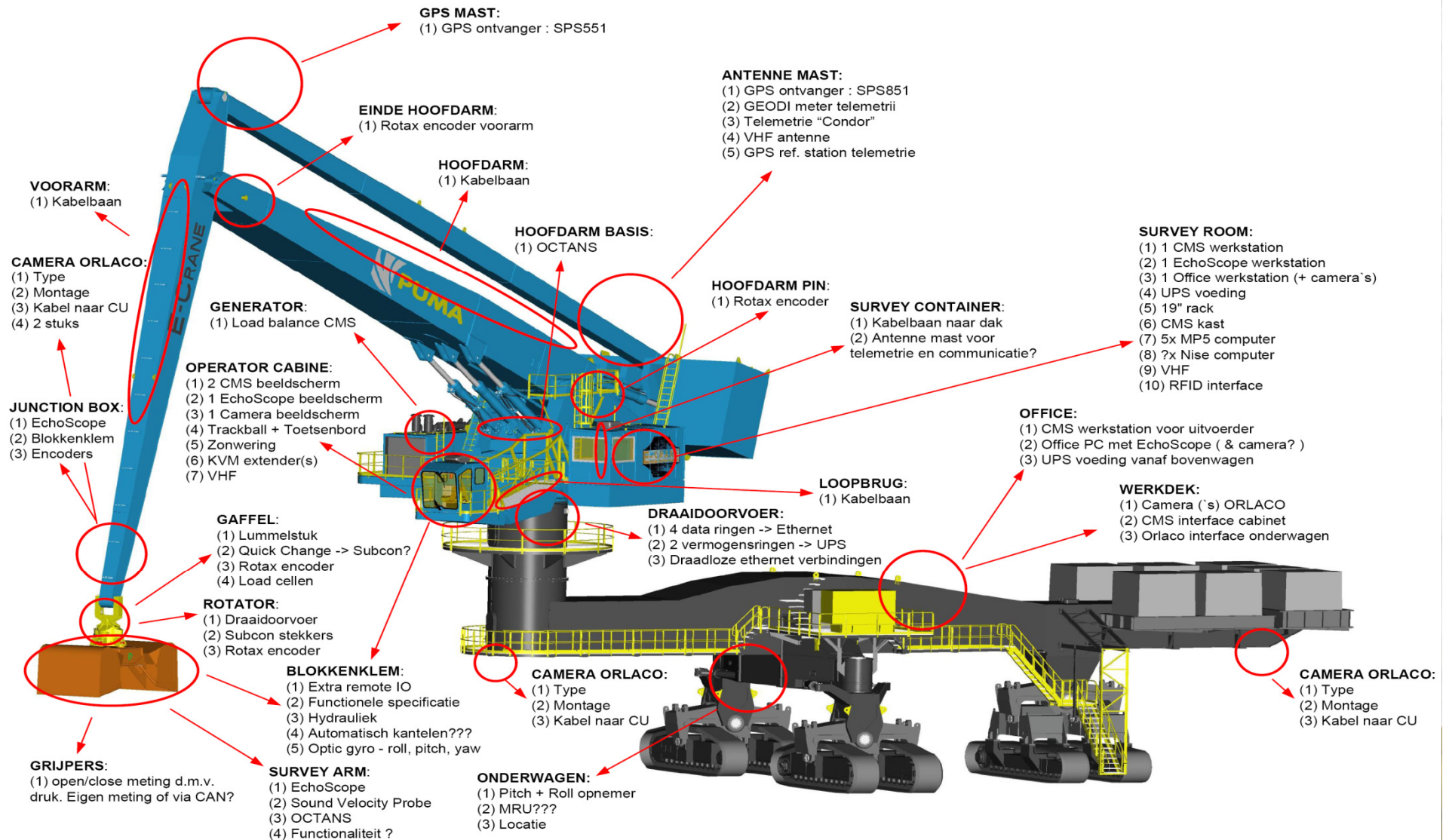
Harde Zeewering HZ



Harde Zeewering HZ

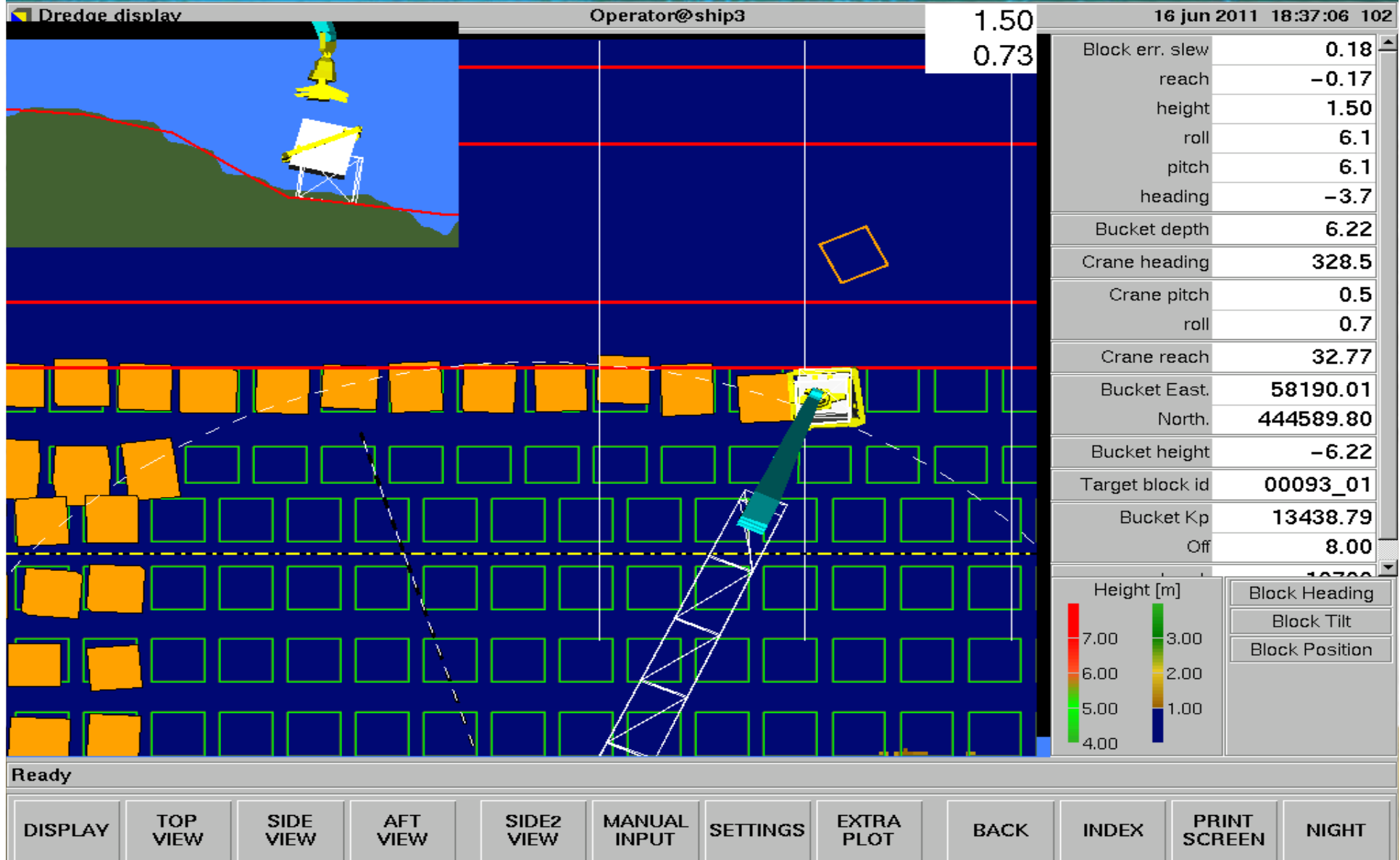


Blockbuster – Function overview





Blockbuster Crane Monitor System



Blockbuster position calculation system



Blockbuster in action



Blockbuster innovations

- Places blocks of 40 tons at 50m distance
- Horizontal and vertical accuracy $<0.10\text{m}$
- Crane monitoring system with 3D presentation of blocks
- Gyroscopes that measures the position of the clamp after the placement
- Linking crane monitoring system to PLC for automation purposes
- Automatic calculation of weight to be placed using an integrated grid cell.
- Sensors that monitor the inclination of the chassis
- Direct connection with recording computers for transfer measurement results

How do we measure this now??

Objectives:

- Measuring in shallow water to determine layer thickness of the quarry run.
- Measurement of the crown in order to determine altitude.

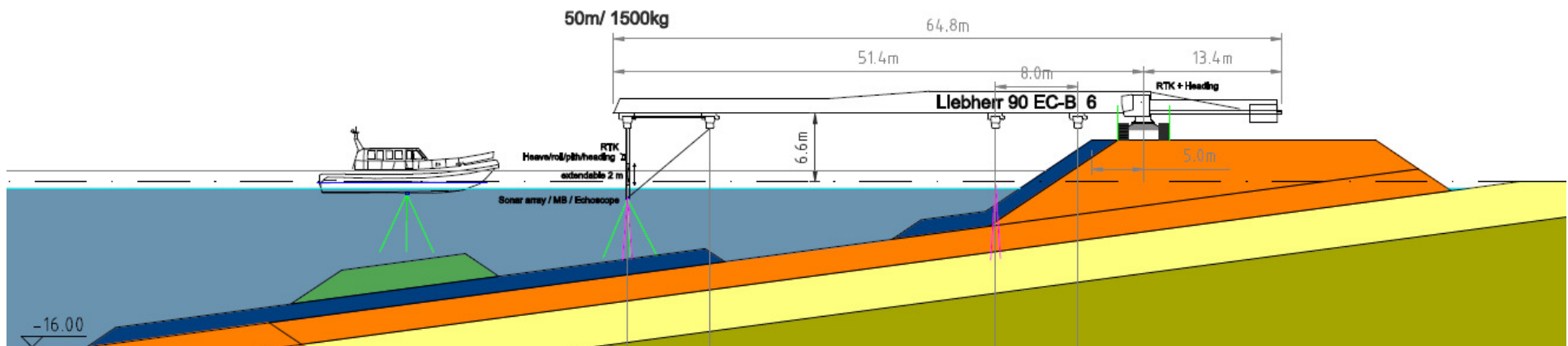
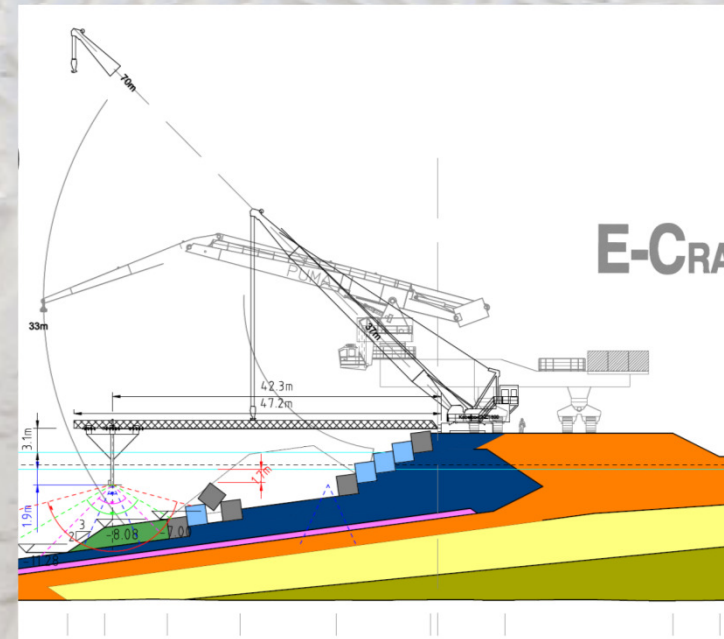
Which must be taken into account:

- High accuracy
- poor weather conditions

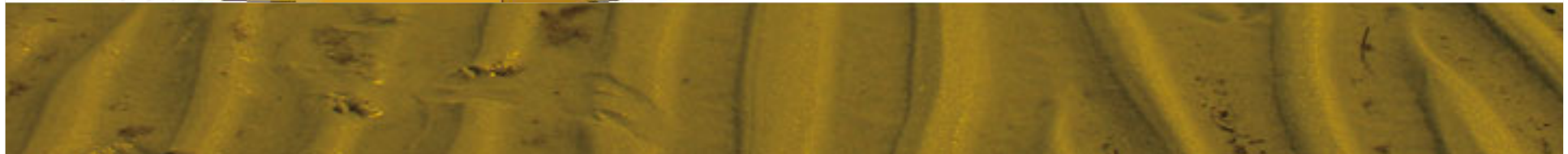
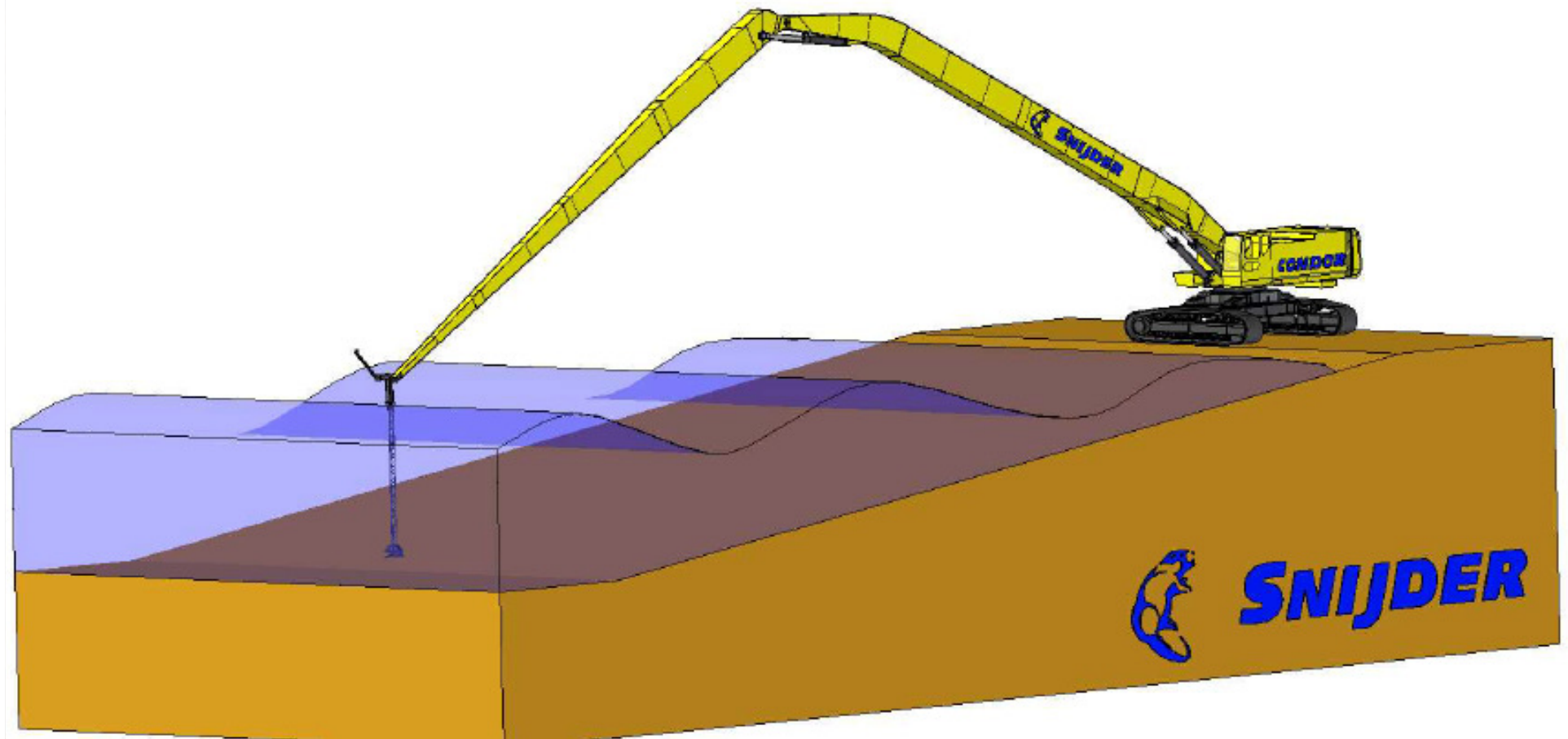
Progress of Blockbuster must be guaranteed!

With what kind of crane?

- Tower crane
- Crawler crane
- Hydraulic crane
- Telescope crane



Condor CAT 385, 46.5m



Condor other dimensions

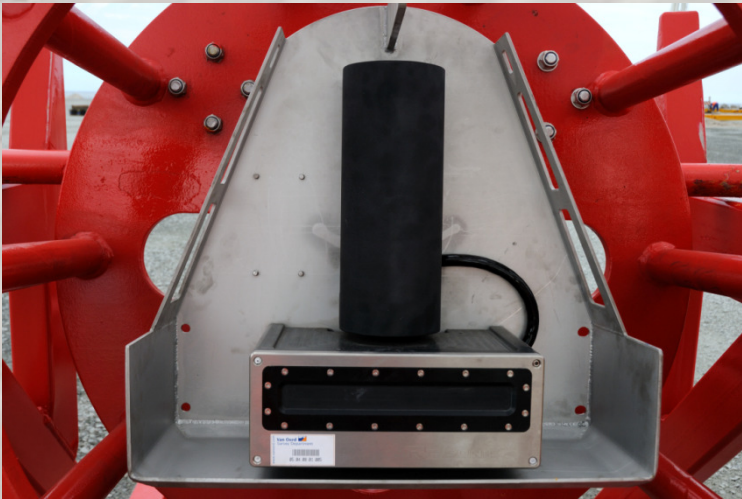




Condor – no more seasickness



Condor - Measuring Equipment



Condor - Measuring



Multibeam survey after the placement of the first 3 blocks.



Multibeam survey on the 1-10 tonne toe structure and the second layer of blocks below the waterline



Laser scan survey of the crest blocks. Additionally the survey vessel will survey the remaining part of the 1-10 tonne toe structure.

Condor – In action

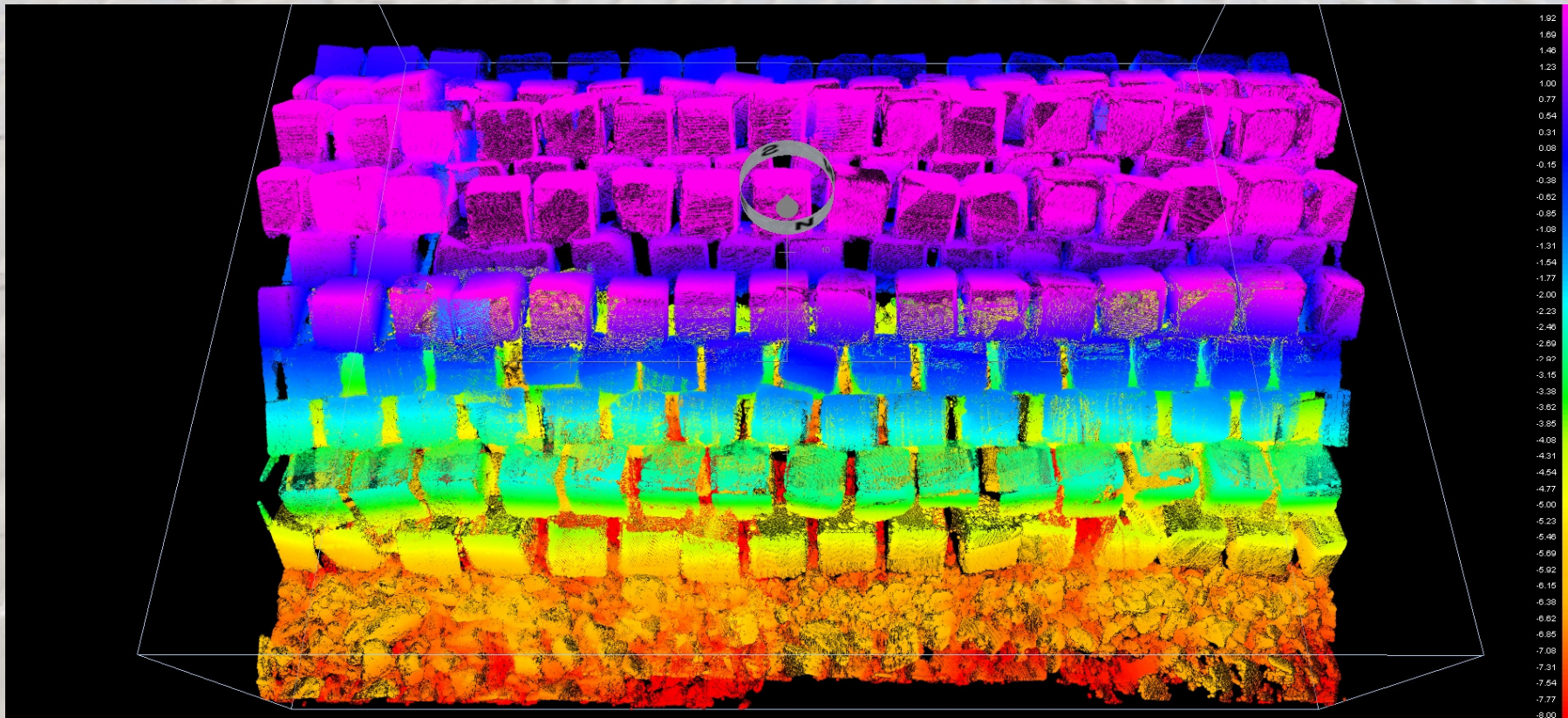


Condor – Echoscope Data

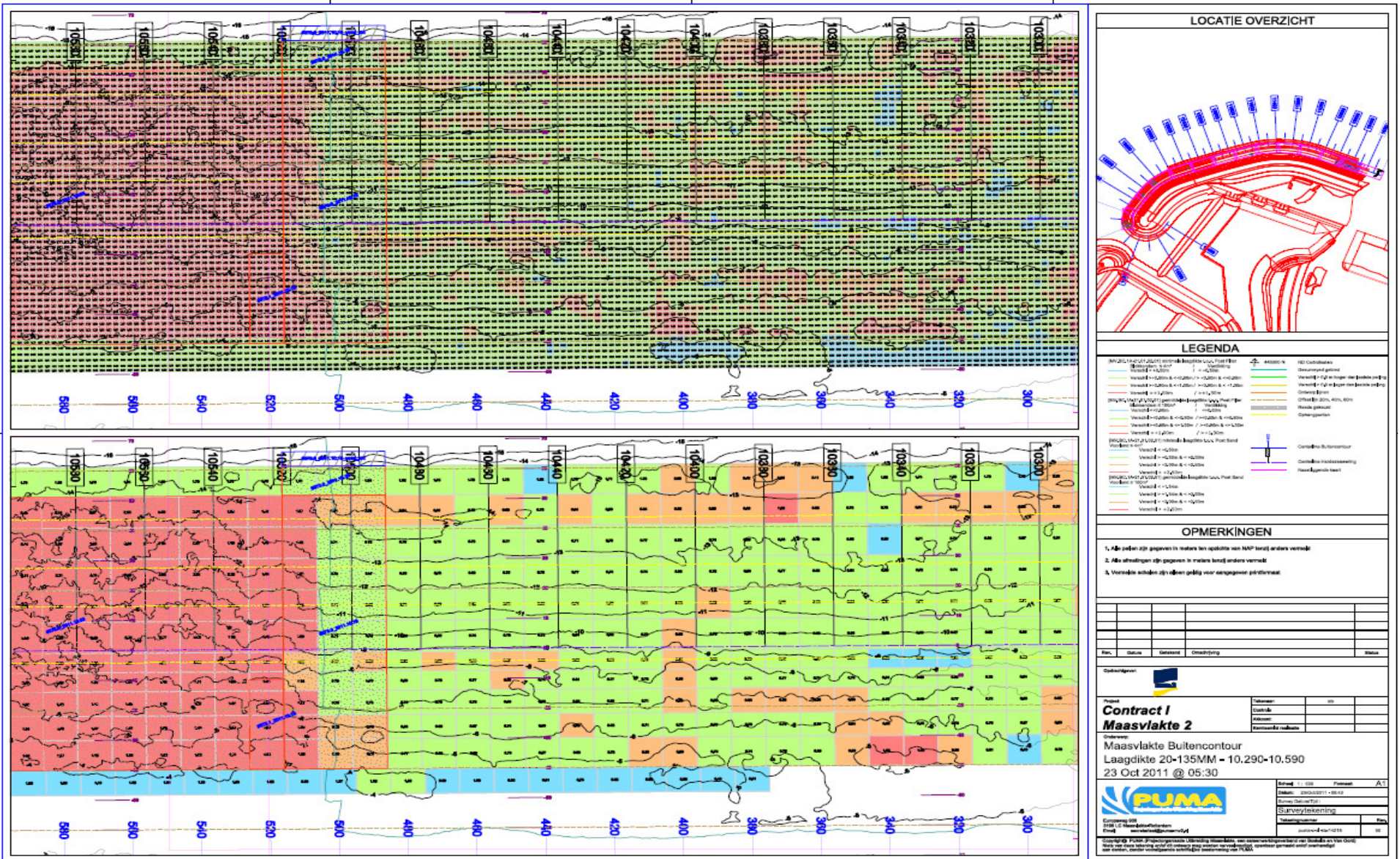


Condor - results

Combined survey with Multi-beam and laser scan data



Condor – Combined bathymetry results



LOCATIE OVERZICHT

LEGENDA

SYMBOLICHT TOEGANGSVERBODEN

- Belemmering (0.50m)
- Belemmering (1.00m)
- Belemmering (1.50m)
- Belemmering (2.00m)
- Belemmering (2.50m)
- Belemmering (3.00m)
- Belemmering (3.50m)
- Belemmering (4.00m)
- Belemmering (4.50m)
- Belemmering (5.00m)
- Belemmering (5.50m)
- Belemmering (6.00m)
- Belemmering (6.50m)
- Belemmering (7.00m)
- Belemmering (7.50m)
- Belemmering (8.00m)
- Belemmering (8.50m)
- Belemmering (9.00m)
- Belemmering (9.50m)
- Belemmering (10.00m)

SYMBOLICHT TOEGANGSVERBODEN

- Belemmering (0.50m)
- Belemmering (1.00m)
- Belemmering (1.50m)
- Belemmering (2.00m)
- Belemmering (2.50m)
- Belemmering (3.00m)
- Belemmering (3.50m)
- Belemmering (4.00m)
- Belemmering (4.50m)
- Belemmering (5.00m)
- Belemmering (5.50m)
- Belemmering (6.00m)
- Belemmering (6.50m)
- Belemmering (7.00m)
- Belemmering (7.50m)
- Belemmering (8.00m)
- Belemmering (8.50m)
- Belemmering (9.00m)
- Belemmering (9.50m)
- Belemmering (10.00m)

SYMBOLICHT TOEGANGSVERBODEN

- Belemmering (0.50m)
- Belemmering (1.00m)
- Belemmering (1.50m)
- Belemmering (2.00m)
- Belemmering (2.50m)
- Belemmering (3.00m)
- Belemmering (3.50m)
- Belemmering (4.00m)
- Belemmering (4.50m)
- Belemmering (5.00m)
- Belemmering (5.50m)
- Belemmering (6.00m)
- Belemmering (6.50m)
- Belemmering (7.00m)
- Belemmering (7.50m)
- Belemmering (8.00m)
- Belemmering (8.50m)
- Belemmering (9.00m)
- Belemmering (9.50m)
- Belemmering (10.00m)

SYMBOLICHT TOEGANGSVERBODEN

- Belemmering (0.50m)
- Belemmering (1.00m)
- Belemmering (1.50m)
- Belemmering (2.00m)
- Belemmering (2.50m)
- Belemmering (3.00m)
- Belemmering (3.50m)
- Belemmering (4.00m)
- Belemmering (4.50m)
- Belemmering (5.00m)
- Belemmering (5.50m)
- Belemmering (6.00m)
- Belemmering (6.50m)
- Belemmering (7.00m)
- Belemmering (7.50m)
- Belemmering (8.00m)
- Belemmering (8.50m)
- Belemmering (9.00m)
- Belemmering (9.50m)
- Belemmering (10.00m)

SYMBOLICHT TOEGANGSVERBODEN

- Belemmering (0.50m)
- Belemmering (1.00m)
- Belemmering (1.50m)
- Belemmering (2.00m)
- Belemmering (2.50m)
- Belemmering (3.00m)
- Belemmering (3.50m)
- Belemmering (4.00m)
- Belemmering (4.50m)
- Belemmering (5.00m)
- Belemmering (5.50m)
- Belemmering (6.00m)
- Belemmering (6.50m)
- Belemmering (7.00m)
- Belemmering (7.50m)
- Belemmering (8.00m)
- Belemmering (8.50m)
- Belemmering (9.00m)
- Belemmering (9.50m)
- Belemmering (10.00m)

SYMBOLICHT TOEGANGSVERBODEN

- Belemmering (0.50m)
- Belemmering (1.00m)
- Belemmering (1.50m)
- Belemmering (2.00m)
- Belemmering (2.50m)
- Belemmering (3.00m)
- Belemmering (3.50m)
- Belemmering (4.00m)
- Belemmering (4.50m)
- Belemmering (5.00m)
- Belemmering (5.50m)
- Belemmering (6.00m)
- Belemmering (6.50m)
- Belemmering (7.00m)
- Belemmering (7.50m)
- Belemmering (8.00m)
- Belemmering (8.50m)
- Belemmering (9.00m)
- Belemmering (9.50m)
- Belemmering (10.00m)

SYMBOLICHT TOEGANGSVERBODEN

- Belemmering (0.50m)
- Belemmering (1.00m)
- Belemmering (1.50m)
- Belemmering (2.00m)
- Belemmering (2.50m)
- Belemmering (3.00m)
- Belemmering (3.50m)
- Belemmering (4.00m)
- Belemmering (4.50m)
- Belemmering (5.00m)
- Belemmering (5.50m)
- Belemmering (6.00m)
- Belemmering (6.50m)
- Belemmering (7.00m)
- Belemmering (7.50m)
- Belemmering (8.00m)
- Belemmering (8.50m)
- Belemmering (9.00m)
- Belemmering (9.50m)
- Belemmering (10.00m)

SYMBOLICHT TOEGANGSVERBODEN

- Belemmering (0.50m)
- Belemmering (1.00m)
- Belemmering (1.50m)
- Belemmering (2.00m)
- Belemmering (2.50m)
- Belemmering (3.00m)
- Belemmering (3.50m)
- Belemmering (4.00m)
- Belemmering (4.50m)
- Belemmering (5.00m)
- Belemmering (5.50m)
- Belemmering (6.00m)
- Belemmering (6.50m)
- Belemmering (7.00m)
- Belemmering (7.50m)
- Belemmering (8.00m)
- Belemmering (8.50m)
- Belemmering (9.00m)
- Belemmering (9.50m)
- Belemmering (10.00m)

SYMBOLICHT TOEGANGSVERBODEN

- Belemmering (0.50m)
- Belemmering (1.00m)
- Belemmering (1.50m)
- Belemmering (2.00m)
- Belemmering (2.50m)
- Belemmering (3.00m)
- Belemmering (3.50m)
- Belemmering (4.00m)
- Belemmering (4.50m)
- Belemmering (5.00m)
- Belemmering (5.50m)
- Belemmering (6.00m)
- Belemmering (6.50m)
- Belemmering (7.00m)
- Belemmering (7.50m)
- Belemmering (8.00m)
- Belemmering (8.50m)
- Belemmering (9.00m)
- Belemmering (9.50m)
- Belemmering (10.00m)

OPMERKINGEN

- Alle punten zijn gegeven in meters ten opzichte van NAP tenzij anders vermeld.
- Alle afmetingen zijn gegeven in meters tenzij anders vermeld.
- Verreinde schalen zijn alleen geldig voor navigatieve doeleinden.

№.	Datum	Gedraagt	Omschrijving	Status

Opdrachtgever

Contract 1 Maasvlakte 2

Maasvlakte Buitencontour
Laagdikte 20-135MM = 10.290-10.590
23 Oct 2011 @ 05:30

PUMA

Contract 1 Maasvlakte 2
Laagdikte 20-135MM = 10.290-10.590
23 Oct 2011 @ 05:30

Surveyingenieur

Project

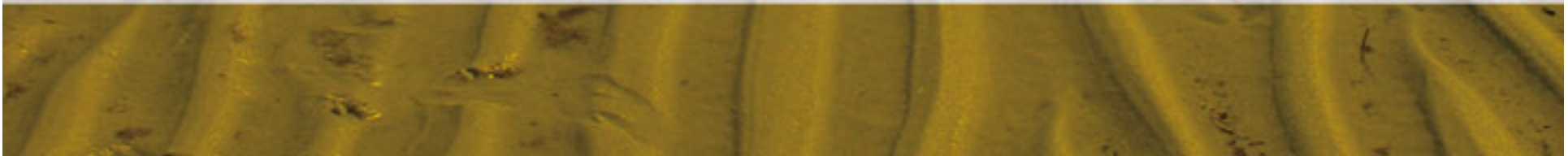
№.	Datum	Gedraagt	Omschrijving	Status

Condor - innovations

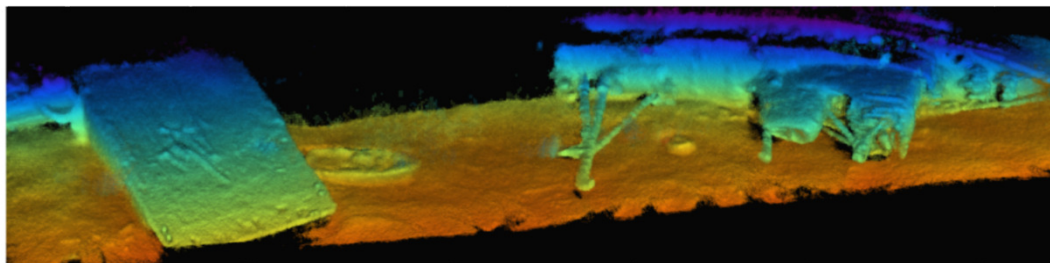
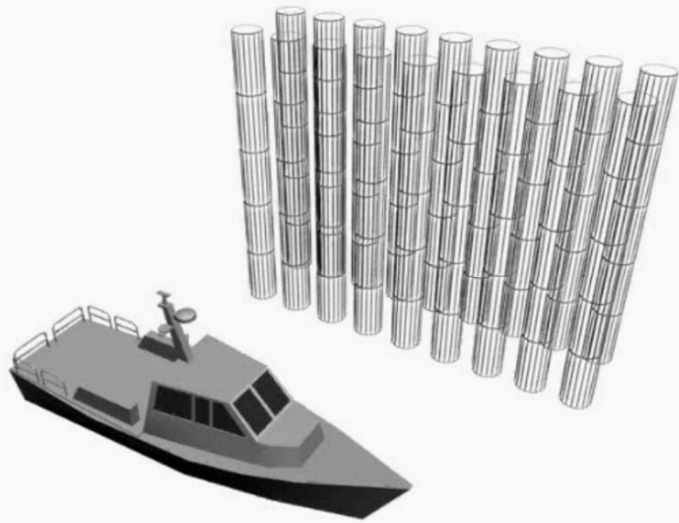
- Unprecedented range of 46.5 m
- Integrated Laser Scan for measuring crown blocks
- Multi-beam measurements to $\pm H_s$ 2m, and 0.5m water depth under the Multi-beam
- High measurement accuracy by mounting all sensors on a single pole
- Camera for visibility



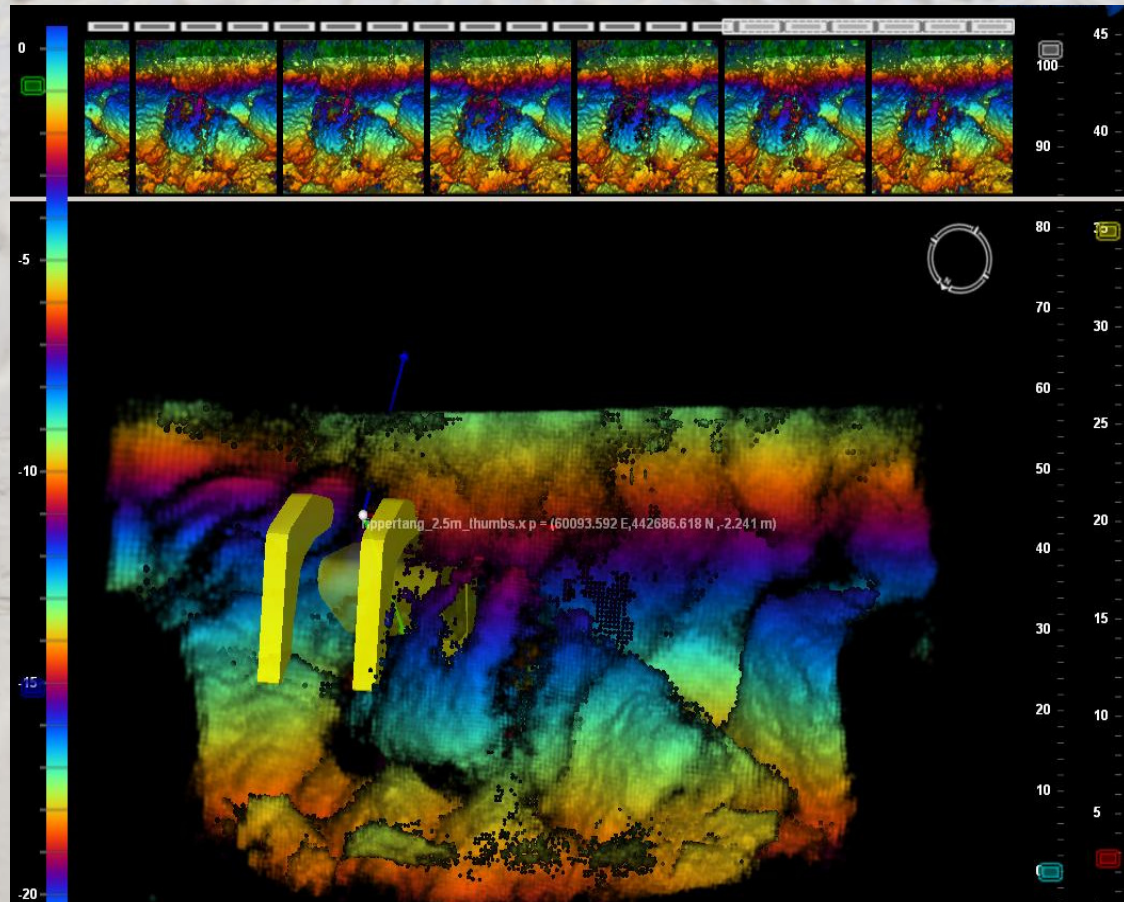
Removal Concrete Blocks on MV1



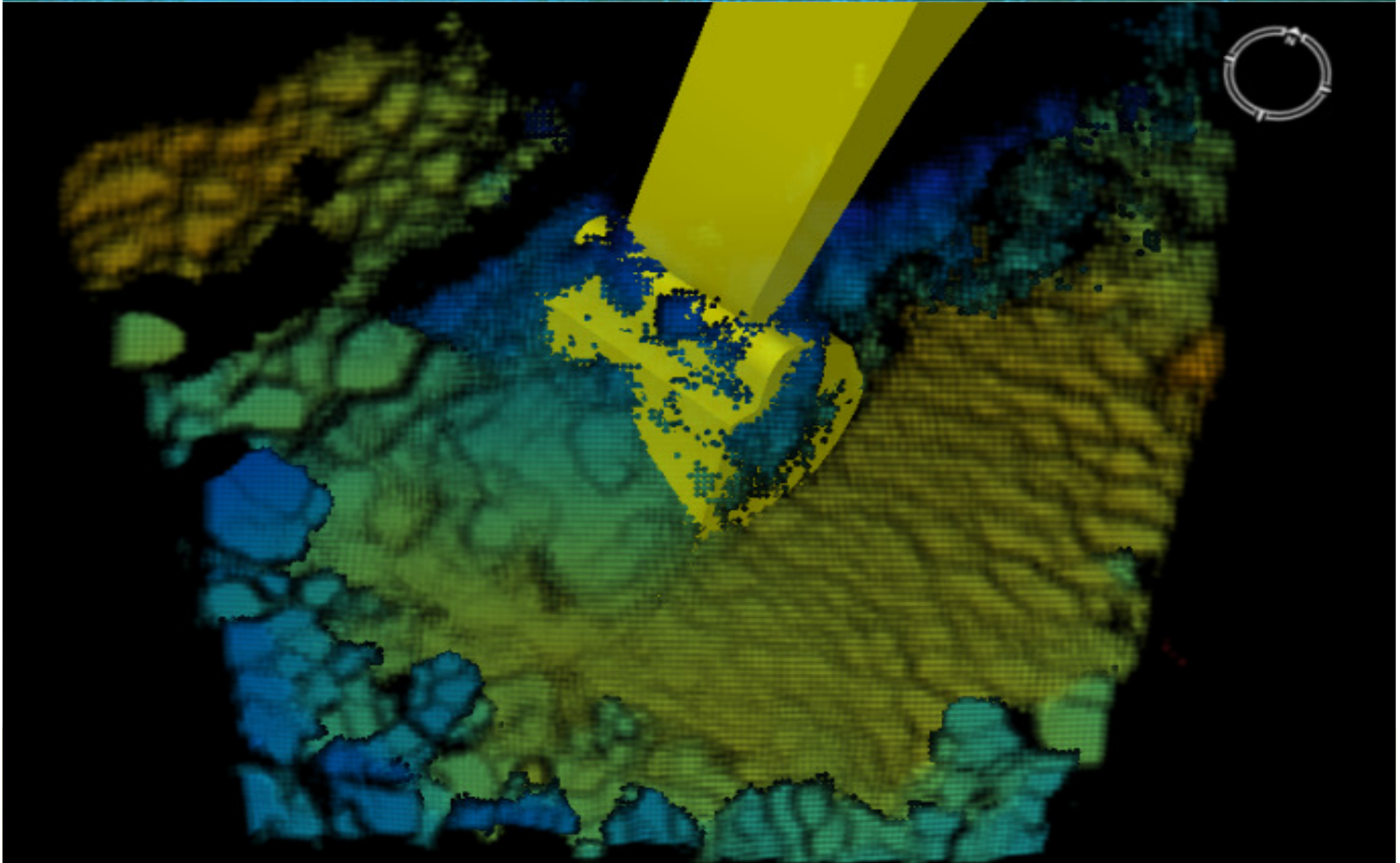
Echoscope as “underwater camera”



Echoscope as “underwater camera”



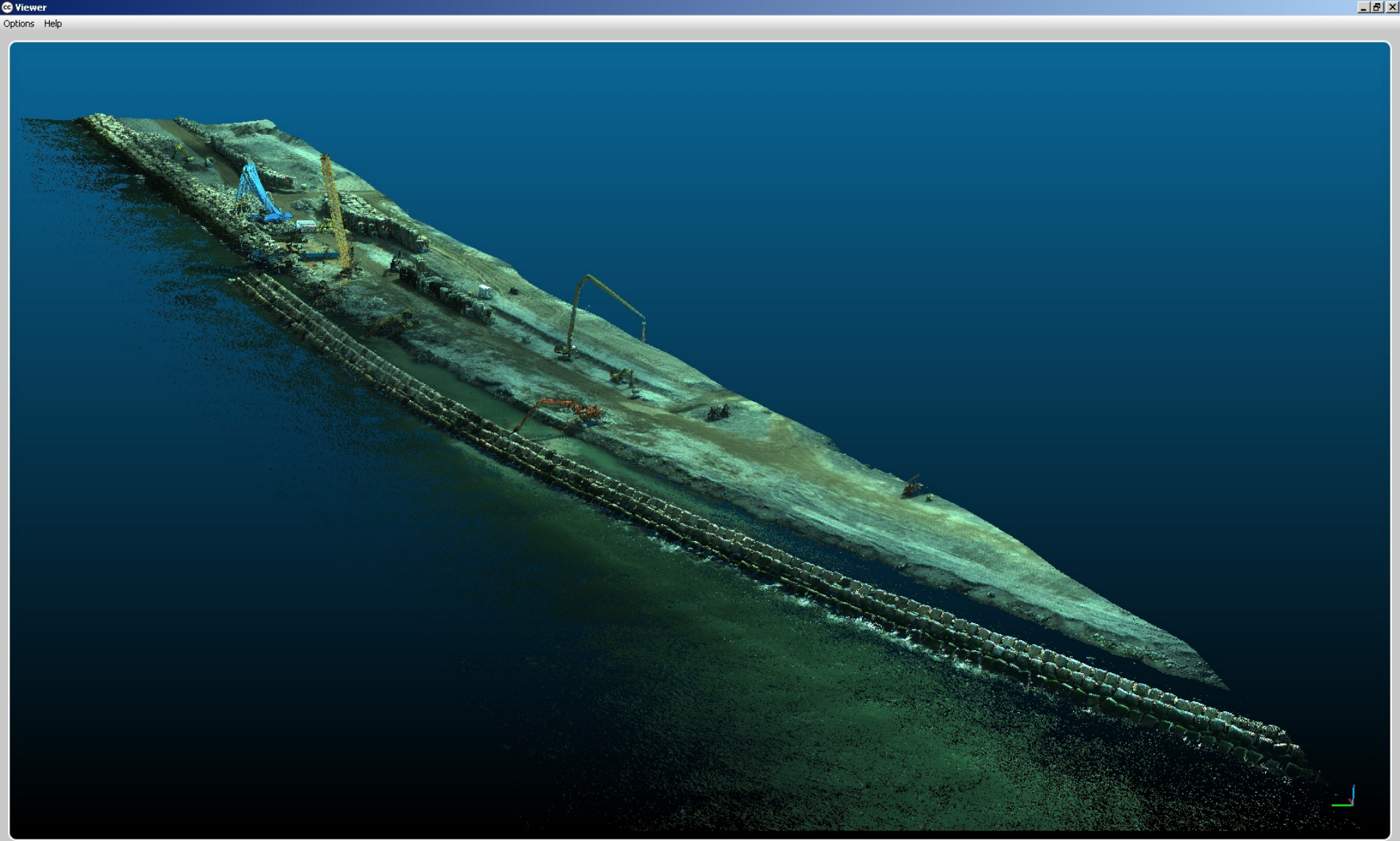
Echoscope 3D rendering



Echoscope innovations

- 3D Underwater camera to support the crane operator.
- 3D rendering of the ripper for better interpretation of the scope echo image.
- Ability to load a 3D model as reference layer.
- Automatically tracking the ripper by coupling with crane monitoring system
- Implementation of sound profile readings for accurate measurement
- Using Echo Scope as a survey instrument

FUGRO Fli-Map



Alternative : Gatewing X100



Gatewing X100 Autodesk infrastructure modeler



Evolution of mobile measurement methods on PUMA



ARGO amphibian

Evolution of mobile measurement methods on PUMA



Quad Yamaha Grizzly 350 4WD

Evolution of mobile measurement methods on PUMA

Opps!.....



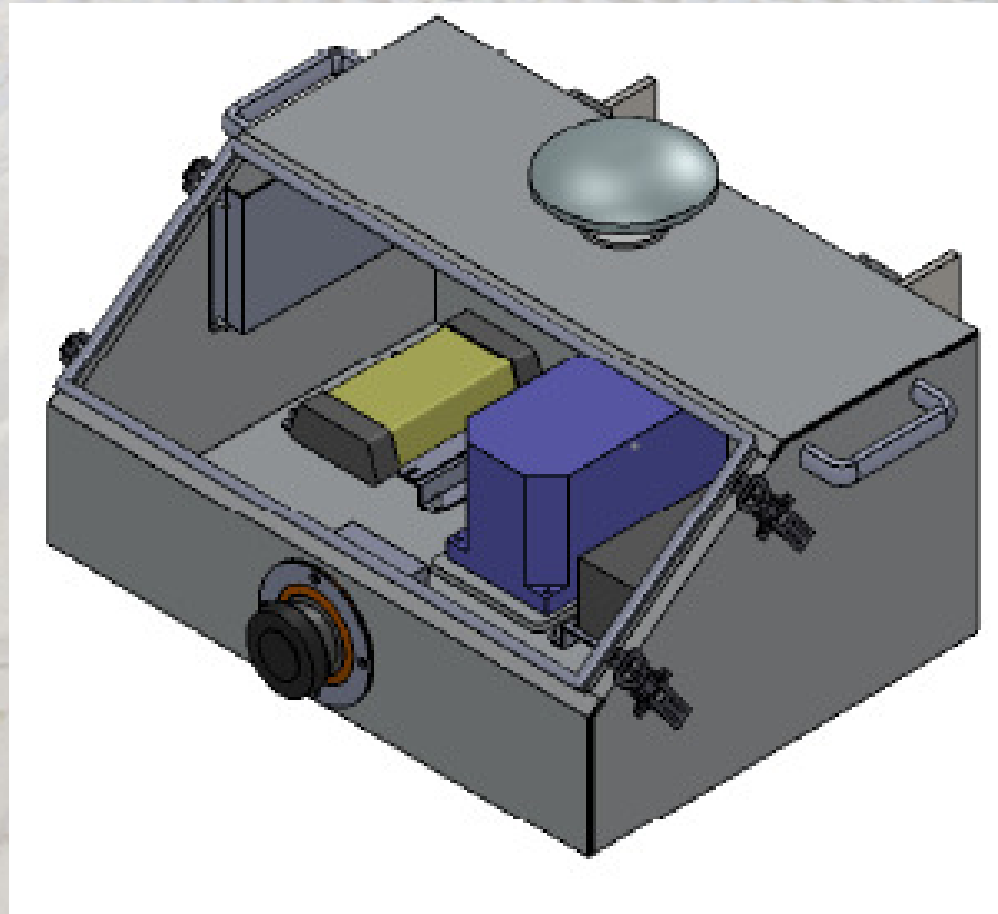
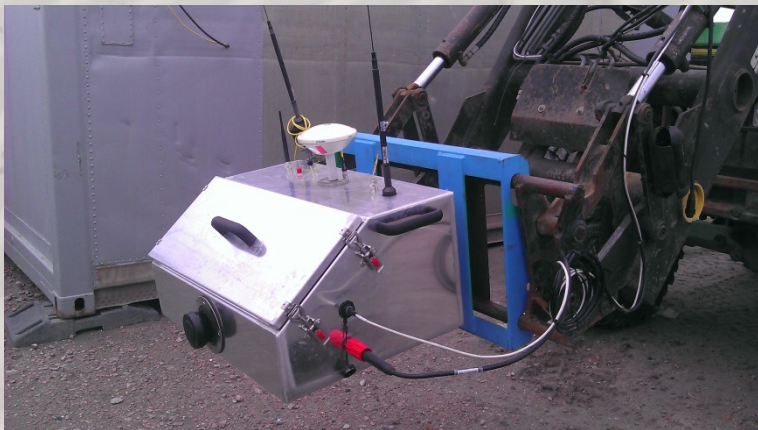
Evolution of mobile measurement methods on PUMA



Mobile SICK

- Design

- SICK LMS151
- Trimble SPS851
- Octans IV
- WiFi



Mobile SICK - innovations

- Cheap (3500,- EURO)
- Small and robust
- Easy interfacing through existing software (PDS2000)
- Quick measurement of large surfaces
- Safe measuring coarse stone gradations
- Measuring stone depots

Survey Innovations Resume

- The development of a unique Crane Monitoring System (CMS)
- A new feature was added to the Echoscope to present the stick and ripper tool as 3D models
- Survey crane Condor with a massive 46.5 m reach was constructed.
- Recycling the block dam required special use of acoustic viewing systems as underwater cameras.
- Airborne systems like the Gatewing x100 represent a breakthrough which can clearly be applied to future projects.



Thanks for your attention

**Waar zee was
heerst land
Water verdronken
in zand
Jules Deelder**

**Where there was water
The land dominates.
Water sank
in sand
Jules Deelder**