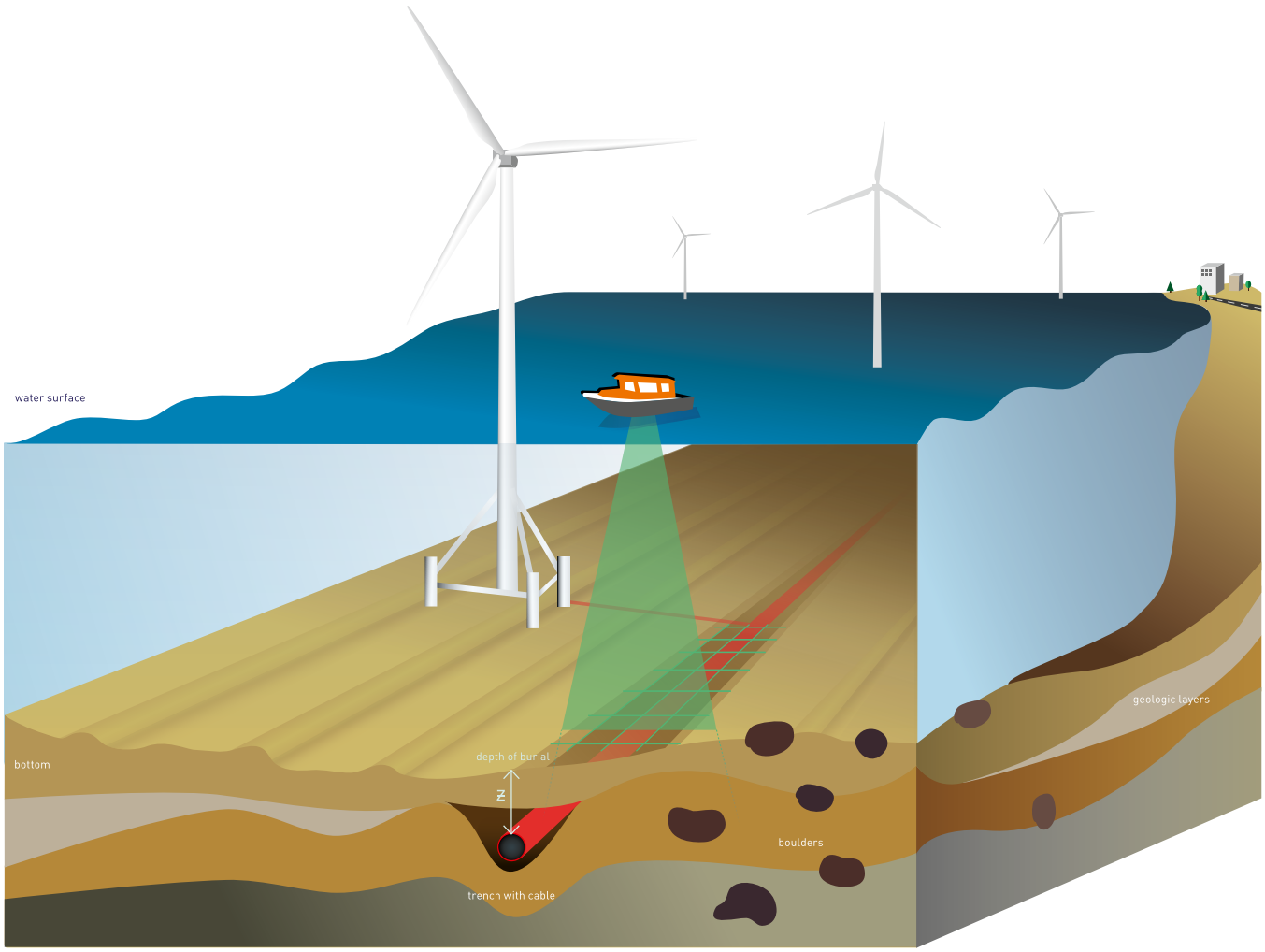


Sub-bottom specialist
Geophysical solution provider

Stema Systems

Stema Systems has since 1986 been delivering specialized services and equipment to the hydrographical survey industry, we have done so while keeping in mind the strenuous and strict requirements that our customers work with and have come to expect of Stema.

Stema Systems has a history of providing hydrographic equipment to the survey, dredging industries as well as some well renowned educational institutions. The reason that Stema Systems clients chose our service and products over and over again is for our in-depth knowledge, our insight into their needs and our willingness to go over and beyond to ensure that the client achieves the goal that they have set themselves.

As part of these investigations Stema Systems provided active assistance in acoustical investigation of the seabed with Stema Systems purposely developed Silas Software Suite together with sampling and rheological analysis of (semi)-fluid sediments.

Given the ever changing environment that Stema Systems operates in, it is continuously improving and developing new products, these range from complete survey boats to the detection of sub-sea cables, our philosophy is to work with our customers to achieve the needed solutions that will enable them to perform at an optimal level.

In 2016 Stema developed a cable detection system that would enable the location of cables and object buried in the seabed, based on the EBP system in combination with the Silas Software Suite, adding this capability into the Stema portfolio, providing our clients with the possibility to monitor depth of burial of cables for installation and also maintenance projects.

Stema Systems welcomes all questions and opportunities to think with and work with solution providers and to this end we would welcome you to contact us for any and all questions, enquiries or potential projects that you may have.

With regards,

Pepijn P. Peter
managing director

www.stema-systems.nl

Provide end users with the most accurate nautical depth measurement by using the combination of echo sounders and density measurement equipment

Pieter J. DE BOER, Coen J. WERNER

Keywords: nautical depth, fluid mud, acoustic density mapping, yield stress, cable and pipeline detection

ABSTRACT

Harbours and their access channels need to be dredged to the nautical depth to ensure safe vessel passage. When fluid mud is present, a critical density value is determined to establish this depth, which is area specific. Another consideration for establishing the level of safe vessel passage is yield stress. The yield stress indicates the level in the fluid where solidification of the mud occurs.

Traditional survey techniques are not capable of detecting multiple density levels or yield stress. To optimize dredging operations and continuous harbour management one could benefit of using an ultra-high resolution sub-bottom profiler in combination with in-situ density and yield stress measurements.

The geophysical software package SILAS will link both type of measurements and can in real-time determine density levels which spatially cover the entire harbour or access channel, therefore excluding interpolation in the process. The SILAS software enables all users to manage the nautical depth, while batch processing and data cross-referencing acquired using different sources can improve the overall data quality as well as provide the user with a more detailed understanding of sub-bottom features, such as cables and pipelines. Recent studies show that the SILAS system can detect various types of sub-bottom objects not only limited to cables and pipelines, but also individual boulders. These objects can be detected with a success rate of 75% and over on objects and cables with a diameter of 25 cm or higher.

1. INTRODUCTION

A global trend of increased harbour traffic can be partially attributed to the economic growth arising after the recovery from the setback of the 2008 crisis, resulting in an increase in cargo traffic of shipping vessels with more draught making use of the harbour on a daily basis. For instance, significant growth can be seen in ports like: Mombasa (Kenya), Cochin (India), Tianjin (China), Rotterdam (Netherlands), not to mention port facilities on the North American east coast (New York, Savannah, Jacksonville, Miami), the latter being due to the recent opening of the Panama Canal expansion in June 2016 introducing Post-Panamax vessels from Asia.

To ensure safe passage of these vessels, harbours and their access channels need to be dredged to the nautical depth. This depth is established by defining a critical density value which is related to a particular yield stress value. Both depth and the relationship between density and yield stress is area specific and does not remain constant during the year, especially in high-tidal or even monsoon environments. The presence of fluid mud will cause fluctuations and might even give a false value for the defined bottom depth in the first place. Correct harbour management implies continuous monitoring of the fluid mud and its physical properties.

In this paper the nautical depth principle will be explained. Accurate prediction of the nautical depth saves time and operating costs. The preferred working methods include in-situ density measurements and the relationship between density and yield stress will show that there is an even better understanding of the nautical depth today. Improved acquisition methods are introduced as well as real-time density calculations and batch processing, the latter acting as quality assurance. Integrating all this in one geophysical software package has many benefits. The discussed software package SILAS is not only suited for nautical depth assessment, but mainly for processing and managing of sub-bottom seismic data, including detection of cables, pipelines and boulders.

2. NAUTICAL DEPTH

2.1 General principle

Navigational channels and harbours are often covered with a fluid mud layer, which is characterized by a low density and weak shear stress (Delefortrie et. al., 2004). When this water-mud interface is considered as the actual bottom the navigation depth will frequently be much shallower than the one required. In these conditions it is better to define a nautical depth as "the level where physical characteristics of the bottom reach a critical limit beyond which contact with a ship's keel causes either damage or unacceptable effects on controllability and manoeuvrability" (PIANC, 1997).

This depth is usually defined by a physical level of a certain density within the fluid mud layer (Van Craenenbroeck et. al., 1998). As the physical characteristics of mud vary, the critical density used to determine the nautical depth is site specific. For instance muds from Guyana, Southern America show a very low yield stress at densities as high as 1.5 ton/m3, while North European harbours show a significant yield stress increase at density levels varying between 1.15 and 1.25 ton/m3 (Fontein, Werner, Van Der Wal, 2006). Therefore the decision to pass through a particular mud should not be based on its density alone, but by yield stress values as well, as will be explained later in this paper. Due to influences of nature, the actual nautical depth will vary over time as well and a proper monitoring system is required.

Traditional survey techniques are not capable of detecting multiple density levels or yield stress and will only acquire the top of the fluid mud layer. An ultra-high-resolution sub-bottom profiler in combination with in-situ density and yield stress measurements will be able to capture the full profile and detect all required density levels. The recommended operating principle is discussed below.

2.2 Recommended operating principle

Traditional survey techniques consist of using a Singlebeam or Multibeam echosounder with a relative high frequency which is unable to penetrate to the bottom of the fluid mud layer. Figure 1 displays the clear difference in penetration between traditional Multibeam surveys (black and green lines) and the preferred use of a high-resolution sub-bottom profiler (blue and red lines). In the morning the top of the fluid mud layer is marked by the blue line, while the base is marked by the red line, according to the sub-bottom profiler. The Multibeam echosounder measures only the top (black line), but is inconsistent and penetration of top of the fluid mud is too high.

On the other hand it is unable to penetrate towards the bottom of the fluid mud layer. In the afternoon the top of the fluid mud is marked by the blue circles, while the base is marked by the red circles, according to the sub-bottom profiler. The red circles align with the red line, showing consistency over time in measurements of the bottom of the fluid mud with this technique. The green line represents the Multibeam echosounder measurements in the afternoon. At this time the Multibeam has too little penetration to detect even the top of the fluid mud. The difference between both Multibeam surveys – morning (black line) and afternoon (green line) - shows that this traditional survey can give variable outcomes in one day only and should not be considered reliable. The way forward is to use a combination of a high-resolution sub-bottom profiler and an in-situ density profiler which is able to measure both density and yield stress. The recommended system setup is described in Figure 2.

Related products

Silas

EBP

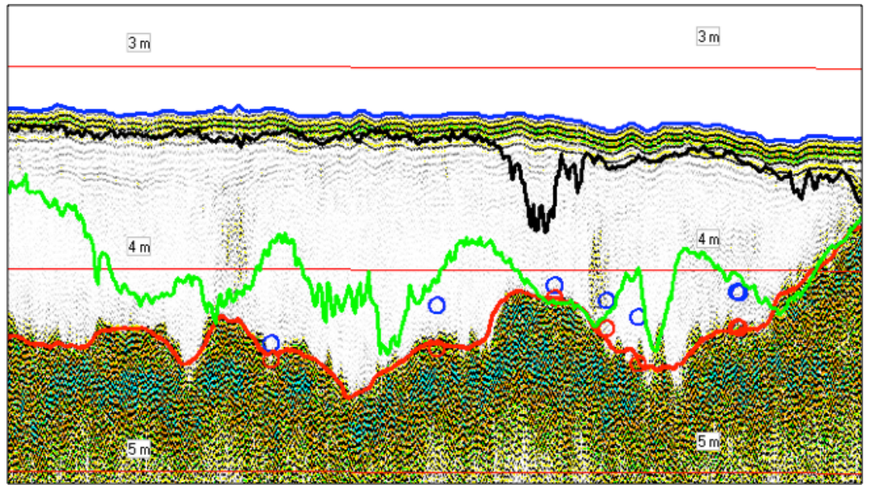


Figure 1. Example of a seismic recording including two depth levels determined by traditional Multibeam surveys. The black line is acquired in the morning, while the green line is acquired in the afternoon. The top of the fluid mud is marked by the blue line in the morning and by blue circles in the afternoon, while the nautical depth (1200 g./L.) is consistent during the day (red line and circles). The latter is acquired with a high-resolution sub-bottom profiler.

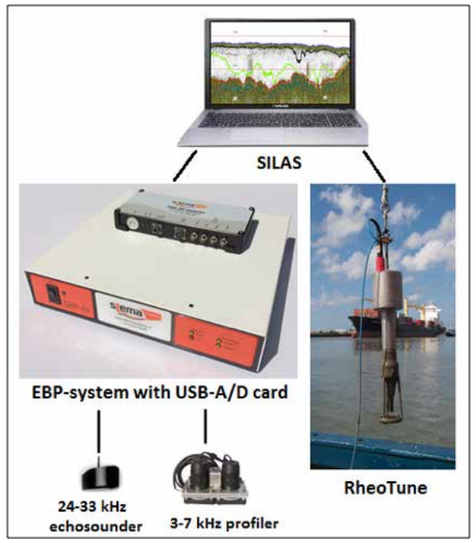


Figure 2. Recommended system setup for determination of nautical depth and sub-bottom features. The SILAS software (top) can integrate both profiler data, acquired with an echosounder or low frequent profiler set (bottom left), with an in-situ density and yield stress measurement. The latter is recorded with a RheoTune (right-hand side). To optimize the quality of the data output of the profiler a low frequency transceiver with an USB Analogue to Digital converter is preferred (left hand-side).

The ultra-high resolution geophysical software package SILAS (Fig. 2 top) can link profiler data (Fig. 2 bottom left) with in-situ density and yield stress measurements recorded by the RheoTune (Fig. 2 right-hand side). It is able to determine density levels which spatially cover the entire harbour or access channel and can detect density gradients as small as 0.4 g./L. per cm in fluid sediment of low yield stress (< 5 Pa) (Werner, 2012). The spatial coverage of the profiler data will result in the necessity of less point-measurements while SILAS will provide continuous information on lines in-between these points. This conclusion is confirmed in a validation study in the Netherlands by Deltares (Kruiver, Diafera, Vermaas, 2013). Interpolation in between point-measurements is not required anymore as the profiler data spatially covers the area and therefore continuous harbour management becomes more easy. Interpolation based on only in-situ measurements involves risk, as the fluid mud does not behave linearly.

Prior to the use of the above mentioned methodology nuclear density probes were used for the in-situ measurements (Van Craenenbroeck et. al., 1998), but nowadays they are largely replaced by tuning fork systems, like the RheoTune (Fontein, Werner, Van Der Wal, 2006). This probe is more environmentally friendly and handling is easy due to the ergonomic design of the system. Besides that, it is capable of measuring rheological parameters like yield stress, simultaneously with density resulting in a much more detailed analysis. Operation of the RheoTune (Fig. 2 right-hand side) is based on the vibrating element principle which is used in processing industry and widely accepted as one of the most accurate methods to measure continuous real time density, concentration and dynamic viscosity. As will be explained below, the rheology of the mud provides a better justification of the chosen nautical depth than density alone.

2.3 Rheology for nautical depth assessment

The density of fluid mud can be defined by the amount of sediment particles within the fluid. Unfortunately this density does not provide you with information required to determine if a layer is still safely penetrable by a ship's keel, as it will not give enough knowledge about the strength of the mud. Rheology of the mud and especially yield stress does this, to a very accurate degree. Yield stress is the rheological property defined as the stress at which the mud begins to deform plastically. It can be considered as the initial stiffness of the mud (Fontein, Werner, Van Der Wal, 2006). Mud has different properties than sand. Shear strength of a mud is derived from cohesion between particles (cementation between sand grains and electrostatic attraction between clay particles), and frictional resistance between particles. Hence, the ratio between sand grains and clay particles is important, which is not uniquely related to density.

The sudden presence of a higher yield stress in (part of) the mud gives a more precise identification of the level in the fluid where solidification of the mud occurs. The latter causing the safe passage of vessels not to be guaranteed anymore. The in-situ tuning fork system RheoTune can detect differences in yield stress with an accuracy of 1 Pa. This device determines a direct relation between density and yield stress in a specific mud and/or area at a particular point in time. Unfortunately this relationship is not stable over time, hence a direct in-situ measurement of the rheological characteristics remains required (Fontein, Werner, Van Der Wal, 2006).

Related products

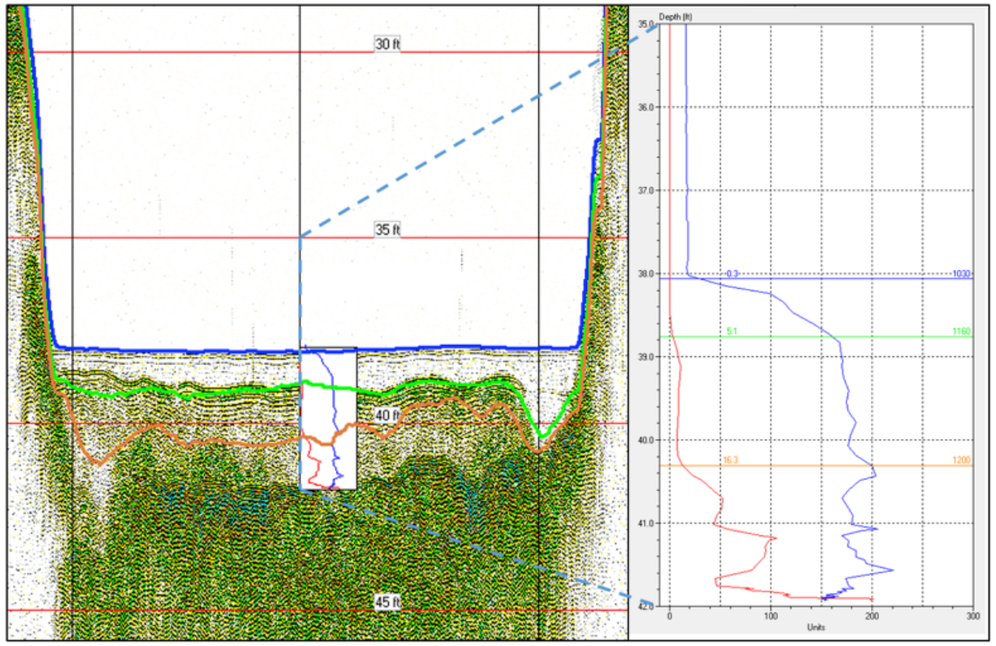
- Silas
- EBP
- RheoTune

2.4
Case example: acoustic density mapping

An example of a seismic recording including an in-situ density and yield stress measurement is displayed below (Figure 3 left-hand side). These measurements were performed near the Calcasieu Lake, Louisiana. The seismic recording was acquired with a 24 kHz profiler. The vertical profiles represent density (blue) and yield stress (red) measured by the RheoTune. These profiles are used to calibrate the seismic section and establish the calculation of the density levels within (horizontal blue, green and orange lines). The density levels computed are 1030 g./L. (blue), 1160 g./L. (green) and 1200 g./L. (orange). The SILAS software will calculate the density profile through the rest of the section so only a few point measurements are necessary to cover a large area (Kruiver, Diafera, Vermaas, 2013).

In Figure 3 on the right-hand side the density and yield stress profiles of the in-situ measurement are enlarged. The vertical blue line displays the density, while the vertical red line indicates the yield stress. The density increases quite linearly with depth, while the yield strength remains stable up to the 1200 g./L. density level (orange) and then suddenly increases rapidly from 15 Pa to around 50 Pa. This increase in yield stress is a better indication for the cohesion of the mud and the possibility of a vessel passing through as explained previously. This yield stress level can be related to a specific area, provided the material composition remains unchanged.

Figure 3. Example of a seismic SILAS recording (left) including an in-situ density and yield stress measurement (right) near the Calcasieu Lake, Louisiana. The vertical profiles represent density (blue) and yield stress (red) measured by the RheoTune. The density levels computed are 1030 g./L. (horizontal blue), 1160 g./L. (green) and 1200 g./L. (orange). Corresponding yield stress values are 0.3 Pa (blue) 5.1 Pa (green) and 16.3 Pa (orange). A strong increase in density is visible near the water-mud contact (1030 g./L.) where after the increase is less explicit. The first strong increase in yield stress (15-50 Pa) is visible near the 1200 g./L. density level, indicating a sudden increase in cohesion of the mud (De Boer, 2016).



3. IMPROVED ACQUISITION METHODS

3.1
Real-time acoustic density mapping and volume calculation

The above recommended operating system has been used in multiple projects and can be enhanced with improved acquisition methods and equipment like the ultra-fast USB AD Converter, which results in a higher resolution (Werner, 2016). This USB-A/D converter (Fig. 2 left-hand side) is a piece of hardware which is easy to deploy and can be interfaced with an echosounder, profiler, non-linear parametric source, boomer and sparker system. It can be used to convert the full signal for both low and high frequency single beams.

Real-time heave correction, as well as real-time density calculations, have been improved significantly. If a position and heave input is available, SILAS has the ability to provide a real-time output of the required density levels after a calibration survey has been executed. In this case it is possible to perform surveys with real-time acoustic density mapping (Fontein & Byrd, 2007). This would enable a post dredging survey (if required) at an accelerated pace.

3.2
Quality assurance

An automated batch processing module has been created for easy and faster initial processing of the data. This batch processing involves ringing reduction, heave correction, first order filtering and auto-tracing of the seabed. Ringing reduction can be necessary to reduce noise that appears at constant time interval after shot transmission. All processing steps are optional in the batch processing module and can be corrected afterwards if required.

The module can easily be added to the acquisition setup. The benefit of which would be to assure the quality of the data saving a significant amount of time, enabling to identify errors or highlight opportunities during acquisition, instead of afterwards. For instance, basic processing of profiler data is required during a nautical depth survey when determining the exact locations for in-situ density and yield stress measurements. The batch processing module can perform this step fully automated, resulting in significant less down-time of the vessel. A further example of the ultra-high resolution applications of batch processing is that it helps to detect pipelines which are not clearly visible during acquisition. In this case one knows the survey is performed at the right spot while you are still on site. More details will be described in the next chapter.

4. INTEGRATION OF GEOPHYSICAL DATA

4.1
Import and export capacity of SILAS

The ultra-high resolution geophysical software package SILAS has been cited earlier in this paper. Beside hydrographical applications, the SILAS package disposes of many geophysical processing options. One of the main benefits of this system is recording of the full seismic signal which can be used for multiple geophysical solutions, making the application thereof more polyvalent. Hydrographical data like Multibeam, Side Scan Sonar and geological maps can be integrated into the required deliverable as well. Cross-referencing data acquired via different sources can assure the overall data quality.

Geophysical solutions that can be provided by the software package include:

- Import of full in-situ density measurements (e.g. RheoTune) for calibration of density levels and real-time display in seismic sections (Fig 3)
- Import of boreholes and Cone Penetration Tests (CPT) including all additional data like grainsize, formation factor, porosity and shear strength
- Import and integrated processing of Ground Penetrating Radar (GPR)
- Import and export of several data formats including commonly used SEGy data
- Advanced filtering techniques like multiple reduction, deconvolution and frequency filtering
- Automated contact detection for sub-bottom cable, pipeline and boulder detection
- Import and integrated processing of magnetometer data
- Determination and validation of Sidescan and Multibeam contacts for cable, pipeline and boulder detection

Related products

Silas
EBP
RheoTune

4.2
Case example: sub-bottom cable and pipeline detection

To illustrate the polyvalence of the SILAS program the author would like to highlight a new application that will permit the reader to further gain insight into the quality that SILAS has to offer. The new application referred to is automated sub-bottom cable and pipeline detection. Figure 4 displays outcomes at different stages within the process of automatic detection. In the three seismic sections two hyperbola are clearly visible, which are the signatures of cable and pipelines. The double 1.5m pipelines are located at an average depth of 3m below the seabed. Raw data gathered during acquisition (Fig. 4A) can be batch processed during the survey, which is a very useful tool to highlight and identify the position of the cables or pipes (Fig. 4B). If the data would not be as clear as shown below (Fig. 4B), this step will assist the user to establish the correct area of survey.

The automated detection module is an advanced processing tool. This module uses an algorithm which can identify and rate the quality of hyperbolic structures (based on probability) within the data set. Figure 4C shows two contacts that were detected automatically, which are marked by purple and red triangles. The purple and red windows indicate the horizontal range where the algorithm was applied. A vertical range can be adjusted as well. This not only saves time but also increases overall quality as some hyperbolas - which are hard to identify by the human eye only - will be detected by the algorithm. Furthermore, the algorithm is constant in the way it calculates the top of each hyperbola, while human interpretation will vary over time and can change per individual.

The vertical depth display (Fig. 4D) shows all auto detected contacts of the pipeline on the left (marked by purple triangles). The grey line running through provides the user a first- second- or third-order polynomial estimation of the pipeline location. The small triangles facing down indicate the depth of the bottom as found directly above the contacts. Multibeam data can be imported in here as well to cross-reference data acquired via different sources.

Recent studies show that the SILAS system can detect various types of sub-bottom cables as well. These objects can be detected with a success rate of 75% and over, on cables with a diameter of 25 cm or higher. Results of one of these studies are shown in Table 1. In this study both export cables and infield cables were surveyed on 14 different locations with varying water depths (up to 35m). Depth of burial varied between 1,5m and 3m while diameter of cables varied between 11cm (infield cables) and 25cm (export cables). A clear difference in results is visible between the two type of cables. On export cables a hit rate of 77,2% has been acquired if we exclude the two areas where rock dumps or vast amount of boulders are present. If we consider a cable to be detected with confidence when at least a hit rate of 50% is acquired and these hits have a good dispersion in all lines surveyed we can increase this number to 100%. The results for infield cables are – as is to be expected – significantly lower.

A cable or pipeline detection survey can be a vital tool in the dredgers arsenal when planning the upcoming works, given that it will utilize almost the same set up as the post-dredging SILAS density survey parameters.

4.3
Case example: sub-bottom boulder detection

The pipeline and contact detection module of the SILAS processing program is also able to detect boulders (large stones > 25 cm diameter) or other small objects of similar diameter. These features can be recognized in seismic data by a hyperbola signature (Fig. 5) that can be detected in an automated manner, which saves significant processing time while improving quality and objectivity. The detection procedure consists of a calibration phase, automated detection phase and finally validation and export of detected contacts.

The contact detection is calibrated using available data, consisting of either seismic reflection data on the seabed and if possible also Sidescan data. During the calibration process the hyperbola detection parameters; such as semblance and power, of the signal in the hyperbola of a valid boulder detection in the seabed are determined, and compared with detection parameters of boulder contacts on the seabed (Fig. 5). The semblance is a value that describes how well the hyperbola is defined.

During the automated contact detection all contacts are detected automatically using the power and semblance settings resulting from the calibration. During the validation stage the detected contacts are validated by the user who can apply different types of displays to validate the data: both the true amplitude (Fig. 5) as signal power display (Fig. 6). During the final export phase all contacts are exported to a format which includes contact number, x, y, z position, power and semblance.

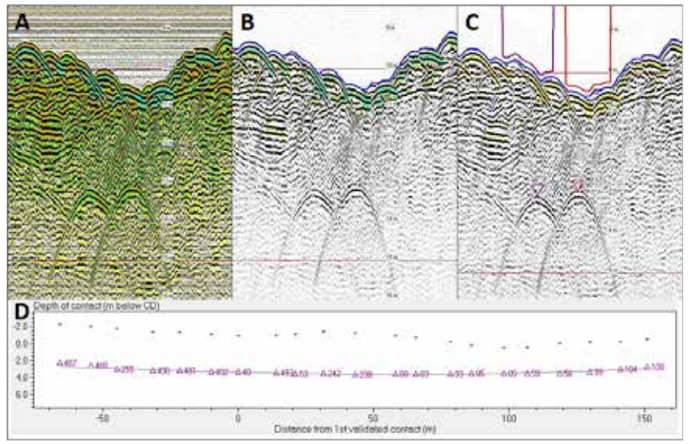


Figure 4. Example of automated contact detection proceedings displaying outcomes at different stages. Two 1.5m pipelines are visualized as hyperbola in the upper three seismic displays (A: raw data B: batch processed data C: processed data with automated contact detection applied). The vertical depth display (D) shows all auto detected contacts of the left-hand pipeline (purple) and the bottom depth as found directly above the contacts. The grey line running through is a third-order polynomial estimation of the pipeline location (De Boer, 2016).

Table 1. Hit rates (%) per cable type (Silas Trials Cable Detection, 2016, not published).

hit rates of detecting contacts per crossing	hit rate (%)	remarks
average all export cables	77.2	excluding rock dump & boulder areas
average all infield cables	39.2	
number of cables detected with confidence		**> 50% hit rate & good dispersion**
export cables	100	excluding rock dump & boulder areas
infield cables	37.5	

Related products

- Silas
- EBP
- RheoTune
- Object detection

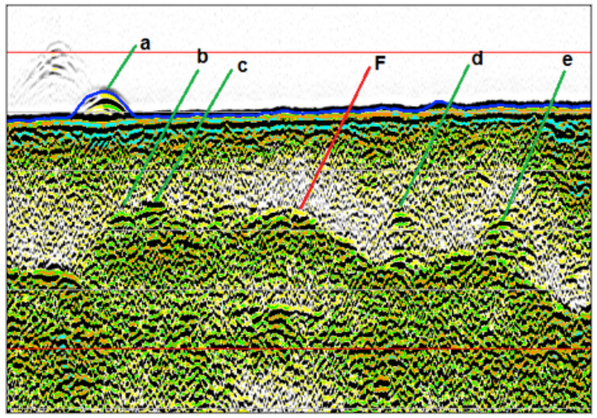


Fig. 5: Example of seismic boulder registration at seabed surface (a) and below seabed (b, c, d, e). All detections are visible as hyperbolas. Blue line: seabed. A deeper level is visible at the reflector below f. This layer consists of numerous cobbles and boulders.

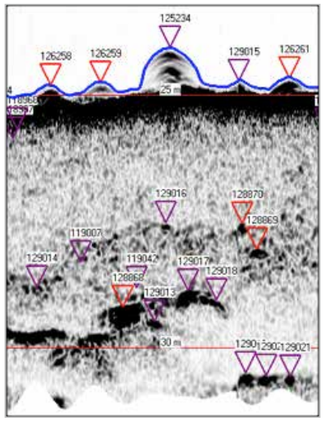


Fig. 6: Example of validated boulder contacts in seismic power display (red and purple triangles). Individual boulders are clearly visible as high power reflections (black) with discrete boundaries.

5. CONCLUSION

To ensure safe vessel passage, harbours and their access channels need to be dredged to the nautical depth. This depth is established by defining a critical density value, which is area specific. Yield stress measurements can aid in establishing the critical density value as the sudden increase in yield stress gives a more precise identification of the level in the fluid where solidification of the mud occurs. Traditional survey techniques are not capable of detecting multiple density levels and will only acquire the top of the fluid mud layer. An ultra-high-resolution sub-bottom profiler in combination with in-situ density and yield stress measurements will be able to capture the full profile and detect all required density levels. The ultra-high resolution geophysical software package SILAS can link both types of measurements and is able to determine density levels which spatially cover the entire harbour or access channel. Therefore interpolation is not required anymore and continuous harbour management becomes more easy. The modular approach of the SILAS software enables customers with standard hydrographical skills to manage the nautical depth. Real-time density mapping, batch processing and data cross-referencing acquired via different sources can assure the overall data quality. Moreover the software package offers extensive geophysical modules for those who wish to use the package to integrate seismic data with geotechnical and geophysical data of various origin. Automated contact detection of cables, pipelines and boulders is an example of one of these modules.

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BIOGRAPHICAL NOTES

P.J. de Boer graduated in 2014 with a MSc in geophysics from the University of Utrecht. In the same year he joined Stema Systems as geophysical engineer. At present he is managing multiple geophysical projects including but not limited to the use of Silas and high-resolution sub-bottom profilers.

C.J. Werner is senior geologist and manager R&D at STEMA systems and responsible for the development of Silas and Tune systems. Prior to this he was involved as seismic specialist for more than 25 years in nautical depth research and numerous route, site and assessment surveys for the dredging and offshore industry.

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Silas

Seismic acquisition and processing software suite

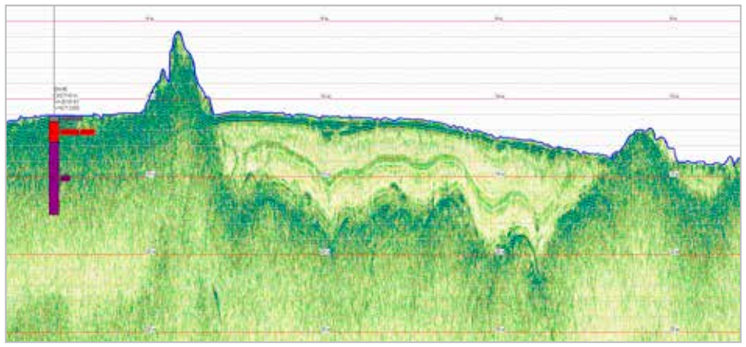
Deliverables

- Nautical Depth
- Site investigation / Layer detection
- Object / Cable / Pipeline detection

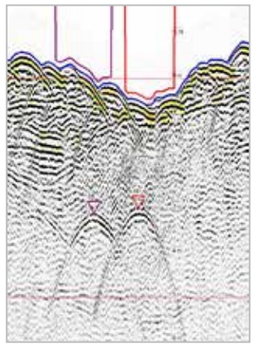
Silas is a complete data acquisition, processing and interpretation software suite, that covers a wide range of tasks.

The Silas software package has been developed to allow you to obtain the best quality data and easy access to multiple data types to best evaluate the subsurface conditions. It is **compatible with multiple sources** and can process the full-wave signal from sub-bottom profilers, boomers, sparkers, parametric and chirp systems.

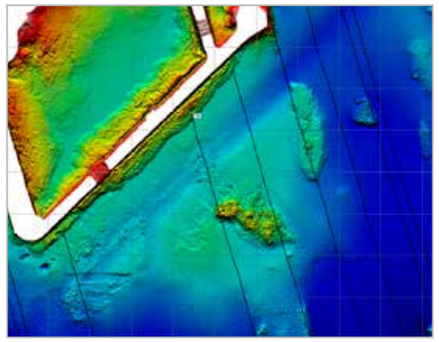
The system covers the range **from deep penetration to ultra-high resolution**. Whether you look for general sub-surface geology, cables, pipelines and other objects or fluid mud surveys. For sub bottom classification and interpretation the Silas Software Suite can easily integrate borehole and map data into the data set, providing the information that is sought allowing for detailed interpretation.



Silas recording with integrated borehole data.



Pipeline detections with Silas Object detection.



Mapview of Silas profiles with multibeam bathymetry.

Key features

- Import of profiles for accurate seismic interpretation
- Ultrahigh resolution (combination with USB-A/D)
- Seg Y Import - Export

Related products

EBP	Geo Consulting
RheoTune	Rental
Object detection	

Silas

Seismic acquisition and processing software suite

Specifications

Acquisition

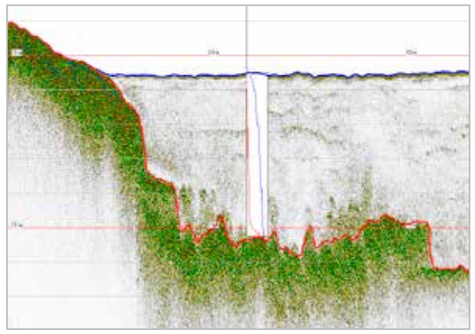
Digital high resolution seismic acquisition. Supports USB-A/D card and UDP inputs/outputs. Real-time data and single trace monitoring, including real-time output of depth values of bottom track and a bottomlayer: hard bottom or iso-density level (requires calibration).

Processing

Silas Density Pro License
Digital seismic processing package that enables the user to identify, analysis and interpret the geological features found in the sea bottom.

With features such as:

- Layer tracing
- Position and tide corrections
- Navigation view
- Cross-points
- Batch filtering
- Signal correction
- Borehole import/export
- Density calibration of seismic data for nautical depth management
- Fluid mud migration studies
- Predictive multiple reduction
- Seismic parameter assessment
- Sub-bottom classification module



Density (red) and yield stress (blue) profiles in a fluid mud layer recorded by the RheoTune, implemented in Silas.

Automated contact detection
Contact recognition based on two quantifiable parameters which enable a more objective classification of detected contacts.

SEG Y import / export
Silas module: reads and stores seismic data in various SEG Y-formats.

Matrix import
Silas module: displays multibeam or gridded data loading in seismic records to check against or match with height data.

Frequency filtering
Silas advanced signal processing modules for S/N enhancement providing a wide range of frequency filters.

Deconvolution
Silas advanced signal processing modules for S/N enhancement providing spiking deconvolution tools.

Horizontal stacking and multiple suppression
Silas advanced signal processing modules for S/N enhancement by suppression and enhancement techniques.

Density calibration and calculation
Tool to match acoustic data with in-situ density profiles. Calculation of synthetic density profile per trace. Tool required for real time density mapping.

Overlay borehole and geotechnical data
Import and overlay of borehole data (BH, CPT, chemical tests, density, etc.) on seismic records.

Subbottom material classification
Signal analysis and matching to material properties of subbottom layers: Impedance, absorption and velocity module.

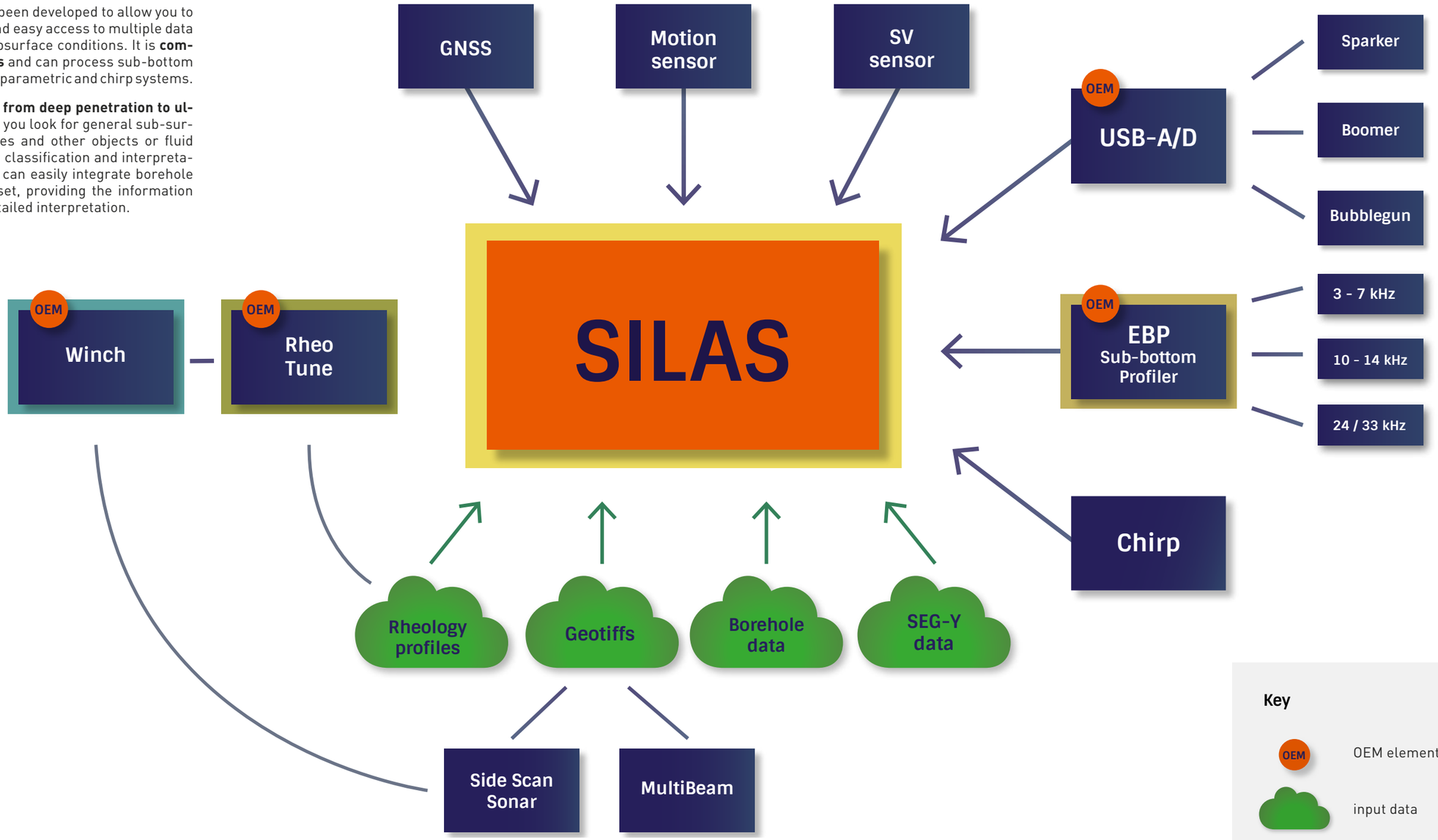
GeoTiff mapviewer
Import of geotiff data (multibeam, sss, geological map etc) and presentation in plain view.

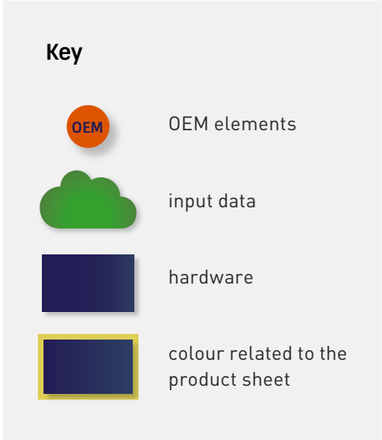
Silas

SILAS is a complete data acquisition, processing and interpretation software suite, that covers a wide range of tasks.

The Silas Software Suite has been developed to allow you to obtain the best quality data and easy access to multiple data types to best evaluate the subsurface conditions. It is **compatible with multiple sources** and can process sub-bottom profilers, boomers, sparkers, parametric and chirp systems.

The system covers the range **from deep penetration to ultra-high resolution**. Whether you look for general sub-surface geology, cables, pipelines and other objects or fluid mud surveys. For sub bottom classification and interpretation the Silas Software Suite can easily integrate borehole and map data into the data set, providing the information that is sought allowing for detailed interpretation.





EBP

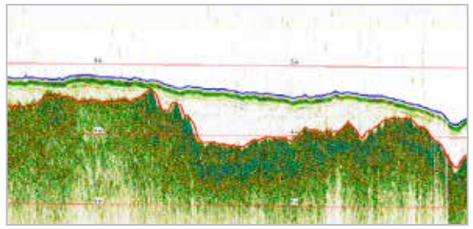
Ultra-high resolution sub-bottom profiling

Deliverables

- Ultra-high resolution sub-bottom profiling
- Cable detection
- Fluid mud detection

The EBP system has been developed to yield optimal results in the area of 3 – 33 kHz sub bottom acquisition range.

It offers the choice of transducers dependant on requirement and processes this via its unique USB-A/D configuration to ensure the highest resolution of your data. With the full digitalization of the signal the system enables **full and quick import** of the acquired data into the Silas Software Suite, ensuring the **high resolution transmission of data** for full processing.



Silas profile recorded with EBP system to identify top and bottom of fluid mud layer.

Example of transducers used with EBP system to detect export and infield cables.

Stema EBP Sub-bottom Profiler system.
Choice of transducers will be recommended to fit required result.

Key features

- Easy to deploy and operate
- Multiple frequency range 3 - 33 kHz
- Easy to integrate in survey setup

Related products

Silas
Object detection
Rental

EBP

Ultra-high resolution sub-bottom profiling

Specifications

Frequency
High band: 100 kHz - 1 MHz
Low band: 3.5 kHz - 50 kHz

Power
Output High band: 900 W RMS at 200 kHz
Output Low band: 2 RMS

Input
110 or 220 V AC - 24 V DC, 120 W

Interfaces
4xRS232
Ethernet interface

Output
Raw seismic wiggle (user select sampling rate)
Digitized depth levels (echo-sounder pre-sets)
Real-time density level (requires calibration)

Transducer options

- 3 – 7 kHz
- 10 – 14 kHz
- 24 / 33 kHz

Vertical resolution

- Depends on frequency and cycle selected
- 24 kHz 1 cycle < 10 cm
- 4 kHz 1 cycle < 40 cm

Penetration

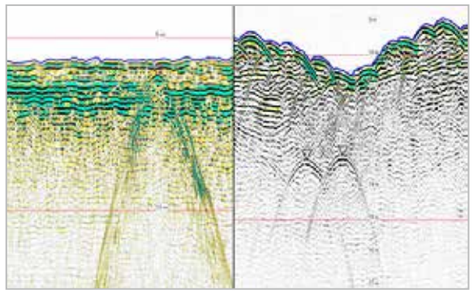
- Depends on soil type and frequency
- 24 kHz: clay / mud, typical 5 m
- 4 kHz: clay / mud, typical 10 – 20 m
- 4 kHz: sand, typical 5 m

Peripheral equipment options

- Boomer
- Sparker
- Bubblegun

Data acquisition
Display profile and individual trace, external heave, colour control, position input, signal offset correction, auto-start (slave from Survey PC), real-time density computation

Data processing
Display profile and individual trace, unlimited layer definition, auto-tracing, layer copying, swell filter, external heave/tide, sub bottom amplification, navigation display, cross points and quick line select, targets, export layers to ascii or CAD, graphics export to html, bmp, jpeg



Example of Silas sections with detected cable (left) and detected pipelines (right).

RheoTune

Density and yield stress measurement

Deliverables

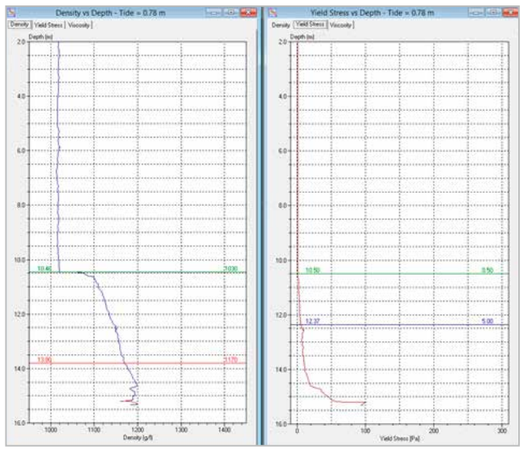
- Properties of fluid mud
- Yield stress profile
- Density profiles

The RheoTune is a versatile system that provides both density as well as yield stress profiles of fluid mud simultaneously.

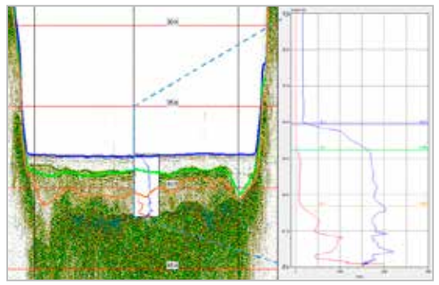
The fact that the RheoTune is **pre-calibrated** makes it easy and quick to deploy, enabling **swift and accurate data acquisition**. Running proprietary software for both acquisition and processing results in a detailed almost real time display of the profile that can be imported into sub–bottom profiling processing suites enabling a full and comprehensive picture of the fluid mud and its characteristics.

To increase productivity further an automated electrical winch or manual light weight winch with slip ring is available. The Tune system is optimized to integrate with the Silas Seismic Processing Suite.

Stema RheoTune in action. Both density and yield stress are measured in-situ without the need of field calibration.



RheoTune software displaying both density (left) and yield stress (right).



Density and yield stress results of RheoTune plotted in a Silas record.

Key features

- Constant accurate results
- Easy to deploy and operate
- Pre-calibrated

Related products

Silas
Winch
Rental

RheoTune

Density and yield stress measurement

Specifications

System
RheoTune

Output parameters
Density, Yield stress, Viscosity
Dry solids, Temperature, Depth (P)
Material classification

Density

Accuracy	< 1% of density (Newtonian fluid)
Resolution	1 g/L
Range	800 – 1500 g/L (semi fluid materials with Bingham yield stress < 1 kPa) 1500 – 1800 g/L (with adapted calibration in semi fluid materials)

The design of RheoTune is kept simple and robust.

Yield stress (Bingham)

Accuracy	Ca. 5% of Yield stress
Resolution	1 Pa
Range	0 – 500 Pa

Viscosity

Accuracy	Depending on site calibration*
Resolution	1 Pa s
Range	0 – 600 Pa s

* Viscosity is derived from density based on a roto visco laboratory test for site specific material.

Temperature

Accuracy	2% FS
Resolution	1 °C
Range	0 – 60 °C

Depth

Accuracy	0,25% of depth
Resolution	0,01 m
Range	0 – 60 m

Housing

Probe	Stainless steel (IP68, 250 m) Fork
Control box	Plastic box (IP65)

Dimensions

Probe	75 cm with ⌀ 15 cm
Transport case	80 x 58 x 48 cm

Weight

Probe	15 kg (+9 kg weight optional)
Transport	35 kg (excl extra weight)

Power

Input	110 / 220 V AC, 35W

Output

Type	UDP and Ethernet standard, Wi-Fi optional
Update rate	20 Hz

Object detection

Cables, pipelines and boulders

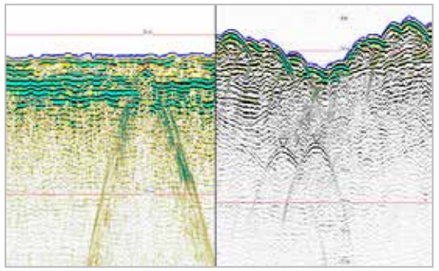
Deliverables

- Depth of burial surveys
- Cable and pipeline mapping
- Location of objects within the sea bed

A combination of the Stema EBP system and the Silas Acquisition Suite enables the user to perform high resolution object detection surveys.

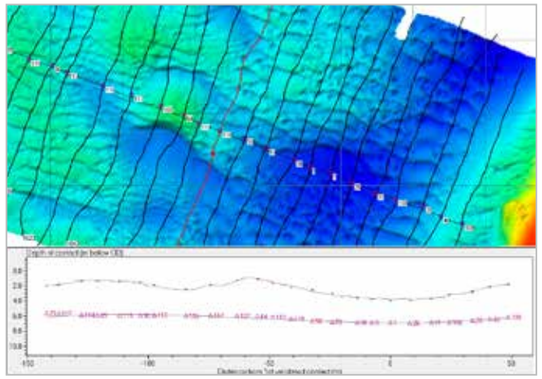
The Silas Object detection module then allows an **automated contact recognition**, identifying objects such as cables, pipelines and boulders. These objects can be detected with a success rate of 75% and higher both for objects and cables.

The contact recognition consists of the automated determination of two quantifiable parameters which enable a more objective classification of detected contacts. Besides the object contacts themselves, the sub-bottom data also shows the sub-bottom structures, including the cable trenches. The latest development of the Silas Software Suite provides the possibility to import multiple data sets for cross correlation and mapping of the objects in X, Y and Z coordinates.



Example of Silas sections with detected cable (left) and detected pipelines (right).

Cross-section of typical export cable, which can be detected sub-bottom with Silas cable detection.



Topview of detected pipeline with multibeam overlay and cross-section of the same pipeline which clearly depicts depth of burial.

Key features

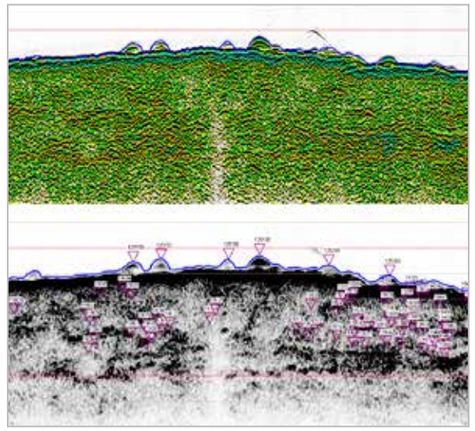
- Automated contact detection
- Correlation with other data (MB, SSS, Magneto)
- More objective classification of detected contacts

Related products

Silas
EBP
Rental

Object detection

Cables, pipelines and boulders



Comparison of seismic boulder registration in regular Silas display (top) and seismic power display (bottom). The latter has been developed specifically to identify individual boulders sub-bottom.

Objects detected:

- Infield cables
- Export cables
- Oil pipelines
- Gas pipelines
- Water pipelines
- Boulders for cable trenching
- Wrecks

The Stema Silas Object detection package enhances the high resolution data acquired from the EBP system by integrated processing techniques and applies an automated contact recognition technique.

The contact recognition consists of the automated determination of two parameters:

- Semblance of apex of hyperbola (top of contact)
- Power of hyperbola

These parameters are quality figures which also enable a more objective classification of detected contacts. Plan view with track lines, contacts and multibeam data.

The contact data and its parameters can be managed and inspected in several displays:

- Plan view with Geotiffs
- Contact display
- Navigation View

The Stema Silas Object detection package can be interfaced with DXF-files and contacts from other data sources such as:

- Multibeam
- SSS
- Magnetometer
- GPR

This integration permits the user to present a full cable passport, with multiple data sources to illustrate the exact cable lay.

Geo consulting

Geological and seismic analysis and project advise

Deliverables

- Pre-survey advise
- Processing
- Interpretation and reporting

Stema Geophysical Consulting has proven its added value many times.

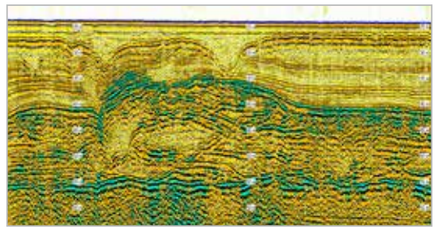
Due to our hydrographical and geophysical experience the consultants know the best way to prepare and /or process your sub-bottom survey. Our approach guides you to an efficient and effective survey for the best results.

- Inventarisation i.e. desired result, methodology and equipment choice
- Initiation of survey i.e. mobilization, fine tuning and training
- Processing raw data
- Interpretation of data into established deliverables

Data processing can commence as soon as data has been acquired. Stema's consultants offer their **assistance** to their clients in the early stages of a (geo-seismic) project. Thereby establishing the appropriate project approach and the application of the relevant equipment, processing resulting in more efficient and accurate processing.

As a result the clients survey team is provided with the right tools to acquire the raw data in order to obtain the best quality result for further processing, which takes place in our office where the raw data will be processed by our **highly experienced geophysicists**.

Experienced Stema personel can assist in sparker and boomer surveys, both single- and multi-channel.



Silas record acquired with a boomer.

Key features

- Vast geophysical equipment knowledge
- Large pool of professionals processors
- On-site analysis pre-report

Related products

Silas	Geo Consulting
EBP	Winch
RheoTune	Survey Vessel
Object detection	Rental

Geo consulting

Geological and seismic analysis and project advise

Our team

Stema Systems has developed a market leading sub-bottom profiling methodology using a combination of uniquely designed equipment with in-house developed software, resulting in a system that can provide a host of sub-bottom analysis results catering to the clients' specific needs.

Over the past 30 years this combination of hardware and software has resulted in thorough insights into the sub-bottom in which we now consult. The way our team works is easy and reliable. Each project will be executed by a junior or medior geophysical consultant depending on the skills needed for the project and is always monitored by one of the senior geologists.

For each assignment a plan will be made in collaboration with the customer and internally approved by the senior geologists. The final client report will be signed off by the project consultant and the senior geologist. Each staff-member has at least 5 years of experience and holds a MSc Geology degree. Every employee at Stema also has knowledge of hydrological equipment and hydrographical field experience.

Our references

Winch

Automated hydrographic and rheological equipment deployment

Deliverables

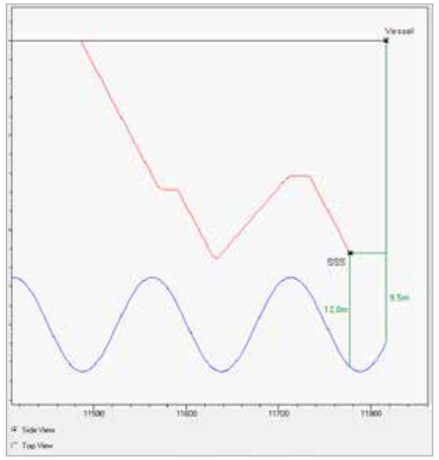
- Transfers data real-time
- Maintains hover altitude automatically
- Fully automated

The Winch is a compact size instrumentation winch steered with a PC based control unit that can be integrated with other sensors for fully automated operation.

Thus facilitating **both horizontal** as well **as vertical deployment** of hydrographical equipment.

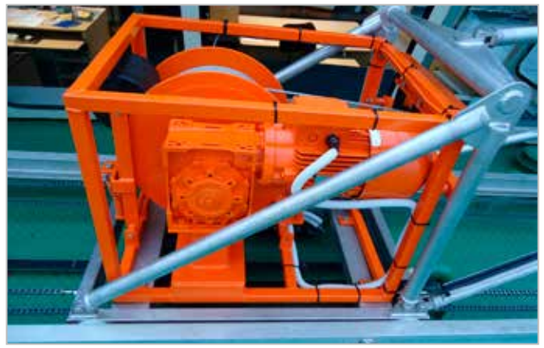
The Winch system is designed to enable the highest productivity when acquiring water column data, fluid mud profiles amongst others. Working with equipment such as the RheoTune probe short turn-around times for nautical depth surveys.

The design focuses on **fully automated measuring cycle** with sufficient guarantees for probe safety. Speed over ground and echo-sounder nadir depth input are combined with operator set thresholds to account for external factors when using in combination with Side Scan Sonars and other towed equipment.



Smart software enables user to gain insight in height above seabed of towed equipment.

Winch used to enable RheoTune measurements.



Winch installed on a moving frame.

Key features

- Programmable deployment
- Multiple equipment application
- Vertical and horizontal towed deployment functionality

Related products

RheoTune
Rental

Winch

Automated hydrographic and rheological equipment deployment

Specifications

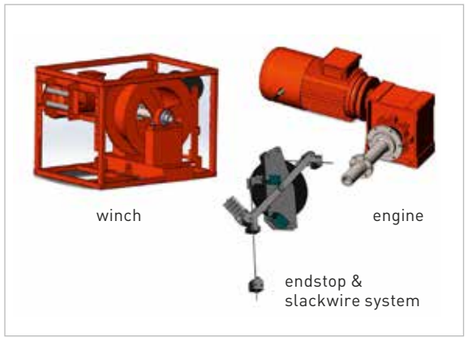
Winch control

The Winch control menu can be used to operate the Winch. The switch on the handheld unit must be set to automatic. For correct use, a number of settings must be understood, and set correctly. The main-buttons for the Winch control are Up, Down and Stop. The probe lowering can be stopped automatically by using the stopping criteria in the settings menu of the Winch software.

Cable Out menu
This box shows the length of cable that is unrolled from zero cable out.

Zero (Button) menu
The zero-cable out value is used as the standby position of the winch. So, after a measurement is stopped, and UP is pressed, the probe is brought back up to this zero point.

Depth menu
Actual probe water depth display.
Note: in air it should indicate about 0.53 m.



Compact Winch designed to deploy and / or tow equipment like RheoTune, SVP and Side Scan Sonars.

Winch settings

Max SOG
Maximum Speed Over Ground. Measurements cannot be started when the drifting speed is too large.

High Speed
Speed used to quickly go to measuring depth. After the measurement the same speed is used to bring the probe back to the surface.

Slow Speed
Speed used below a certain depth in the expected silt layer.

Break Path
Vertical interval that is used to slow down the Winch from quick lowering (with high speed) to slow lowering (slow speed).

Stop Criteria:

Slack Wire
Stop when there is no more tension on the cable (info of 'slack' is received over COMport).

Tilt
Stop when the tilting (tipping over) exceeds [...]
in degrees

Speed <
Stop when measured probe subsidence is slower than [...] in m/s

Density >
Stop when measured density exceeds [...] in g/L

Survey Vessel

Plug and play survey ready

Deliverables

- Full customizable Survey Vessel
- World wide reach in a container
- Real-time data transfer from vessel to shore

Stema Systems' 30 years of surveying experience within the hydrography and geophysical field has led to the design of this practical, highly manoeuverable lightweight, trailerable and containerised boat.

Reason for us to build our boat was to get the highest quality data while surveying and **to minimize the mob and demob costs**.

This boat is a **turn-key Survey Vessel**, calibrated and ready to survey. Crews reach and survey larger areas in less time, the pre-calibrated survey gear allows them to quickly start working. It works fast and comfortable for its crew. It saves lots of time and money for her owners.

Highly manoeuvrable plug & play Survey Vessel in action during trials.

Hoisting eyes are present to deploy the vessel from almost any dock.

The light-weight vessel fits into a standard container so it can easily be deployed all over the world.

Key features

- Survey ready
- Calibrated and ready to go
- Pick and mix survey equipment

Related products

Silas	Geo Consulting
EBP	Winch
RheoTune	Rental
Object detection	

Survey Vessel

Plug and play survey ready

Specifications

Characteristics

LOA	7.25 m
BOA	2.28 m
Draft	0.70 m
Dry Weight	2,220 kg incl. engines
Engine	Honda LKU
Type	2 outboard 60hp
Propulsion	Sterndrive
Speed	40 km/h
Range	+/- 275 km
Fuel	190 L
Crew limit	4

Hull & Cabin

Material	5 mm sea grade aluminum
Shape	V- bottom
Climate	Air-conditioned cabin
Windows	Double glazing
Transport	Trailerable Containerable Hoisting eyes

Interior

Plug & play Survey Vessel

- Bench & desk for surveyors
- Comfortable captain chair
- Waterproof interior woodwork
- Storage compartments
- Necessary sailing equipment
- Chart plotter, radar, autopilot, etc.

40 ft HC Container

Workspace contains:

- Total station and internet connection
- Sleep and shower facility

Survey Equipment

Multibeam	R2Sonic
Singlebeam	Stema EBP
Geotechnical	RheoTune
Motion sensor	IX Blue
Sound Velocity	AML
Positioning	Stema GNSS
Software	Qinsy

Rental

For all survey needs

Deliverables

- Hydrographic equipment
- Geological analysis equipment
- Processing software

Stema Systems has been renting out equipment of the highest quality for the past many years, supporting the hydrographic and geological survey industries with equipment as well as its wide knowledge base, not only supplying equipment but also providing advice and installation assistance when needed.

During this period of time Stema Systems has been able to assemble what it believes to be **the best product range** that suits its customers' needs based on its own experience and requirements.

Stema Systems can through its flexible and its **wide network of equipment suppliers** provide **specialist equipment** not listed below for almost every water based survey need. Therefore please enquire if the equipment that you would require is not listed and Stema Systems will do its utmost to endeavour to locate it for you.

Selection of Stema suppliers.

Key features

- Major suppliers portfolio
- Large stock
- Customizable packages

Equipment

Echosounders Multibeam

- R2Sonic 2024 MB 100m depth rating add-on options available
- R2Sonic 2024 MB 3000m depth rating
- R2Sonic 2022 MB 100m depth rating
- R2Sonic 2024 MB Truepix / Snippets, UHR (700kHz) add-on only

Profiler

- Teledyne Odom MK III dual frequency transceiver (Paper chart) incl Stema Systems USB-A/D Card
- Stema Systems Silas EBP
- Transducer: 3-7 kHz dual transducer array
- Transducer: 3-7 kHz quad transducer array
- Transducer: 10-14 kHz
- Transducer: 24 kHz - 210 kHz
- Transducer: 210 kHz

Geotechnical

- Stema Systems RheoTune incl softwarelicense and tools
- Stema Systems Winch, automated instrument winch
  incl sheave block

Motion/Gyro sensors

- IXblue Phins II motion sensor, inertial navigation
- IXblue Octans G4 Surface motion sensor/gyro
- IXblue Octans G4 3000 motion sensor/gyro
- IXblue ROVINS 3000m inertial navigation
- R2Sonic I2NS (OEM applanix wavemaster)
  only in combination with R2Sonic MB

GNSS Positioning and heading

- Stema Systems GNSS982H RTK including heading (50Hz), Rover

Rental

For all survey needs

Equipment

Soundvelocity sensors

- Valeport miniSVS continuous soundvelocity probe
  incl 25 m cable
- AML Micro X SVS including 25m cable
- AML Base X SVP selflogging soundvelocity profiler
  incl WiFi
- AML Base X 2 SVP selflogging soundvelocity profiler
  incl WiFi

Side scanning sonars

- Klein 3900 SSS
  incl interface box and 50m softtowcable

ROV

- Saab Sea-eye Falcon ROV (300m depth rated)
- McArtney Nexus MK IV MUX subsea and surface unit

USBL

- Kongsberg HiPap 350P USBL system
- Kongsberg HiPap Cnode mini Transponder
  incl charger

Stema EBP Sub-bottom profiler system is available for rent.

Laserscanner

- Riegl VZ400 laserscanner

Boomer/sparker

- Applied Acoustics CSP-D 700 kJ energy source
- Applied Acoustics Boomer AA201 (50-200 J) in sledge,
  50 m cable
- Applied Acoustics Sparker Squid 501 (300-600 J),
  50 m cable
- Applied Acoustics 12 element streamer, 50 m cable
- Geo Acoustics GeoPulse Receiver (amplification, analog filtering, trigger, output to thermal printer)

Magnetometers

- Marine Magnetics SeaSpy magnetometer (300m)
  incl 100 m softtow and isolation transceiver
- Marine Magnetics Explorer mini magnetometer (300m)
  incl 100 m softtowcable and power isolator
- Geo Metrics Gradiometer

Environmental (ADCP)

- SeaProfiler ADCP 600 kHz, 300 m depthrating, direct reading

Software Packages

- QINSy Survey LITE incl multibeam add-on
- Silas acquisition per license (seismic data acquisition)
- Silas processing per license (seismic data interpretation)
- RheoTune software suite per license
  (data acquisition, validation and calibration)

Computer Hardware

- Industrial Silas PC incl one LCD 22"
- Stema Systems USB-A/D Card

Related products

Silas	Geo Consulting
EBP	Winch
RheoTune	Survey Vessel
Object detection	

Stema Systems

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