DensX

MODEL DX-01

User's Manual

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Contents

Introduction

This user manual contains information required to operate and use the DensX model DX-01 (X-Ray Sediment Density Profiler).

System Description

The DensX is a high accurate in situ mud density measurement system on the market measuring densities between 1.0 T/m³ and 1.5 T/m³ with an accuracy of 0.25 %. The DensX technology is based on X-ray and is a direct measurement method. With a sampling speed of 10Hz the system supports fast profiling. The technology does not suffer from strong legislation restrictions like radioactive density measurement systems. The system weighs 70 kg and is able to deeply intrude in soft sediment layers.

Along with the DensX comes a user friendly software that controls a fully automated winch. The software visualizes the density profile, the winch speed, the winch torque and the tilt of the DensX. When several density profiles are taken the software generates a mud grid and interpolated dredging volume.

Today the DensX is applied in ports and access channels to characterize mud layers, to measure density based nautical bottom criteria and to prepare and evaluate dredging works. The accurate density measurement capability allows to determine precisely the ton dry weight of dredging material.

Features

- X-ray based, direct measurement method
- High accuracy (0.25 %)
- Fast sampling (10 Hz)
- Standard Ethernet communication
- Software controlled Ethernet winch with variable speeds

Benefits

- Fully integrated and automated fast profiling system
- Interpolated mud grid and dredging volume
- Live visualization of density profile, depth, inclination, winch speed and cable tension
- User friendly software

Measurement principle

The principle is the transmission of X-rays emitted by a micro tube in the medium between source and detector. The photons emitted by the source interact with the electrons of the matter along their path. The higher the density, the higher the number of electrons. Only the photons interacting in the detector crystal NaI(Tl) are taken into account by the DensX. The signal received by the detector is an exponential function decreasing with the density of the mixture.

The relationship between medium density d and the value of the signal delivered by the detector is:

$$d = Kdo + Kd1 \,.\, (Nc/No - 1) + Kd2 \,.\, Ln\,(Nc/No)$$

Where:

- *d* is the medium density
- *No* is the signal delivered by the detector in clear water
- *Kdo, Kd1* and *Kd2* are the calibration coefficients of the DensX

This equation is presented here in a general form with 3 terms:

- The first term *Kdo* is mainly related to salinity
- The second term *Kd1 . (Nc/No - 1)* is used for a backscattering DensX
- The third term *Kd2 . Ln (Nc/No)* is used for a transmission DensX

Additionally, a corrective term can be used to correct the measurement in case of counting losses (can occur with X-ray DensX mainly). This correction depends upon the counting system and cannot be detailed here.

Associating density *d* and depth *P*, we obtain a vertical profile of density inside the mud deposit.

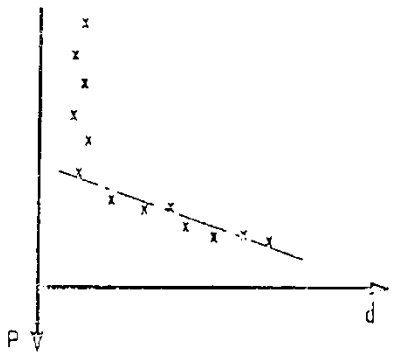


Figure 1: Example of a vertical profile of density

Technical specifications

DensX

Model:	DensX
Type:	DX-01
Weight:	70 kg
Dimensions:	70x34x13 (WxHxD in cm)
Density range:	1 – 1,5 kg/l
Accuracy:	-2.5 +2.5 ‰
Stability:	< 0.1 % (5 – 40 °C)
Radiation:	1 uSv/h (distance < 10 cm)
X-ray voltage:	< 30 kV
Power consumption:	< 20 Watt
Activation depth	5 m
Pressure range:	0 – 3.5 bar
Resolution:	0.00014 bar
Depth accuracy:	± 1.5 %

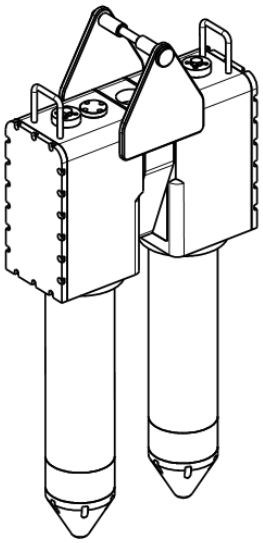


Figure 2: DensX

Hardware

LED indicator

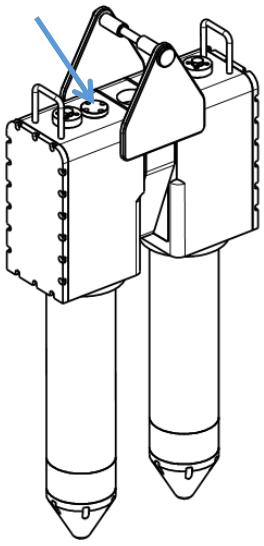


Figure 3: LED indicator

The LED indicator is blinking when the X-ray source is activated.

Security contacts

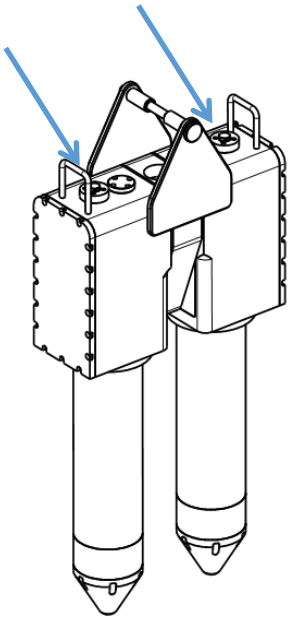


Figure 4: Security contacts

The security contacts prevent the activation of the X-ray source when the DensX is not under water.

X-Ray source and detector

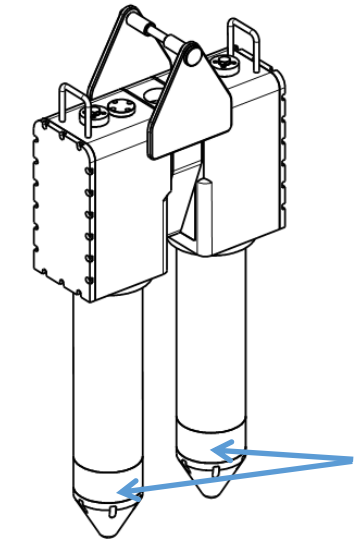


Figure 5: X-ray source and detector

The black plastic parts on both legs of the DensX are for the X-ray source and detector. The X-ray source is indicated with the X-ray logo.

Pressure sensor

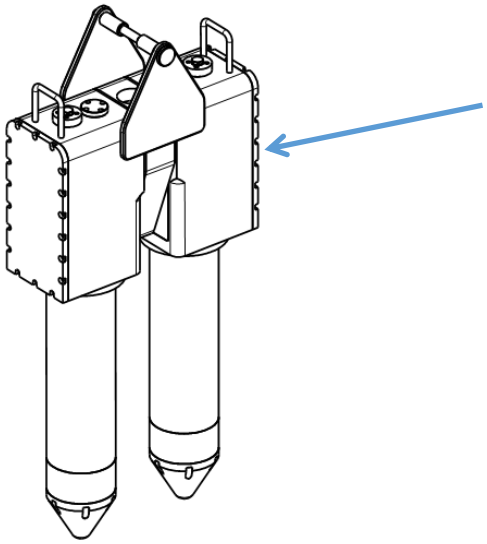


Figure 6: Pressure sensor

The pressure interface must be connected to a water tube to prevent mud in the sensor.

Communication connector

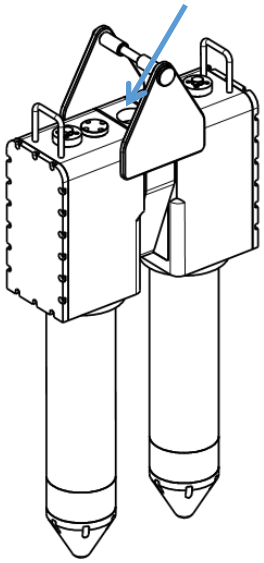


Figure 7: Communication connector

The communication connector is the red Subconn connector on top of the DensX.

Steel termination connection

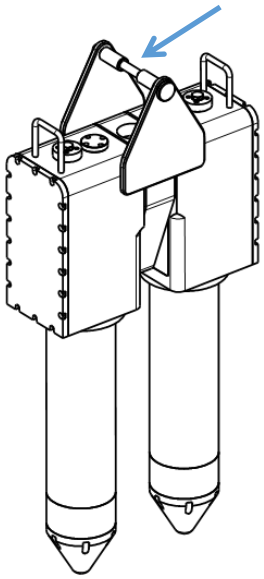


Figure 8: Steel termination connection

The steel termination connection is to connect the winch cable termination to the DensX.

Handles

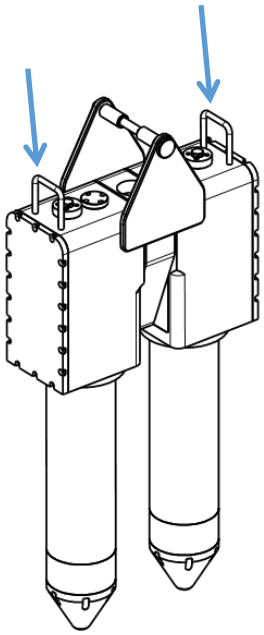


Figure 9: Handles

The handles are used to carry the DensX without the winch.

Control-command unit

The control-command unit has a key and a LED-control.

Figure 10: Control-command unit

Key OFF (LED OFF): Power supply of the X-ray is **disconnected**

Key ON (LED ON): Power supply of the X-ray is **enabled**

Remark! The LED on the control-command unit might be ON even when the DensX isn't under water! This is because the control-command unit provides the power to the X-ray source but the security contacts can override this if the DensX isn't underwater. To avoid damaging the X-ray please always put the key OFF when not measuring!

Note! Remove the key when no measurement is needed. Only trained personnel may use this key to operate the DensX.

Software

Recording data from the DensX, operating the winch, switching the DensX on or off and processing the data are all combined in one easy-to-use software.

The software is project based. A project is stored in a proprietary file format and can be easily opened. The settings are stored in the software. Calibration settings are stored separately and need to be installed on every PC.

The directory in which the project will be opened will also be used as a "temp" directory. Therefore it will not be possible to use other directories in the system (security).

Individual profiles can irrevocably be deleted.

System requirements

- +1 Ghz dual core CPU
- 2 GB of RAM
- 40 GB free space on hard drive
- Windows 7, Windows 8
- Minimal screen resolution: 1280x768

Recommended System Requirements

- +2 Ghz quad core CPU
- 6 GB of RAM
- 100 GB free space on hard drive
- Windows 7 of Windows 8
- Minimal screen resolution: 1600x900

Important notices

Consequential damage

The DensX has been designed with the purpose to be able to operate with the highest reliability as possible.

However if an error occurs and the operator chooses to bypass the safety systems it could result in limited warranty.

No consequential damages will be covered by the warranty, neither damage to the DensX itself, nor to other equipment or to personnel.

Working safely

The DensX is a device with ionizing radiation, which has to be only used by skilled personnel with the required training. The following safety instructions need to be followed:

- During periods of non-use of the DensX (outside the measurement operations), the control panel-key must be removed and stored in a safe place by the responsible person(s)
- Any manipulation or utilization of the DensX is prohibited by non-trained personnel or people who are not authorized by the company
- Working with the DensX does not cause any radiological classification of the staff
- It is forbidden to leave the DensX unattended even if it is in the water
- The handling staff must be empowered by their company
- Physical control by AIB-Vinçotte Controlatom, Belgium states:

  Equivalent dose rate measured at 10 cm accessible at any point around the unit values below 1 µSv.h^{-1} measuring mode or in calibration mode.

- The DensX can be stopped at any time by removing the key

Figure 11: Logo ionizing radiation

Assembly

1. Connect the terminal of the cable to the top of the DensX
    a. Remove the locking pin (1)
    b. Remove the axle (2)
    c. Put terminal between triangles (3)
    d. Place axle back, with terminal between
    e. Place locking pin back

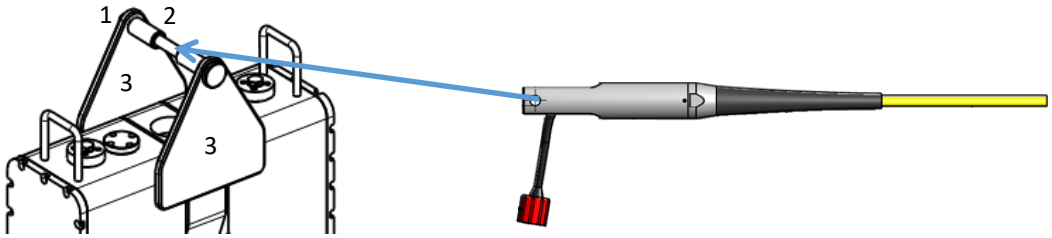


Figure 12: DensX connections

2. Mount the connector

Figure 13: DensX cable assembly

3. Connect the water tube to the pressure interface

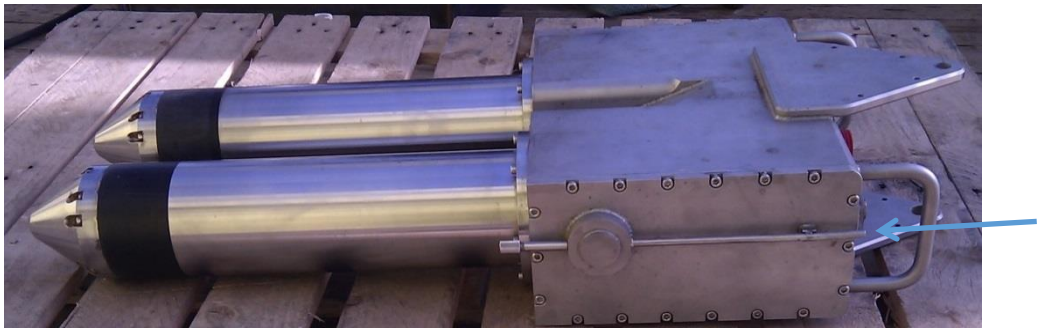


Figure 14: Water tube on DensX

4. Fill the water tube
    a. Remove the end screw
    b. Fill the tube with fresh water
    c. Close the end screw

Figure 15: Water tube end screw

Note: Make sure that there are no air bubbles in the tube!

Tip: Use a funnel and a bucket to prevent air bubbles in the tube.

Operational instructions

DensX

Start Measurement

Start winch to enable the winch and the DensX.

Set winch **local** to manually move the winch with the remote control.

Put DensX with the remote control into the **water**. Check that the mark on the cable is on the top of the water level.

Activate the X-ray on the DensX with the key of the control-command unit.

Set the winch to **pc mode** to control the software.

Stop measurement

Set winch **local** to manually, move the winch with the remote control.

Deactivate the X-ray on the DensX with the key of the control-command unit.

Put the DensX on deck with the remote control.

Clean the DensX with fresh water.

Stop winch to disable the winch and the DensX.

Software

Network settings

The DensX system uses an IPv4 network range (from 192.46.111.1 to 192.46.111.254) so before connecting the computer to the DensX-network, the user must set a fixed network IP-address within Microsoft Windows.

The following settings are recommended:

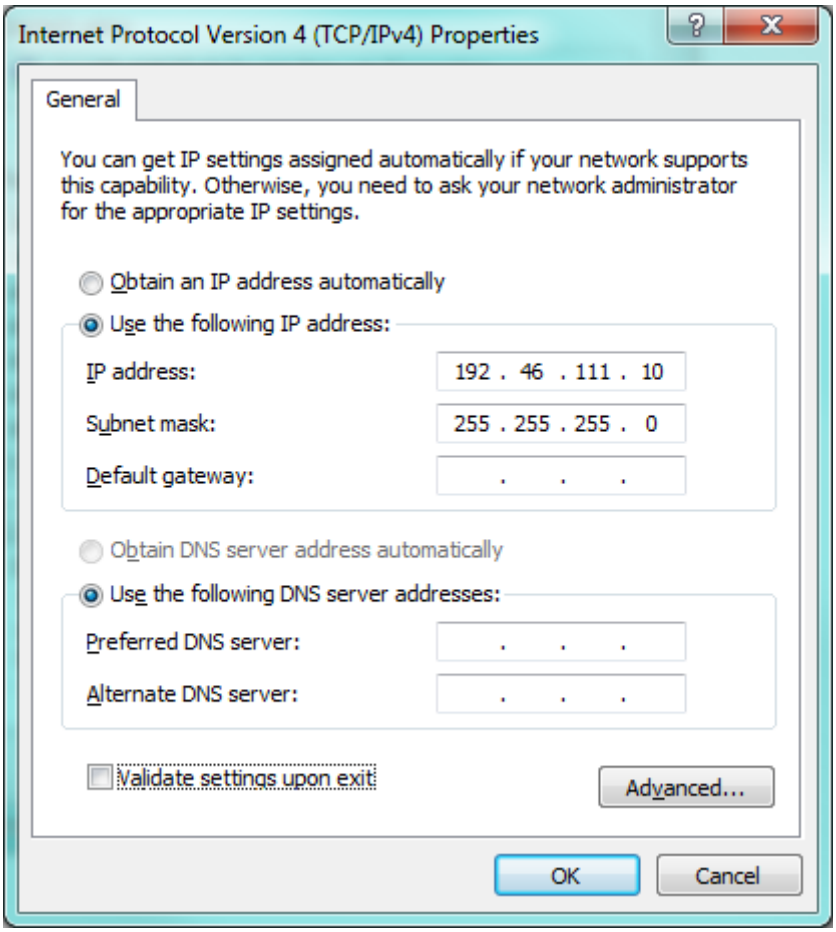


Figure 16: Network settings

Main window

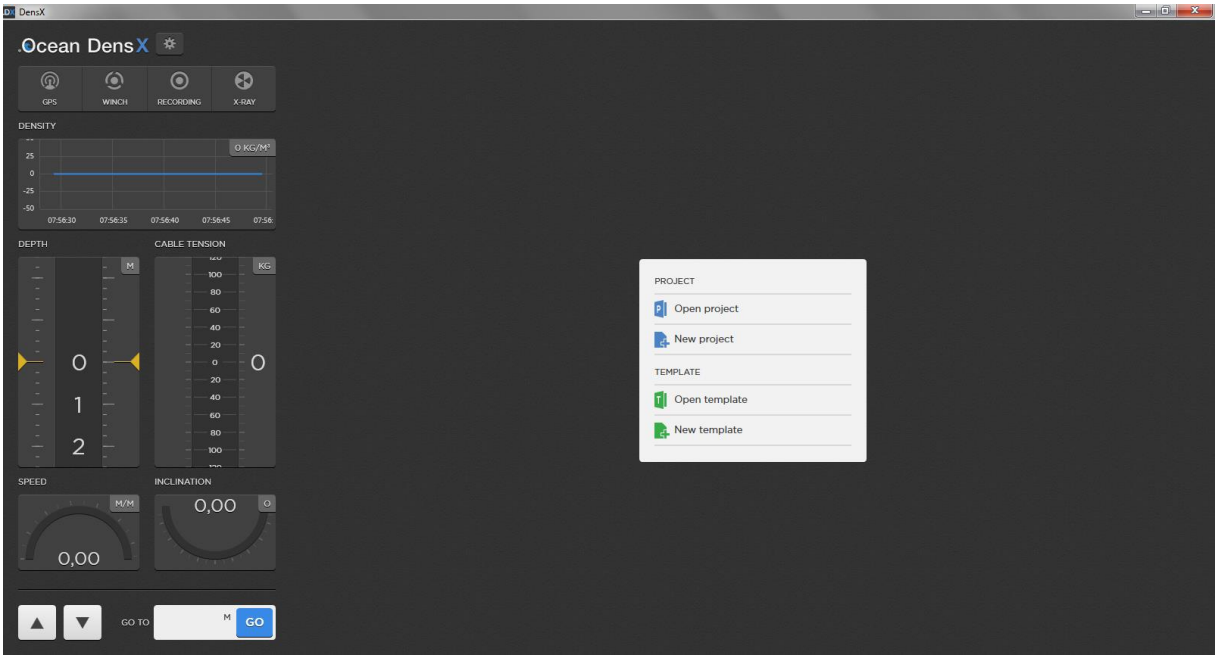


Figure 17: Main window

There are 2 views when opening the software. On the left side there is the control panel and in the middle there is the project/template view.

Control panel

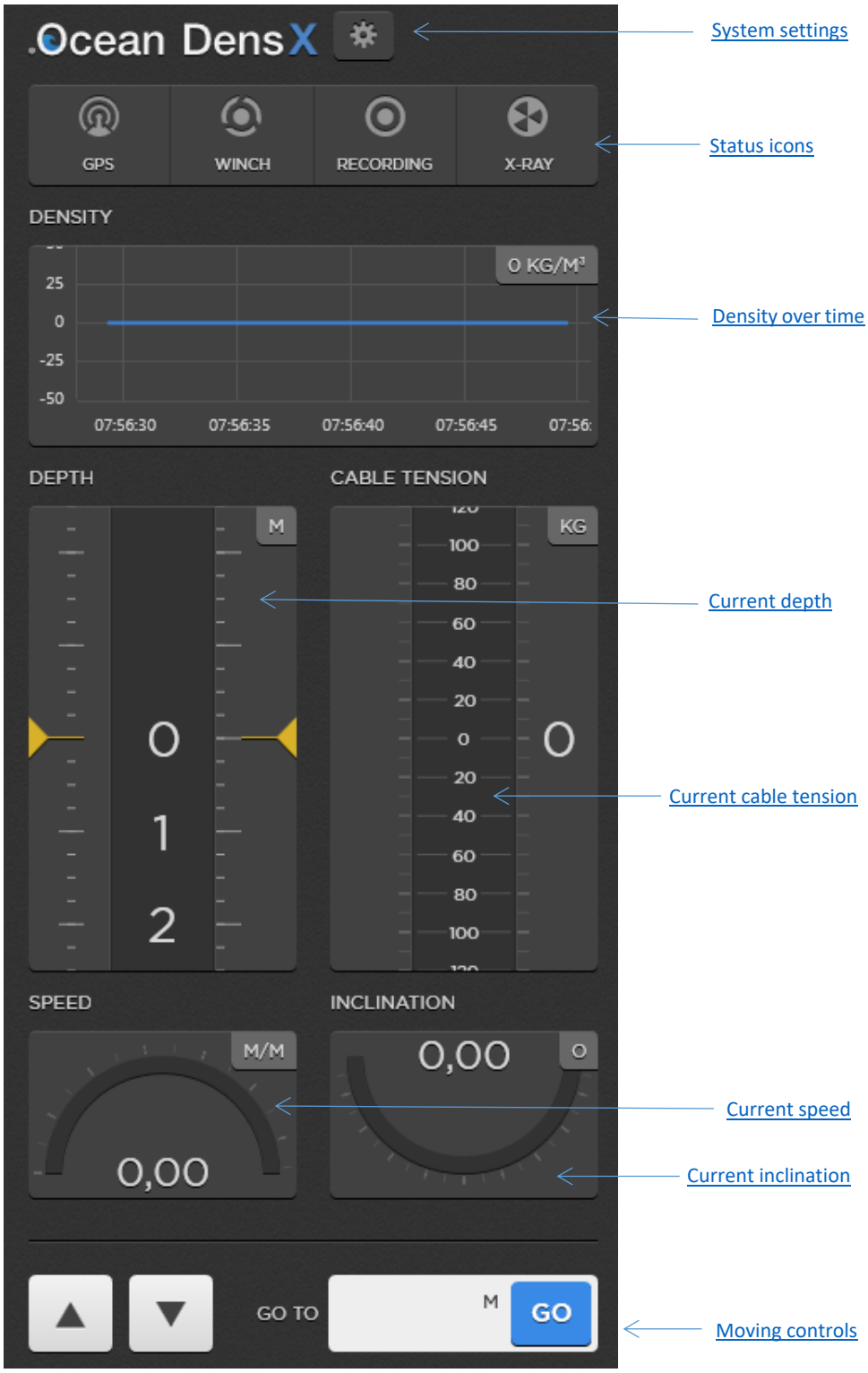


Figure 18: Control panel

Status icons

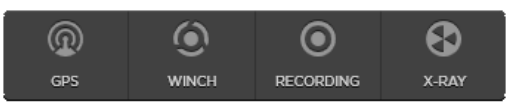


Figure 19: Status icons

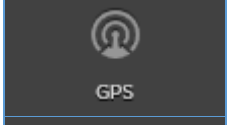
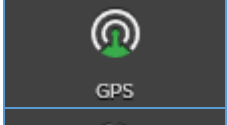
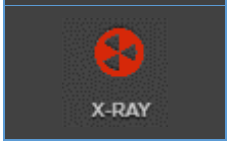
Symbol	Description
	No connection with GPS
	GPS connected
	No connection with winch
	Winch is in error
	Connection with winch is ok Winch in idle mode
	Connection with winch is ok AND Winch is moving
	Connection with winch is ok AND Winch is in local mode (no software control)
	Recording off
	Recording on
	X-ray source off
	X-ray source warming up
	X-ray source working
	X-ray error

Figure 20: Status description

Density

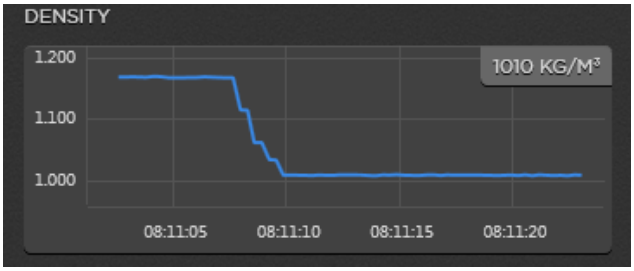


Figure 21: Density graph

This graph shows the real-time density measured by the DensX in a time window of 20 seconds in kg/m³. The current value is visible on the top right side of the graph.

Depth

Figure 22: Depth graph

This graph shows the current depth of the DensX in meters.

Cable tension

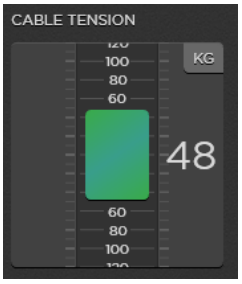


Figure 23: Cable tension graph

This graph shows the current tension on the cable of the DensX. The unit of the cable tension is kg.

Speed

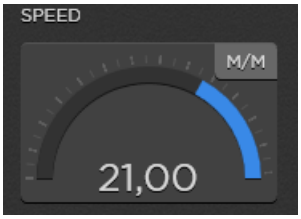


Figure 24: Current speed graph

This graph shows the current speed of the DensX. The unit of the speed is m/min.

Inclination

Figure 25: Inclination graph

This graph shows the maximum inclination of the DensX. The unit of the inclination is degrees. The DensX can tilt in two directions, but only the maximum value is shown.

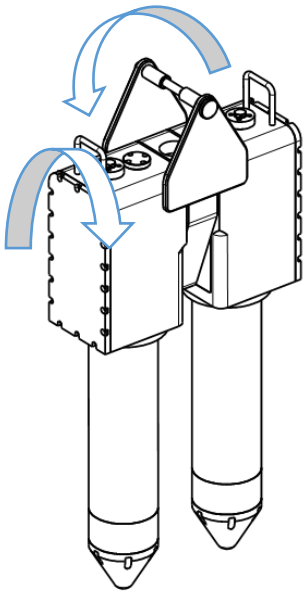


Figure 26: DensX tilt

Moving controls

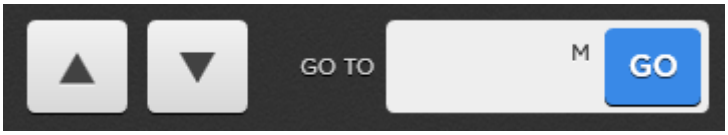


Figure 27: Moving controls

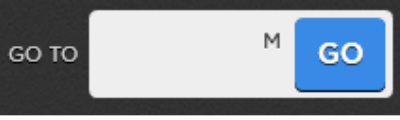
Symbol	Description
	Move up at maximum speed
	Move down at maximum speed
	Fill in the desired depth value and press the “GO” button or press “ENTER”. The winch moves at maximum speed.

Figure 28: Description moving controls

When the software has no connection with the winch, the moving controls are disabled.

Figure 29: Moving controls disabled

Note! Check that the local/pc button on the main panel of the winch is in PC MODE. Otherwise the winch will block the communication from the pc to the winch.

Safety precautions! When the winch controller doesn’t receive data from the software in PC mode, the winch will block the movement. So in case of cable damage or software interruption, the movement will be blocked.

System settings

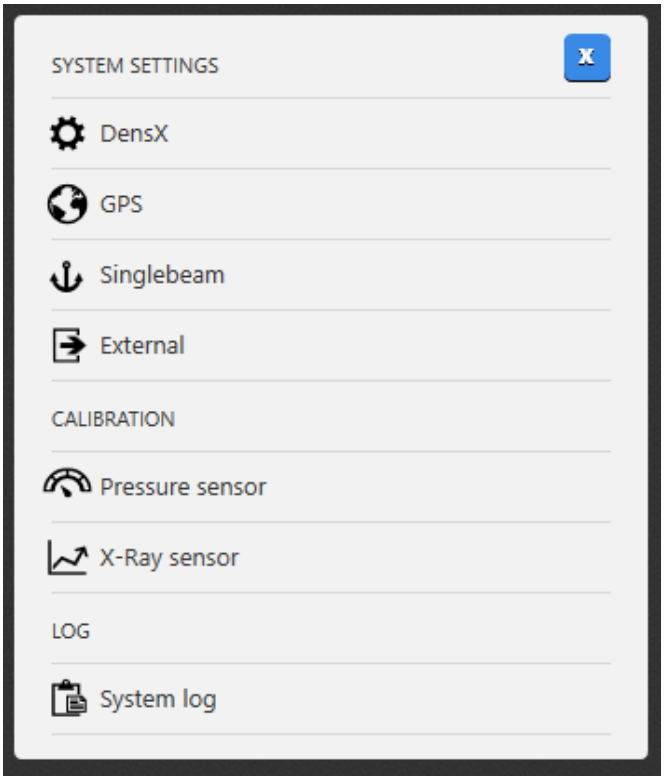


Figure 30: System settings

DensX

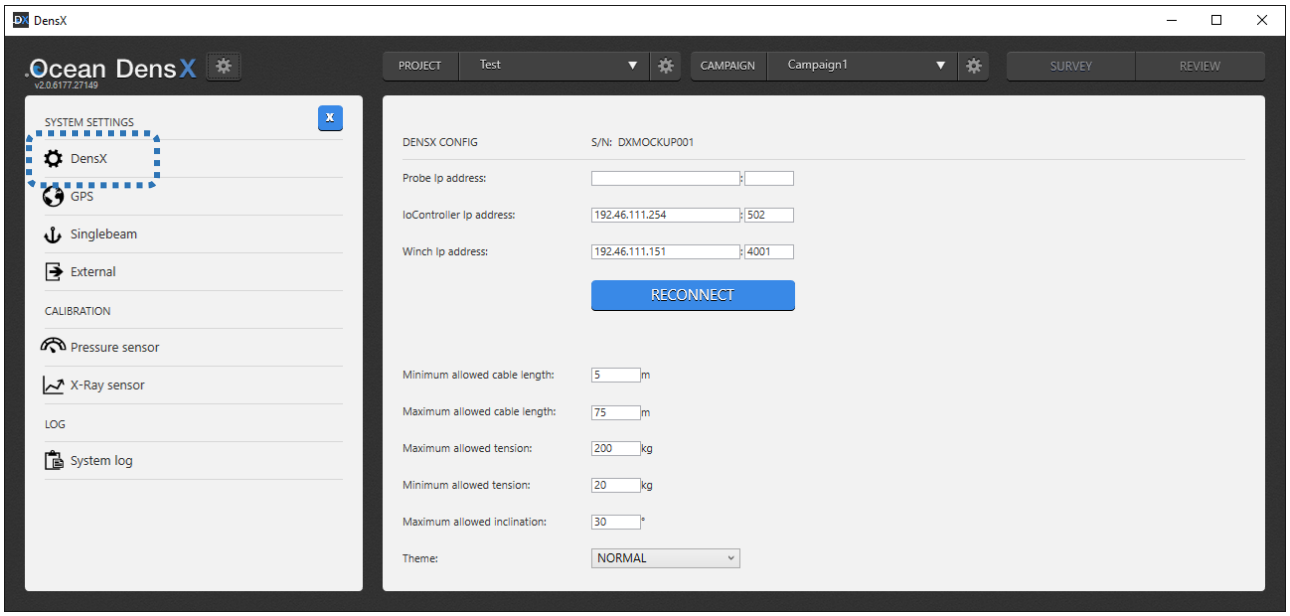


Figure 31: DensX settings

De DensX configuration window displays the IP addresses of the connected devices. The probe's IP address is read-only and will be shown as soon as the DensX is enabled. Other various settings can be changed here: Minimum and maximum allowed cable length, minimum and maximum allowed tension, maximum allowed inclination and the theme of the software program.

GPS

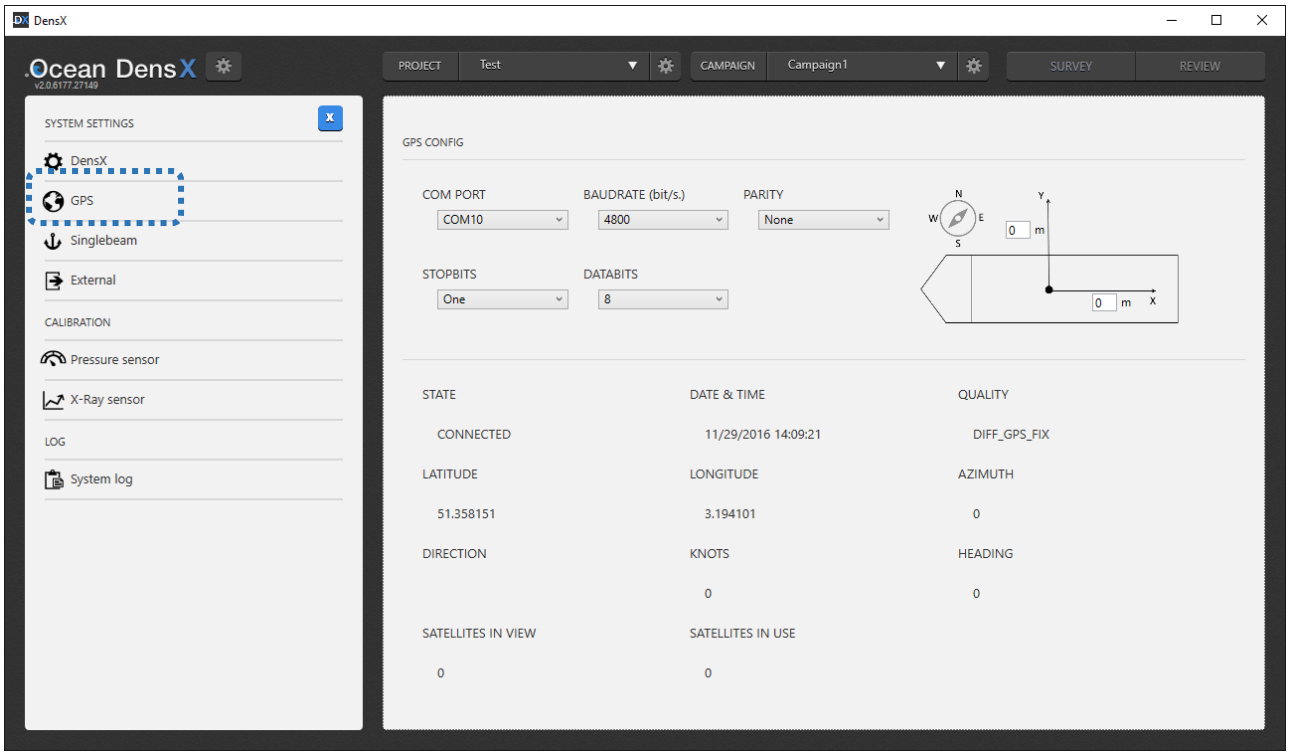


Figure 32: GPS settings

The GPS configuration displays the serial COM-port settings and the status of the GPS.

Item	Comment
COM port	The COM-port of the GPS port
Baudrate	The baudrate of the GPS port
Parity	The parity of the GPS port
Stopbits	Number of stopbits of the GPS port
Databits	Number of databits of the GPS port
X-Offset	X offset in meters
Y-Offset	Y offset in meters

SINGLEBEAM

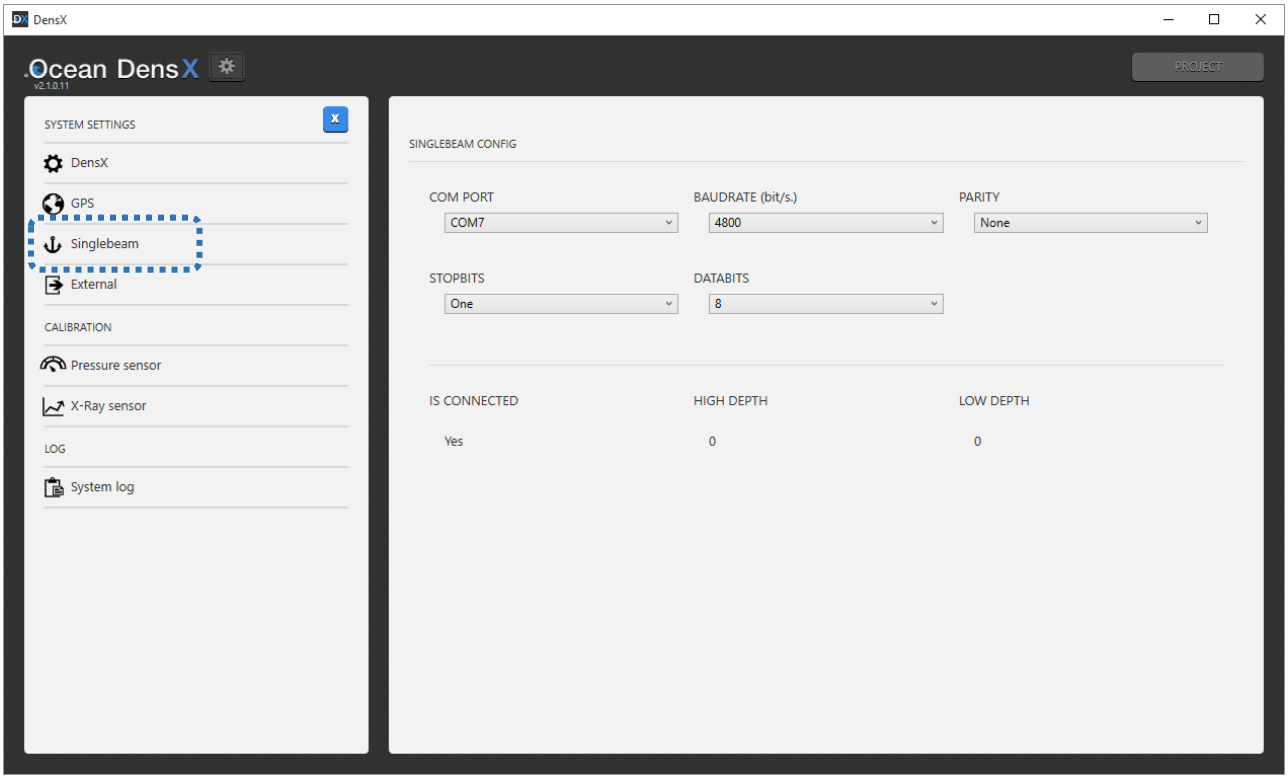


Figure 33: SINGLEBEAM settings

The Singlebeam configuration displays the serial COM-port settings and the status of the Singlebeam.

The supported data formats are

- $..DBT sentence from the NMEA-0183 standards.
- DBT protocol from the Echotrac MKIII dual echo sounder with both frequencies active.

Item	Comment
COM port	The COM-port of the Singlebeam port
Baudrate	The baudrate of the Singlebeam port
Parity	The parity of the Singlebeam port
Stopbits	Number of stopbits of the Singlebeam port
Databits	Number of databits of the Singlebeam port

External

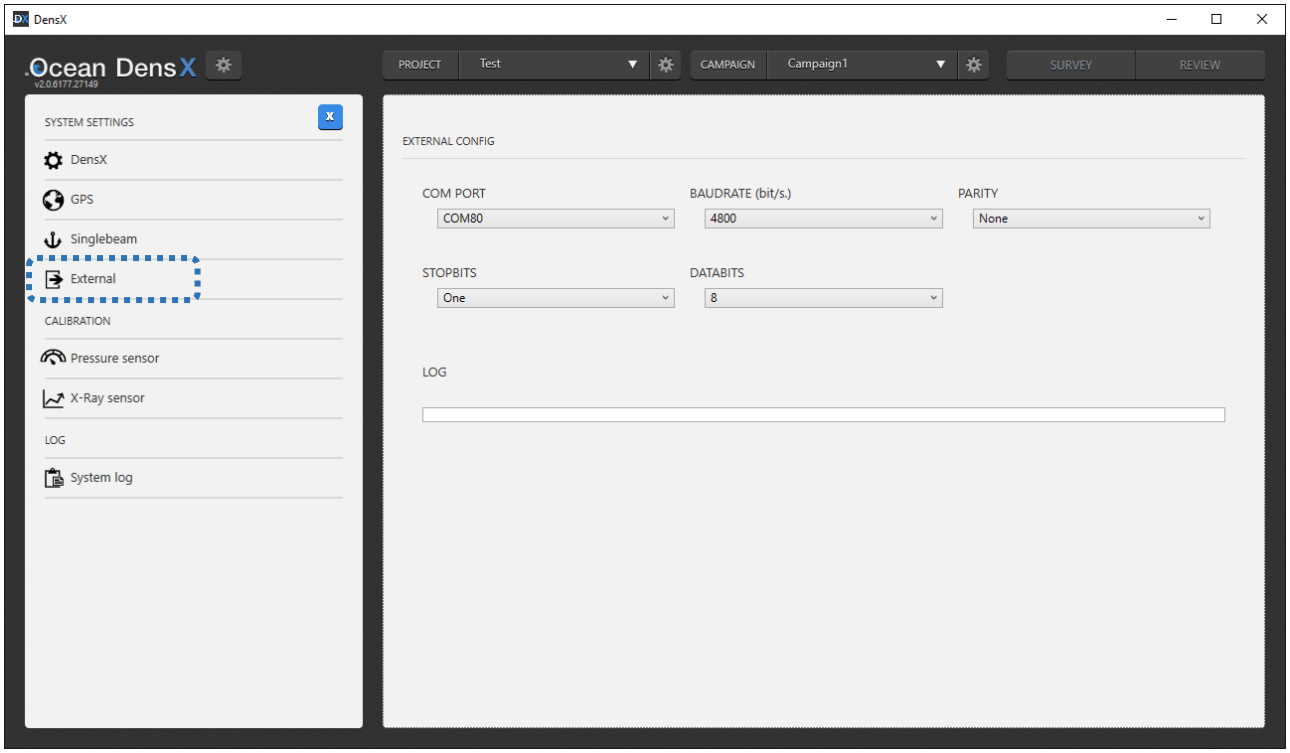


Figure 34: External settings

The external port is a serial output with the current depth and density. The external configuration display the COM-port settings.

Item	Comment
COM port	The COM-port of the external port
Baudrate	The baudrate of the external port
Parity	The parity of the external port
Stopbits	Number of stopbits of the external port
Databits	Number of databits of the external port

Calibration

See Calibration

Logging

There are two different log files in the software. The system log tracks every change in the software and logs every action in the software.

The calibration log logs every calibration action.

System log

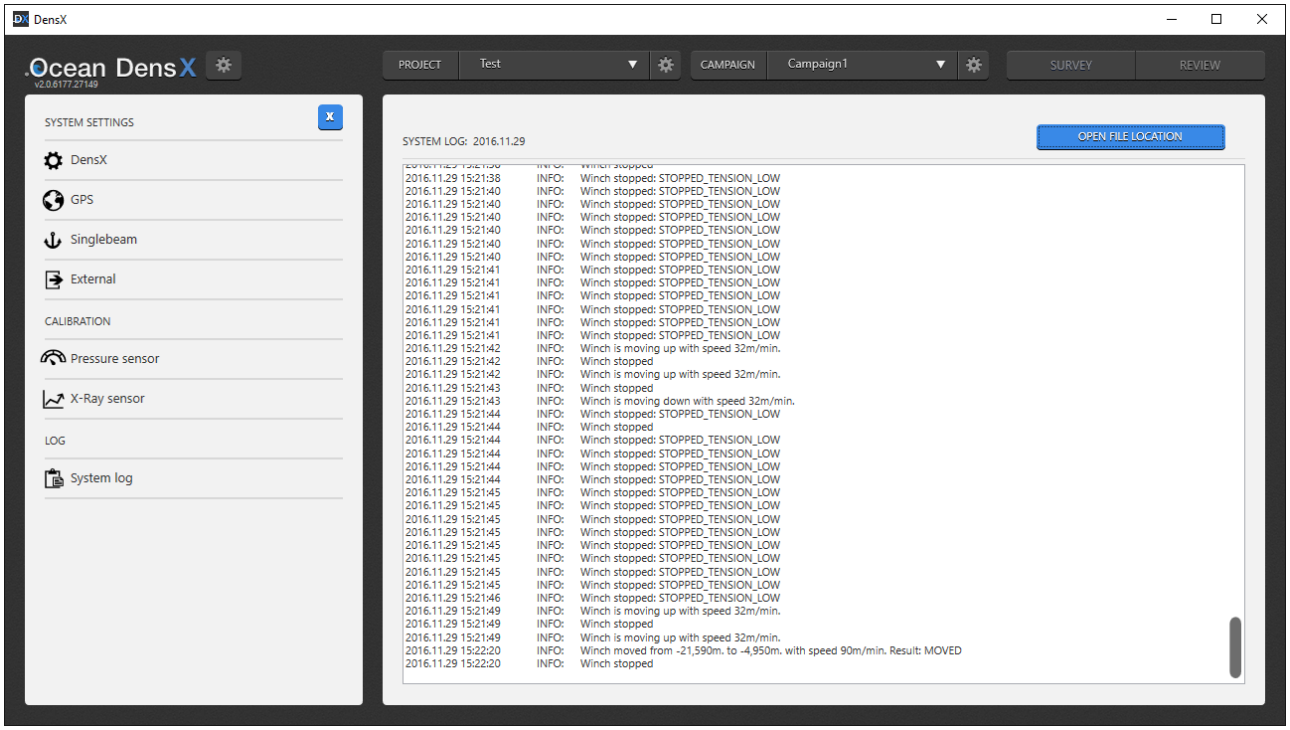


Figure 35: System log

Projects / templates

Project

A project is a collection of profiles.

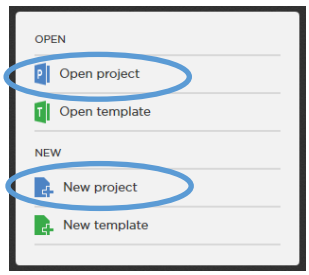


Figure 36: Project

Create new project

Create a new project and choose project location. If a new project is created, the software will ask for a name of the first campaign.

Open existing project

Choose the project location and select the project file.

General

When opening a project a new project item appears on top of the window.

Figure 37: New project item

When clicking on the project name, the next menu appears:

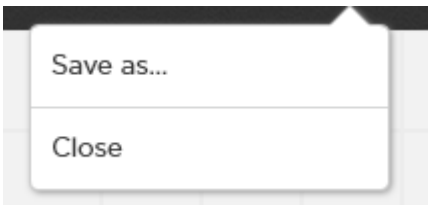


Figure 38: Menu after clicking

With this menu you can save a project with another name or close the project.

All project changes are saved automatically.

Project settings

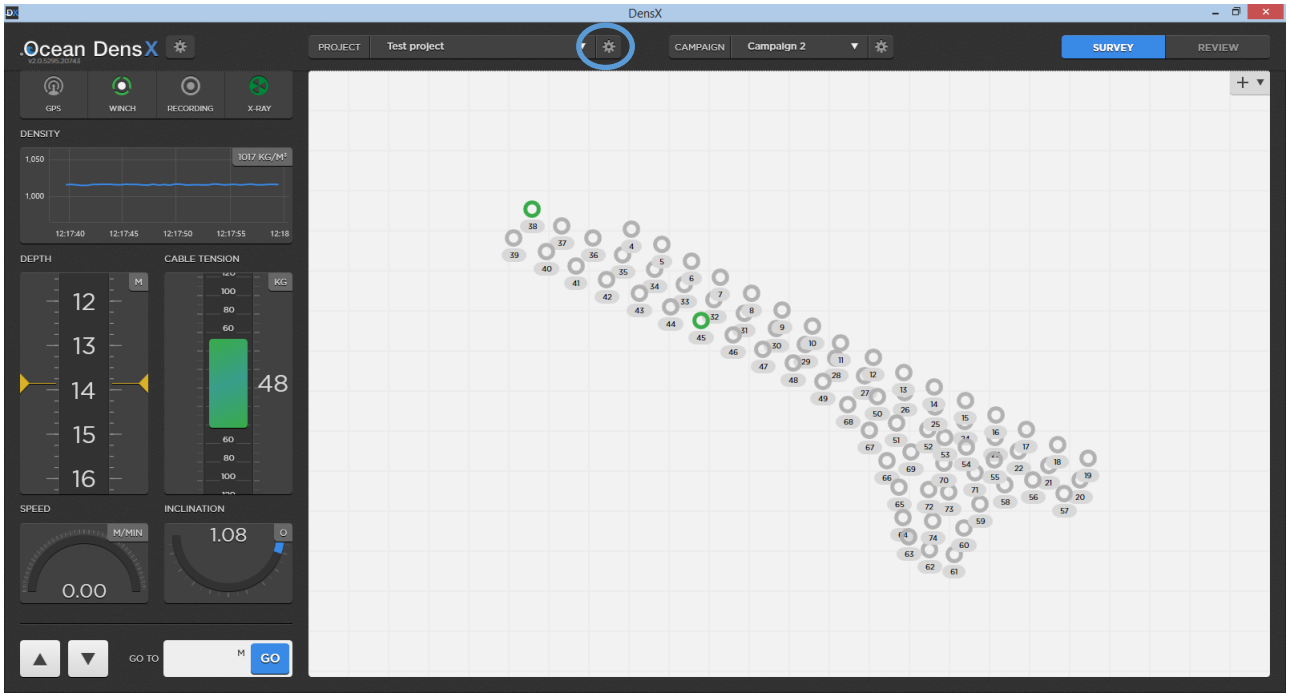


Figure 39: Project settings

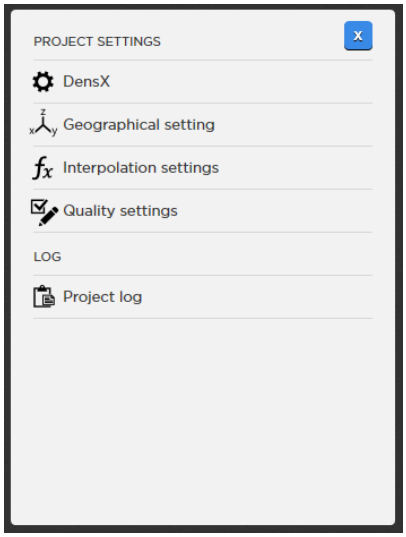


Figure 40: Project settings menu

1. DensX

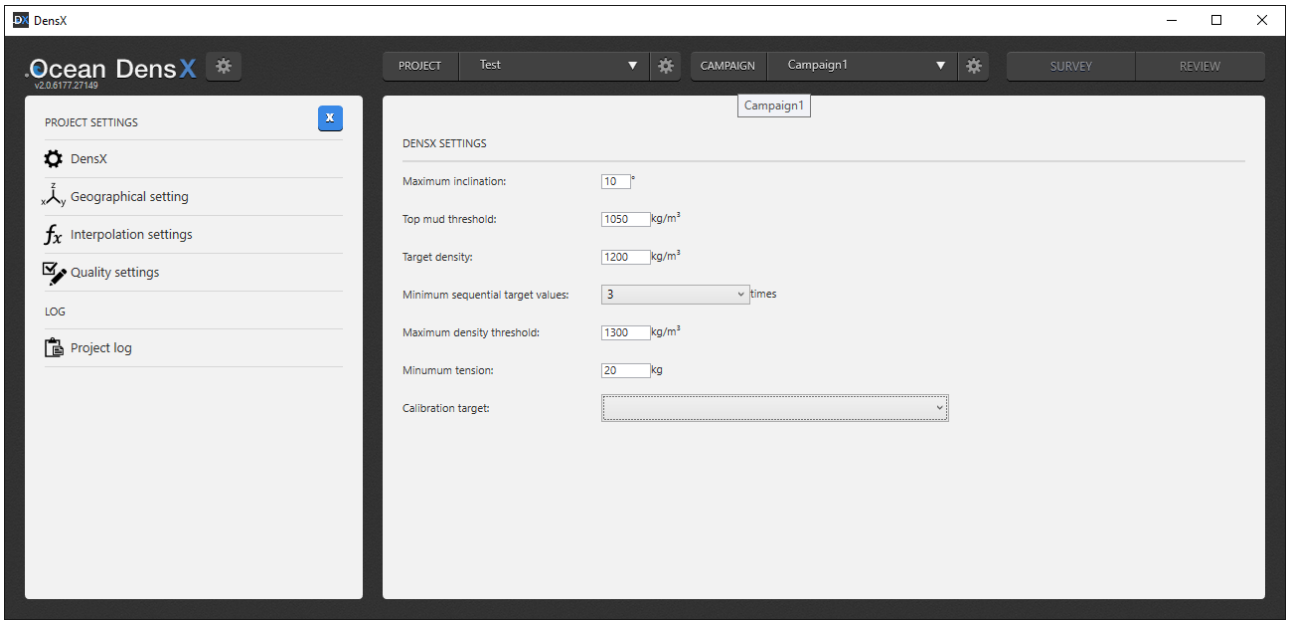


Figure 41: Project settings DensX

Item	Comment
Maximum inclination	Maximum inclination when measurement will be stopped
Top mud threshold	First line in density graph
Target density	Second line in density graph
Minimum sequential values	Number of sequential values past target density before target density is picked (first occurrence is picked)
Maximum density threshold	Maximum density when measurement will be stopped
Minimum tension	Minimum tension necessary on the cable, otherwise measurement will be stopped
Calibration target	The target which needs to be calibrated

2. Geographical settings

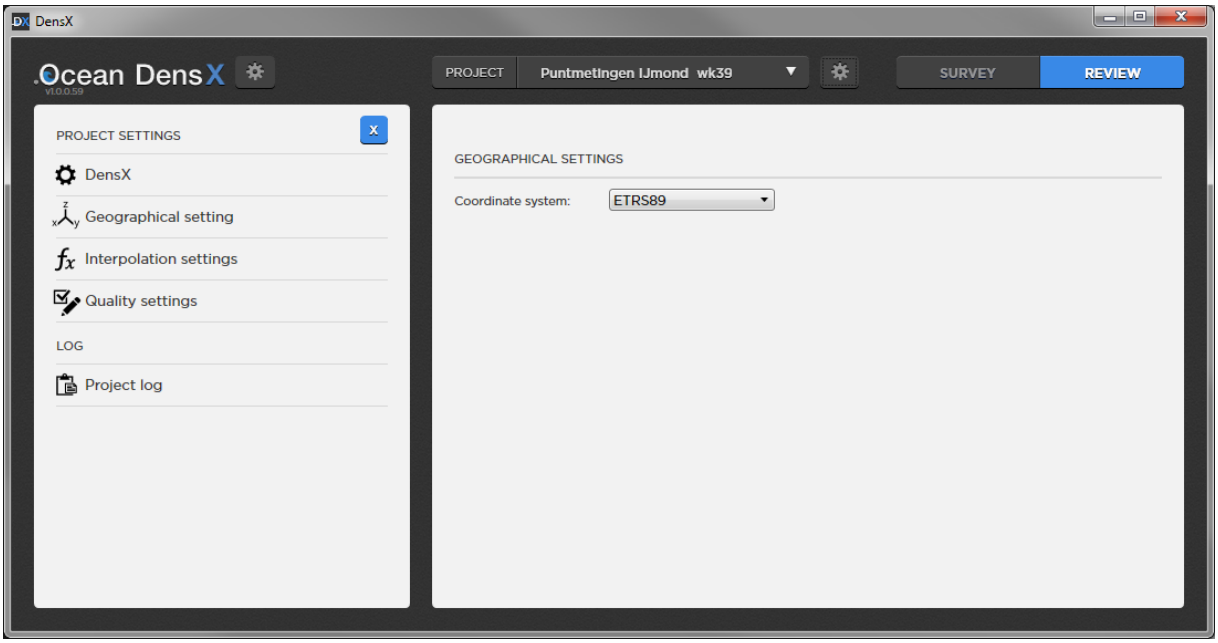


Figure 42: Geographical settings

Item	Comment
Coordinate system	Type of coordinate system in the project: WGS84 ETRS89 Rijksdriehoek

3. Interpolation settings

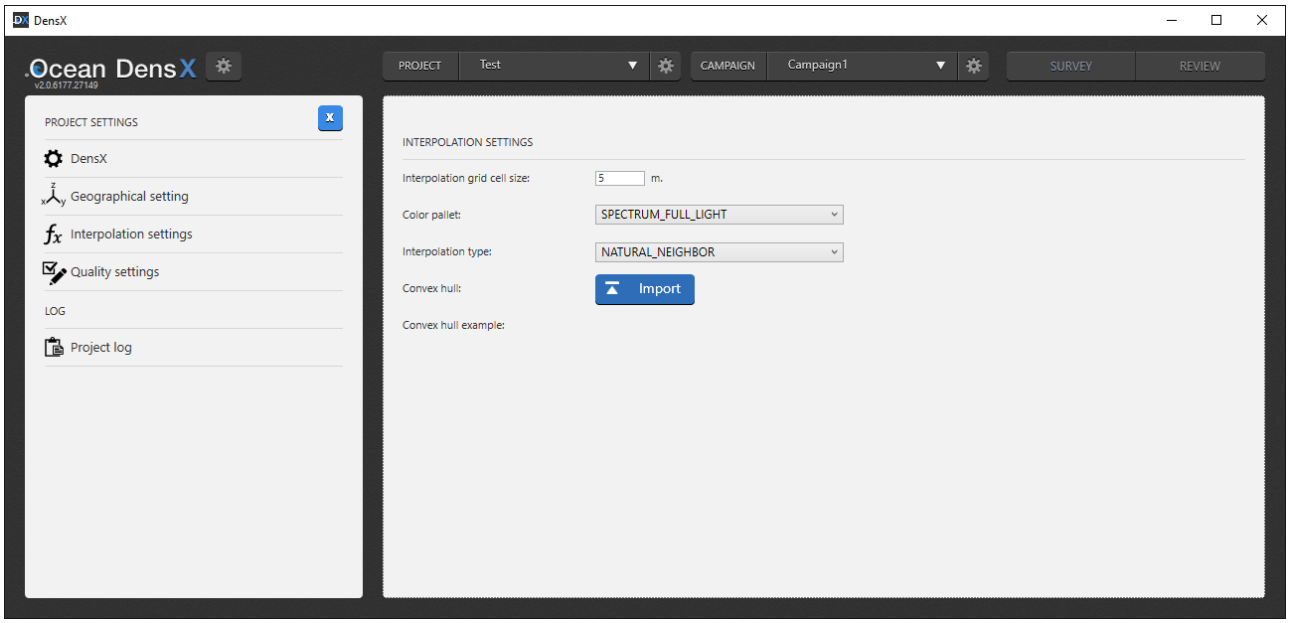


Figure 43: Interpolation settings

Item	Comment
Interpolation grid cell size	Size of grid
Color pallet	The color of the interpolation
Interpolation type	Type of interpolation in the project: Natural Neighbor Inverse Distance Weight
Convex hull	The convex hull describes the borders of your survey plane. All points on the convex hull have a value of 0.0. If there is no convex hull, the software will automatically generate this.
Convex hull example	Here you can see an example of the imported convex hull

4. Quality settings

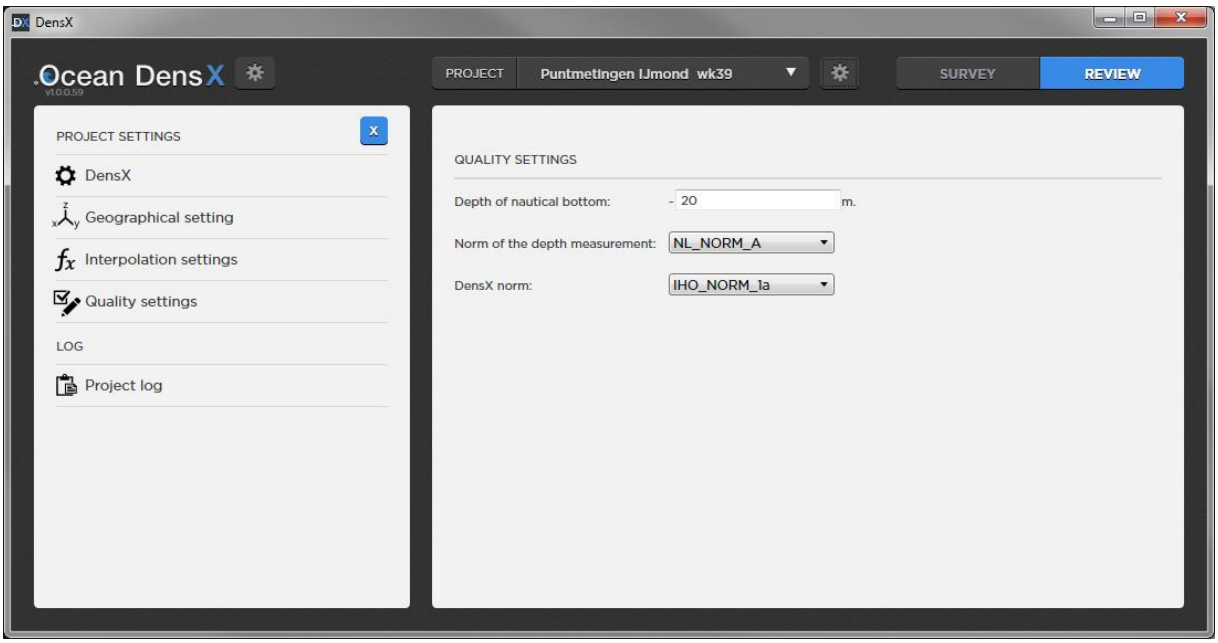


Figure 44: Quality settings

Item	Comment
Depth of nautical bottom	Used depth to calculate standards
Norm of depth measurement	Type of norms in the project: • NL NORM A • NL NORM B • NL NORM 1A • NL NORM 1B • NL NORM 2 • NL NORM SPECIAL
DensX norm	Type of DensX norm in the project • IHO NORM 1A • IHO NORM 1B • IHO NORM 2 • IHO NORM A • IHO NORM B • IHO NORM special

5. Project log

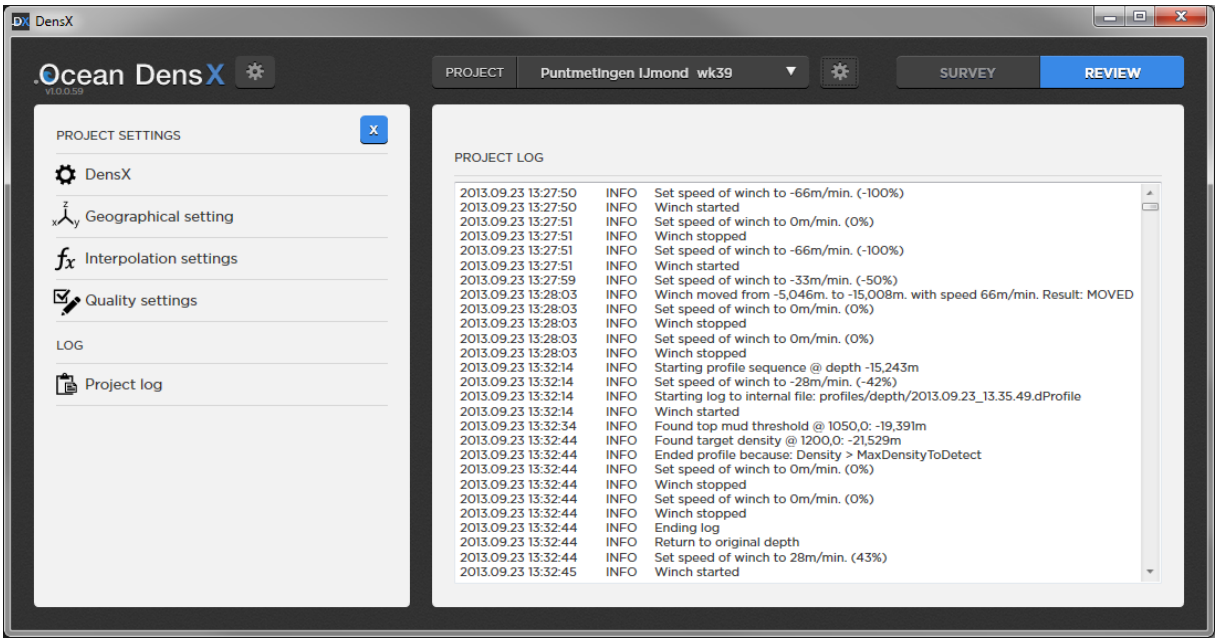


Figure 45: Project log

The project log contains the project specific changes (winch actions, speed settings, …)

Template

A template is a layout of a project with predefined settings. A template can also contain a collection of grid points.

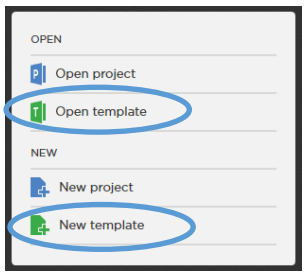


Figure 46: Template

Create new template

Create a new template and choose the template location.

Open existing template

Choose the template location and selected the template file.

Campaigns

In the software there is a possibility to store historical data. This can be achieved by the use of Campaigns.

With the use of campaigns the surveyor can store his recorded data together with historical data inside the same project.

Change campaign

To switch to another campaign, click on the name of the current campaign. After this, click on the campaign you want to load data from.

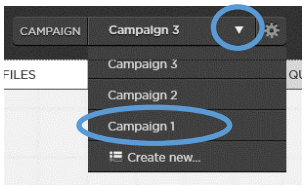


Figure 47: Change campaign

Add/Start new campaign

To add/start a new campaign, click on the name of the current campaign.

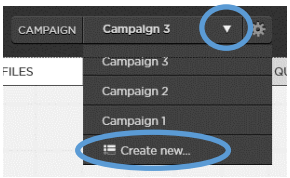


Figure 48: Add campaign

Change campaign name

To change the name of the current selected campaign, click on the settings icon.

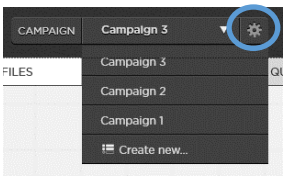


Figure 49: Change campaign name

Figure 50: Save campaign name

Survey map

The survey map is a grid of positions. Every point is a location where a profile can be taken.

Current position on the grid

Grid point without data

Grid point with measured profile data

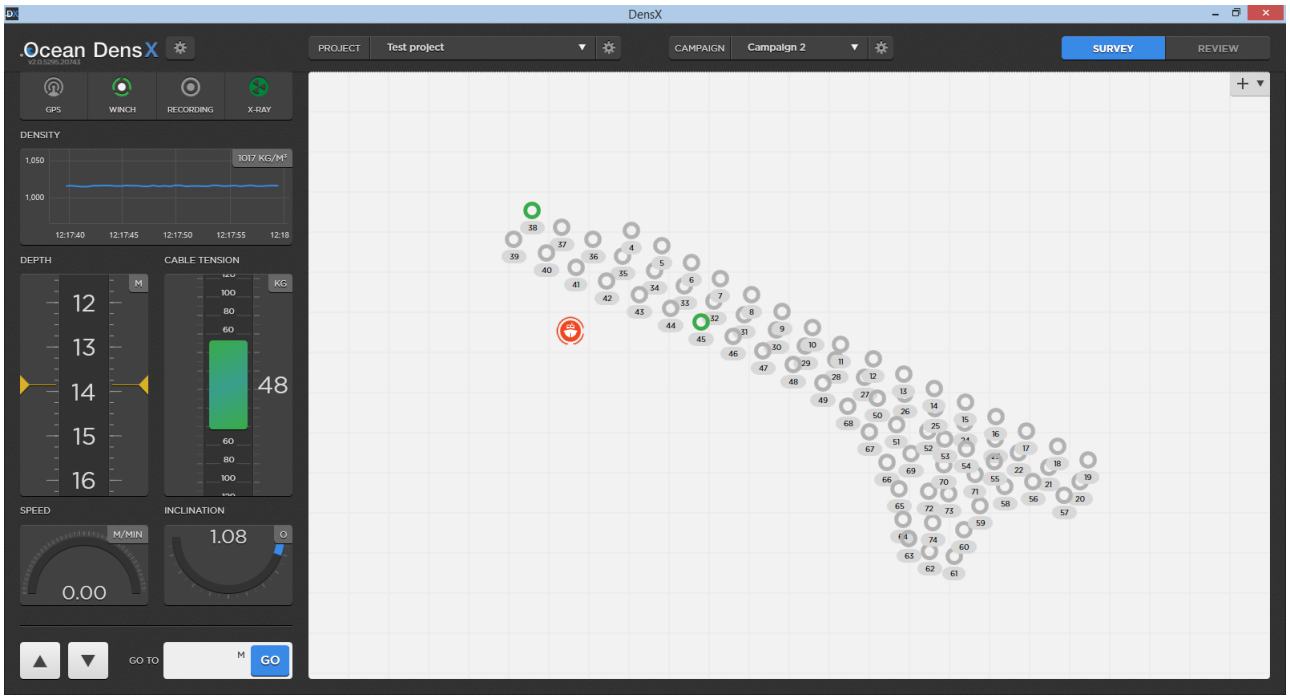


Figure 51: Survey map

When the current position is close to a grid point, the start measurement window will pop up. Manual choosing a grid point is also possible by clicking on it.

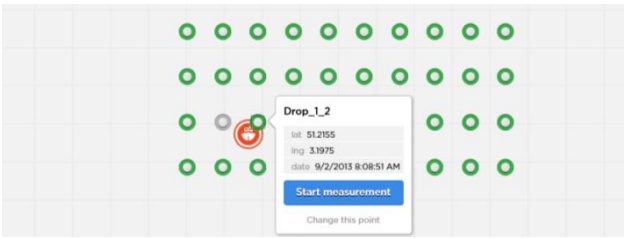


Figure 52: Survey map on location

Measurement

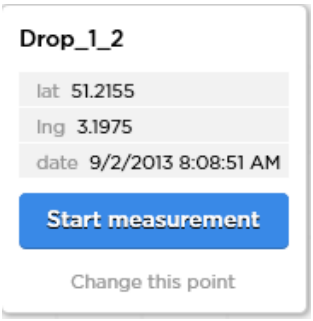


Figure 53: Start measurement

Item	Comment
Header	The name of the drop point
lat	The latitude of the drop point
lng	The longitude of the drop point
date	The date when the data is recorded

Click “Start measurement” to take a profile.

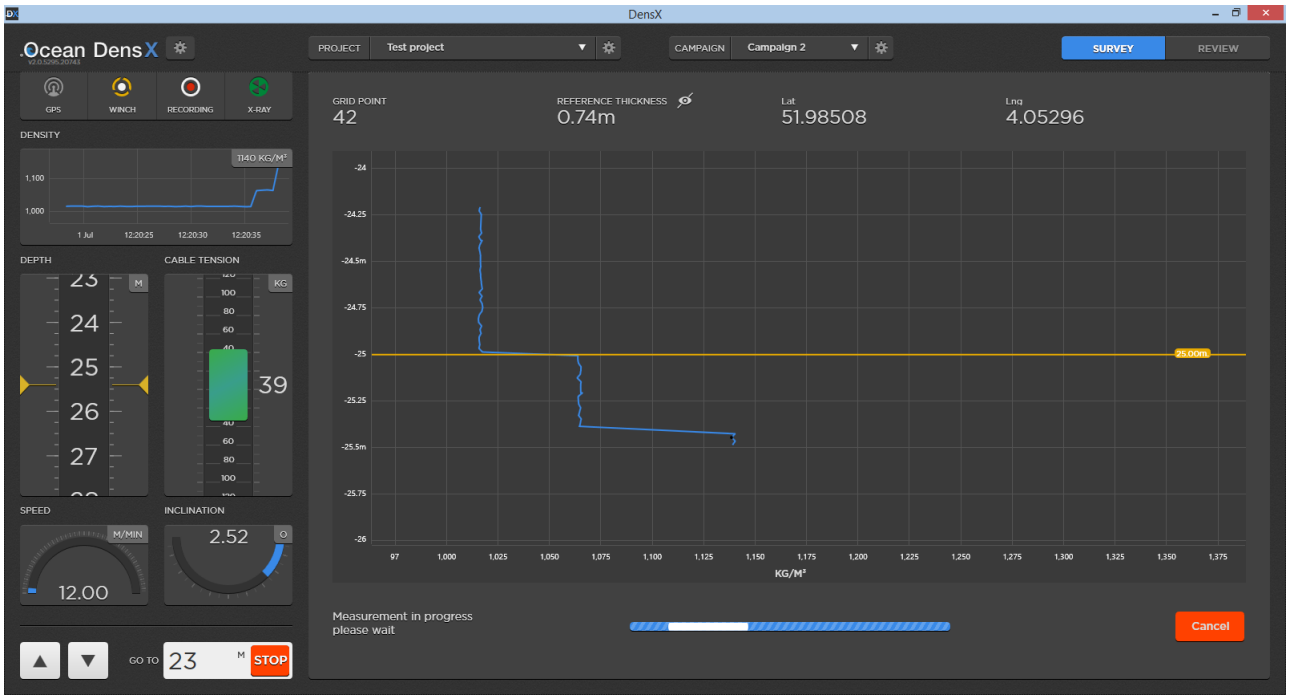


Figure 54: Measurement in action

In the above figure measurement is in action at 12 m/min.

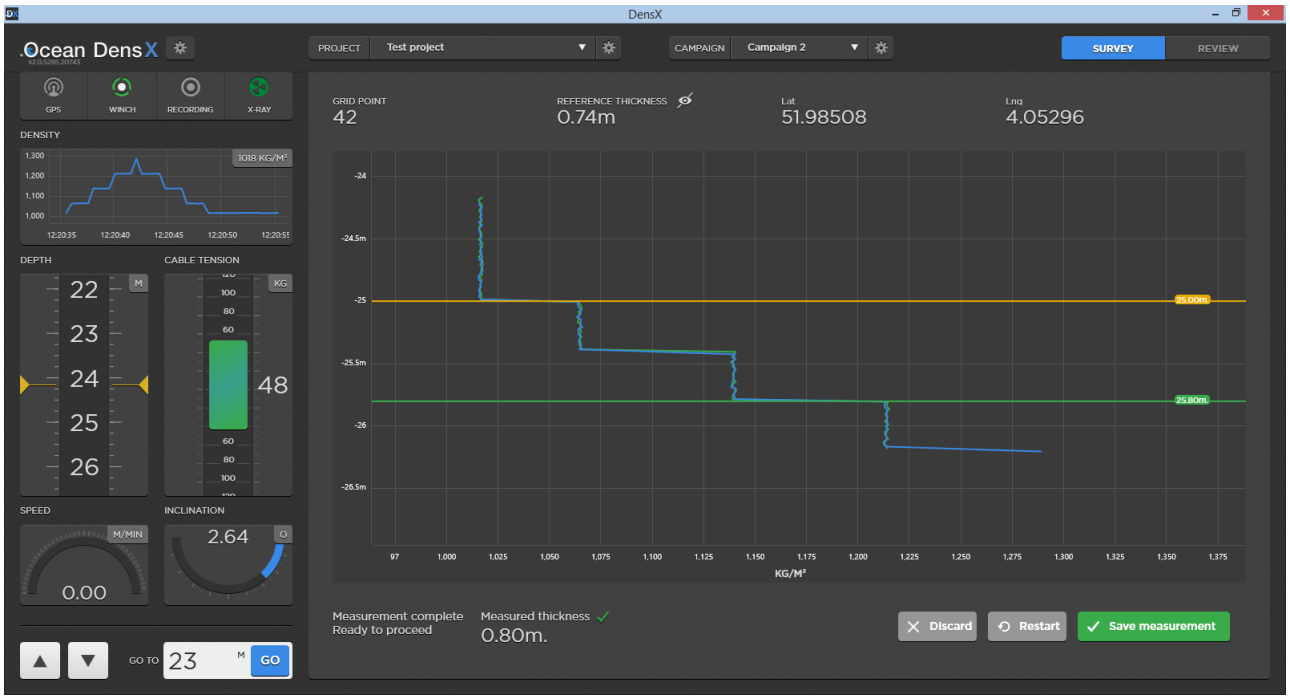


Figure 55: Profile completed

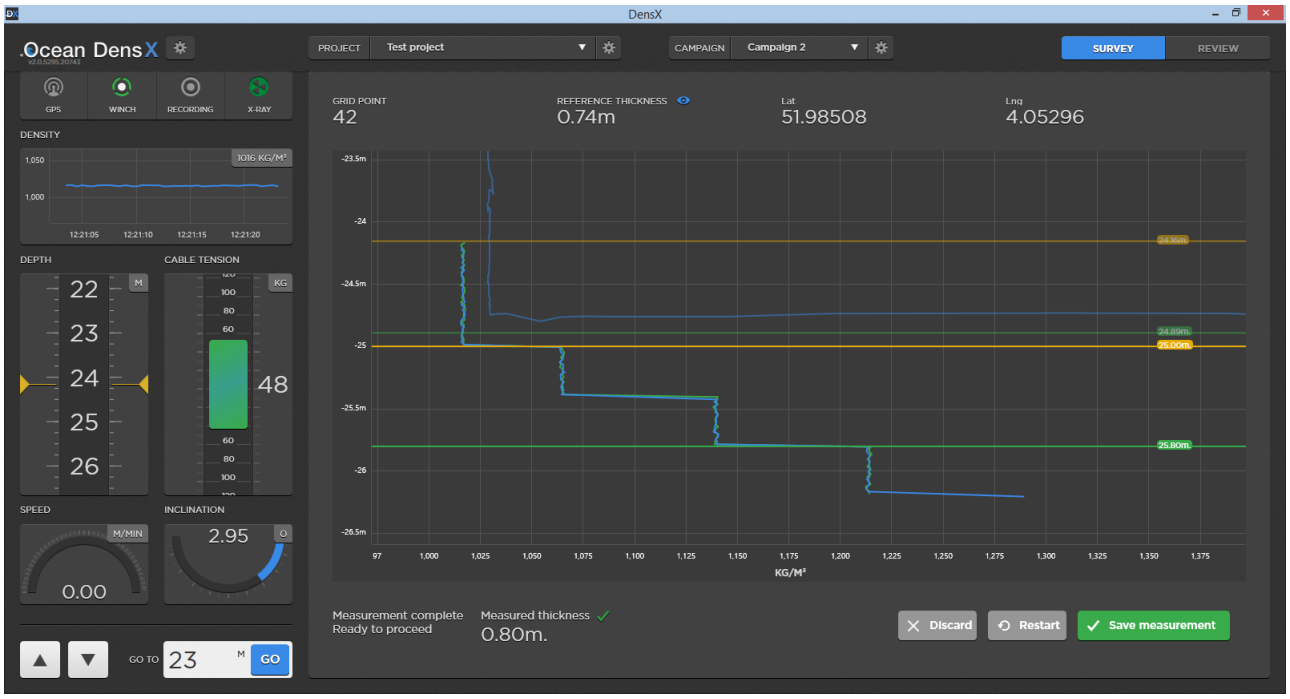


Figure 56: Show reference profile

When the profile is completed there are three options available:

- Save measurement: will save the profile at that point
- Restart measurement: will ignore the current measurement data and restart the measurement at this location
- Discard measurement: will discard the profile

Profiles

To review the profiles, the REVIEW section in the top-right corner of the window has to be selected.

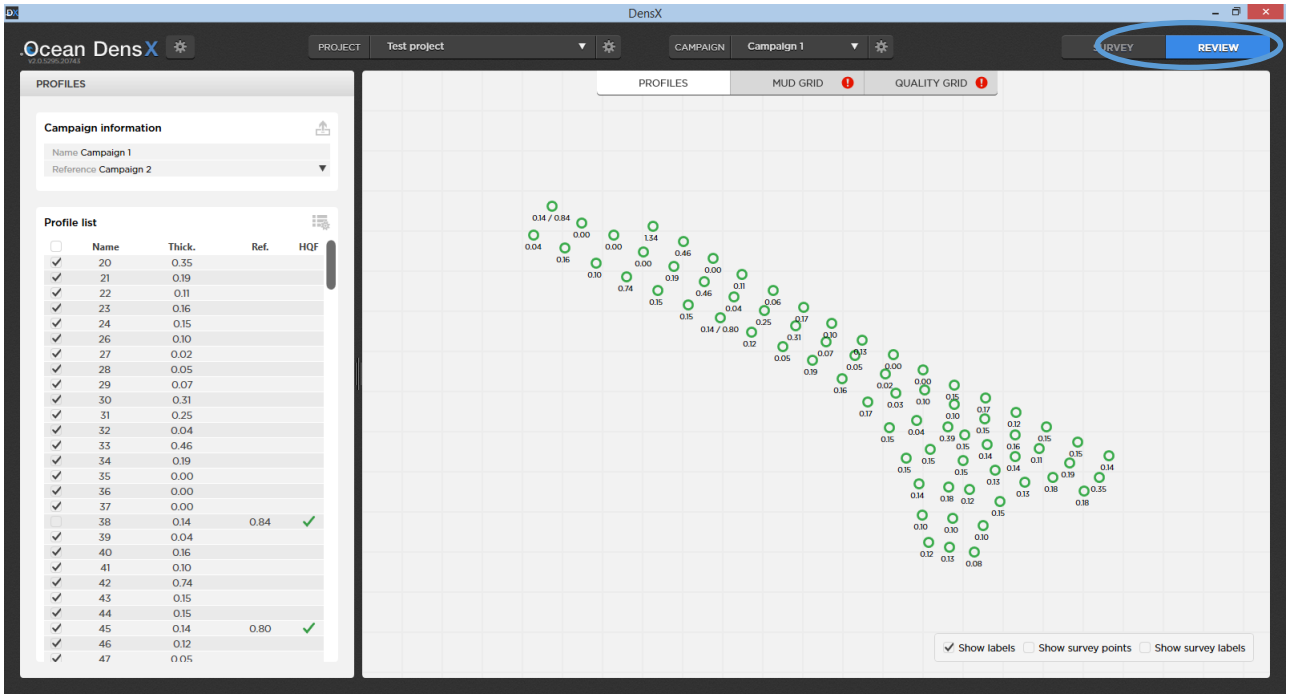


Figure 57: Review profiles

On the left side there is a table with all grid points. Grid points in the table can be selected for export. When clicking on a grid point, the table disappears and the profile is shown on the left.

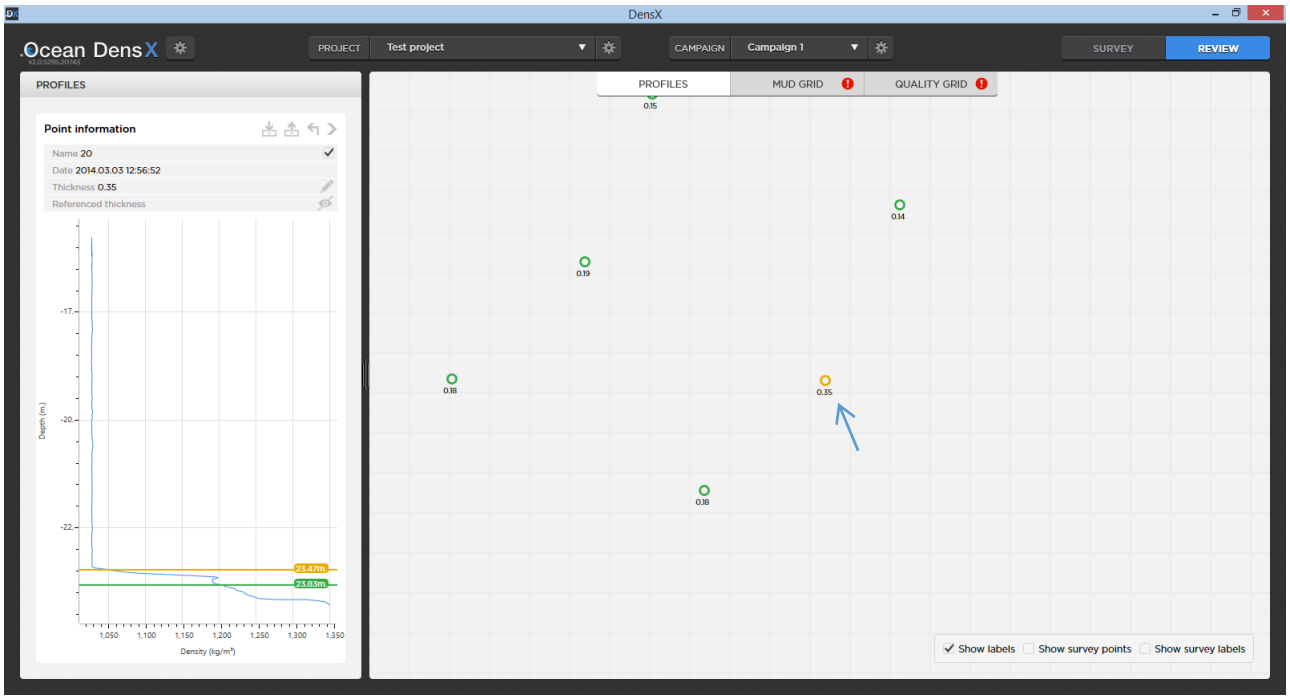


Figure 58: Profiles

To zoom in or out, point the mouse in the graph and use the scroll wheel

Click on another grid point to see its graph or double-click on the grid (no grid point) to see the table again.

Select all profiles in the table

Select none of the profiles

Return to the list of profiles

Previous profile

Next profile

Edit profile

Show/Hide referenced profile

Edit profile

The mud thickness can be edited. To show the edit panel, click on the edit profile button: 

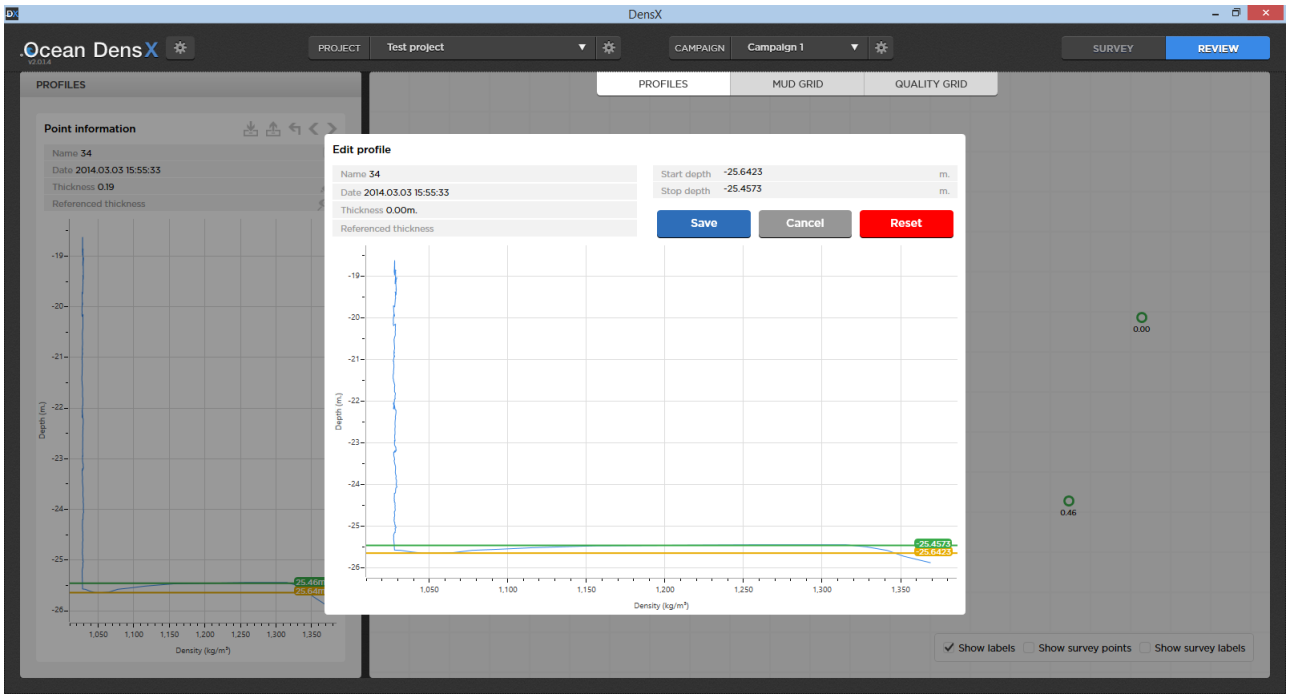


Figure 59: Edit profile panel

You can enter new values into the 'start depth' and 'stop depth' textboxes or you can drag the lines to the preferred depth.

To reset the profile to its original state, press the Reset-button: 

Export

Select the profile in the left table to export. There's also a possibility to export the complete table. Use the 'select all' or 'select none' buttons.

Select all profiles in the table

Select none of the profiles

Press the "Export selection" button and the profiles will be exported in a csv file.

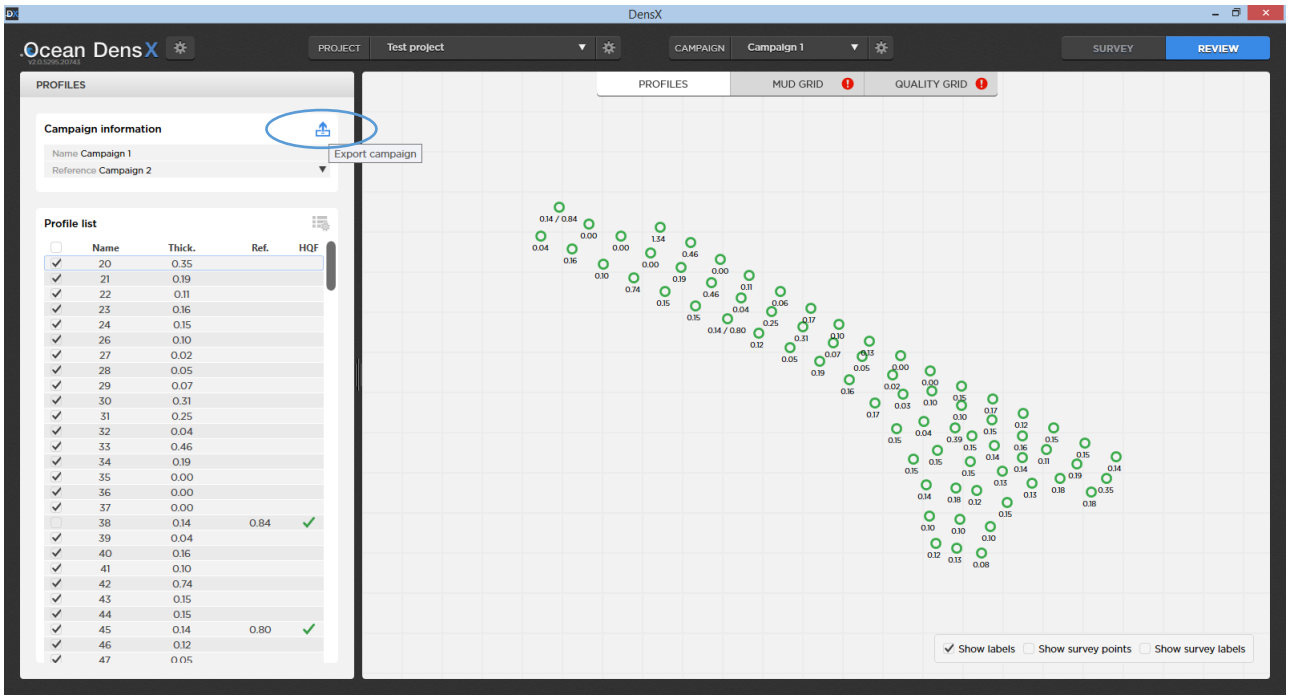


Figure 60: Profiles exporting

Mud grid

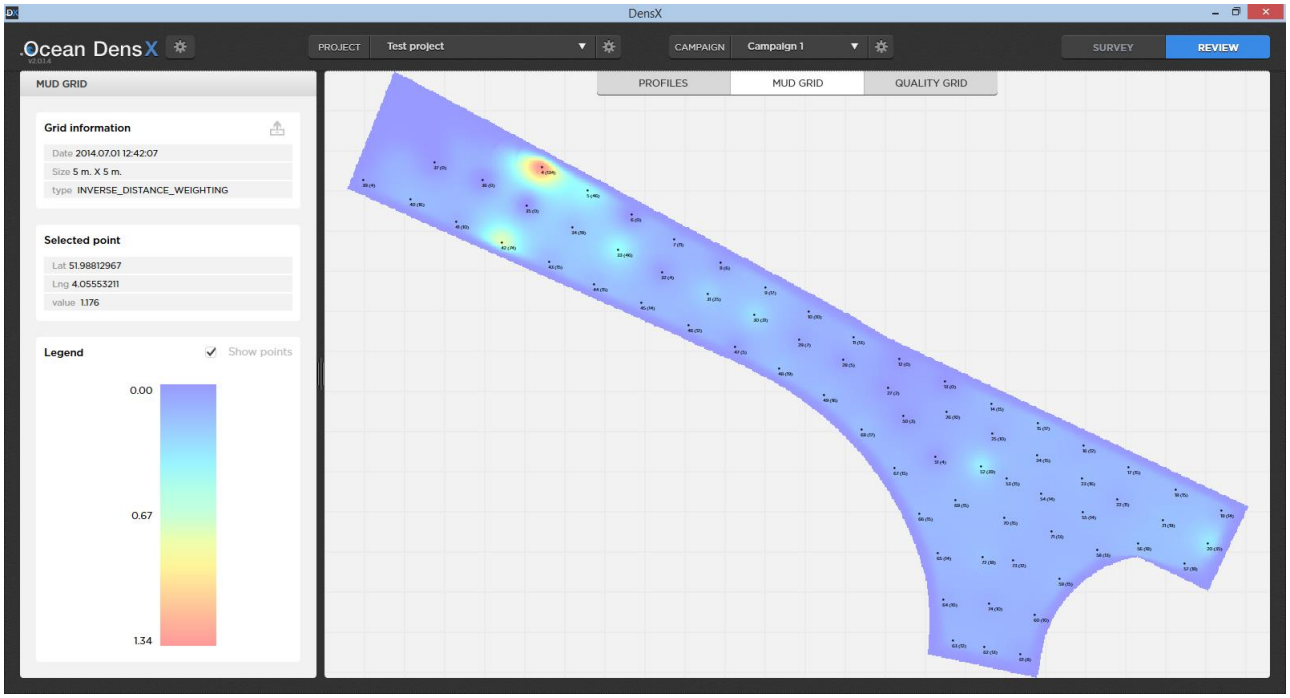


Figure 61: Mud grid with grid points

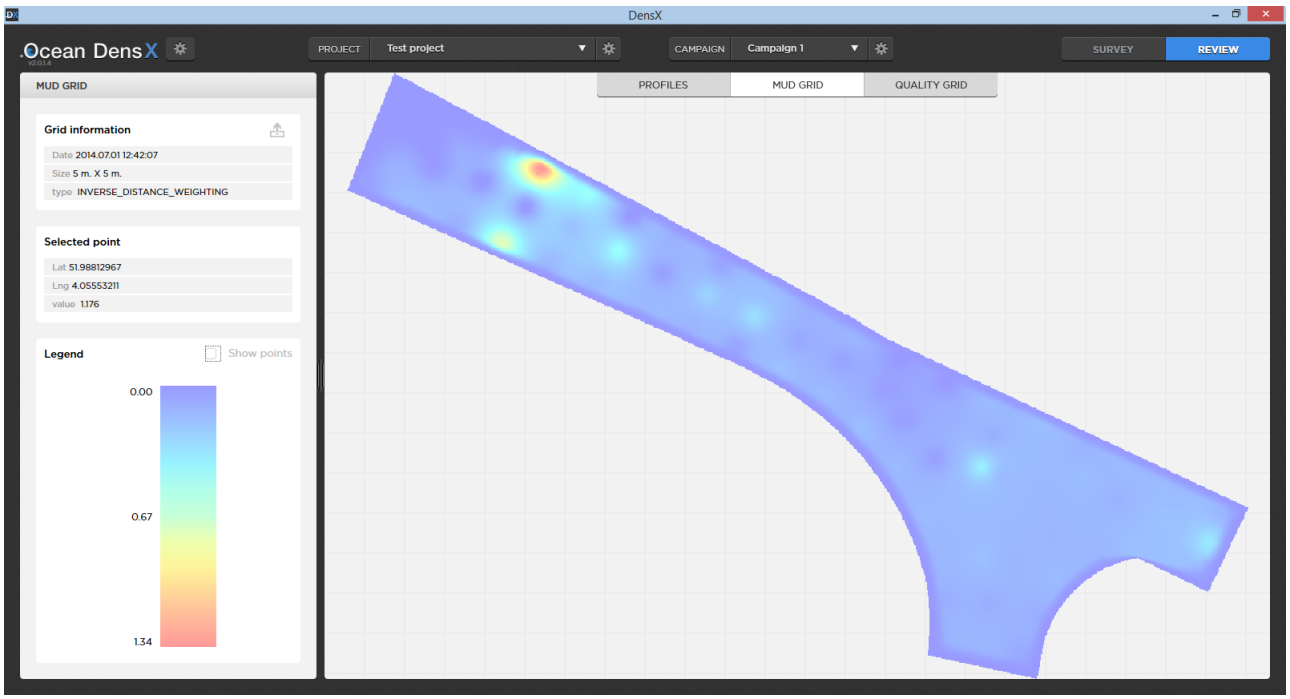


Figure 62: Mud grid

Quality grid

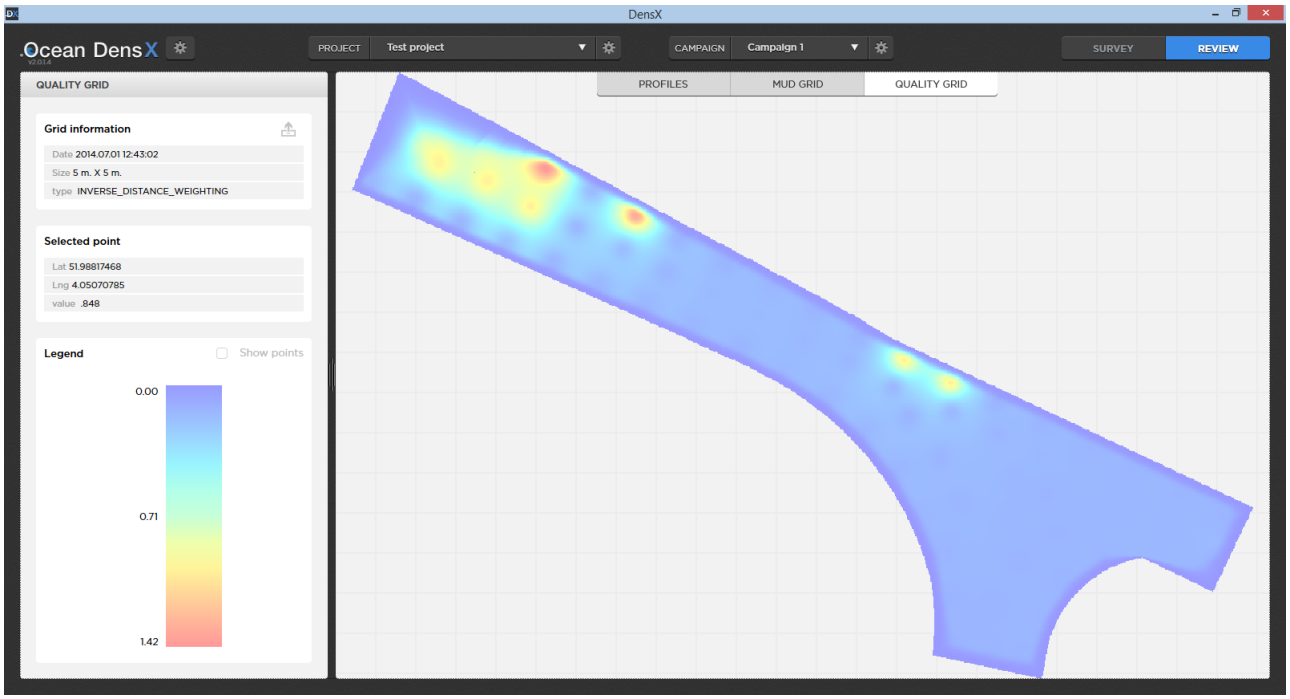


Figure 63: Quality grid

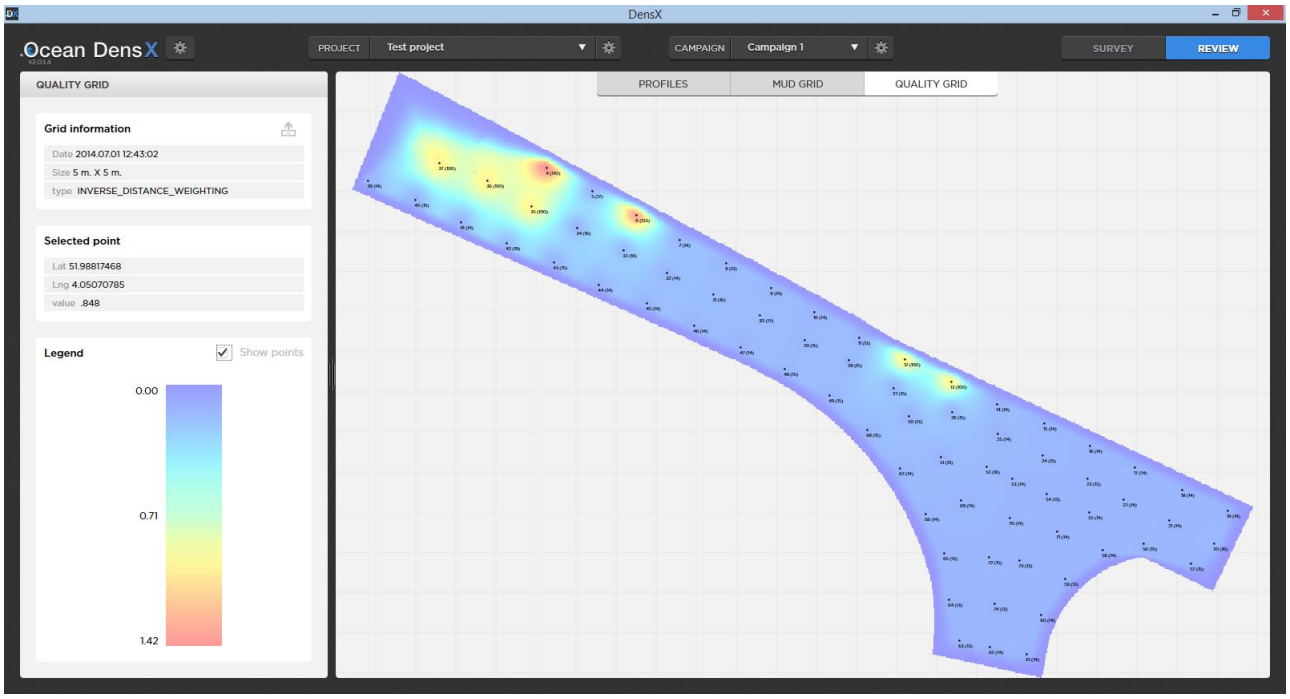


Figure 64: Quality grid with grid points

Error messages

State	Description
NO_ERROR = 0	No error
XRAY_STARTUP=1,	X-ray starting
XRAY_SHUTDOWN=2,	X-ray is shutting down
WINCH_COMMUNICATION_ERROR = 20,	No winch connection
WINCH_ERROR_STATE = 21,	Winch is in error state
IOCONTROLLER_COMMUNICATION_ERROR = 22,	Communication error with the IO-controller
XRAY_KEY_OFF = 23,	The X-ray hardware key is not active
INCLINATION_ERROR = 24,	Inclination is out of range
WINCH_ISLOCAL = 25,	Winch is turned to a local state
INCLINATION_SENSOR_ERROR = 26,	Inclination sensor is faulty
PRESSURE_SENSOR_ERROR = 27,	Pressure sensor is faulty
XRAY_COMMUNICATION_ERROR = 28,	Not connection with the probe
XRAY_STARTUP_ERROR = 29,	Error with the X-ray module on start-up
XRAY_SHUTDOWN_ERROR = 30,	Error with the X-ray module on shutdown
DEPTH_ABOVE_XRAY_SAFETY_DEPTH = 31,	Probe is above the X-ray safety depth
OVERRIDE_MODUS_ACTIVE = 32,	Override modus is active
WINCH_COMMUNICATION_STARTUP = 33,	Winch communication start-up

Users qualification

The personnel using the DensX must be trained and authorized by the customer. No specific qualification is required. Working with this DensX doesn't require being under a radiological safety program.

Operational conditions

A responsible surveyor must be designated by the customer to manage the DensX. The key of the control-command unit must be hold by the designated surveyor.

Working conditions

Mode 1: system shut turned off

The start/stop switch on the winch is in "STOP" mode. This disconnects the power supply of the DensX. The key of the control-command unit is removed to avoid the system to be turned on by any unauthorized people. The key must be hold by the surveyor and the DensX has to be placed in a storage appropriate place.

Mode 2: system turned on

These steps must be completed to turn on the system:

- Start/stop switch on the winch on "START" mode
- DensX is under water
- The key of the control unit is inserted and in position "1"
- The software is running

Only when those steps are fulfilled the indication LED on the DensX is blinking.

Mode 3: calibration

These steps must be completed to turn on the system:

- Start/stop switch on the winch on "START" mode
- DensX is in the calibration unit and the calibration unit is closed
- The key of the control unit is inserted and in position "1"
- The software is running in calibration X-ray sensor

Verifications before and after using the DensX

Before a field measurement work, a visual examination of the cable terminal has to be performed to check if there is any symptom of wear or corrosion on this part which is the most stressed.

X-Ray source on/off conditions

There are a few security features embedded in the software and the hardware. The hardware security features are by design not linked to the software & overrules all the software security features.

In the table below, you can find the condition where the x-ray will be on or off.

Software: min. depth reached	Software: Calibration mode	Hardware: Security key	Hardware: DensX water sensor submerged	Xray State
Yes	OFF	ON	Yes	ON*
No	OFF	ON	Yes	OFF*
Yes	OFF	OFF	Yes	OFF
No	OFF	OFF	Yes	OFF
Yes	OFF	ON	No	OFF
No	OFF	ON	No	OFF
Yes	ON	ON	Yes	ON*
No	ON	ON	Yes	OFF*
Yes	ON	OFF	Yes	OFF
No	ON	OFF	Yes	OFF
Yes	ON	ON	No	OFF
No	ON	ON	No	OFF

* Only if the software is not disconnected.

As you can see in the above table this could result in a condition where the software “activates” the x-ray source. But the hardware security features won’t allow the activation, resulting in the x-ray source not being activated.

Maintenance

The DensX must be calibrated with mud at least once a year.

Periodically it is interesting to perform calibrations with copper using the calibration system. The DensX is placed inside the calibration unit and copper sheets are placed into the slit. It is useful to have a follow up of the offset of the X-ray source and scintillator. A more detailed calibration schedule can be discussed with the customer.

The most crucial point in terms of security is the maintenance of the cable head and cable. A visual examination of the cable head has to be performed to check if there is any symptom of wear or corrosion on this part which is the most stressed.

The maintenance of the DensX must be done by authorized and trained personnel only.

Electrical drawings

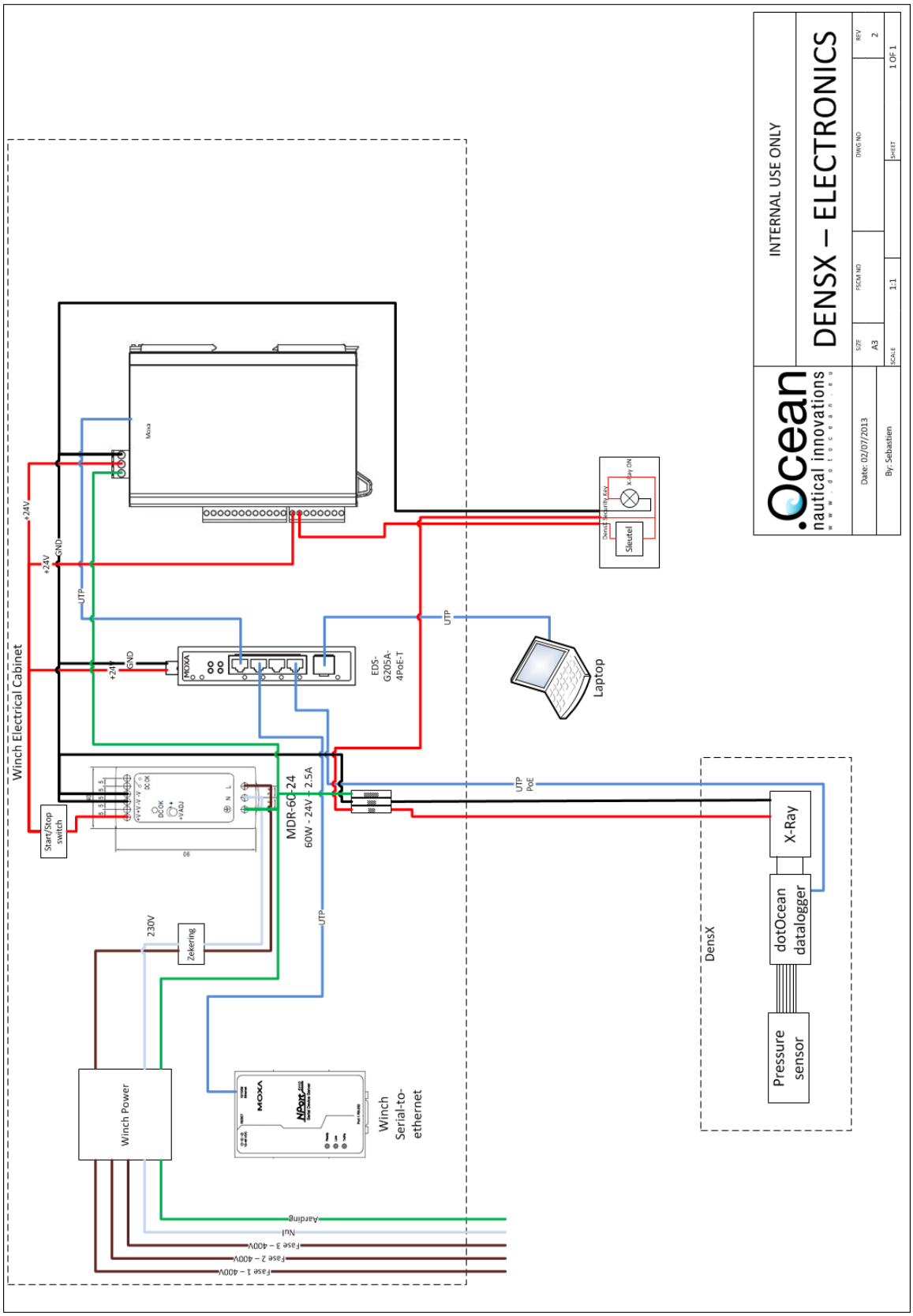


Figure 65: Electrical drawings