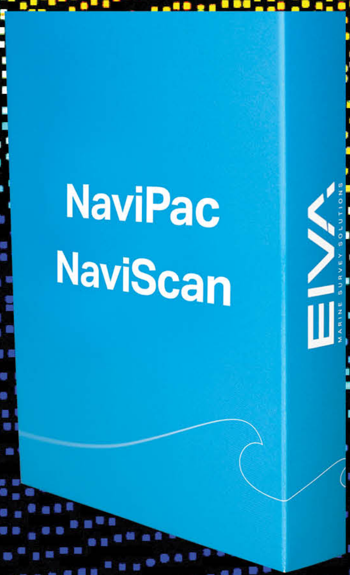
EIVA
MARINE SURVEY SOLUTIONS



Online software

Product specifications

Contents

1 General introduction

The general purpose software suite from EIVA – *the Navi family* – is divided into an online SW suite (for onboard acquisition, recording, QC etc) and an offline processing suite for onboard and/or ashore data cleaning, processing and reporting.

This document gives a brief introduction to the online software solution and lists the major features and functions.

The online solution is mainly based on NaviPac and NaviScan, which jointly meet all demands to online software required for online marine applications, no matter the type of task or the level of complexity.

Through its flexible configuration and intuitive user interface it is easy to setup geodetic parameters and select sensor interfaces from a pre-defined list of sensors or alternative through a user-defined generic driver. Port settings are made easily available and allows for thorough testing prior to mission.

The software features layout and storage of operator preferred layout and settings. It supports network solutions and allows dongle-free distribution of Helmsman displays including real-time 3D visualisation of the survey scenario.

- General navigation
- Hydrographic and oceanographic surveys
- Geophysical 2D seismic surveys
- Scientific research
- Harbor surveys
- Marine construction work
- Offshore pipe-laying and inspection
- Cable installation and support
- Barge, tug and fleet management
- Offshore rig operations
- ROV, ROTV and AUV tracking and support
- Dredging

NaviPac provides navigation information and positioning calculations in support of any marine survey project, as well as offshore engineering and construction operations. NaviPac features comprise among others:

- Digital navigation charts
- Advanced survey planning
- Precise time tagging of sensor data better than 50 µsec through use of the EIVA ATTU time synchronised interface
- Input validation (Kalman filtering)

- Support of numerous geodetic parameters
- Pre-defined, selectable sensor interface drivers for the most commonly used sensors
- User-defined generic I/O drivers
- Extensive quality control and warnings/alarms
- Tracking of unlimited number of vessels
- Specification/identification of any number of vessel/dynamic/antenna offsets
- Extensive utility features (e.g. interface tests, geodetic transformation, calibration, US survey feet etc.)

NaviScan acquires data from all major sonars on the market, including among other multibeam echosounders, scanning and profiling sonars, conventional sidescan sonars, pipe-trackers, etc. NaviScan features comprise among others:

- Pre-defined, selectable sensor interface drivers for the most commonly used sensors
- Interfacing of multiple secondary sensors (position, heading, heave/roll/pitch, Doppler log, etc.)
- Automatically controlled start-of-line, stop-of-line and file naming through interface with NaviPac
- Real-time processing of motion, refraction and tide for "on-the-fly" data display
- Full graphical, scalable sensor displays
- Real-time 3D graphical data presentation
- High-level applications for complex survey environment

2 Customer samples

This section presents some sample usage of the EIVA online SW. The information and screenshots are supplied by users.

2.1 Offshore engineering & installation

NaviPac offers a high-accuracy tool for offshore installations, above the water or in the water column.

- Precise navigation via dual or triple GPS RTK solution
- Real time roll/pitch/heading validation via GPS observations in Helmert Transformation
- Operator guidance for placement in 3D
- Dual system setup for fault recovery
- INS aiding for UW construction work

- Integration with video recording systems
- Integrated 3D monitoring
- Compensation for variable antenna placement
- Leg penetration monitoring

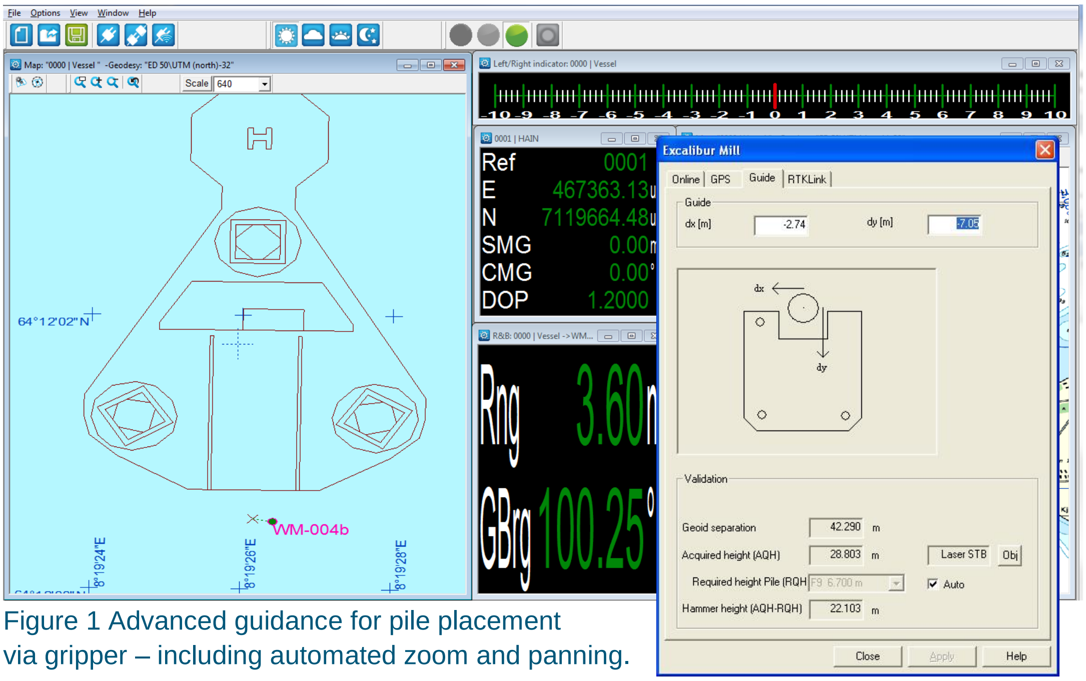


Figure 1 Advanced guidance for pile placement via gripper – including automated zoom and panning.

The solution is heavily used in offshore oil & gas, construction & renewable energy (offshore windmill installation)

2.2 Multibeam survey & hydrography

One of the most general tasks for the EIVA online SW suite is the hydrographic surveys; with for example singlebeam, multibeam and sidescan sonars.

The solution is scalable for both small harbour survey boats to large ROV inspection and MBE vessels.

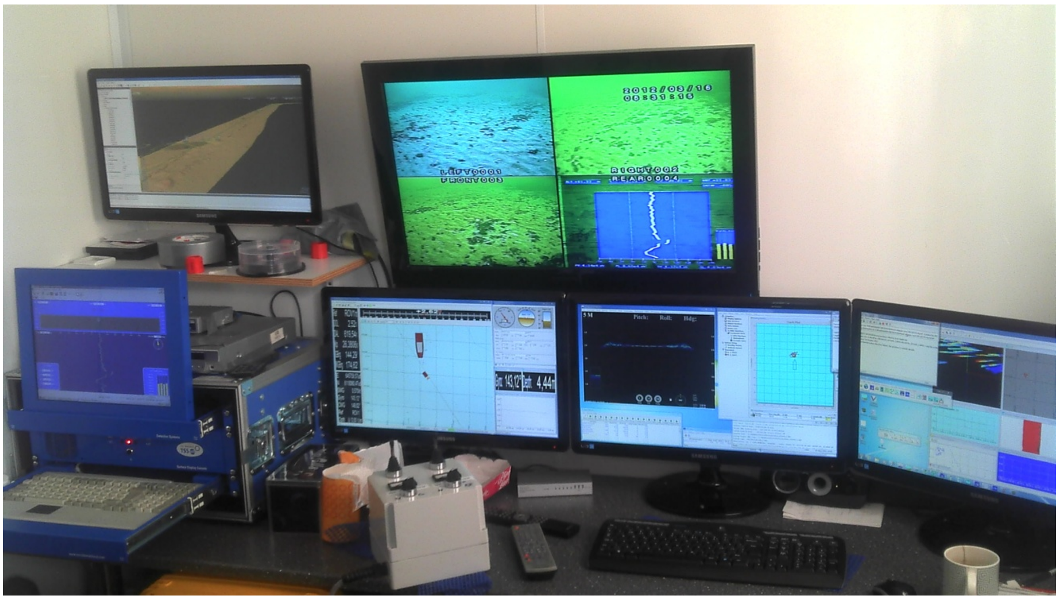


Figure 2 Sample survey setup from JD Contractors: One PC solution with ATTU for timestamp and full EIVA SW suite including real-time 3D DTM.

NaviScan and NaviPac utilise Total Vertical and Horizontal Uncertainty (TVU/THU) as part of the real time QC, and store the information with the raw observations.

The data is normally recorded in open EIVA format for further processing in the EIVA suite. But the system do enable near real-time export to other formats for eg XTF, ASCII, UKOAA and user configurable formats.

The data can be passed into real time DTM (Online3D) and produce final results as DTM. Contour curves etc right after the survey has been completed.

2.3 Barge management & catenary

NaviPac is used widely on high-level rig moves, tug management operations and lay barge controls including anchor management and AHT control.

The system utilises inter-vessel communication based on telemetry and/or WLAN.

Everything is based on standard NaviPac components and gives the operator full flexibility on the barge and allows the AHT to operate totally hands-free.

NaviPac is operating on more than 150 barges and 375 AHT.

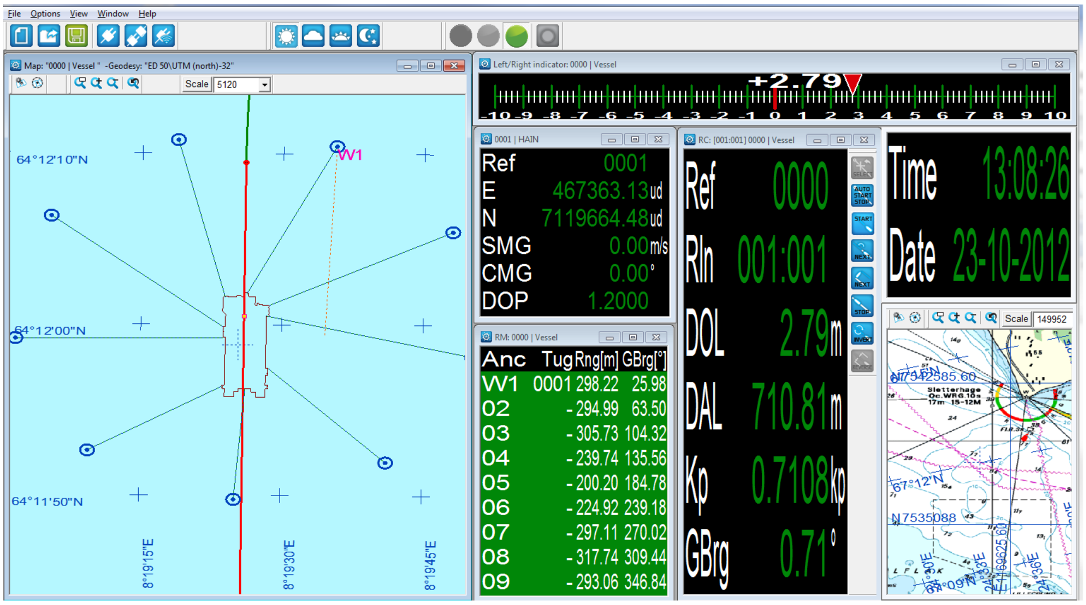


Figure 3 Helmsman's Display on barge. Including anchor pattern, anchor control view and barge line status views.

NaviCat is an add-on to NaviPac TMS, and utilises full 3D calculations of anchor chain catenary calculations.

The catenary model can be used for location planning by estimating all chain curves based on planned location and anchor pattern. This gives a fast and flexible evaluation procedure.

During real-time operations the NaviCat can monitor up to 16 anchor chains based on observed location of fairlead, midline buoys and anchor. This includes even real time evaluation during tug movements.

The calculations are based on configurable chain characteristics, definable weights and lifters and input of seabed information (DTM or assumed flat seabed)

The system calculates tension on all parts of the chains, and enables operator notification as alarms or colour schemes.

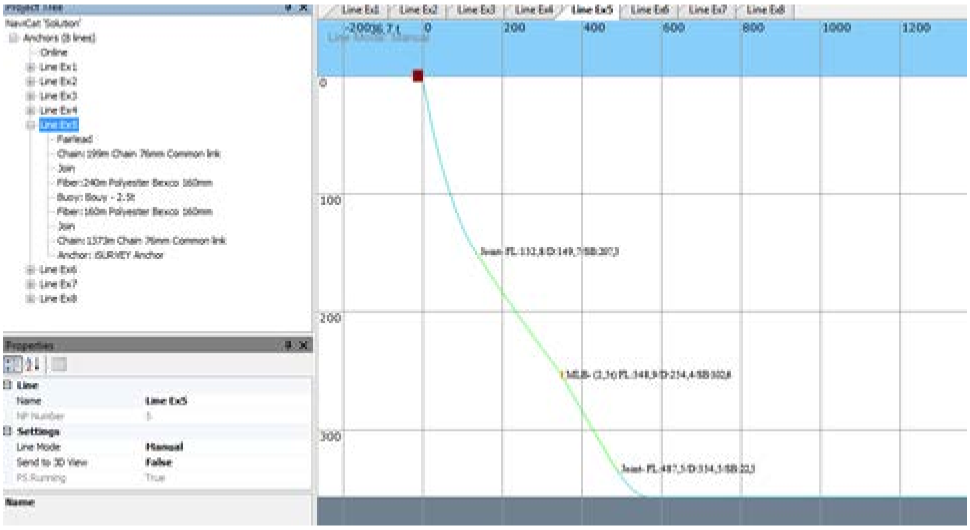


Figure 4 2D profile display of anchor chains in NaviCat.

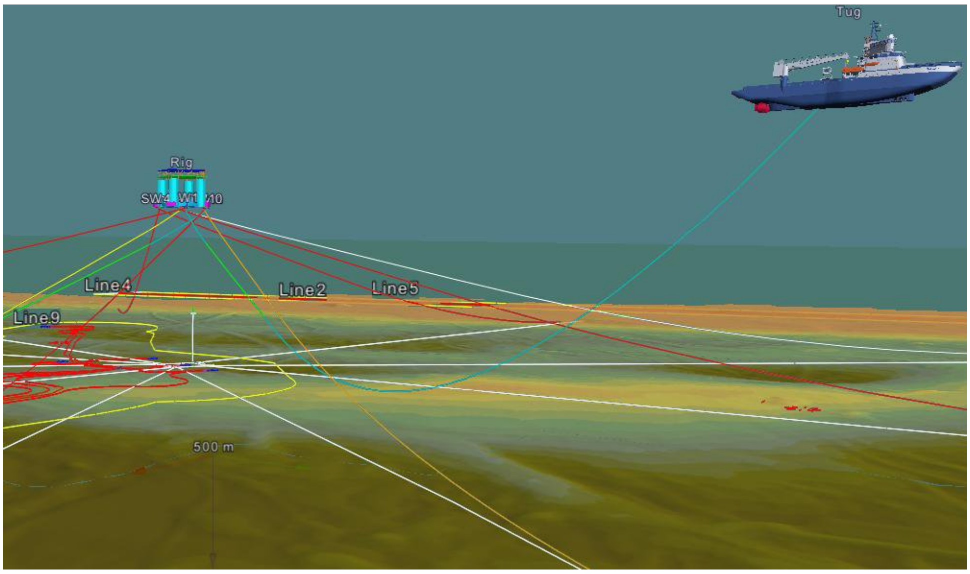


Figure 5 3D chain display and vessel drawings in Online3D.

2.4 Pipeline inspection & video integration

NaviPac and NaviScan are in operation as the workhorse in huge series of pipe and cable inspection solutions. The is typically high accuracy operations where an ultimate solution is obtained.

- Integration of ATTU for the most accurate sensor integration
- Dual sensor interfacing
- USBL, LBL and INS UW navigation

- 100% usage of online QC
- Full video control and recording via for example NetMC X-OPS
- Integration of MBE and pipetracker
- Advanced use of PanGeo SBI for high level cable detection
- Link to the EIVA offline 3D pipeline inspection tool

Figure 6 NetMC XOPs display with NaviPac overlay and control.

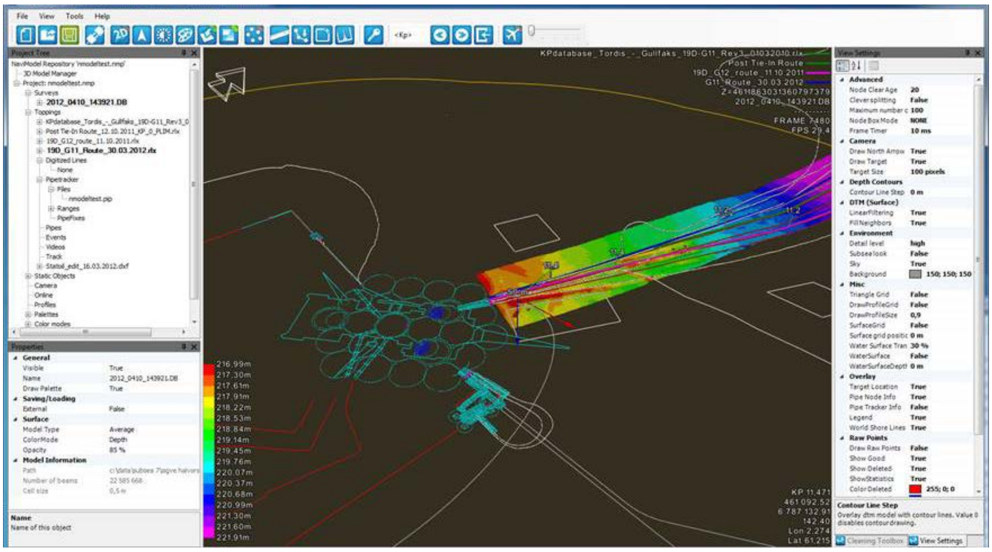


Figure 7 Real time display of MBE, pipeline and ACAD.

2.5 2D seismic

NaviPac includes a special tool for 2D Seismic operations, where the tool optimises accurate distance shooting and integration with most general seismic recording systems.

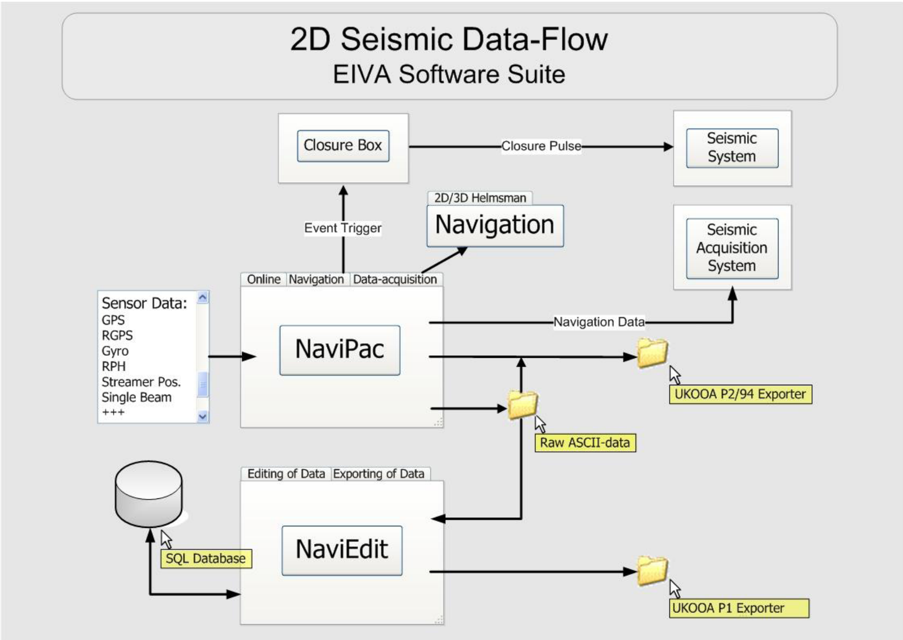


Figure 8 2D Seismic data and operations flow.

NaviPac includes high-level features for

- Survey planning incl. run-in and run-out
- Streamer and tail buoy positioning
- Gun and COS/CMP calculations
- Along line and accumulated distance shooting
- Trigger control
- UKOOA P2/94 recording
- Full recalculation in NaviEdit incl. UKOOS P1/90 and SPS export

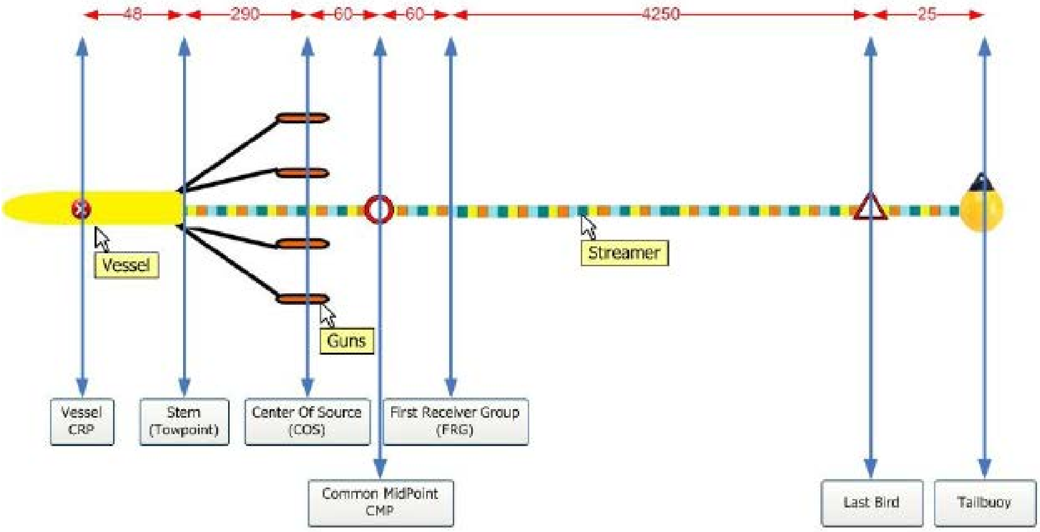


Figure 9 Streamer definition.

The EIVA 2D Seismic offers a very high accurate low cost alternative to the more specialised solutions, and are used worldwide both commercially and in science projects.

2.6 Cable lay operations

NaviPac includes an advanced cable lay option based on the 3D catenary calculation in NaviCat.

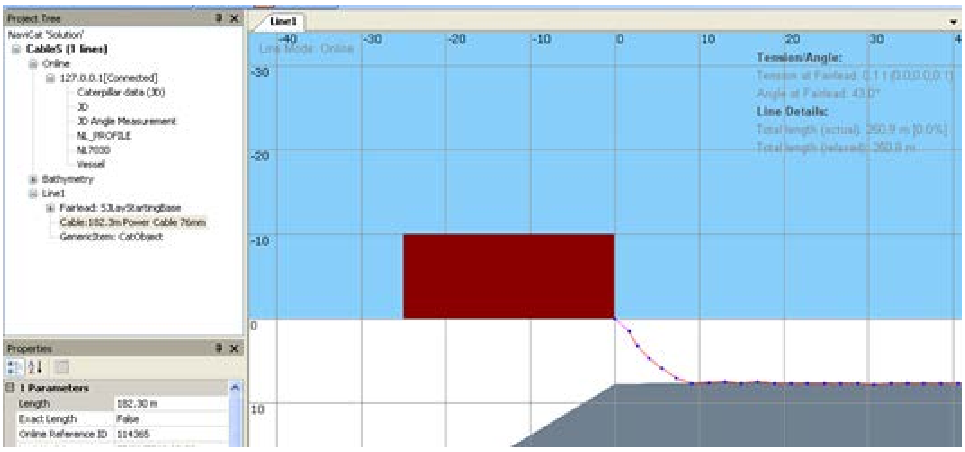


Figure 10 2D profile view of cable.

The brain in the system is the EIVA catenary solution, which performs a full 3D calculation of the cable in the water column and along the seabed.

The catenary model is based on a 3D particle system and allows full computation of forces along the chain. This model can be expanded to include external forces such as currents.

The system loads terrain information (DTM, profile or fixed depth) and uses this for the touchdown estimation and cable curvature calculations.

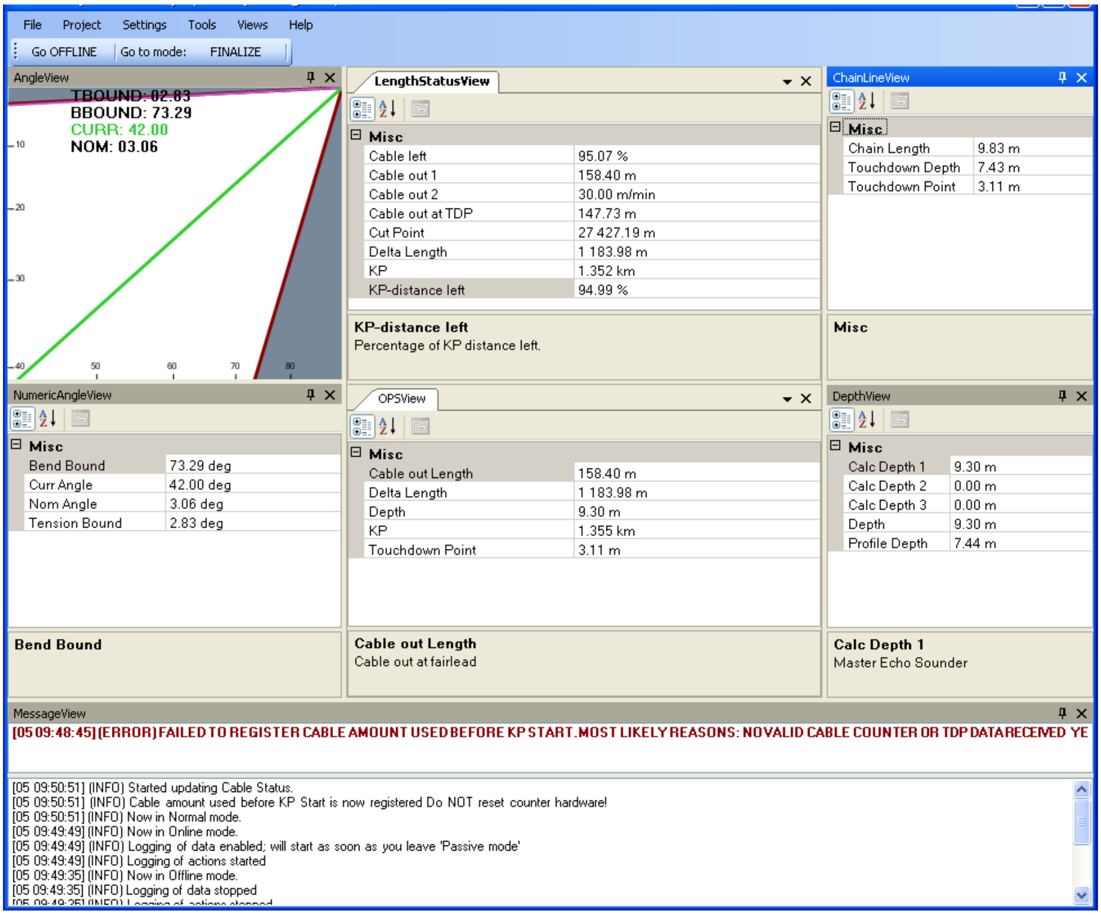


Figure 11 Overall cable lay display including angular control, cable accounting, touchdown monitoring and alarm monitor.

The cable lay application is running beside NaviPac (same pc or remote) and it gives the cable operator the needed displays to monitor cable speed, angle, bending radius etc.

This module is also responsible for the cable accounting, and thus a very important tool.

The cable lay scenario can be connected to NaviPac Online3D, and thus give a user friendly visualisation of the entire project:

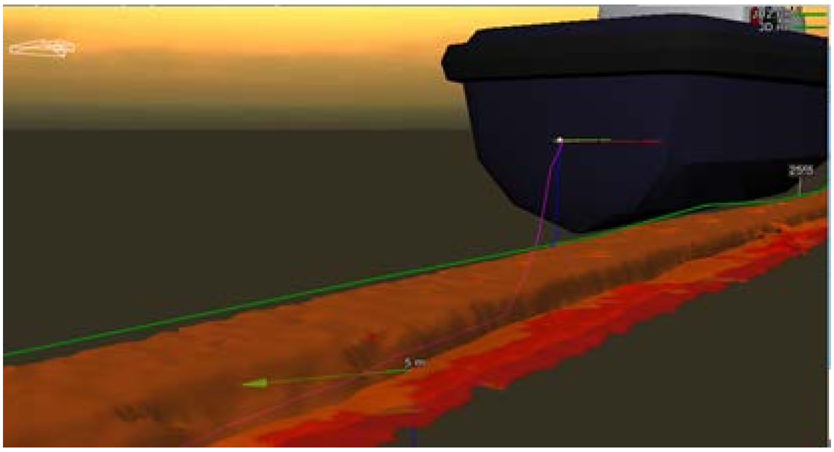


Figure 12 Online 3D presentation of vessel, cable, seabed and touchdown point.

2.7 Excavation

EIVAs NaviPac dredging and excavation software includes a 2D and 3D view of the scanned seabed with the exact real time location of ship, crane and bucket measured by mounted high precision sensors. The crane operator uses the software for placement of the bucket, knowing exactly where and how deep to dig, and have live update of the seabed based on the exact bucket depth and location. This enables the operator to constantly see when the coverage is complete and the next area can be attacked.

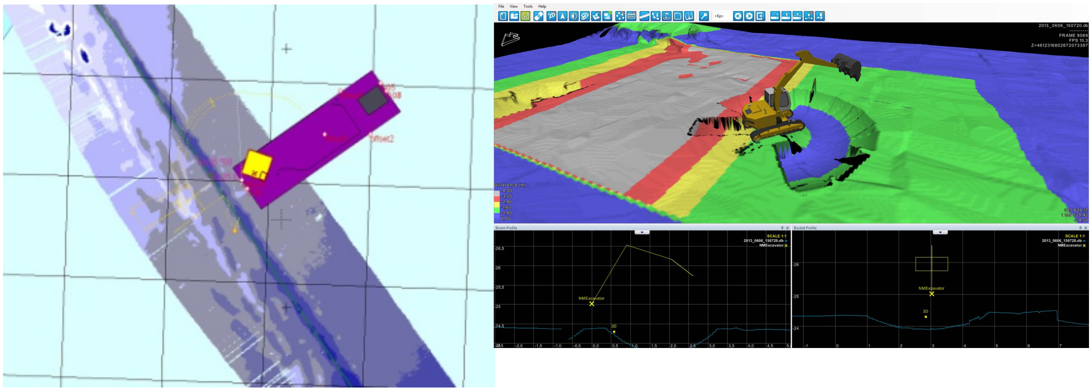


Figure 13 Excavation 2D and 3D operations display.

The precision and real time visualisation offered by EIVAs software has made it possible to develop new work methods of covering and digging and thus increase speed and quality.

The solution is based on NaviPac for sensor interfacing and 3D navigation and real-time NaviModel for display and on-the-fly update of terrain. The solution utilises unlimited number of points in the data model, and gives the operator optimal quality control and thus better overall performance.

2.8 Automated scour monitoring

The scour monitoring system provided by EIVA is comprised by two scanning sonars and optional an acoustic doppler current profiler (ADCP) with wave option.

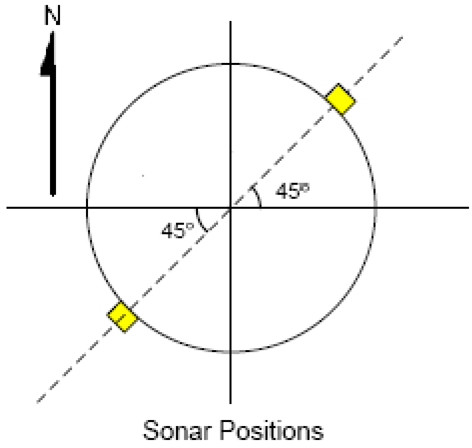


Figure 14 Scour sonar mounting.

The physical installation of the two sonars is performed with one sonar on each side of the monopile, each covering an area of >180 degrees. Full seabed search (coverage) of the area of interest for the scour monitoring can consequently be obtained by combining a scan from each of the sensors. This is illustrated in the figure, where the yellow rectangles show that the sonars have been mounted with an approximate heading of 45 (≈ northeast of the monopole) and 225 degrees (≈ southwest of the monopole), respectively.

An ADCP can be placed on the seabed approximately 50 m from the piles. The ADCP is installed in a vertical looking up fashion for waves and current acquisition.

The complete scour monitoring system has been established and configured to facilitate that both the ADCP- and the sonar related control of sensors as well as the associated data-acquisition can take place remotely, from the client office or similar.

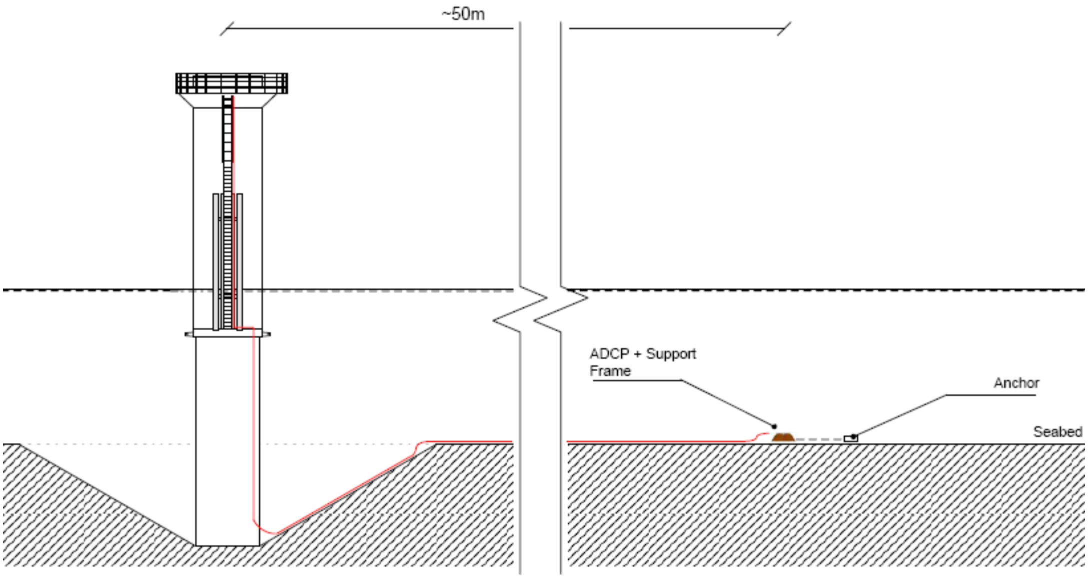


Figure 15 Scanner and ADCP location.

The aim of the EIVA Scour software is that it can be configured and controlled locally, relative to the remote profiling sensors, for example in the EIVA office, and that the logging of data can be performed in formats that can be used for further processing and documentation utilising standard EIVA software. As such the acquisition software must be executed on a computer with internet access; however, the link to the sensors, employed on the site is performed via a dedicated VPN-connection.

The acquisition is executed as a 24/7 service with user defined intervals, so the system guarantees data recording with the required interval.

The data will hereafter be processed in the EIVA Offline SW Suite for time based comparison

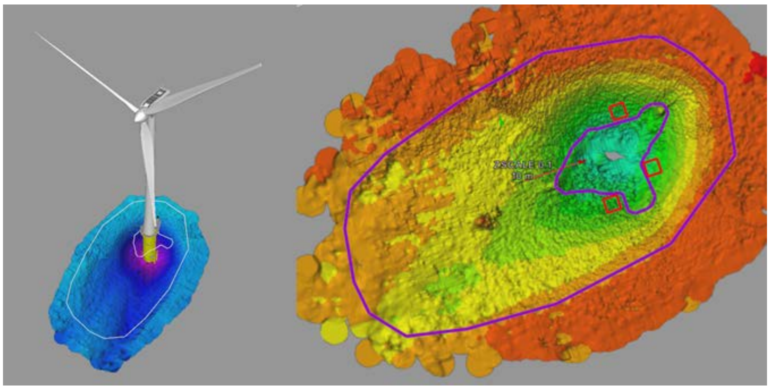


Figure 16 The 3D digital terrain model gives the operator many possibilities to analyse and visualise the data.

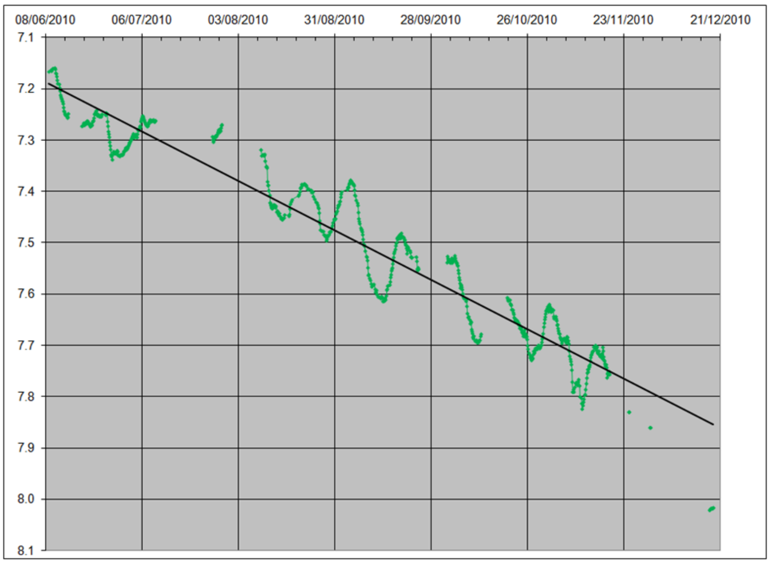


Figure 17 Example scour development over time, showing periodic patterns every two weeks with 70cm of scour developed over 6 months.

3 Software feature matrix

	NaviPac	NaviPac Lt	NaviScan	NaviEdit	NaviModel	NaviPlot
Features & tools						
24/7 license exception service	✓	✓	✓	✓	✓	✓
License free training version	✓	✓	✓	✓	✓	✓
Graphic & numeric data presentation	✓	✓	✓	✓	✓	
Survey meta data management & reporting	✓	✓	✓	✓	✓	
System, sensor & sonar calibration	✓	✓	✓	✓	✓	
Real-time QC & reporting	✓	✓	✓	✓		
UNESCO depth calculations	✓		✓	✓		
3D real-time display	✓	✓	✓		✓	
Real-time DTM	✓		✓		✓	

	NaviPac	NaviPac Lt	NaviScan	NaviEdit	NaviModel	NaviPlot
Alarm monitoring	✓	✓	✓			
Build in simulator	✓	✓	✓			
Data acquisition & recording	✓	✓	✓			
Networked remote display	✓	✓	✓			
Position & data monitoring display	✓	✓	✓			
Survey project management	✓	✓		✓	✓	✓
Catenary calculations	✓				✓	
Eventing	✓				✓	
2D Helmsman's Display	✓	✓				
Anchor handling	✓					
Cable overlength	✓					
Collision detection	✓	✓				
Distance shooting	✓					
Fleet management	✓					
Line planning	✓	✓				
Onshore survey monitoring (network or internet)	✓					
Real-time navigation	✓	✓				
ROV tracking	✓					
UKOOA GPS monitoring	✓					
TVU/TPU analysis (Total Vertical Uncertainty)			✓	✓	✓	
Single & multi tidal correction			✓	✓		
Sound velocity & CTD calculations			✓	✓		
Multibeam acquisition			✓			
Sidescan sonar acquisition			✓			
Sonar waterfall display			✓			
Target analysis and management			✓			
Multiuser/server license				✓	✓	✓
Survey data reporting				✓	✓	✓
Survey data editing				✓	✓	

	NaviPac	NaviPac Lt	NaviScan	NaviEdit	NaviModel	NaviPlot
GPS tide				✓		
Chart manager					✓	✓
Chart layout manager					✓	
Digital terrain model (DTM)					✓	
Video integration					✓	
Volume calculation					✓	
Charting						✓
Instrument interfacing						
GPS and surface navigation	✓	✓	✓			
Attitude sensor	✓	✓	✓			
Dynamic positioning (USBL, LBL, Remote GPS)	✓					
Doppler velocity log	✓		✓			
Singlebeam echosounder & similar	✓	✓	✓			
Pipe & cable tracker	✓		✓			
Bathy sensor	✓		✓			
Magnetometer	✓					
Multibeam sonar			✓			
Sidescan sonar			✓			
Data output	✓	✓				
AIS	✓	✓				
Streamer & tailbuoy - 2D Seismic	✓					
Barge management, anchor handling & rig move	✓(1)					
Inter vessel exchange: WLAN & Telemetry	✓					
Tug & AHT	✓(2)					
Generic I/O drivers	✓	✓	✓			
Interfacing type						
Serial RS 232/422	✓	✓	✓			
UDP/IP	✓	✓	✓			
TCP/IP	✓	✓	✓			

	NaviPac	NaviPac Lt	NaviScan	NaviEdit	NaviModel	NaviPlot
EIVA ATTU High precision timetagged data – TimeBox	✓		✓			
PPS + ZDA/UTC	✓		✓			
A/D converter	✓					
Flexible Geodesy						
Map projection definition	✓	✓	✓	✓	✓	✓
Ellipsoid & datum shift (7 parameters, US Nadcon, etc)	✓	✓	✓	✓		
ITRF (International Terrestrial Reference Frame)	✓					
International scaling (US survey feet etc)	✓	✓		✓	✓	✓
EPSG (European Petroleum Survey Group) database	✓	✓			✓	
Geoid model	✓		✓	✓		
Data storage and export						
EIVA ASCII NPD	✓	✓				
EIVA Binary SBD			✓			
EIVA NED - compressed binary XYZ			✓	✓		
UKOOA seismic data (P2/94, P1/90)	✓			✓		
UKOOA pipeline data				✓	✓	
SPS seismic data				✓		
XTF - extended Triton format			✓			
Generic & fixed ASCII	✓	✓		✓	✓	✓
FAU - Farvandsvæsnets exchange format			✓	✓		
VisualSoft				✓	✓	
PiSYS				✓		
IRAP - binary seabed format				✓		
MBES - German waterways				✓		
ACAD drawing (DXF/DWG)				✓	✓	✓
ESRI shape					✓	
PDF (& similar reports)	✓	✓	✓	✓	✓	
Data display layers						
ACAD drawing (DXF/DWG)	✓	✓			✓	✓

	NaviPac	NaviPac Lt	NaviScan	NaviEdit	NaviModel	NaviPlot
Geotif images	✓	✓			✓	✓
ASCII vector and point files	✓	✓		✓	✓	✓
Digital terrain models	✓	✓			✓	✓
Runlines & digitised lines	✓	✓		✓	✓	✓
Microstation DGN					✓	
ESRI shape					✓	
C-Map charts	✓(3)	✓(3)				
7C charts	✓(3)	✓(3)				
S-57 charts	✓(3)	✓(3)				
ECDIS charts	✓(3)	✓(3)				
Data display symbols						
2D ASCII HP plotter symbols	✓	✓		✓		✓
3D objects 3DS	✓				✓	
ACAD drawing (DXF/DWG)	✓	✓			✓	
Special nautical fonts	✓	✓				
000 fonts - German waterways	✓	✓				
Data filtering & cleaning						
Navigation Kalman filter - incl. DVL integration	✓	✓		✓	✓	
Sensor prediction & robust weighing using Kalman filter	✓	✓				
Sensor spline filter				✓		
Asynchronous data interpolation	✓	✓	✓	✓		
Sonar range, angle & quality filter			✓	✓		
Manual spatial plane cleaning					✓	
Automated S-CAN spatial cleaning for large data volumes					✓	
Calibration						
Position fix	✓	✓				
Attitude	✓	✓				
USBL	✓					

	NaviPac	NaviPac Lt	NaviScan	NaviEdit	NaviModel	NaviPlot
Doppler velocity log	✓		✓	✓		
Multibeam patch test			✓		✓	
Data importing for post processing						
NaviPac NPD				✓		✓
NaviScan SBD				✓	✓	
Generic ASCII				✓	✓	
XTF - extended Triton format				✓	✓	
Kongsberg EM files				✓	✓	
L-3 XSE				✓	✓	
GSF				✓	✓	
Hain Nav files				✓		
Navlab processed navigation & depth files				✓		
TerraPos				✓		
POSMV delayed heave				✓		
Applanix POSProc				✓		
IXSEA Delph INS				✓		
Visualsoft event files				✓	✓	
Visualsoft video					✓	
NetMC video					✓	
Pangeo SAS cubes					✓	
Seabed elevation model					✓	
FAU - Farvandsvæsnets exchange format					✓	
Data replay/edit						
Survey data header edit (offsets, time, geodesy etc)				✓		
Survey data edit on sensor level				✓		
Tidal correction			✓	✓		
Sound velocity ray bending			✓	✓		
CTD Profile depth compensation - UNESCO	✓		✓	✓		
Playback & fast review	✓		✓	✓	✓	

	NaviPac	NaviPac Lt	NaviScan	NaviEdit	NaviModel	NaviPlot
Batch processing				✓	✓	
Merge third party data processing (delayed heave, INS, …)				✓		
Spatial data editing: manually & automated				✓	✓	
Data reporting						
ASCII	✓	✓	✓	✓	✓	
Contouring					✓	✓
Bathy plot					✓	✓
Digital terrain model (TIN/TRN)					✓	
Long/cross profiles				✓	✓	✓
Geocoded images (geotif)					✓	✓
Events	✓			(✓)	✓	✓
Volume calculation					✓	
Pipeline inspection report				(✓)	✓	✓
TVU analysis & report					✓	
Density of soundings					✓	
Beam count statistics					✓	
Data gap analysis					✓	
S57						✓(4)
PDF reporting	✓	✓	✓	✓	✓	✓

1) Requires special TMS add-on to NaviPac Pro
2) Special tug license
3) Requires license from the supplier (C-Map/7C)
4) Requires special 7C license

3.1 System solution matrix

	NaviPac	NaviScan	NaviEdit	NaviModel	NaviPlot	ATTU
2D Seismic	✓		✓			
Automatic scour monitoring		✓		✓		
Barge management	✓					
Basic navigation	✓					
Cable lay	✓	(✓)	(✓)	(✓)	(✓)	
Cable route inspection	✓	✓	✓	✓	✓	✓
Eventing	✓			✓	✓	
Excavation	✓					
Hydrography	✓	✓	✓	✓	✓	✓
Multibeam survey	(✓)	✓	✓	✓	✓	✓
Offshore engineering & installation	✓					
Pipe lay	✓	(✓)	(✓)	(✓)	(✓)	
Pipeline inspection	✓	✓	✓	✓	✓	✓
Sidescan sonar survey	(✓)	✓		✓	✓	
Singlebeam survey	✓		✓	✓	✓	
UXO	✓		✓		✓	

4 Modules & features

4.1 Flexible geodesy

The SW suite utilises a flexible solution for setting up the working geodesy.

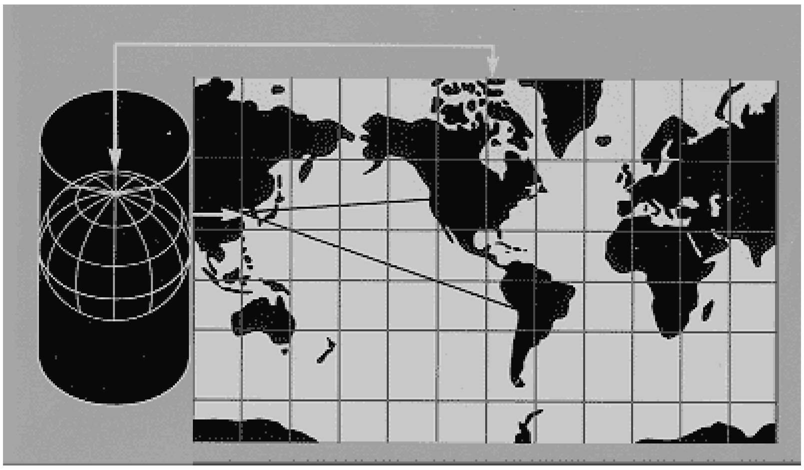


Figure 18 Traditional Transverse Mercator.

4.1.1 Map projection types

The software utilises the most general projection types used worldwide. Use of projection is mainly based on user selections rather than typing.

- Transverse Mercator
- UTM north
- UTM south
- Gauss Krueger
- National Grid of Great Britain (NGGB)
- Gauss Boaga east
- Gauss Boaga west
- System SBF
- RT38/RT90
- System 34
- Mercator
- Stereographic
- Polar stereographic
- UPS north
- UPS south
- Equatorial stereographic

- Oblique stereographic
- RD
- Rectified Skew Orthomorphic
- New Zealand Map Grid

4.1.2 Datum and ellipsoids

The software utilises selected datum by covering list of most common ellipsoids or entering user defined ellipsoid definition.

4.1.3 Datum shift

The conversion from GPS coordinated (WGS84) to user datum is handled in multiple ways depending on the local rules. The datum shift is purely applied to the latitude and longitude as the height is too inaccurate.

- Normal Bursa-Wolff 7 parameter (NGO)

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} Tx \\ Ty \\ Tz \end{pmatrix} + \begin{pmatrix} PPM & -Rz & Ry \\ Rz & PPM & -Rx \\ -Ry & Rx & PPM \end{pmatrix} \times \begin{pmatrix} X0 \\ Y0 \\ Z0 \end{pmatrix} + \begin{pmatrix} X0 \\ Y0 \\ Z0 \end{pmatrix}$$

- Modified Bursa-Wolff 7 parameter

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} Tx \\ Ty \\ Tz \end{pmatrix} + \left(1/(1-PPM)\right) * \begin{pmatrix} 1 & -Rz & Ry \\ Rz & 1 & -Rx \\ -Ry & Rx & 1 \end{pmatrix} \times \begin{pmatrix} X0 \\ Y0 \\ Z0 \end{pmatrix}$$

- Special North Sea
  A multi-step operation, which is commonly used in the Norwegian sector of the North Sea.
  Transform from WGS84 to ED87 using a normal 7-parameter (NGO) transformation.
  If the resulting latitude is below 62 degree, use dedicated algorithm to get from ED87 to ED50.
  If the resulting latitude is above 65 degree, use dedicated 7-parameter transformation from ED87 to ED5.
  If the resulting latitude is between 62 and 65 degree, use a weighted average of the algorithm and the dedicated 7-parameter.
- US Nadcon
  The support of US NADCON (between NAD83 and NAD27) is supported by using the empirical shift models supplied by NOAA. Default files are supplied by EIVA, but we do recommend that users check the official sites.
- ITRF
  The Software supports furthermore a special ITRF (time dependent shift) 7-parameters compensation which a.o. is used in the US/Canada region

4.1.4 Geiod model

The online software includes absolute height correction from GPS ellipsoid height to local datum (local zero). All methods are based on empirical models which are loaded into the software and applied to the GPS height:

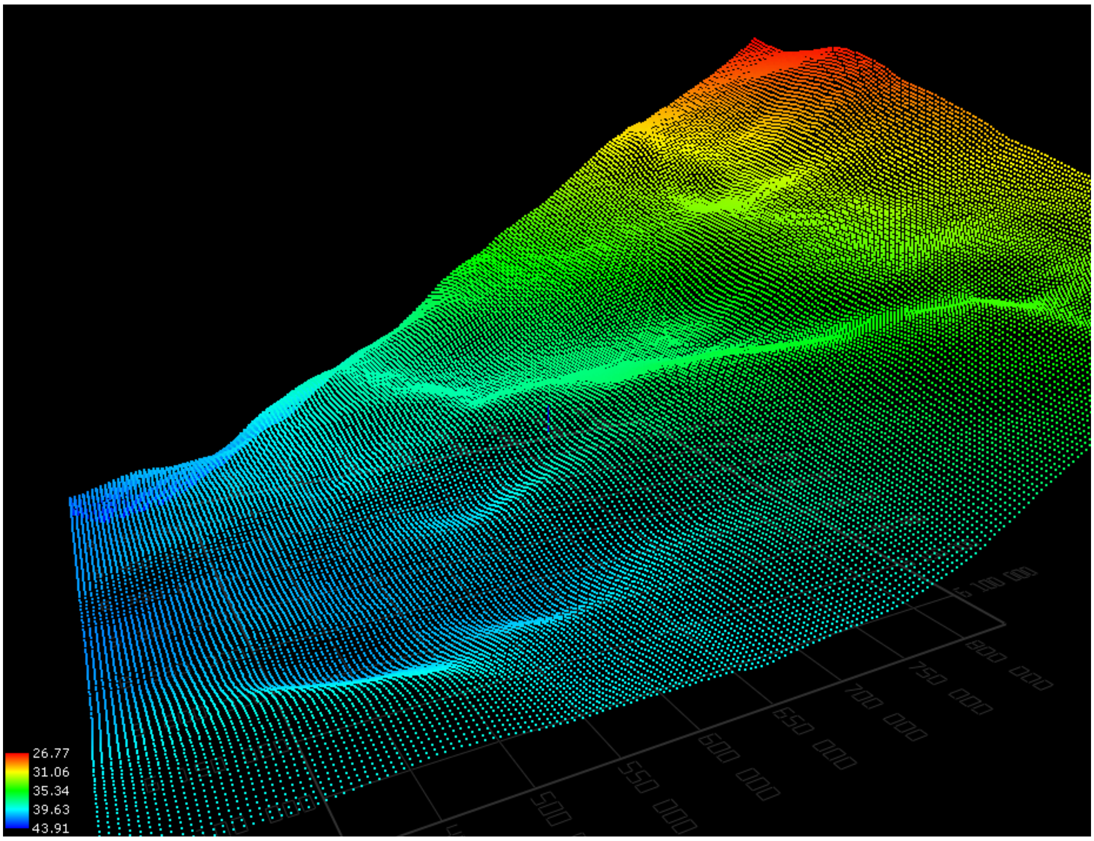


Figure 19 3D model of the geiod of Denmark. The graphical presentation is made in NaviEdit and NaviModel 3D point view.

- KMS
  ASCII file data model defined by Kort and Matrikel Styrelsen in Denmark. KMS is supporting models for most of the world. The EIVA SW includes test model for Denmark
- EGG97
  the European Gravimetric (Quasi) Geoid 1997 (EGG97) by importing the binary geoide file (bin) files. Some details can be found at http://www.ife.uni-hannover.de/forschung/egg97_e.html
- GCG05
  German combined quasi geoid model GCG05 – see http://www.geodatenzentrum.de/docpdf/quasigeoid.pdf
- Fixed correction

4.1.5 EPSG

The online Software is expanded so it supports integration with the general geodesy database from EPSG (European Petroleum Survey Group).

The Online SW includes the most recent version of the EPGS database (SQL Lite Based) built into the software applications (for efficiency), and it allows the operator to select between most of the general settings.

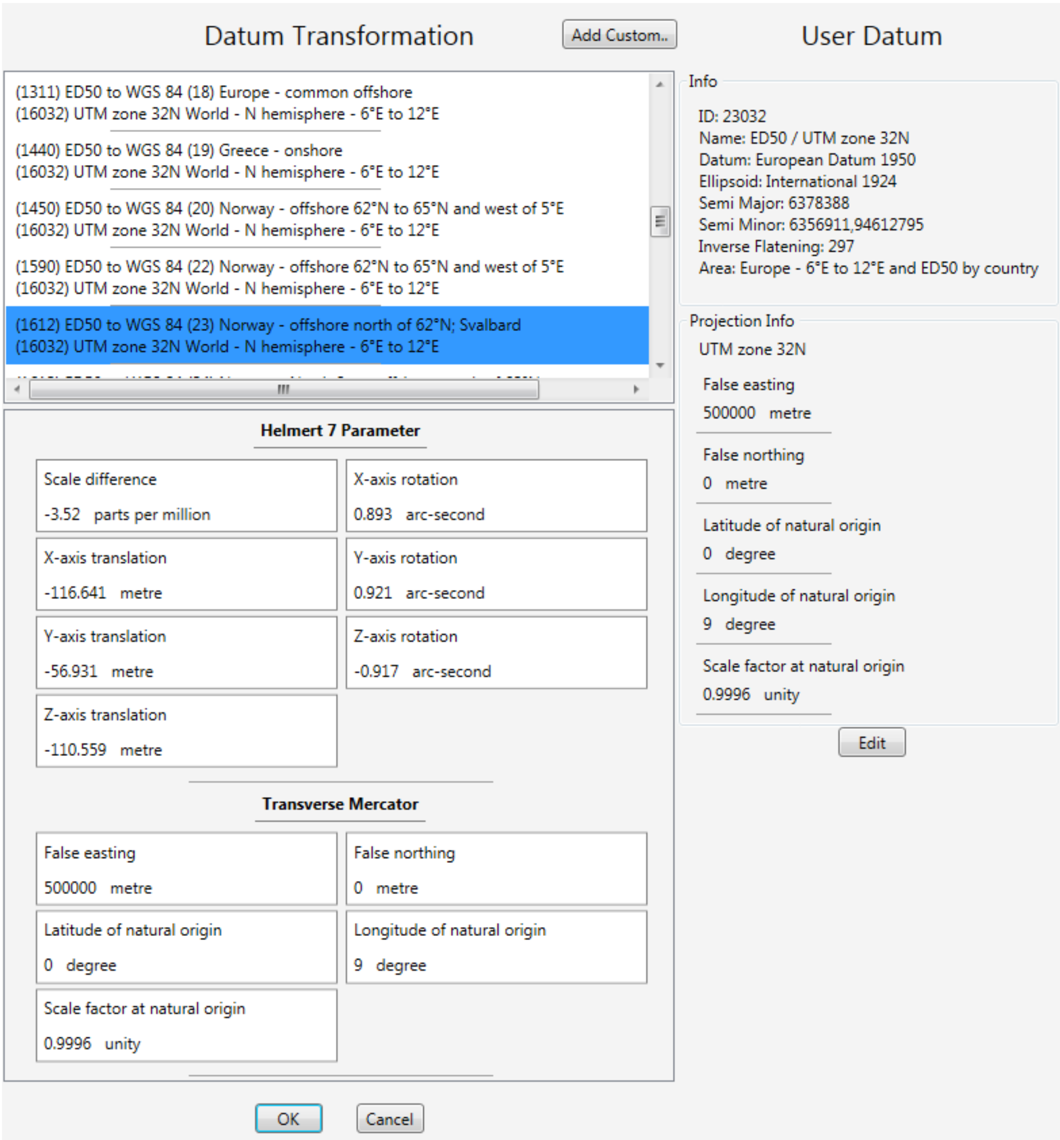


Figure 20 Advanced search and selection feature for EPSG support.

This does also mean that the SW supports the ITRF datum which requires more than the traditional 7 parameter shift.

4.1.6 Free calculator

The online software utilises a small stand-alone geographical calculator GEOCalc. It is installed with NaviPac, but can be used dongle free on any computer.

4.2 Accurate time tagging

Time is critical to all aspects of the survey solution, and to gain the absolute accuracy we recommend the use of ATTU (Accurate Time Tagging Unit) for the interfacing of critical sensors (motion sensor, gyro etc).

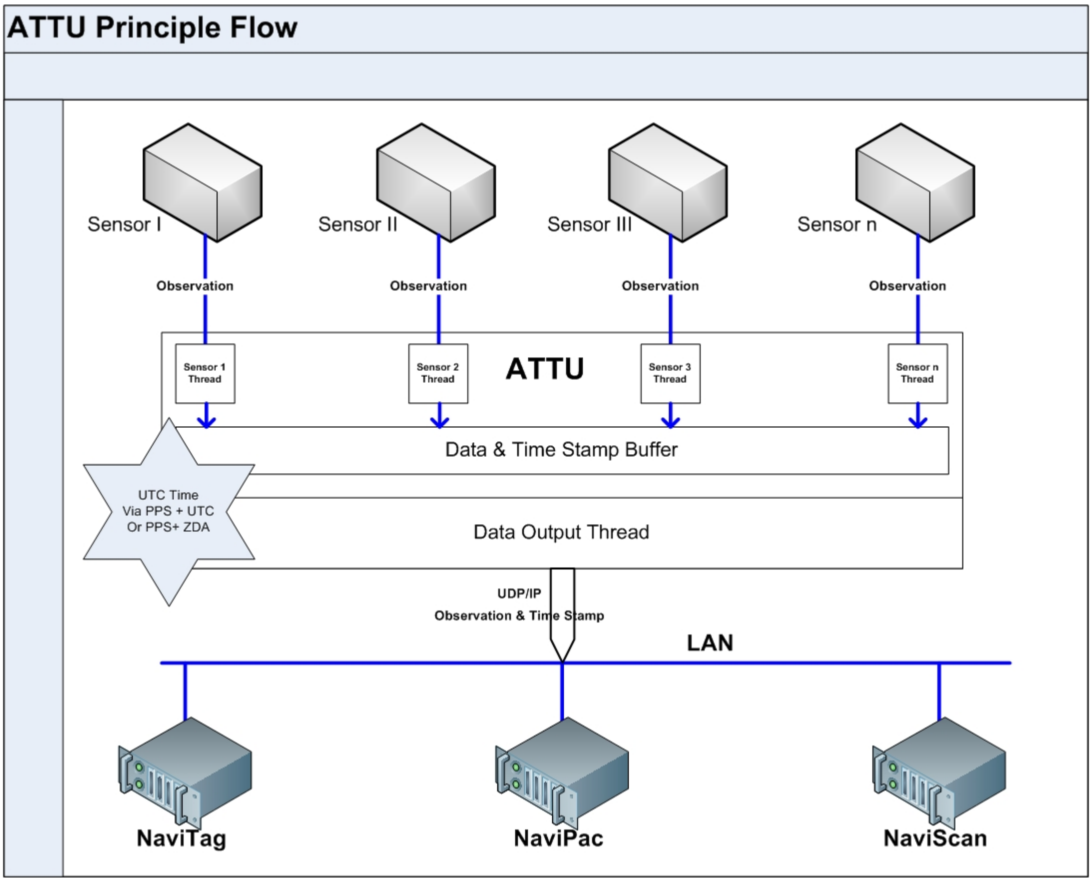


Figure 21 ATTU flow and usage.

The ATTU is a setup, where time tagging of your survey data is performed by the use of one or more HW boxes. The ATTU can be placed close to your equipment and thus minimise the need for long serial cable etc.

One of the ATTU's must be interfaced with GPS time and PPS input for the synchronisation. This unit can hereafter act as network time server for other ATTU's and the survey computers (NaviPac and NaviScan).

4.2.1 The Box

The ATTU is a dedicated computer running a stripped down LINUX kernel. This ensures that the EIVA firmware on the pc has unlimited access to resources on the pc, and thus ensure the precise time tagging as requested.

The box is equipped with a web interface or special pc application for configuration, update and monitoring.

4.2.2 Interfacing

The ATTU can be equipped with up to 3 interface cards with each 8 COM ports. The boards can be selected as either RS 232, RS 422 or RS 485.
The unit can interface any data input as long as you can define a packet characteristic allowing the unit to recognise the packet. This can for example be strings ended with <cr><lf> of binary data starting with <0x90>< 0x90>

The data packets is then encapsulated in a special EIVA telegram (timestamp, identifier and port identification) and delivered as UDP/IP message on the network.

4.2.3 Tests

The requirements for the system was defined to be better than ½ ms, but we have via lab-test been able to prove that the system in 99% is significantly better than 50µsec and in 100% is better than 100 µsec

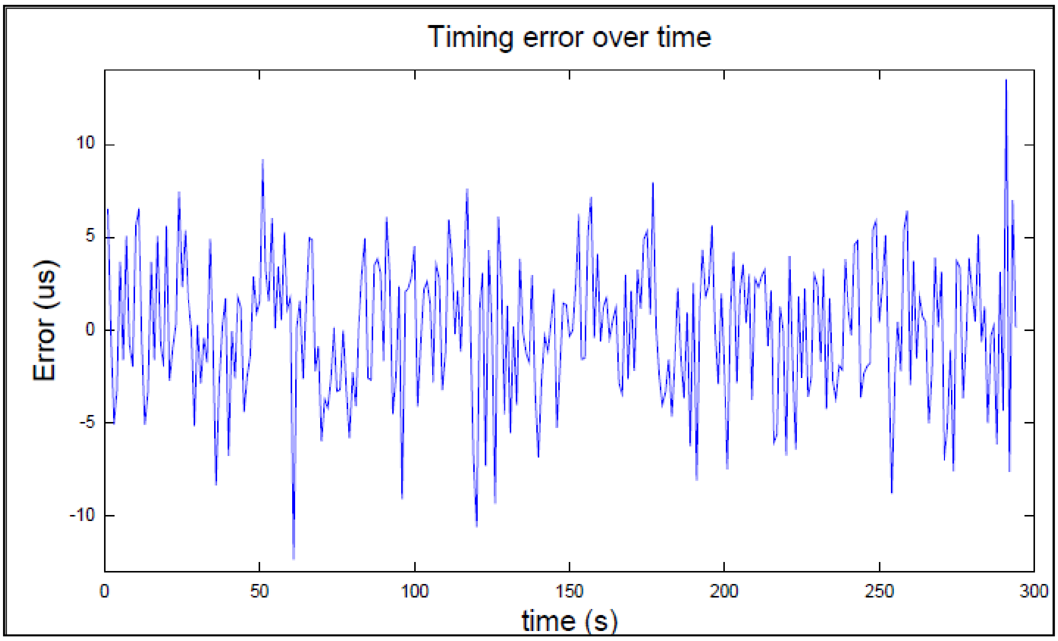


Figure 22 Field test onboard high-level survey vessel showing timing errors less than 15 µs.

4.3 Data filtering

The online SW uses advanced Kalman Filters and least square computation for the final result. Data is always recorded as raw observations together with the final calculations, which means that results can be fine-tuned during processing.

NaviPac gives the user the option to use robust estimation principles both in the least square module and in the Kalman module. We consider this option of robust adjustment and filtering a very important improvement in comparison with the classical computation methods, as blunders are fully automatically and properly detected without time delay and have no influence on the resulting position determination.

4.3.1 Observations

The measurement is preliminarily checked for the presence of blunders. For this purpose the measurement is compared with its predicted values. The Kalman filter from the predicted position at the time of measurement computes the latter. The measurement is first corrected for the projection system and other physical and geometrical aspects.

The difference between measurement and prediction is compared to its standard deviation (mean square error). A gate of two times the standard value is used. If the difference is acceptably small, the measurement is preliminarily accepted for further calculations. Otherwise, the measurement may be either fully rejected or weighted with weight depending on the magnitude of the difference found (robust estimation).

4.3.2 Full 3D compensation

In using the measurement for positioning, one has to remember that ranges of direction are usually not measured to the ship's reference point for which primary coordinates are required, but to various antenna positions on the vessel.

Thus the relative position of the antenna to the ship's reference point and the roll, pitch and heading of the vessel must be taken into account. In NaviPac, a rigorous treatment of this layback is made, and corrections to measured values are avoided. This both speeds up the computation and eliminates inaccuracies with large layback values or with short ranges, and is achieved by relating the measurement directly to the proper position.

4.3.3 Least squares adjustment

Most survey solutions are based on multiple sensor inputs and thus introducing the needs for weighted average of the observations.

In NaviPac, a weighted least squares adjustment is performed, considering simultaneously all measurements at one instant in time. If one particular measurement is not available or is not desired, its weight is set to zero.

Least squares require a linear relationship between the measurements and the unknowns. For this purpose the observation equations are ruled around the predicted position that results from the Kalman filter.

The corrections dX, dY resulting from the least squares adjustment are applied to the predicted position of the ship's reference point and the computation is repeated to compensate for errors in the linearisation. In NaviPac, however, due to the accurate prediction of the ship's position, no new compensation is necessary, and in fact not even a repetition of the least squares method is necessary. This repetition (iteration) is only necessary in the presence of blunders. Thus a considerable saving in computation time is achieved.

4.3.4 Accuracy of least squares

After least squares adjustment NaviPac estimates both the accuracy of the original measurement and the adjusted co-ordinates. In commencing the least squares adjustment, variance and weights were assumed for the individual measurements. Now after adjustment and the previously assumed variance are converted into the most appropriate variance estimates. If this variance properly describes the accuracy behaviour of the sensors, the conversion factor will be a round unity.

The conversion factor, also called 'variance of unit weight' is computed to:

$$Variance = \sum \frac{E(I)^2 \times P(I)^2}{\delta^2 \times (acc-2)}$$

Where E(I) = RC(I) - RA(I)

RC = Range Converted

RA = Range Adjusted

Acc = Total number of measurements.

If this variance factor differs very strongly from unity, and the previously assumed variance was chosen to the best knowledge, a blunder in the measurements must be suspected. NaviPac will during the next fix adapt itself to the erroneous sensor using robust estimations. Thus no interaction of the user is necessary.

Accuracy of the co-ordinates is monitored by computing error ellipse, which shows shape and direction of the cloud of points that would emerge if the same fix were to be taken a large number of times. Around 39% of the fixes would be inside the ellipse and 86% inside two times the error ellipse.

4.3.5 The Kalman filter

NaviPac uses a Kalman filter to correct adjusted vessel position for an assumed smooth movement. This is implemented as independent filtering of X and Y co-ordinates or as co-operate filtering. The filtered values can be used to obtain corrected positions or to predict future positions. Filters may also be applied to data sources, as e.g.gyro or ranges may be included.

In NaviPac the user is also allowed the option to choose a robust Kalman filter, which automatically adapts to changing vessel behaviours. This is a very important feature because it avoids problems with determination of the position at the end of survey lines, when the vessel starts a turn or with other sudden changes of the ships course.

4.3.6 Weighting and robust estimation

The least squares algorithm in NaviPac is a weighted least squares algorithm, thus allowing the user to make optimal use of his knowledge of different accuracy of different ranges, bearings or sensors. It also allows the user to enhance or degrade the influence of individual measurements on the results. Weight changes may be introduced on-line.

This weighted least squares adjustment is a prerequisite for the possible interpreted adjustment of all sensor types in NaviPac and it **creates a hitherto unique feature to the user as compared with competitive systems**.

Least squares and Kalman filter yield only optimal results in case of purely normal distribution of the measurements and errors. Any deviation from this normal distribution, e.g. the presence of blunders in the measurements, makes the classical least squares and Kalman methods extremely ineffective. In fact, blunders often become completely unnoticeable in the least square result, although they seriously distort the adjusted position. Thus, even though the least squares method and Kalman filter have found acceptance in offshore survey systems, we seriously warn against the uncritical application of these methods.

4.3.7 Multi Beam Filtering

The data acquisition of MBE data in NaviScan offers a series of data filtering mechanisms. They will mark observations as bad – but not erase any data points.

The filtering utilises among other,

- Beam quality
- Sonar opening angle
- Running average and median filters
- Min/max range filters
- TVU

4.4 Calibration

The software solution incorporates a series of advanced sensor and solution calibration tools

4.4.1 Position fix

NaviPac includes an advanced position fix tool which can be used for position calibration of vessel and all dynamic objects in action, both surface and underwater solutions.

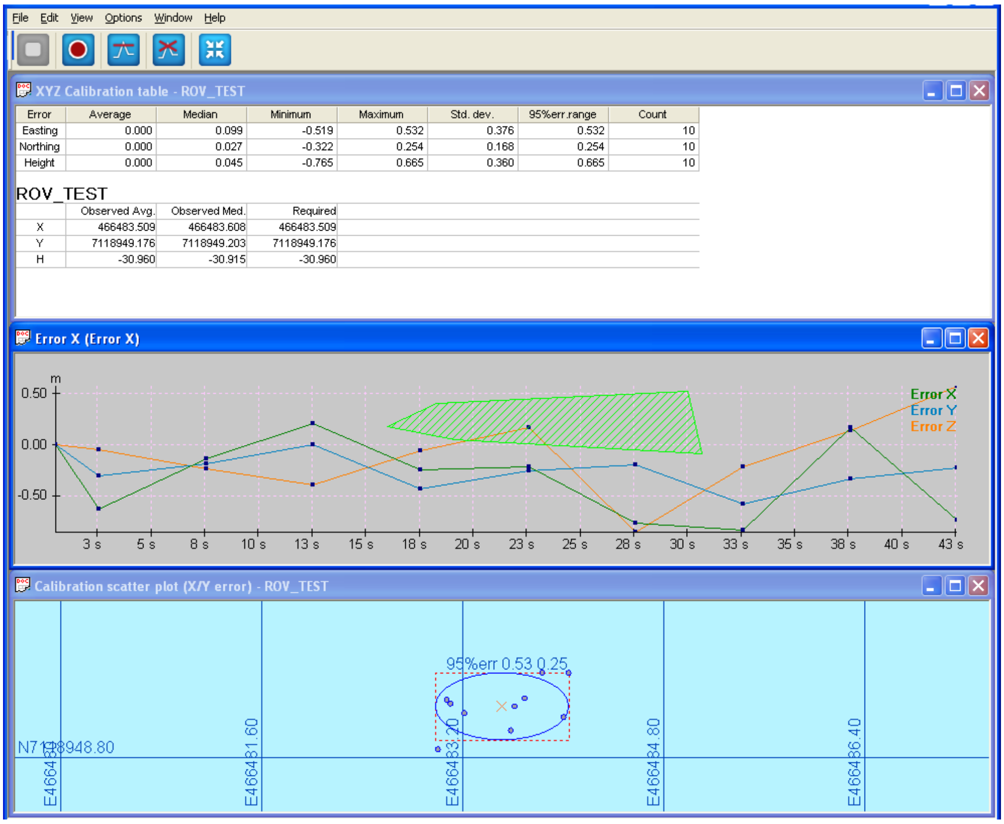


Figure 23 Sample position fix layout including error distribution and scatter plot.

The operator may perform data cleaning before utilising the final calibration result. The outcome can be saved as ASCII report or generated as location waypoints for further use.

4.4.2 Gyro

NaviPac includes a semi-automatic calibration for vessel and ROV gyro. The solution is based on a known baseline and continues measuring of gyro vs 2D baseline distance.

The outcome is a resulting correction value (C-O).

4.4.3 Motion sensor

NaviPac includes a semi-automatic calibration for vessel motion sensor (roll and pitch). The solution is based on known baseline and continues measuring of roll/pitch vs 3D baseline distance.

The outcome is a resulting C-O value.

4.4.4 Ultra short base line

The software includes a generic USBL calibration tool for applied Ultra Short Baseline positioning systems. The solution includes

- Spin for validation of sensor offsets
- Box-in for establishing mount errors and scaling factor
- Transponder fix for on-the-fly validation
- Range fix for circle-around check

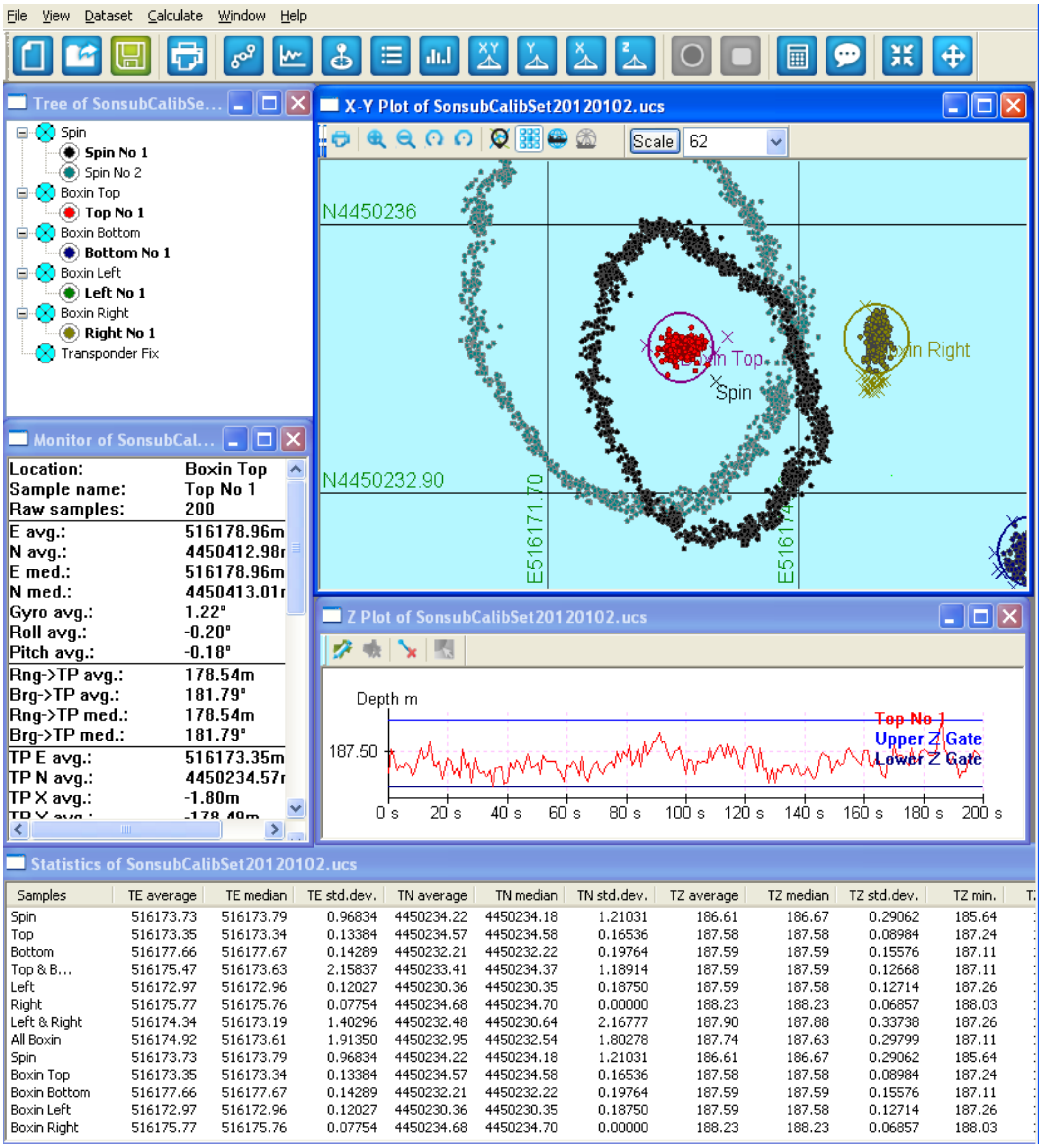


Figure 24 USBL Calibration data and report display.

The system generates advanced HTML reports for solution hand-out.
The mount errors can either be applied in the software driver or input to the USBL unit.

4.4.5 Doppler velocity log

NaviPac and NaviScan includes an integrated DVL calibration module, which compares the observed raw track (USBL, LBL or similar) with the speed observations from the DVL.

The calibration computes

- Scale error
- Mounting error (yaw)
- Recommended filter settings

The mount errors can either be applied in the software driver or input into the DVL unit.

4.4.6 Multibeam patch test

The EIVA software solution utilises an advanced MBE patch test where the operator automatically or interactively can establish mount errors

- Roll
- Pitch
- Heading
- Position delay
- Dual head alignment

The system also includes intuitive checking routines for sensor offsets and individual sensor time delays.

The patch test is based on the advanced data model used in NaviModel and allows the user to perform calibration on all raw observations (and not "just" the gridded model).

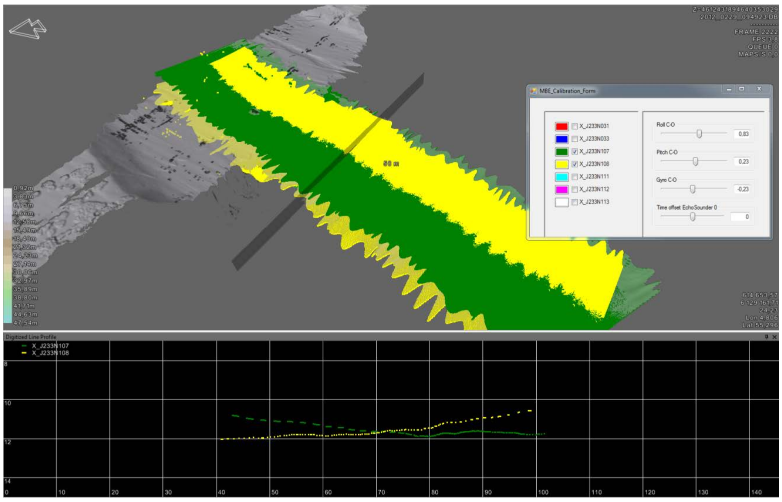


Figure 25 MBE Patch test roll alignment.

4.5 Distributed solution

The EIVA online SW is a client server solution with one master system running interfacing, acquisition and logging. NaviPac and NaviScan can be located at the same computer or running in parallel on two – and still share data interfacing and thus minimise cable spaghetti.

The system can be configured with a number of intelligent clients for eg. Helmsman's Display, ROV Pilot, Survey QC, Rig master, Clients Rep etc.

The remotes are connected to the master via standard TCP/IP network connections, and it allows easy setup and connection.

Each display can be configured individually and thus gives the operator the ultimate display and control platform.

The data distribution also includes a lite network protocol for the Online 3D solution. The need for data throughout is so small that this can be published on an open network and thus been brought from vessel to office.

4.6 Realtime monitoring & QC

The online SW suite includes a series of data displays helping the surveyors to validate that:

- Data is being recorded
- A sufficient quality has been obtained
- It's safe to move on to next location

To support this, a series of applications and views are available all-over the vessel.

- **Traditional Helmsman's Display**

Figure 26 Traditional display utilizing geocodes image, runline control status and data views.

The Helmsman's Display is traditionally the user front-end for most NaviPac operators. The module includes graphical (map view) and ASCII presentation of all survey data, and supports import of background information from charts, CAD drawings, vector drawings and geo-referenced images.
The MBE and Sonar data can be displayed in the graphical map and create realtime quality and coverage control.

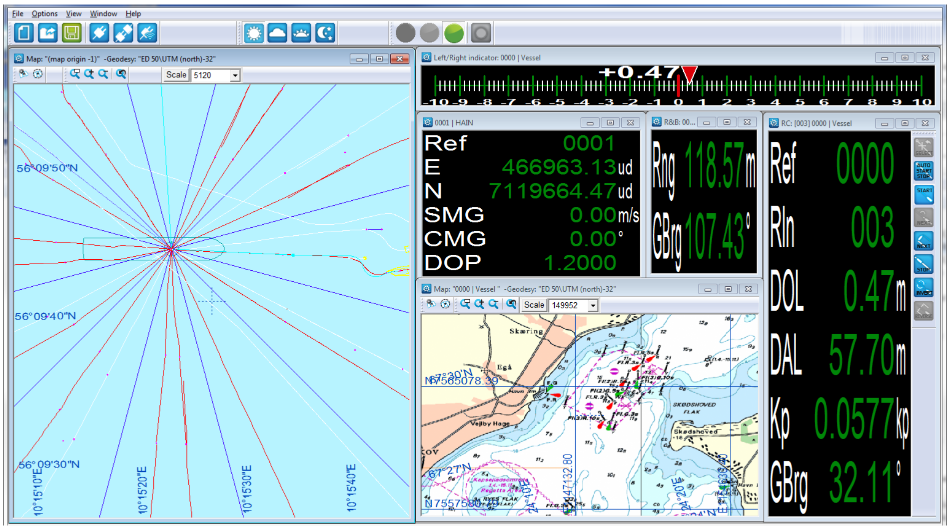


Figure 27 Display with combination of sea charts and ACAD drawings.

- **3D Data Display**
  The 3D Helmsman's Display is an alternative solution to the traditional 2D, and gives the user ultimate display and control for inspection work, IMR, dredging, MBE QC etc. The 3D display uses a lite network protocol and can thus be used on low band-width interfaces for on-shore display.
- **Sensor Data Display**
  All incoming sensor data can be visualised in real time as ASCII tables, time series plots and kp plots (data along the survey line).
  All graphical displays can be shown on master and remote displays.
- **MBE Coverage and QC**
  Evaluation of the quality of the sonar data and checking sufficient data coverage and intensity is critical for all operations. This is handled in the NaviScan realtime display and supported remotely by raw data display and coverage in eg. Helmsman's Display and Online3D:

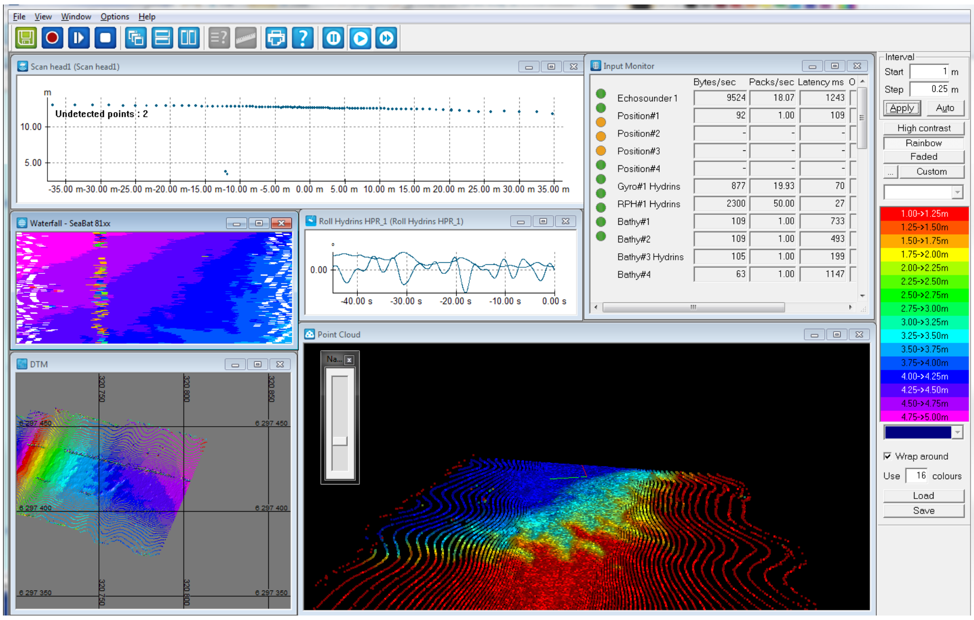


Figure 28 NaviScan sonar and QC display.

- **Sonar display**
  The NaviScan sonar display gives an excellent tool for sidescan (traditional sidescan sonar's and MBE snippets) evaluation as configurable waterfall display.

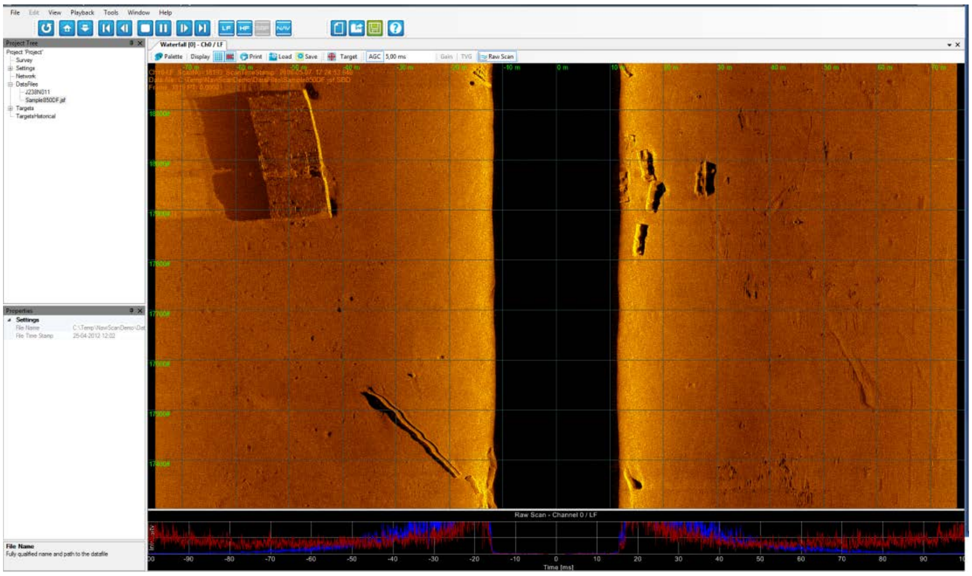
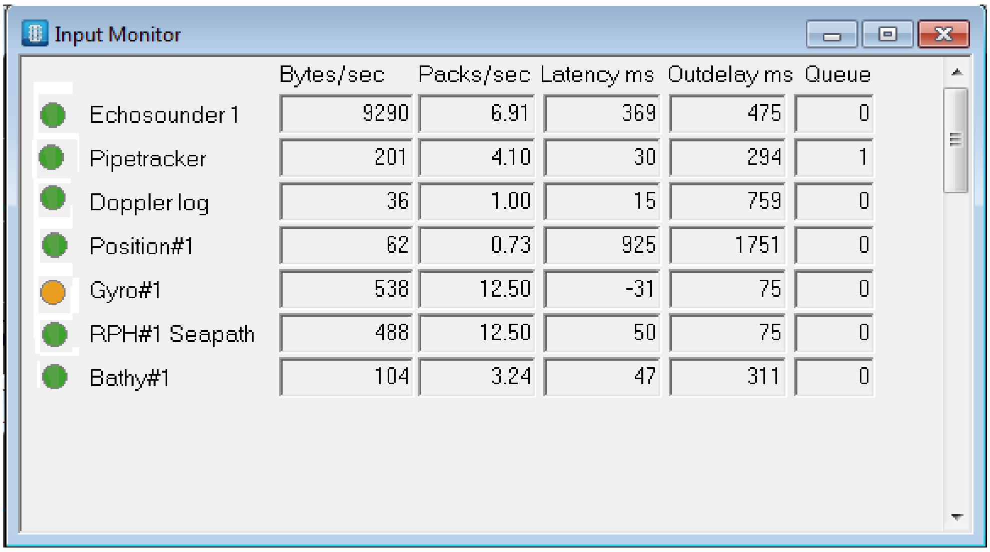


Figure 29 NaviScan Sidescan Sonar waterfall.

The system utilises an advanced target management system for target marking, evaluation and comparison.

- **GPS Status**
  NaviPac supports a full UKOOA GPS monitoring tool for display of status for realtime QC. The same data fields are available for recording for later use in eg. NaviEdit.
- **Input/Output monitor**
  The online software utilises special input monitors which via traffic light and input statistics gives tools for fast problem detections.



	Bytes/sec	Packs/sec	Latency ms	Outdelay ms	Queue
Echosounder 1	9290	6.91	369	475	0
Pipetracker	201	4.10	30	294	1
Doppler log	36	1.00	15	759	0
Position#1	62	0.73	925	1751	0
Gyro#1	538	12.50	-31	75	0
RPH#1 Seapath	488	12.50	50	75	0
Bathy#1	104	3.24	47	311	0

Figure 30 Data input monitor.

- **Raw sensor display**
  All incoming data can be shown in dedicated raw data windows, which shows incoming messages and interpreted data, This gives a very efficient tool for trouble shooting during the mobilisation etc.

4.7 Data recording

NaviPac and NaviScan are normally equipped with each their part of the recording. NaviPac handles navigation and simple data acquisition (echosounders, magnetometers and scientific instruments) and NaviScan covers multibeam – and sidescan sonars.

The recording is based on raw sensor data, meaning that all data is recorded so a full computation from the GPS antenna to the seabed can be performed in the offline processing suite.

The recording also covers computed and filtered observations, which means that you can get a quick result by just using the computations from online and perform modelling and charting. Only in case of problems or external observations a recalculation will be performed.

The data management in the EIVA suite is based on fast throughput, so the offline calculation can be made instant, and not "just" as time consuming replay operations.

All data formats are well documented and can be accessed by 3'rd party after agreement with EIVA.

4.8 3D Online visualisation

The Online 3D module is an integrated part of NaviPac, as the module gives what we call 3D Helmsman's Display. The module supports display of static background information such as runlines, display lines, 3D drawings, waypoints, pipelines and high-level seabed DTM. The DTM is based on the quad-tree model from NaviModel and supports fast and reliable zoom/panning via advanced LOD (Level of Detail) technology – and only the size of the hard drive sets the limit for the size.

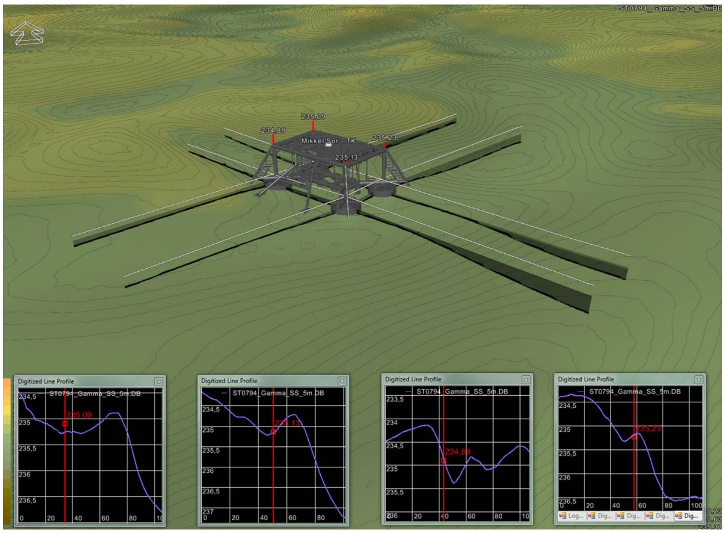


Figure 31 3D Touch-down monitoring.

The module connects to NaviPac and receives continuous 3D positioning updates including attitude for display. The object display can be assigned to an advanced 3D drawing by using 3ds files. If the drawings are proper designed you may even control moving parts (manually) and thus get a very realistic working scene for eg. ROV pilots

The solution supports various control mechanisms for obstacle avoidance, under keel-clearance, 2D depth profiles etc, so it can be used for many operations such as IMR, construction, decommissioning, tug and barge management or traditional 3D surveys.

The online 3D visualisation plays an important role in the TMS catenary and cable lay operations.

4.8.1 Onboard and onshore networked solution

The online visualisation module operates as a networked solution and you may use any Windows workstation on the network.
The system uses a Lite data protocol by exchanging short messages via a centralised server. The data protocol is open, so 3rd party software might send information to the modules if requested. Please contact EIVA for further details.

The data can even be distributed on an internet based solution as long as your system allows a public address of the server pc.

You can try the networked solution yourselves by starting online 3D and connect to ais.eiva.dk, where you get access to vessels active in the Bay of Aarhus close to the EIVA office.

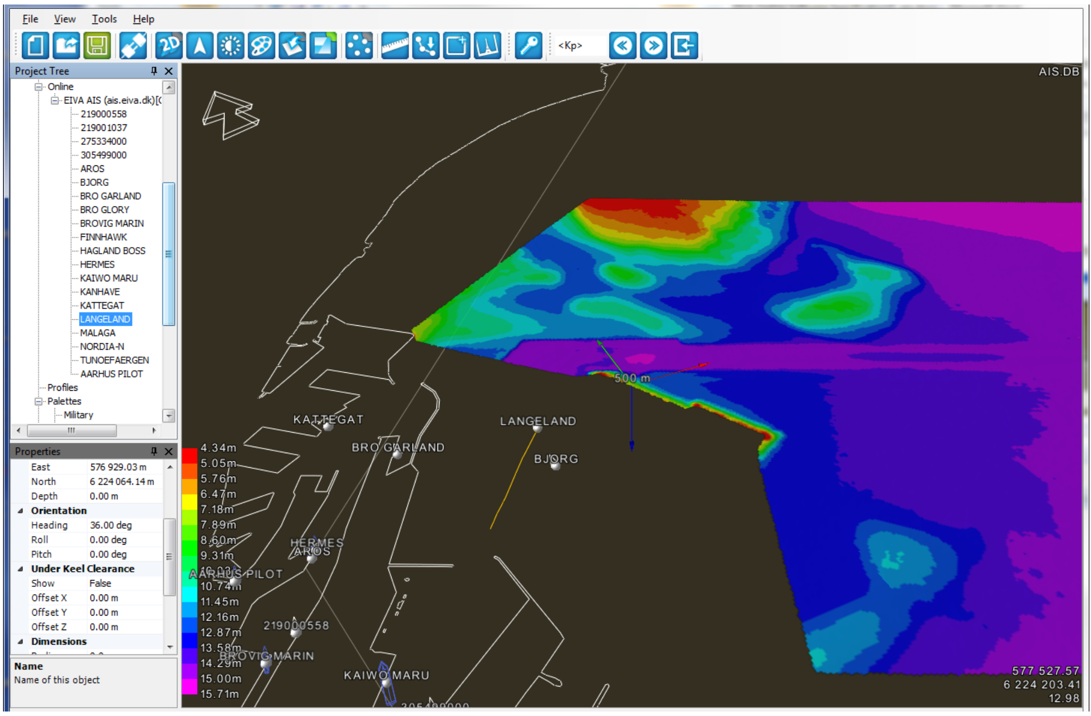


Figure 32 Online 3D showing the Bay of Aarhus with AIS tracked from the EIVA location.

4.8.2 Real time DTM

The online 3D can also connect to a NaviScan system and produce the track of the MBE system on-board. You may even start loading real time data from NaviScan into the online display and show 3D compensated scans for real-time monitoring and QC.

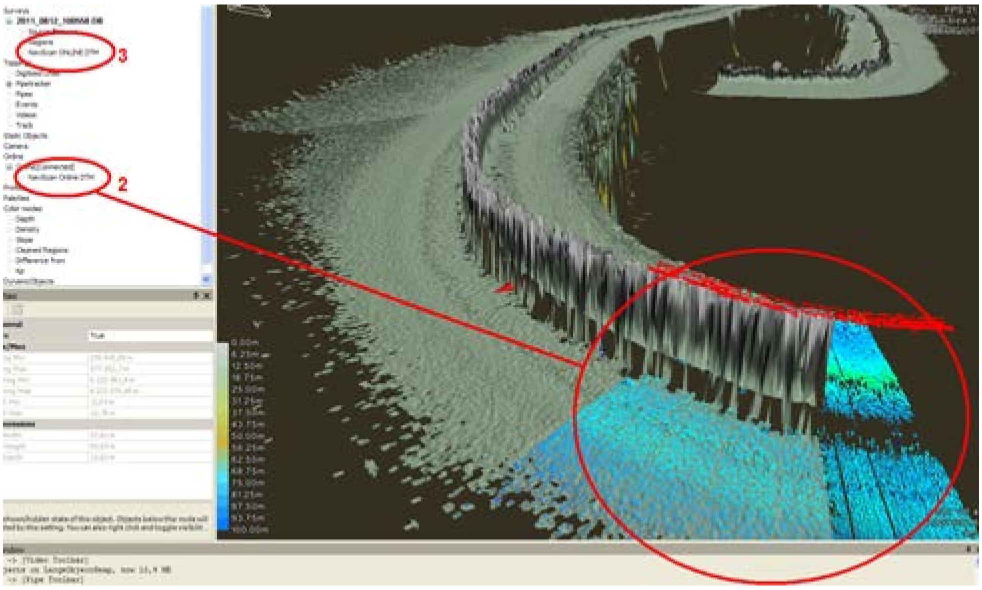


Figure 33 Real-time MBE coverage and terrain modelling.

The real time display will follow the filter and compensation settings from NaviScan and thus give a realistic picture of the expected result. The real-time data can furthermore be added to a DTM and thus build a fast-track result. This can be useful in dredging, dumping or other solutions where time is money.

Online 3D is available for both 32 and 64 bit OS, and for real time DTM we do recommend the use of 64 bit as this give the ultimate performance.

4.9 Barge management & rigmove

The EIVA Tug Management System (TMS) is an optional add-on software module to the NaviPac Integrated Navigation software. The TMS supports multi-vessel operations and its primary applications comprise:

The TMS passes positional data between multiple NaviPac systems by use of telemetry communication links. This allows the NaviPac system onboard each individual vessel to track and display all vessels connected. Major features of the TMS module include:

- Automatic calculation of barge routes
- Monitoring of real-time anchor pattern
- Handling of mid-line buoys
- Inter-vessel communication via telemetry polling system
- High visual impact

4.9.1 Inter vessel communication

Media

- WLAN
- Radio modems
- Telemetry polling

Standard XF

- NaviPac
- IMCA
- WinFrog
- Tracks
- Apache
- AIS
- etc

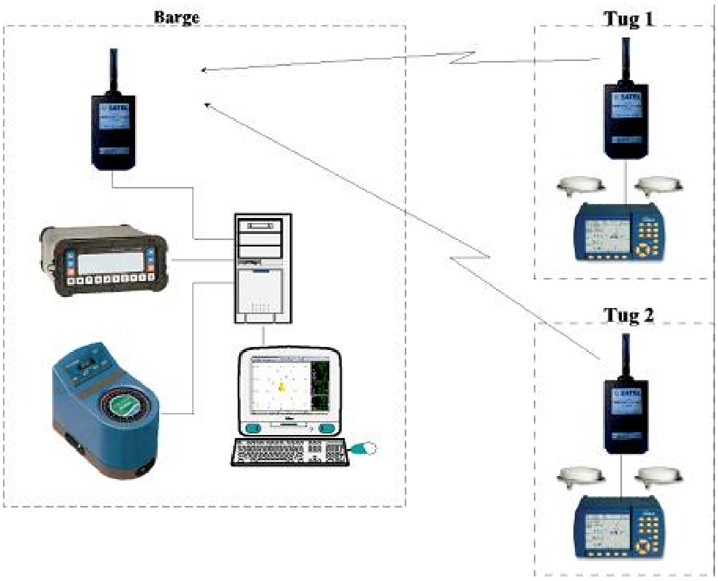


Figure 34 Data telemetry.

Control from barge

All TMS tasks are handled in a TMS master on the barge:

- Graphical control from Helmsman’s Display and standard interface via the RIGMON server application
- Assigning tugs to anchors

- Controlling anchors
- Moving anchors and planning new location
- Assigning runlines
- Assigning waypoints
- Commands to tugs
- Remote monitor and control of tug setup (geodesy, offsets, GPS status, …)

Automated tug operation

The tug boat display can be operated hands-free

- Automatic zoom and pan
- Automatic assignment
- Automatic steering control
- Messages and commands from the barge
- State changes
- Automatic location and pickup/drop commands are send back to the barge and hereafter distributed to all other vessels in the operation
- Reception and activation of runlines and waypoints

4.9.2 3D catenary calculations

By means of the SW add-on module NaviCat you may add an extra dimension to the anchor chain handling in the TMS scenario. You will now be able to model the chains, buoys and anchors in the water column and on the seabed – and even see the result in online 3D.

By utilising predefined cables, MLB (mid line buoys) and anchor libraries, NaviCat makes creation, modification and display of catenaries extremely easy and intuitive. Each library allows for maintenance and extension by the user. During catenary simulation cable types, MLB's and anchors can be replaced / exchanged dynamically and the effect is displayed instantly to the user.

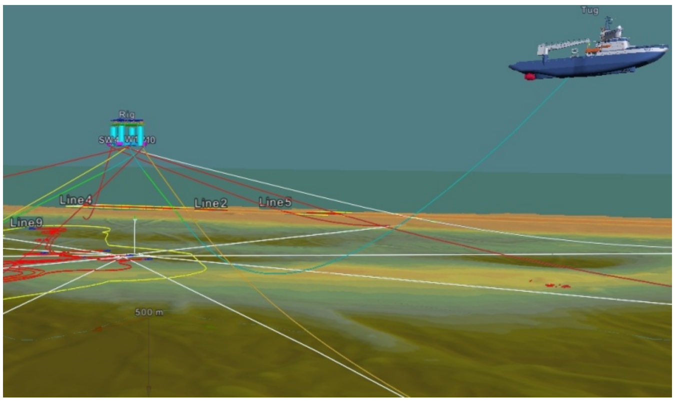


Figure 35 Real-time 3D catenary monitoring.

Defined project files can be stored by the user for later re-use of specific set-ups. Display of catenaries is supported by tools including eg. zooming, measurement, automatic arranging of catenary profiles, drag-and-drop and dockable windows. In NaviCat, each catenary is illustrated as a profile along the catenary in a customisable 2D profile display. Visualisation of catenaries in 3D is handled through integration of NaviPac 3D visualisation module.

During catenary simulations, a large number of parameters for the catenary can be displayed, such as TDP (touch down point), tension and angle at fairlead, tension along catenary, total length, position of anchor and MLB’s, estimated anchor position, display tension alarms along the catenary and much more.

NaviCat can operate in three modes, manual-, calculation- and online mode. In manual mode, NaviCat is used as a planning tool where the impact of different set-ups is easily monitored and visualised. Calculation mode is used for estimation of anchor or tug positions based on a specified tension or angle at the fairlead. In online mode, NaviCat integrates with NaviPac which provides positions and status information about the catenaries including 3D views.

4.10 Online eventing

The EIVA online SW includes an online eventing module. The program connects to NaviPac via network and can be used on one or more workstations at the survey network.

Events are stores in ASCII CSV format for easy access.

The event tablet is user configurable

- Button size, location and color
- Short cuts
- Event recording
- Cascading events
- Incrementing events

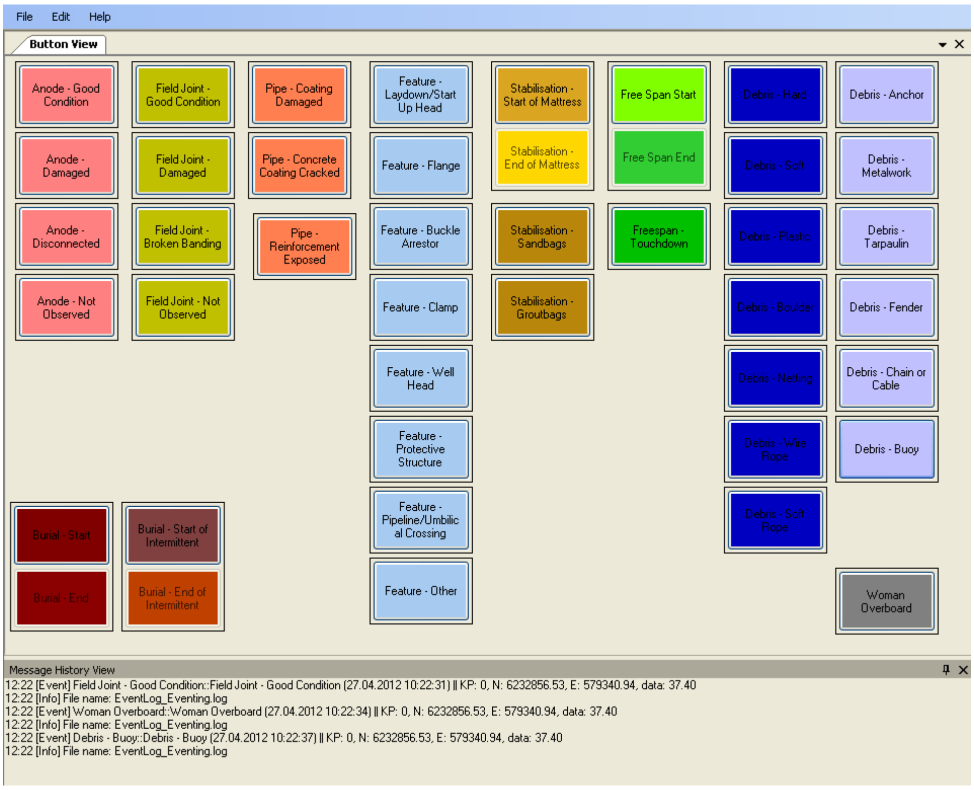


Figure 36 The online eventing is fully compatible with the offline eventing handled in NaviModel.

4.11 Online QC

NaviPac and NaviScan include a series of real time QC features such as sensor plots, alarm handling, 3D depth views and various statistical monitoring. But most of these are handled as momentary solutions – and do not give any proper paper handout.

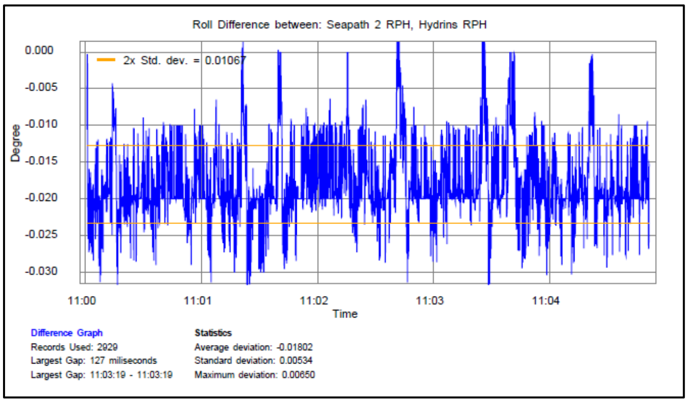


Figure 37 Data report showing error estimates and standard deviation.

4.11.1 Near realtime QC

The Online QC operates on recorded data, and produces line or time based reports showing graphical and alphanumerical results of the collected data. The reports are produced as PDF files in a printable format so they can be used as digital tools or hand-out reports. The reports covers a.o.

- Listing of interfaces, mountings and the maximum data gap
- Graphical and numerical sensor comparisons
- Graphical listing of calculated parameters such as DOL, SMG and DOP
- Graphical sensor listing
- Graphs as time or kp based
- Shaded relief of MBE depth, density and deviation
- Alarms
- Data gaps due to missing input or timing problems
- Time series plots of GPS status parameters

4.11.2 The model

The OnlineQC monitors the data recording folders after new data (NaviPac, NaviScan, Kongsberg, alarms, runlines, CTD and tide) and when available (when the file is closed) it's imported directly into a SQL database.

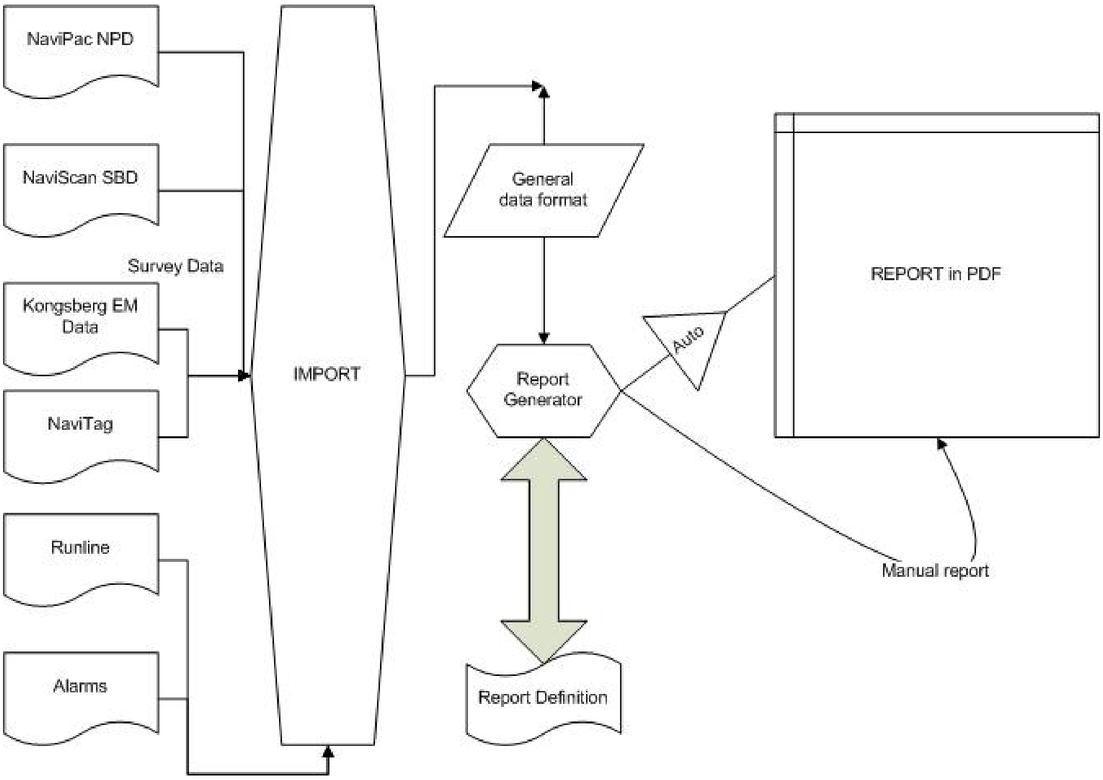


Figure 38 Online QC data and operations flow.

After the import, the reporting tool is automatically started (end-of-line or time driven) and the report is generated based on a user defined selection of sensors to be included in the report.

4.11.3 Redo after processing

A major advantage with this solution is that NaviEdit uses exactly the same database as online QC, This means that the automated import saves the processors a series of manual steps prior to the real processing. Another advantage is that the QC report can be reproduced with the same settings at any stage during the processing based on the processed data in the database. This will hopefully show that all errors and outliers have been fixed.

5 Instruments

NaviPac/NaviScan supports most sensors on the market, and if not found then please contact us for further check or evaluation of implementation.

An updated driver list can be found below, as it's ordered according to the NaviPac sensor grouping. Please refer to the Help menu in your installation for sensor details.

The data input handles different HW platforms

- Direct serial input
  Traditional input of sensor data via COM ports. Time accuracy: 1 ms
- Serial input via ATTU
  High accurate time tagging input from EIVA ATTU units. Time accuracy: 50 µs
- Networked UDP/IP
  Data on network broadcast. Note: To be used for non time critical inputs or timetagged data (eg. MBE)
- Networked TCP/IP
  Data on network connection based exchange. Note: To be used for non time critical inputs or timetagged data (eg. MBE)
- ASCII file (output only)
- GP_IB IEEE (output only)
  Requires special IEEE I/F board – only valid for very old instruments
- A/D converter (special inputs)

5.1 Surface navigation

The surface navigation input covers all sensors that supply direct (eg. GPS) or relative position input (eg tracking system) for the positioning of the primary vessel

Name	Format
NMEA GPS	GGA, GGK and GLL plus GSA/GST
Ashtech GPS	GGA – special variant of NMEA
Trimble GPS	NMEA plus special Trimble format
C-Nav GPS	NMEA or C&C TRIN format
Geco Prakla GPS	TRINAV and GECO3 format
Racal UKOOA	Special Racal ASCII format
TOPCON GPS	NMEA GGA or Topcon NP format
Applanix POSMV	Binary networked interface
Leica MC1000 GPS	Special Leica Binary Format
Fanbeam	Fanbeam range/bearing tracking MKII and MDL
Leica Total Station	3D tracking system via GSI format
Geodimeter ATS600	3D tracking system
AGA Geodimeter	3D tracking system
Topcon Total Station	3D tracking system
Position from USBL	Position vessel via reverted USBL from Kongsberg HiPap, Edgetech Ore etc
User configurable input	ASCII string with absolute position (latitude/longitude or easting/northing) or range/bearing

NaviPac and NaviScan will also accept final positions from external integrated systems, but that will not be the recommended way. Beside this we support a series of older range/bearing systems like Mikrofix, Polartrack and Syledis.

5.2 Gyro

The online software supports most sensors on the market. Note that the list is more detailed in NaviPac than NaviScan. This is mainly because low accuracy units may be OK for navigation purposes but not for hydrography. Please refer to the reference manuals for detailed list

Name	Format
NMEA	HDT, HDM and HDG
Ixsea Halliburton (Phins)	$PIXSE,HSATIT
Ixsea Octans	HDT (to be used with the Octans motion drivers)
Seapath	Binary EM format or $PSXN
Robertseon SKR80	4 bytes binary
Robertson RSG-4	$<gyro>…
MDL	H<gyro>
CDL RLG	RLG1, RLG2 and Tokimec2

Digilog/Trimcupe	"Hggggg.." with gyri in 1/10 degree
S. G. Brown	GGGg heading in 1/6 degree
KVH Tracking	"%<pitch><roll><gyro>
Kongsberg SDP	$PSALS
Anschutz standard 20	Binary Std 20
Honeywell HMR3000	$PTNTHPR
RDI PRDID	$PRDID
RDI DVL	Compass data from RDI PD0
Topcon	$GPHDT or Topcon specific $PTPSR,ATT
POSMV	Binary network telegram group 102
RTK Calculated	NaviPac calculated on base of 2 RTK GPS observations
Solo ROV	"G<gyro>…" or "H<gyro>"
Triton XL Rov	$PPTIROV
Magnum ROV	: .... <gyro>
Innovator 3	$PSSI
Oceanteam Plough	$SMD
Heading from USBL	Gyro from USBL system such as HiPap PSIMSNS
Constructed Direction	Gyro defined as baseline between two observations
Manual	User controllable heading
Edgetech	From integrated Edgetech 4600
User defined	Free ASCII decoder

5.3 Motion Sensor

The online SW supports most motion sensors on the market. Note that the list is more detailed in NaviPac than NaviScan. This is mainly because low accuracy units may be OK for navigation purposes but not for hydrography. Please refer to the reference manuals for detailed list

Name	Format
Ixsea Octans	$PHTRH and $PHTRO – GYROCOMPASS2 and B&A
Ixsea Halliburton (Phins)	$PIXSE,HSATIT
Seapath	Binary EM format or $PSXN
Seatex MRU	Binary coded data
TSS335b	Standard TSS ASCII format (DMS, TSS, …)
TSS332	TSS332 roll/pitch
MDL	P<pitch> R<roll>
CDL RLG	RLG1, RLG2 and Tokimec2
Digilog/Trimcupe	"PppppPRrrrrr.." with data in 1/10 degree
Dynabase CRU	Binary Atlas Format
KVH Tracking	"%<pitch><roll><gyro>
Kongsberg SDP	$PSALS
Honeywell HMR3000	$PTNTHPR
RDI PRDID	$PRDID
Topcon	$PTPSR,ATT - pitch only
POSMV	Binary network telegram group 102

Solo ROV	" …P<Pitch>…R<Roll>…."
Triton XL Rov	$PPTIROV
Magnum ROV	: …. <rrrrr> <ppppp>
Innovator 3	$PSSI
Oceanteam Plough	$SMD
Motion from USBL	Roll/Pitch from USBL system such as HiPap PSIMSNS
Edgetech	From integrated Edgetech 4600
Triaxus	Sensor data from MacArtney Triaxus
User defined	Free ASCII decoder

5.4 Doppler velocity log

NaviPac and NaviScan supports mainly the Teledyne RDI DVL, as this is the most generally used unit. The modules supports

- ASCII PD6
- Binary PD0, PD3, PD4 and PD5
- Schilling UHDRov

5.5 Data acquisition

The term data acquisition covers generic data input in NaviPac and depth/altitude in NaviScan. The drivers have been grouped in logic sensors to keep the long list as understandable as possible

5.5.1 Echosunder & altimeter

Name	Format/Note
Atlas Deso 25	DA/DB
Kongsberg EA	EA200, 300P and 500
BENTHOS PSA 900	
TRITECH	Altimeter
NaviSound 2000	
NMEA	DBT, DBS and DPT
L-3 (Elac)	LAZ 4700, LAZ4721 & HS4300
Odom Echotrac	Metric only
Altimeter from RDI DVL	PD0 only
Fahrentholz	
User defined ASCII	Free definable driver

5.5.2 Depth & bathy sensor

Name	Format/Note
Digiquarts	Pressure in PSI
Digiquarts Barometer	Surface pressure for depth reference
Tritech SCU 3	WINSOR Processed
Simrad UK90/94	
Ulvertech Bathy	
SCS ROV	
Solo ROV	
Magnum ROV	
Triton XL ROV	$PPTIROV
Innovator 3	
SIS1000	Depth and range
NASNetR	
Seabird Pressure	
Triaxus	
NMEA GPS	GPS as height reference
Edgetech	From integrated Edgetech 4600
Triaxus	Sensor data from MacArtney Triaxus
ScanSense PS30	PS-30 ASCII
User defined ASCII	Free definable driver

5.5.3 Pipe & cable tracker

Name	Format/Note
TSS340/350	
Innovatum Pipetracker	

5.5.4 Magnetometer

NaviPac only

Name	Format/Note
G-880 Censium Magnetometer	$<mag>
EG&G MAG G-866	
User defined ASCII	Free definable driver

5.5.5 NaviPac Science

NaviPac only

Name	Format/Note
NMEA Wind Sensor	
ScanFish	Data from ScanFish II and Mini
Valeport	Raw, processed and current meter
SAIV SD-204	
WET Labs ECO FLNTU	
HydroC PAH	CO_2
SBE-49	Format 0 and 3
Cyclops 7	Simple A/D data from ScanFish or processed ASCII from Triaxus
AMT Oxygen	O
AMT PH	PH
Aanderaa 4330 Optode	Variable ASCII
User defined ASCII	Free definable driver

5.5.6 Other inputs

NaviPac only

Name	Format/Note
CTC Trencher	Trenching information
Subspection CP	CP
Correocean CP	CP
GSSI Georadar	Scan number
Current from RDI Doppler log	PD0 only
OS-9 JetKnife	Selectable parameters
CapJet	Selectable parameters
Oceanteam Plough	Selectable parameters
Aanderaa pressure	Water level etc
Feather angle	2D Seismic – calculated angle between line and streamer
Distance shooting	2D Seismic – statistics on shooting
iUSBL QC	2D seismic – UW streamer QC
Eilersen Tension	Cable lay
Caterpillar data	Cable lay
JD Angle counter	Cable lay
MiniCon-30/40	
User defined ASCII	Free definable driver

5.6 Dynamic positioning

Dynamic positioning is handled only in NaviPac, and covers solutions for positioning of remote vehicles such as ROV, ROTC, AUV and remote vessels.

5.6.1 USBL

NaviPac supports most generally used Ultra Short Base Line system, either directly or via emulators.

Name	Format/Note
Kongsberg	HiPap, APOS, HPR400 (binary or NMEA PSIMSSB) HPR300 (Binary BCD) HPR300P (Portable unit)
Ore Trackpoint	TP-II, TP-III and Bats
Nautronix	RS29
Posidonia	$PTSAG
Sonardyne	$PSONUSBL

5.6.2 LBL

NaviPac supports most generally used Long Base Line system, either direct or via emulators

Name	Format/Note
Sonardyne	APS3, Pharos and Fusion
Kongsberg	NMEA $PSIMLBL
Nautronix NASNetR	$NASPOS

5.6.3 INS

More and more systems are supporting INS, which can be interfaced into NaviPac either via standard drivers or emulators.

Name	Format/Note
Kongsberg	Hain $PSIMSSB
Sonardyne	Sprint via NMEA GGA
Hugin FFI	$PFFILLD
Ixsea GAPS/Phins/ROVINS	$PTSAG and $PIXSE, HSPOS

5.6.4 Remote navigation

Data from remote vessels – either via remote navigation input or direct telemetry of GPS data.

Name	Format/Note
Remote GPS	$GPGGA or $GPGLL
NaviPac	Special NaviPac exchange protocol
Winfrog	NMEA GGA and HDT merged
Thales Tracks	$PRPS,POSN
IMCA	$ TEL, PH
Century Subsea Spar	
Apache	$SFPOS
User configurable input	ASCII string with absolute position (latitude/longitude or easting/northing) or relative range/bearing
AIS	Input all objects and assigning important items to NaviPac vessels

5.6.5 Tracking & others

This covers range/bearing total stations, tracking systems and other special instruments.

Name	Format/Note
Leica autotrack	
AGA Geodimeter	From vessel or from target
Topcon	
Fanbeam	
Artemis	
Golf III Laser	
Leica Disto WH15/WH30	Distance only
Tritech Seaking	Target from sonar
Digicourse tailbouy positioning	Streamer positioning system
Seatrack tail position	Relative GPS information
Sonardyne iUSBL	USBL on USBL – NMEA $PSIMSSB
Trimble CB430	Excavation system

5.7 Special input

The special input is mainly used in NaviPac (a few in NaviScan though) and covers in general drivers that doesn't match the global structure.

Name	Format/Note
NMEA ZDA	GPS $..ZDA plus special input of PPS
Trimble UTC	GPS $..UTC plus special input of PPS
NMEA Targets	Radar targets as $RAATM, $RAEST or $PXSPT
Raytheon Radar	Radar targets as

AIS	Vessel tracking. Class A & B
NMEA Waypoints	Runline waypoints $..WPL
Osprey Waypoints	Binary BCD data as special binary protocol
Kongsberg Runlines	$PRTRC+ $PRWPT or $PRTNW
NaviPac Control	Internal NaviPac communication for TMS and rigmoves
Sercel Nautilus	Special TCP/IP Streamer data

5.8 Data output

The data output is a special tool in NaviPac which allows the operator to distribute data from the navigation system to other systems onboard or via telemetry to other vessels or onshore installations.

5.8.1 EIVA to EIVA

Internal EIVA protocols.

Name	Format/Note
Data to NaviScan	ASCII protocols with position, height, runline control and geodesy information
Data to tug boats	Position, anchor pattern etc to AHT
Data to external NaviPac	Position, runline etc to remote NaviPac
Sideboat	Data exchange with environmental sideboat NaviPac
Online 3D	Special lite protocol for Online 3D (NaviModel) via SceneServer
Online Eventing	Position information for Online eventing
EIVA Dredging	Position of bucket and rectangle of cleared area. Special ASCII telegram for Online3D presentation

5.8.2 Export to other acquisition systems

Name	Format/Note
Edgetech	NMEA protocols exporting position, speed and heading
Triton ISIS	Position, speed etc needed by the ISIS system
Coda	Position, speed, depth etc required by the Coda Acquisition system
L3 HydroStar	Special XSE data exchange protocol
L3 HDP4060	Position, heading and speed
Kongsberg SIS	Runline Control $NPR
NMEA	Controllable NMEA output supporting position, heading, speed, time, depth and autopilot
Libnitz Lann Video Overlay	Special format supported by Libnitz, Taylor and NEtMC
Outland Video Overlay	Start/stop video, overlay and headers
EMRI Autopilot	Sem200 and similar
Kongsberg DP	NMEA or binary BCD
NetMC	Special video recording control
CDL	Data exchange with CDL MiniPos

Sonardyne telegram	$PSONDEP
Rob Track	$DNRTR
BOTS MVP	Special NMEA combination
OS/9 Jetknife	Navigation and raw sensor data
ROT-II	Sensor data and position
CapJet	Position and runline control
Hugin	Summary of vessel position and USBL data
Schilling ROV	Runline info to ROV pilot
iXsea ROVINS/Phins	$GPGGA/$PUSBA

5.8.3 Annotation

Annotation of traditional recording systems.

Name	Format/Note
Deso 25	Start, Stop and events
Delph 1	Time, position and event
Datasonics Chirp	Time, position and event
Edgetech 260 and 560	Start, Stop, position and events
EPC4800	Start, Stop and events
EPC1086	Start, Stop and events
Klein 595	Start, Stop and events
L3 LAZ4700	Start, Stop and events
L3 LAZ4721	Start, Stop and events
L3 HS4300	Start, Stop, kp and events
Waverly 3700	Start, Stop and events

5.8.4 Seismic operations

Special 2D seismic data exchange.

Name	Format/Note
Geometrics Stratavie Seismograph	Navigation header information of shot point
Geoacoustics	Special ASCII format
Bodensee	Special ASCII string on shot point
Digishot	Distance shooting into
Seal Spectra	Spectra and IO formats

5.8.5 Inter vessel communication

Exchange of navigational information with remote vessels.

Name	Format/Note
Winfrog	NMEA GGA/HDT alike
Pseudo NMEA	NMEA GGA/HDT alike

IMCA	$..TEL,PH
Apache	$SFPOS
Sonsub	$PSURP
EIVA	NaviPac special compressed ASCII
Caesar TMS	Special message for tug and anchor info
Kongsberg	NMEA $PSIMSSB with position in radians

5.8.6 Client specific

Various export formats made for specific clients or vessels.

Name	Format/Note
Head Up	Special output for Acergy/Subsea 7 Head—up System
ROV_LOG2	Special output for Acergy/Subsea 7 ROVLog System
CMS	Special output to Acergy Catenary Monitoring System
Acergy Acq	Special $ACGDAT telegram
Asean Restorer	Special NMEA telegrams
Balder ROV	Position and steering information
Sperre ROV	Dedicated control system
Geosubsea Pipe	Special DVL and sensor output
IOW TGO	Special file based output to IOW

5.8.7 Generic output and export

The user defined data export allows you to generate your own data string by combining and formatting data from all parameters in the current navigation solution.

5.9 Multibeam sonars

All the multibeam echosounders, scanning sonars and interferrometric sonars are interfaced into the NaviScan part of the online SW.

Name	Format/Note
Reson	9001, 9002, 81xx, 81xx-DH,7K, 7K-DH
R2Sonic	2000 single and dual head
EM3000	Raw Ranges
Odom	Echoscan and ES3
L3 Hydrostar	XSE format (single and dual head)
Imagenex DeltaT	single and dual head
Blueview 3D	single and dual head
Atlas Fanswwep	FS15, FS20 and Hydrosweep
Benthos C3D	
Edgetech 4600	
Kongsberg SM2000	

Seaking Profiler	Single and dual head
ST1000 Profiler	Single and dual head
Hyspec modular scanner	MK-II
MS 1000	
Teledyne Odom	MB1

5.10 Sidescan sonar

All the dedicated and multibeam echosounder integrated sonars are interfaced into the NaviScan.

Name	Format/Note
Reson	8100, 7K SS & 7K Snippets (single and dual head)
R2Sonic	2000 single and dual head, Truepix
Atlas Fansweep	FS20 and Hydrosweep
EM3000	Snippets
Benthos C3D	
L3 Hydrostar	XSE
Edgetech	4200 and 4600
Odom	MB1 Snippets
Imagenex	872 Snippets

6 Data formats

The online software supports a series of data importers and exporters. For a final list please refer to the documentation site.

6.1 Data recording

The online software utilises data recording by EIVA defined formats, which is well documented for further use. The global principle in the EIVA recording is raw data recording with metadata, which makes it possible to make efficient reprocessing from antenna to the seabed in the offline software no matter which settings you are using online.

- **NaviPac survey format**
  The survey format is designed for use in the EIVA processing software and includes all metadata and interpreted and calculated solution. The information is kept at a level so the results can be re-calculated from GPS antenna to the seabed. The format is ASCII.
- **NaviPac general format**
  The NaviPac general format is an extension of the survey format (but not to be

considered as an alternative) as it contains the same as the above plus copy of all raw sensor data. The metadata is kept in a more readable format. The format is ASCII and is normally used for test and troubleshooting.

- **NaviPac custom format**
  The NaviPac custom logging is a simple CSV format where operator may design his own recording. This solution is normally used for testing and simple hand-outs.
- **NaviPac P2/94**
  NaviPac supports export of the survey data to the special UKOOA P2/94 format. This is mainly used for seismic operations.
- **NaviScan SBD**
  The NaviScan data recording is based on a binary proprietary format SBD, which basically consists of a streaming of all the sensor data to disc with metadata, identifier and timestamp. The SBD format is directly usable in the EIVA offline suite and can also be read by some 3rd part systems (Caris etc).
- **NaviScan XTF**
  The NaviScan data can also be exported to XTF (eXtended Triton Format) as part of the data recording. This is mainly used for sidescan data as this enables processing in most mosaic solutions. Please note that NaviScan supports sensors that isn't defined in XTF, so please contact EIVA before use.

6.2 Data overlay

The most general data display in the software can be combined with external data in both the Helmsman's Display and the online 3D display.

6.2.1 Lines & points

NaviPac supports runlines, display lines and waypoints based on simple ASICII formats. The format definition is open and delivered with the SW.

- **Runlines**
  The internal EIVA runline format (RLX) is a simple ASCII protocol defining each segment by defining start, end, curvature, kp scale, status etc.
  We do also support the standard POI (Norwegian Sector) format directly

```
# 4/4/2011 23:18:14
"+0"; 72; 0.0000; "Meter"
617575.190; 6291694.866; 612292.026; 6296855.276; 0.00179478; 7.38702686;
0.0000; 1; 72
"+29"; 72; 29.0000; "Meter"
617506.306; 6291802.688; 607566.937; 6301511.116; 0.12641270; 14.02046277;
0.0000; 1; 72
```

- **Display lines**
  Display lines can be used as either inactive display lines or as danger zones etc. The files are defined as simple point to point drawings using a HP Plotter Language.

Display lines can also be imported from ACAD DXF/DWG.

```
     2          0     3
124822.87  271454.99 -2
125103.55  271213.90 -1
115443.84  259967.86 -1
```

- **Waypoints**
  Waypoints is defined as single point location (multiple can be defined in a line) defined by position, danger zone and graphical symbol. The waypoint format (WP2) is simple ASCII format:

```
"Black"; 499000.000; 6007000.000; 0.000; 0.1; 0.1; 0.1; ""; 0.00; -10.1; "";
0.00; ""; 1; 0.000; 0.000; 0.000; 0; 0.05
"White"; 499000.000; 6006900.000; 0.000; 1.1; 1.1; 1.1; ""; 0.00; -10.1; "";
0.00; ""; 1; 0.000; 0.000; 0.000; 0; 0.05
```

6.2.2 Symbols

The presentation of dynamic (vessel, ROV, AUV) and static objects (waypoints) can be made as simplified symbol (square, triangle, …) or graphical drawing

- **2D**
  The 2D drawings are based on a simple ASCII format (called SHP – which isn't the standard shape format) based on HP Plotter language. The format is point to point drawings with selection of colors and fillings. A small drawing utility /FileAsc) is supplied with NaviPac.
  The drawings can be imported from ACAD DXF/DWG.
- **3D**
  A 3D drawing can be assigned to objects in the online 3D display. The drawings must be in the format called 3DS. Drawings can be produced in a number of standard tools such as 3DS Max.

6.2.3 Charts

NaviPac supports the use of commercial and free charts as background display for the Helmsman's data window.

- **C-MAP**
  Commercial chart delivered from Jeppesen. The charts can either be based on systems bought from Jeppesen or own charts compiled with the C-Map. C-Map require a special dongle from Jeppesen.
- **7Cs**
  Commercial chart delivered from SevenCs. The charts can either be based on systems bought from the supplier or own charts compiled with the 7C kernel. 7Cs require a special dongle or license code.

- **S57**
  You may use your own S57 (ECDIS) charts via commercial compilers from either Jeppesen or 7Cs.
- **Geocoded images**
  NaviPac supports import of a series of geocoded images (pictures with world coordinate information) such as Geotif etc. This is license free.
- **ACAD**
  NaviPac supports use of large DXF/DWG drawings on your display by utilising LOD technology for loading, zoom and pan.

6.2.4 Models

The online displays may use historical or real time data (bathymetric or sidescan) as background display for guidance and quality control.

The data can either be delivered as final models or build in the Helmsman's Display or online 3D.The following data is supported.

- Final model from NaviModel
- Real time or historical data from NaviScan
- Realtime or historical data from Kongsberg SIS
- Realtime or historical data from L-3 XSE
- Realtime or historical data from ASCII XYZ

The data modelling is based on the quad-tree principle from NaviModel – and utilises a very efficient data model which allows fast zoom and panning on unlimited data sizes.

7 HW & SW requirements

The EIVA online SW solution is built on the windows platform and supports PC's running Windows XP, Vista or Windows 7. The OS must be delivered in the PRO version. For configuration of Windows 7, please refer to special EIVA guidelines.

The system requires .NET 4, which is distributed with the EIVA install DVD.

If you are using the online QC feature then the Microsoft SQL server must be installed on the pc. A free edition of this is supplied with the installation DVD.

The online SW is designed to utilise multiple processors, and we recommend the use of multiple core pc.

Minimum RAM: 4 GB

Minimum HDD: 500 GB

The software is compatible with both 64 and 32 bit OS, and a few modules utilise the 64 bit for the optimal performance.

Serial sensor interfacing is either done via the EIVA ATTU or build-in serial interface boards.

The ATTU is interfaced into the online SW modules using a network interface and it requires no special HW. It may in certain installations be considered if the ATTU network is separated from the ordinary vessel network. It that case it will require a second network interface board on the pc.

The online supports most windows compatible interface boards, but it is on Windows 7 important to check for compatibility. EIVA is normally using MOXA or Digiboard solutions for our installations.